The Aircraft, the Rotorcraft and the Life of Walter Rieseler 1890-1937

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ABSTRACT

Walter Rieseler was a German aeronautical pioneer, who initially was successfully designing fixed-wing aircraft, then was the first to invent an automatic feathering control mechanism for autogyros. Today he is mentioned in conjunction with the Wilford gyroplane, where his invention came to fruition. Back in Germany, he designed helicopters competing with the famous aeronautical pioneers Henrich Focke and Anton Flettner, until after his sudden death all activities ceased and his name fell into darkness.

INTRODUCTION

Henrich Focke (1890-1979) and Anton Flettner (1885-1961) are pre-war Germany's most famous helicopter pioneers, while Friedrich von Doblhoff (1916-2000) followed during WW II. But there was a fourth one named Walter Rieseler (1890-1937), whose name has all but disappeared from the history books, Ref. 1.

As early as 1926 Walter Rieseler, together with his companion Walter Kreiser (1898-1958), patented the automatic feathering mechanism for rotating wing aircraft in Germany, Ref. 2, and England, Ref. 3. An amendment to increase the effectiveness of the invention was patented only in Germany, Ref. 4. The first patent was also issued in France, Ref. 5, and in the U.S., Ref. 6. Some years later Rieseler's invention was applied to the Wilford Gyroplane of the Pennsylvania Aircraft Syndicate (PAS) in the U.S. as described in Ref. 7, but later this control type was mainly associated with Wilford's name only.

Little can be found in the archival literature about Walter Rieseler and his rotary wing developments. A first summary of his autogyro developments is found in Ref. 8 of 1936. Some account was also given in the *Göttinger Monograph N* of 1946 about German Research and Development on Rotary-Wing Aircraft (1939-1945), Ref. 9. It only focused on the description of Rieseler's helicopter developments from 1935-1937. A translation of this early post-war document is available today, Ref. 10. Some account of especially flight testing experiences can be found in Steve Coates' book about German Helicopters 1930-1945, Refs. 11, 12. Rieseler's helicopter designs are also mentioned by Witkowski in Ref. 13. In Jean Boulet's book about the history of the helicopter Rieseler is barely mentioned as "another German builder of two helicopters with co-axial rotors", Ref. 14. Therein the first design is said to have had a weight of 400 kg and a 44 kW [60 HP] engine, to have flown 160 km/h (which Boulet considered unbelievable) and to have crashed Sept. 3, 1936. The second design with two Siemens Sh 14A engines has had its first flight in December 1937 and crashed soon after.

Another historian mentioned Rieseler only indirectly in a section about the Wilford Gyroplane, Ref. 7: "Wilford incorporated a blade incidence control system that made use of the flapping–feathering interchangeability. He based his design, in part, on the inventions patented, and the prototype built, by Rieseler and Kreiser in Germany in 1926. The successful application by Wilford, Hafner, and Kellett was to become the key element in helicopter control and stability." It was not mentioned that both Germans were at the Wilford company for some years to help implementing their patents, and no reference is made to their successful helicopters thereafter in Germany.

A large source of information on Rieseler, however, can be found in the Helicopter Museum in Bückeburg, Germany, Ref. 15, the German Museum in Munich, Ref. 16, and on a website hosted by Walter Rieseler's grandchild Hartmut Rieseler, Ref. 17. And while digging deeper and deeper into the subject, more and more sources of information were identified in aeronautical journals of the time, booklets about the history of the Berlin-Johannisthal airport, and others.

FROM BIRTH TO AIRBORNE

Walter Rieseler was born on Dec. 3, 1890, in the city Burg near Magdeburg in Germany as the oldest of three children. He had a brother named Werner, with whom he later designed sports aircraft. His interest in aeronautics was awakened early and as a schoolboy he had built and tested airplane model gliders. He closely followed the aeronautical developments and achievements that could be found in the newspapers of the time. The worldwide hype that developed after the first successful motorized flights of the Wright brothers left him with the desire to fly himself. Together

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with a friend of him, Gustav Schulze, he shared the dream of flying and both were known as the “Burg’s Aviators”, Figure 1. Note that the wings on the table, looking like a trophy, actually were connected with a linkage revealing its true purpose: a flapping wing toy. It is not reported, however, whether it made successful flights or not.

1908 experiments with hang gliders at the Gütter-mountains nearby followed, Figure 2. From the photo of a successful flight shown in Figure 2(c) the glide angle can be estimated as almost as steep as the slope of the hill. Therefore they could not fall deep as the ground was always nearby, and this must have been the impression that Otto Lilienthal must have had during his glider experiments 1891-1896. It must have been quite frightening almost scratching over ground at any time. Even catapult starts on an island in a lake near a popular restaurant destination are reported for the following years.

(a) The friends, age 18, posing for a photo.
Walter Rieseler (right): note the beard

(b) The bird’s wings on the table – a flapping wing toy!

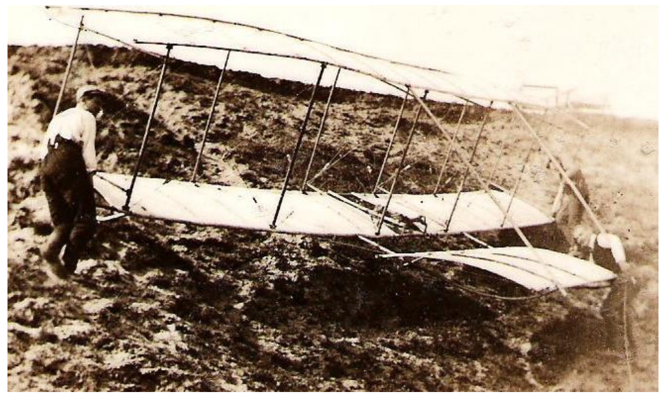
Source: Hartmut Rieseler

Figure 1. Gustav Schulze, left, and Walter Rieseler, 1908.

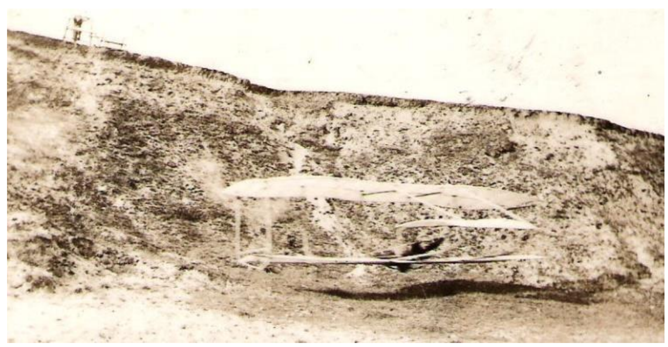
From Trainee to Flight Instructor

In the following years Walter Rieseler and his friend were looking for the opportunity to learn flying on a more professional basis, which opened up in 1910. Hans Grade (1879-1946) was a famous German aeronautical pioneer and engineer, who started in aeronautics as early as 1905 with the establishment of the Grade Motor Company in Magdeburg that moved to Borkheide in 1909. His pilot school opened a year later. Grade died in 1946 and the Hans Grade Museum at the airport Borkheide keeps up the memories.

(a) “Dry”-Training for flight



(b) The hard thing: uphill



(c) Finally: airborne! Note: the glide angle is almost as steep as the slope of the hill.

Source: Hartmut Rieseler

Figure 2. Glider experiments, 1908.

Rieseler and Schulze soon took advantage of this opportunity in front of their homes and learned flying on the Grade monoplane. After sufficient flight training on various aircraft, the one shown in Figure 3(a) appears to be an Obotrit monoplane (the wing in shoulder height is lower than in the Grade monoplane, and Rieseler is mentioned as pilot of the Obotrit in 1913, Ref. 18), Walter Rieseler obtained his flying license (No. 481) from the flying school of Hans Grade in Borkheide southwest of Berlin on a Grade monoplane on August 11, 1913; Figure 3(b).

(a) Walter Rieseler as flight trainee

(b) Walter Rieseler (X) in the middle of other pilot trainees

(c) Pilot license no. 481, August 11

Source: Hartmut Rieseler

Figure 3. Rieseler becomes a pilot, 1913.

Rieseler became a skilled pilot, won some flight competitions and started as flight instructor in Berlin-Johannisthal in 1914, Figure 4(a). The airfield Johannisthal-Adlershof was founded 1909 as second airport in Germany and quickly became quite famous and most important, since all aircraft designers and manufacturers having rank and name - including the Wright brothers, Albatros, Parseval, Zeppelin, Harlan, Rumpler, Schwandt, Jeannin, Fokker, Ago, Luftfahrzeug-Gesellschaft, Luftverkehrsgesellschaft (LVG), Sablatnig, and many more - had their facilities there, as well as the German Aeronautical Testing Establishment (Deutsche Versuchsanstalt für Luftfahrt, DVL), founded 1912. After opening of Berlin Tempelhof in 1923 the airport lost its importance for passenger transport, and after WW II it was closed completely. Today the area is converted to industrial use and residences.

World War I

During WW I Walter Rieseler made use of his pilot's license and served as a pilot for the LVG in Berlin Johannisthal. The LVG manufactured more than 5000 aircraft during WW I and became the second largest aircraft company behind Albatros. His job was to declare the airplanes flightworthy prior to their delivery to the troops, and in parallel he worked as a flight instructor. Later during the war he moved to Köslin (today Koszalin in Poland) and acted as fighter pilot instructor there, Figure 4(b).

(a) Rieseler with a trainee and his son, Berlin, 1914

(b) Rieseler as fighter pilot instructor in the "Flying Squadron Rieseler," Köslin, 1918

Source: Hartmut Rieseler

Figure 4. Rieseler during WW I.

A new Start in 1919

1919 Rieseler returned to Johannisthal opening his own flying school with about 10 biplane aircraft left over from the former German air force, Figure 5. For this business he obtained a former building of the AERO GmbH, Ref. 19. However, during the time of inflation following WW I the operation of this business was increasingly difficult to keep up. Also, due to the Versailles Peace Treaty the aircraft of the flying school were confiscated and the flying school had to close.

(a) Flying school with some of the biplanes obtained

(b) Rieseler's brother Werner (standing on the wing)

Source: Helicopter Museum Bückeburg (a),
Hartmut Rieseler (b)

Figure 5. Rieseler as flight instructor, 1919.

Successful Aircraft Designs

Walter, together with his brother Werner, started developing sports aircraft in 1920, which was allowed by the contract of Versailles. A manufacturing company named "Walter Rieseler Kleinflugzeuge (Small Aircraft)" was opened at the Johannisthal airport. The home address of Walter Rieseler was given in a telephone book of 1923, Ref. 20 and Figure 6.


Rieseler, Walter, Fluglehrer, Johannisthal, Johannes-Werner-Str. 23.
Oberschöneweide 30 37

Figure 6. Address of Walter Rieseler, 1923, Ref. 20.

The first aircraft the brothers designed was the R I, a compact open-cockpit monoplane with strut support of the wings and a two-wheel undercarriage and a tail skid, Figure 7. The fuselage consisted of a welded steel tube frame, the 7 m span wing had ailerons and the tail surfaces had ruder and fin for longitudinal and lateral control. As engine served a two-cylinder Haacke HFM 2 motor with 19 kW [26 HP], but other sources state 21 kW [28 HP] (Ref. 21) or two versions with either 15 or 25 kW [20 or 34 HP].

(a) Light-weight steel tube frame

(b) Ready for first flight

(c) Airborne. Background: Zeppelin hangar.
Source: Hartmut Rieseler

Figure 7. Rieseler R I monoplane, 1920.

Due to the very large wing surface the wing loading was low and very short take-off and landing distances could be obtained at speeds as low as 40 km/h. The photo shown in Figure 8 from Ref. 22 gives a nice impression of the relatively small size of the first Rieseler aircraft.

Source: Helicopter Museum Bückeburg

Figure 8. Size of the Rieseler R I monoplane, 1921.

Walter Rieseler more and more devoted his skills to refinement of the design, while his brother Werner became a very ambitious aerobatic pilot while. With their first development, the R I, Werner participated at many flight competitions and won the 1st prize the same year at a landing competition in Johannisthal.

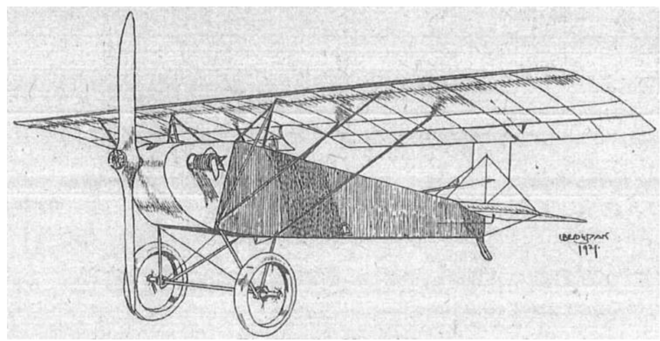
Refinements of the R I soon resulted in the R II, also called “Parasol” in 1921, from the outside almost undistinguishable from its predecessor. A major improvement introduced into the design was that the wings were removable and the entire aircraft could be stowed very compactly on a car trailer, in order to make it roadworthy.

The R II had such a good maneuverability, flight characteristics and handling qualities that the company “Stahlwerk Mark” in Breslau agreed to start a series production of it and of all of its successors. Ref. 23, based on an article published in *Flugsport*, repeated the above description and added a list of specifications. Of interest is the maximum weight of just 230 kg with an empty weight of 165 kg, leaving room just for light-weight pilots. A drawing of the machine given in Ref. 23 is shown in Figure 9(c). A detailed description is also given in Ref. 24. Therein, the total weight is given as 290 kg and the engine power as 22 kW [30 HP].

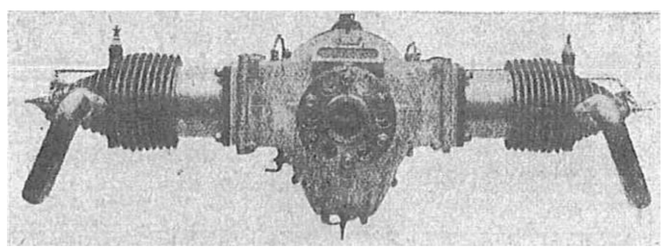
In 1922 Rieseler also obtained certification of the R III/22 (the III is denoting the third vehicle, the 22 denoted the year) by the DVL in Adlershof at the east end of the airport Johannisthal. The R III, now equipped with a stronger Haacke HFM 2a two-cylinder boxer engine with 25 kW [34 HP] became the first German sports aircraft manufactured in noteworthy numbers. This airplane also had foldable wings and thus was transportable by a car or even a motorcycle, Figure 10. This figure also shows the Anzani six-cylinder engine that replaced the HFM 2a and Werner Rieseler in front of the aircraft. Several variants were built, denoted by characters, such as R III a, b, c.

(a) The aircraft on ground

(b) and airborne



(c) Drawing of the R II



(d) Photo of the Haacke engine

Source: (a, b): Hartmut Rieseler; (c, d) Ref. 23

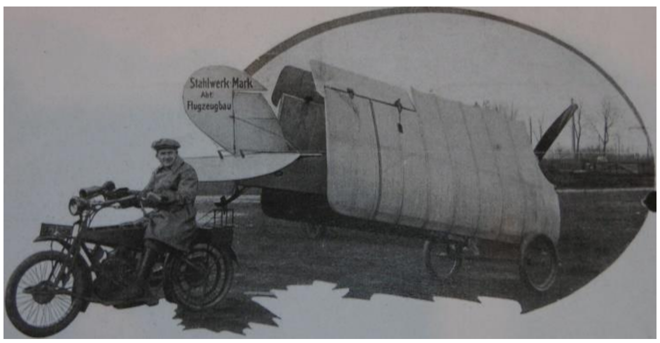
Figure 9. The Rieseler R II monoplane.

A replica of the R III can be seen in the aeronautical museum Hannover-Laatzen, Ref. 25. The Swedish Filip Bendel, who got the drawings from Rieseler when studying in Berlin, also built an R III with the help of friends when being back in Sweden in 1922. This aircraft now is on display at the Stockholm-Arlanda Aircraft Collection, Ref. 26 and Ref. 27.

Ref. 28 provides a most detailed description of the aircraft, emphasizing the high flight performance with a climb rate of 1 km/min, flight speed of 125 km/h, landing speed of

40 km/h and a distance from touchdown to a stop of 10 m only. Production rate was one aircraft a week with the goal of one per day, thus significantly reducing production cost by mass production. The pilots' outside view and the instrument arrangement were rated first-class and the ability of carrying it on land just by a motorcycle was highlighted.

(a) The R III as a car trailer, 1922



(b) R III transport by a motorcycle, 1923

(c) Werner Rieseler in front of the R III, 1922
Source: (a, c) Hartmut Rieseler; (b) Ref. 28

Figure 10. Rieseler R III foldable sport monoplane.

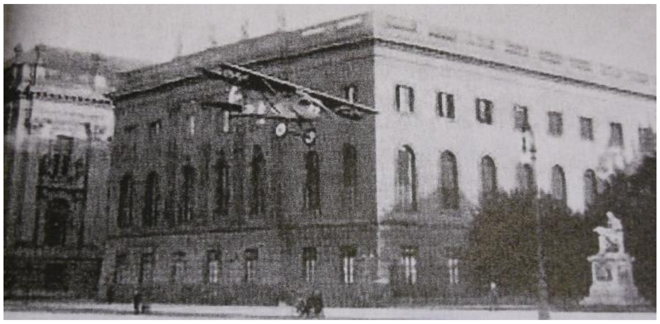
Ref. 28 also gave a technical description as follows. The engine was a motor providing 22 kW [30 HP] at 1300 RPM with horizontal cylinders which arrangement provided good sight for the pilot. The rest of the engine was under a fairing that could easily be removed for service access, also reducing the drag of the vehicle. The engine could be removed within 15 min. The fuselage consisted of a welded steel tube frame that was kept in shape by steel wires and the fuselage was covered by cloth. The landing gear support was also a steel tube frame with elliptical cross-section for drag reduction and had a rubber band spring support to give some way for shock alleviation. Both elevator and rudder had a steel tube frame as well and were covered by cloth.

The article Ref. 28 continues by describing the wing and the fuselage designs. The wing consists of two pieces that made possible an extra-ordinarily fast disassembly. They are connected to the wing support structure by bolts and diagonal steel tube struts that are connected to the bottom of the fuselage. The wings are of wooden construction with an airfoil chosen for a large range of speeds between forward flight and minimum flight speed, and to avoid aircraft spin. The removal of just six bolts changes the wing span of 7.2 m during flight to a width of just 1.4 m for road transport, which is done in just 10 minutes. The wing area is 11 m², aircraft length 5 m, empty weight just 160 kg. Adding 20 kg fuel, 70 kg for the pilot (in 1923 pilots were quite slim) and 50 kg of payload, result in a maximum gross weight of 300 kg. The aircraft's service ceiling is given with 3,500 m and its range with 350 km.

To demonstrate the aircraft's performance and to promote the sales of their aircraft, Walter was also present in foreign countries with his aircraft, such as in Sweden at the Gothenburg International Aero Exposition 1923, Ref. 29, where he demonstrated his single-seater sports aircraft. The same issue of *Aviation* reported about the motor installed in the R III as a "21 kW [28 HP] 2-cylinder horizontal opposed air-cooled engine manufactured by the Haacke company, which is chiefly used on small sport planes, such as the Rieseler R III … now experimenting with a 3-cylinder air-cooled engine of 29 kW [40 HP]," Ref. 30.

A spectacular event serving surely to promote marketing of the R III in Germany was a landing "due to engine problems" of pilot Antonius Raab on the main boulevard "Unter den Linden" in the middle of Berlin on July 8, 1923, that made the headlines of all newspapers, Ref. 31 and Figure 11. "Accidentally" a number of press photographs and a movie team were at the scene to document the event, as well as several friends helping to carry the aircraft after its landing. Once in a while this event is recalled, e.g. Ref. 32.

In the following years, new versions were designed by Rieseler and built at Stahlwerk Mark, such as the R IIIa (1922), R IVa two-seater (1923), R Va three-seater (1924), all with increasing engine power due to their growing size and weight. The manufacturer, Stahlwerk Mark in Breslau, had a catalog of their aircraft, Ref. 33, with photos (shown in Figure 12) and technical data of the R III/22, R IV/23 (a detailed description can be found in Ref. 34), and R V/23. But inflation in Germany was progressive and until 1924 only 40 aircraft were sold, Ref. 28.



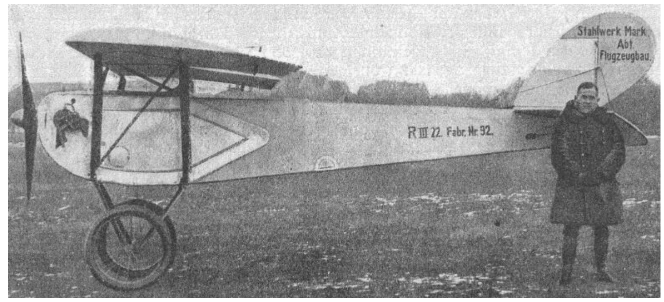
(a) Fly-in in front of the Humboldt University

(b) Pilot Antonius Raab carrying the R III on the boulevard
“Unter den Linden” to the Crown Prince’s Palace
(at the right the New Guardhouse can be seen;
at the left the Humboldt University)

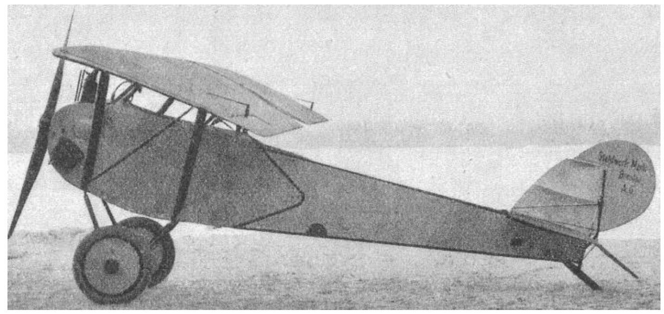
(c) Returning home
Source: (a) German Museum Munich,
(b)-(c) Helicopter Museum Bückeburg

Figure 11. A spectacular R III landing, July 8, 1923.

The aircraft industry’s struggle in Germany to cope with the aftermath of WW I with respect to the rule of the peace treaty of Versailles and the progressive inflation is well described in Ref. 35 as:



(a) R IIIa/22



(b) R IV/a/23

(c) R Va/23
Source: German Museum Munich, Ref. 33

Figure 12. Stahlwerk Mark catalog of Rieseler aircraft.

It is known that Germany is doing everything in her power to rebuild, under the guise of civil flying, that air power of which she was deprived by the peace treaty of Versailles… Germany on Jan. 1, 1925, reacquired full liberty of action in aeronautical matters, save for the nine rules [as laid down by the Interallied Aeronautic Control Commission which limited the performance of German civil aircraft].

Ref. 35 continues:

…that one of the most important German aeronautical associations, the Deutscher Flugsport, has launched upon an ambitious program to rebuild German air power by training of 2000 pilots within the next two years... The ships in question include the Albatros, Dietrich-Gobiet, Stahlwerk Mark (Rieseler) and Udet.

Large Prizes – High Toll

In 1925 an R III aircraft was used by the pilot Hans Schulz during the “Deutschlandflug BZ Preis der Lüfte” (German Cross-Country Race BZ (Berliner Zeitung) Prize of Aviation) competition and some prizes were obtained with the Rieseler R III variant with a 29 kW [40 HP] Anzani engine for flying 994 miles, Ref. 36, winning the 4th place in

Group A (machines under 40 HP) which was worth RM 6,000. On July 19, 1925, he lost his younger brother Werner during an aerobatic flight event in Prenzlau north of Berlin, when the crashed aircraft caught fire and burnt down completely, Ref. 37. Aerobatic performances drew the attention of the public and were very popular, but they also had a high risk of damage, injury and even death in these early years of aeronautics.

FROM FIXED TO ROTATING WINGS

The death of his younger brother Werner – similar to the motivation of de la Cierva – spurred Walter's thoughts about other designs that were safe against blade stall and loss of control. The autogyro of de la Cierva was known already, and Rieseler found a sponsor in Hamburg for his first rotating-wing aircraft autogyro design, then called "windmill plane". The Cierva design had a fixed blade pitch angle, but flapping and lagging articulation of the blades to allow for a blade motion response caused by the periodically varying lift acting on them in forward flight. The flap and lag hinges also avoided broken blade roots caused by large and dynamic flapping moments that in turn generate large and periodic lagging moments by Coriolis forces.

The Rieseler "Rigid Rotor" System

In contrast, Rieseler, together with his companion and designer Walter Kreiser, considered a hingeless rotor blade attachment in their patent (Ref. 2) without flapping or lagging articulation to the hub. Two opposing blades were rigidly connected on a common main spar tube, which had a pitch bearing to allow for a feathering degree of freedom that was restricted in the Cierva type. A great advantage over individually hinged blades is that the interconnecting spar balances all centrifugal forces of the opposing blades and thus the feathering bearings, also acting as blade retention, can be designed with very light weight. Note that this implies rotors having an even number of blades only, while the Cierva design allows for any number of blades because of individual blade attachments. In the Rieseler design, the main spar itself was located in front of the quarter chord position in each blade. Therefore the lift acting on the blade times its arm to the feathering axis also permanently caused a nose-down pitching moment, which required the spar to be very stiff in torsion. Otherwise, a strong elastic torsion would develop.

As long as both of the opposite blades had the same lift, the resulting pitching moments would cancel each other and the pitch angle would not change. In forward flight, however, the advancing blade would generate considerably more lift than the retreating blade on the opposite side, thus its nose-down moment would cause a nose-down pitch of the advancing blade and – due to the rigid spar tube connection with the opposite blade on the retreating side – a pitch-up of that one. The consequence would be the automatic reduction of the advancing blade lift and simultaneous increase of the retreating blade lift until they equalize each other.

As a consequence, no periodic flapping would occur, therefore no Coriolis forces would develop and thus no lead-lag articulation was needed as well. Without all these flapping and lagging hinges required in the Cierva design, the Rieseler hub appeared much simplified, although somewhat bulky from its outer dimensions. In order to carry the steady flapping moment caused by the mean value of the blade lift the pitch bearings were separated widely from each other. This design (Ref. 2) was patented even two days earlier than that of de la Cierva in the UK, Ref. 3. The principal function was tested on a model, but the achievable lift offsets aft of the main spar tube were considered too small for achieving a quick enough equalization of the lift asymmetry and an amendment patent was filed soon after, Ref. 4. In that patent the rotor blades were swept backwards towards the tip, see Figure 14, which generated a large lift offset of the main parts of the blade with respect to the pitch axis.

This design is quite remarkable and it must be taken into account that Rieseler had no engineering education, while his companion Walter Kreiser had one. In Ref. 38 it is postulated that de la Cierva and Rieseler had no knowledge of the work of the other, but this is highly questionable at least for Rieseler, because foreign journals reported about de la Cierva's autogyro multiple times from 1923 on, Refs. 39-43, and in German language it was reported already as early as 1921, Ref. 44, and again in 1923, Ref. 45. It can only be speculated about how much theoretical knowledge and understanding Rieseler had about the dynamics of rotating wings. The fundamental work about rotating wing aerodynamic theory was published by Glauert in 1926, Ref. 46, and by Lock in 1927, Ref. 47.

On July 1, 1926, Rieseler approached the DVL in Adlershof regarding an expertise and model scale measurements of their invention, Ref. 48. In a letter dated July 10, 1926, of the DVL to the AVA in Göttingen it is stated that "they [Rieseler and Kreiser] have shown an invention that circumvents the patents of the Spanish de la Cierva", which makes proof that they were very well aware of the Cireva rotor concept.

The above description of the functionalism of the Rieseler rotor design is at least not taking into account any delayed reaction of the dynamic system "rotor blade" in response to an aerodynamic excitation at 1/rev or 2/rev.

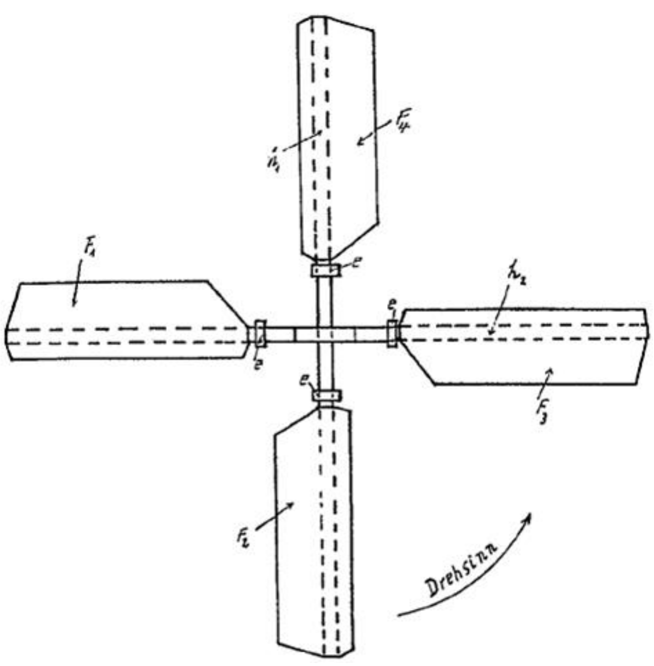
The periodicity of excitation in 1/rev, however, is very obvious to anyone because rotational velocity and flight speed add on the advancing side of the rotor, while they subtract from each other on the retreating side, obviously resulting in a 1/rev variation. This is also given as explanation in Rieseler's patent, Ref. 2. Much less considered, however, is the fact that not the effective velocity at the blades is the important item; rather it is the dynamic pressure, i.e. the square of the velocity. This results in an increase of the mean proportional to $r^2 + \mu^2/2$, a 1/rev sine component with amplitude of $2r\mu$, and a 2/rev cosine component with amplitude of $-\mu^2/2$, wherein r is the nondimensional radial coordinate and μ is the advance ratio of the rotor.

The drawings provided in the two patents are resembling the description given before and are shown in Figure 13 for the first patent, Ref. 2, and in Figure 14 for the second patent, Ref. 4. The first patent was also granted in France, Ref. 5, and in the U.S., where it was issued much later in 1930, Ref. 6. The second patent shown in Figure 14 shows rotor blades with a significant backward sweep of the rotor blades for the purpose to increase the lift offset from the feathering axis, but it will also significantly increase the mean torque that the spar has to carry, which is also suspicious to develop an undesirable amount of elastic twist in the blades.

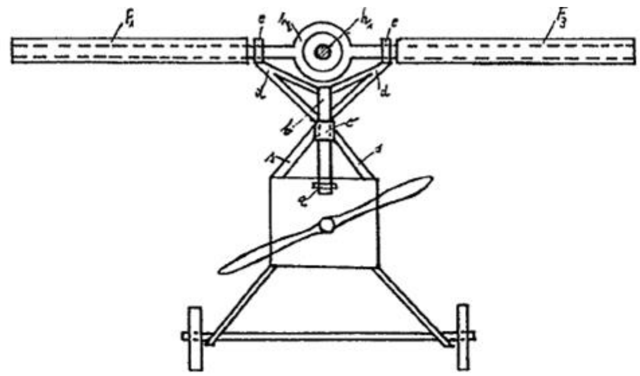
Walter Rieseler obviously built a relatively large proof-of concept rotor model shown in Figure 15.

The invention of Rieseler & Kreiser is remarkable in as much as German inventors mainly concentrated on helicopters so far and not on autogyro designs.

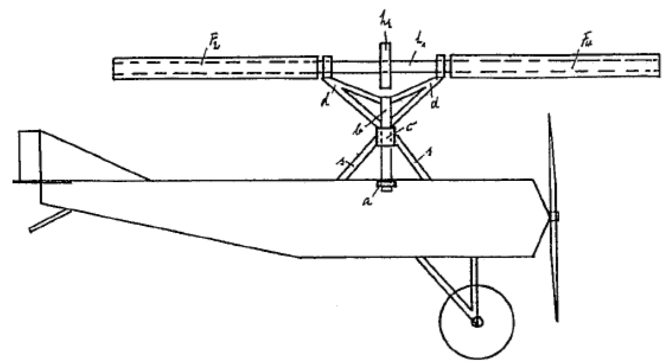
Already in early 1927 the Swiss Aero-Revue reported about the "Auto-Gyro" in general and the de la Cierva and the Rieseler developments emphasizing that due to the omission of blade flapping the Rieseler gyro had twice the rotational speed as his competitor, Ref. 49 [Comment by the author: probably the blade tip speed is meant here, because the rotational speed alone can only be compared when the radius is the same. However, twice the tip speed appears somewhat unrealistic, since autogyros had a tip Mach number around 0.4, and twice of it results in 0.8, leaving little margin for forward flight…].



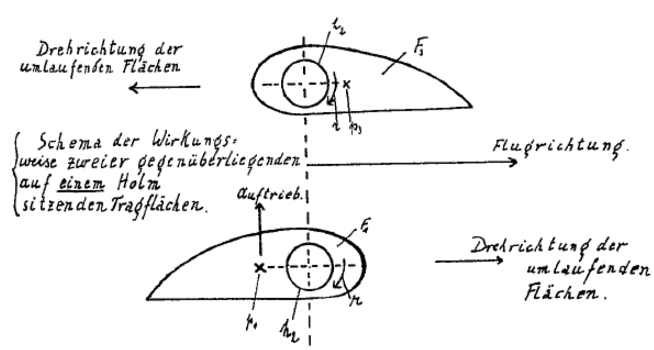
(a) Top view



(b) Front view



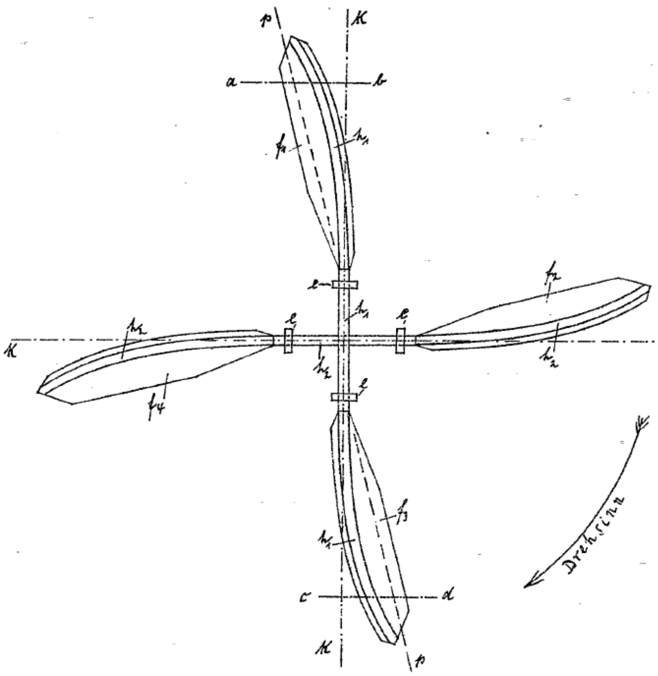
(c) Side view



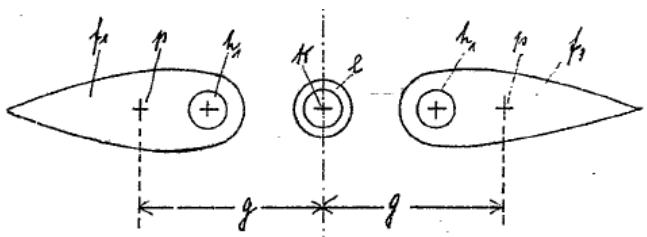
(d) Automatic feathering principle showing lift offset from pitch axis

Figure 13. Rieseler & Kreiser patent drawings, Ref. 2.

Following Ref. 49, the de la Cierva autogyro had fixed pitch and flapping hinges, thus a blade flapping motion develops in forward flight due to more lift on the advancing blade than on the retreating one. The control is performed by rotor shaft angle adjustment by the pilot. In contrast, the Rieseler concept had a cyclic pitch control eliminating the difference in blade lift and with it the flapping, as sketched in Figure 16. The sketch in Figure 16 (c) however seems erroneous. It is supposed to show the flapping motion of Cierva's concept during a revolution atop the feathering motion of Rieseler's concept below. The right (advancing side) position is denoted by "rechts", thus "links" is the retreating side, "mitte" the aft position and "vorne" the front position of the blade.



(a) Top view

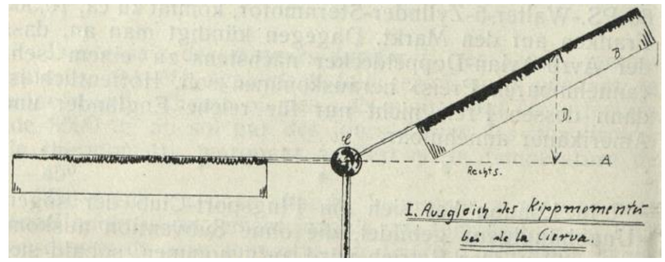


(b) Automatic feathering principle showing large lift offset from pitch axis due to blades swept backwards

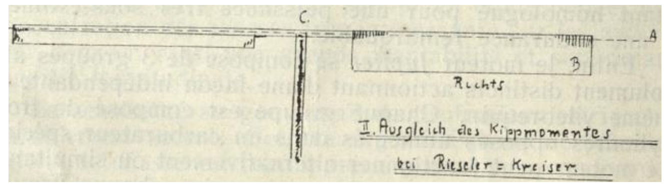
Figure 14. Rieseler & Kreiser Patent drawings, Ref. 4.

Source: Hartmut Rieseler

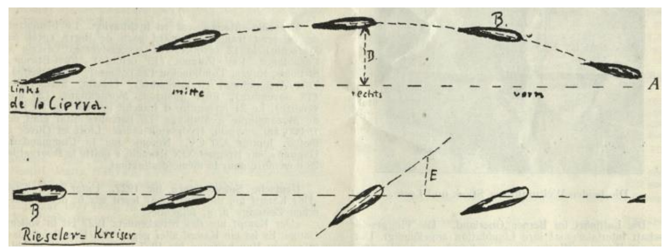
Figure 15. A large model of the new rotor concept.



(a) de la Cierva concept: constant blade pitch, articulated blades, with blade flapping developing



(b) Rieseler concept: feathering hinge only, cyclic blade pitch developing, no flapping



(c) Comparison of both concepts showing flapping and pitching during a revolution

A – plane of rotation; B – rotor blade; C – center of rotation; D – flapping in de la Cierva's concept; E – pitch angle in Rieseler's concept.

Figure 16. Compensation of aerodynamic moments in de la Cierva's and Rieseler's concepts, Ref. 49.

Obviously the artist did not know the essential flapping dynamics of a centrally hinged rotor blade, which responds with maximum flapping position 90° after its maximum excitation, because it is sketched with maximum deflection at the maximum excitation.

It is also unclear why in Figure 16 (c) the pitch angle of the blade is not held constant throughout the cycle in Cierva's concept. The bottom sketch is supposed to show the automatic feathering response of Rieseler's concept, with no flapping developing throughout the cycle. However, the maximum pitch angle is drawn at the location of maximum nose-down moment and should thus rather be negative than positive.

Regarding the free feathering motion, a single blade with no pitch constraint (and a mass moment of inertia as large as the mass moment acting in the propeller moment due to centrifugal forces) has a natural frequency of torsion of 1/rev, i.e. a dynamic response again 90° after the excitation.

In Rieseler's design, where two opposing blades are rigidly interconnected by the blade spar, the total moment of inertia about the feathering axis is comprised of the two blades, and as well twice the amount of propeller moments is acting as a "centrifugal force spring" trying to bring the blades back to zero angle of incidence. Due to the design using a steel tube spar this contributes to the mass moment of inertia, but not to the propeller moment due to its circular cross section. Therefore the propeller moment will be significantly smaller than the mass moment of inertia, leading to a natural feathering frequency of the rigid blades below 1/rev.

The aerodynamic lift generates a pitching moment due to the lift offset behind the pitching axis, and the lift is proportional to the pitch angle as a major contributor to the angle of attack. This represents an aerodynamic spring to the blade, which will raise the natural frequency of rigid blade feathering proportional to the lift offset aft of the feathering axis. No mechanical dampers are attached to the feathering hinges, therefore damping results only from the friction in the feathering bearings and from aerodynamic forces, for example, lift and moment due to pitch rate.

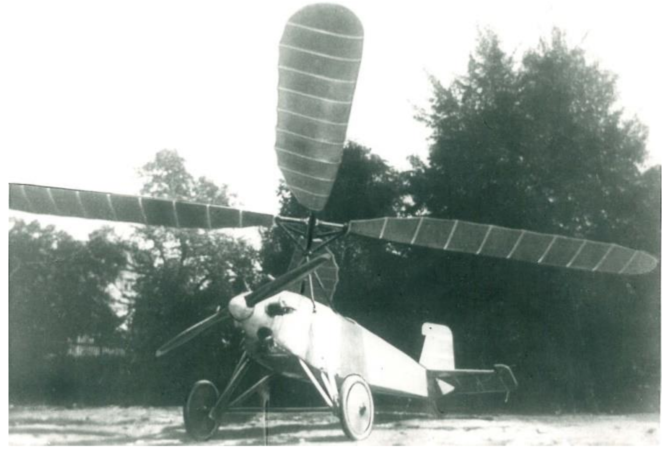
The first Rieseler Autogyro ("Windmill Plane")

An aircraft following the principle of the first patent was actually built early in 1926 in just three months, Ref. 1, which is shown in Figure 17. From this photo the main spar location inside the blade can only roughly be estimated at about 20 % chord position. Assuming the aerodynamic lift acting at the quarter-chord position the lift offset from the spar axis amounts to 5 % of the chord only.

This vehicle had a 40 kW [55 HP] Anzani engine with a propeller in the front, pulling it through the air, and it was equipped with cyclic blade pitch control, Ref. 50. The engine, the fuselage and the landing gear suggest that these components were taken from an R III monoplane as shown in Figure 10 (c) and Figure 12.

Another advanced feature is the omission of fixed wings right from the beginning, in contrast to de la Cierva's designs that kept the fixed wings for long times before being omitted, Ref. 51. It was therefore anticipated that Rieseler's design could perform even steeper ascend and steeper descent than the Cierva model. The hub design of this first Rieseler autogyro as shown in Figure 17 (c) closely follows the drawings provided in their patent, Figure 13 (b). In contrast to Refs. 50 and 51 the patent description does not tell about cyclic blade pitch control, rather it describes automatic blade pitch adjustments.

The progress of this autogyro project was secured by funds from an investor in Hamburg named Kojemann and work began in Berlin-Johannisthal, as described in Ref. 52, and first test flights were performed in Hamburg. The fuselage, landing gear and empennage were of traditional fixed-wing aircraft design and a framework of four struts atop the fuselage carried the rotor.



(a) The "windmill plane" of Rieseler

(b) Rieseler (right) and Kreiser (left), inventors

(c) Close-up view of the hub. Compare to patent drawing, Figure 13 (b) and (c)

Source: Hartmut Rieseler

Figure 17. Rieseler's first autogyro with direct blade pitch control, 1926.

Attempts to fly, however, failed due to weakness of the rotor blades causing strong oscillations of these. The lack of knowledge of Rieseler and Kreiser about rotor blade dynamics and aerodynamics thus had hampered flight trials, as also outlined in Ref. 38. In those times no experiences existed in the construction of rotating wing aircraft and there were no ideas to solve the issue. Consequently the sponsor Kojemann stopped his funding and the project had to be abandoned.

It must be noted that the Rieseler company was very small – essentially a workshop, while in contrast both Henrich Focke and Anton Flettner had a team of aerodynamicists and dynamicists in their companies. Focke also started with license production of de la Cierva autogyros first, then developed his own autogyro, and performed an intense study of all available literature about the theory of rotating-wing aircraft before starting with the helicopter. Anton Flettner as well started with an autogyro design before switching to the helicopter. His chief engineers for theoretical analysis were Gerhard Sissingh and Kurt Hohenemser.

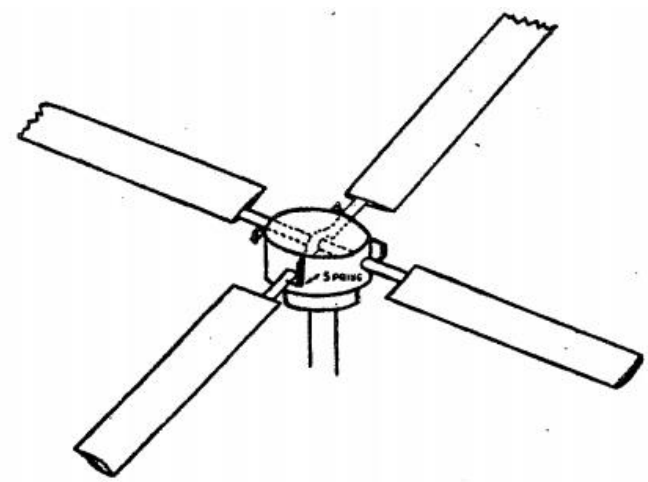
A booklet about the history of the airport in Johannisthal mentions that 1925 the only remaining manufacturer was the Albatros company with production of little commute, training and sports aircraft – the vehicles allowed by the Versailles contract. In addition, some individual aircraft designers built and experimented with sports aircraft and helicopters, Ref. 53.

In Ref. 54 of the same author Rieseler's "windmill plane" is shown half way rigged up with only one pair of rotor blades installed and the fuselage without fairing. The rotor blades had constant chord, elliptic blade tips, and appear untwisted. The chord is relatively large compared to the radius and can be estimated as about 17.5 % of the radius, resulting in a solidity of about $\sigma = (4c)/(\pi R) \approx 0.22$ – a very large value.

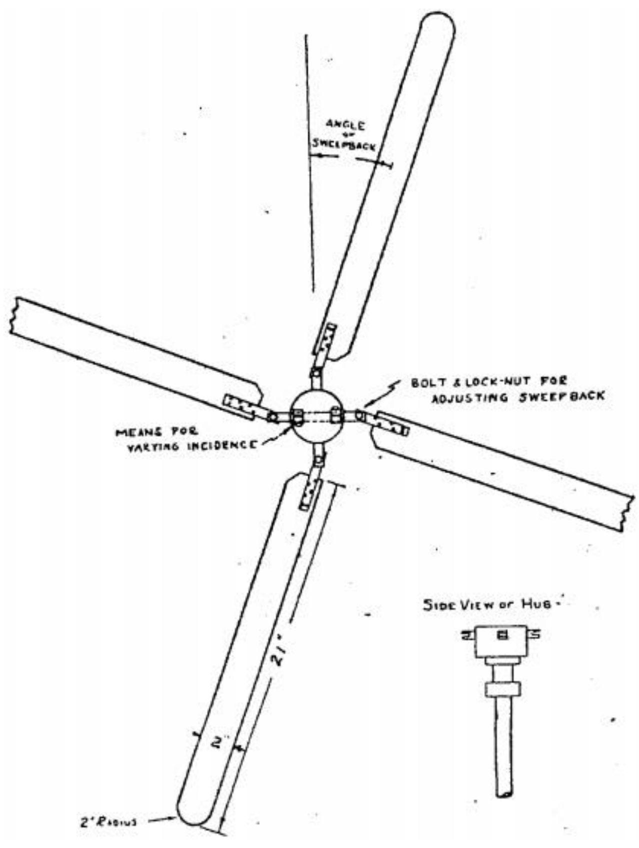
Model Rotor Tests in the Wind Tunnel

Alexander Klemin of the Daniel Guggenheim School of Aeronautics at the New York University became aware of the Rieseler/Kreiser U.S. patent on the direct control autogyro, Ref. 6, and he contacted them in 1928, Ref. 52. Klemin made a contract with Rieseler and Kreiser for designing and building a test aircraft in 1929 using that control mechanism. Following Ref. 55 and its amended reprint in Ref. 56, early model tests began in 1929, with straight rotor blades where the feathering motion was restrained by fixed springs very similar to the patent drawing in Figure 19 (d), in order to prevent excessive feathering, see Figure 18 (a).

It turned out that the spring stiffness was too large and retarded the feathering too much such that large rolling moments resulted in forward flight. Thus, the linkage mechanism as described in the patent was installed and as a result the rolling moments could be eliminated. By varying the spring tension (stiffness) a powerful tool was at hand for controlling both rolling and pitching moments. This mechanism was then used in the flight tests, but the springs were replaced by turnbuckles so as to give the rotor a few degrees of freedom in feathering.



(a) First model design with feathering springs



(b) Third model with adjustable blade sweepback

Figure 18. Gyroplane rotor model used in the New York University wind tunnel, 1929, Ref. 56.

The model tests continued with blades of variable sweepback and incidence, Figure 18 (b), and blades with 15 deg dihedral, but these turned out to be unsuccessful due to high vibration and not reaching autorotative speeds. The dihedral caused the center of gravity to lie above the feathering axis and centrifugal forces introduced moments about the feathering axis preventing autorotative speeds.

The next model had the RAF 34 airfoils with blades of 21 in length and 2 in width, dihedral reduced to 5 deg, adjustable sweep-back and incidence and adjustable feathering stops and feathering springs. [Interestingly, both in the patent description and in Klemin's article the springs were declared as to "damp" the feathering motion. A damping characteristic, however, would require a moment proportional to the pitch rate, not to the pitch angle.] The best settings for smooth operation were: no springs, 5 deg of free feathering before touching the stops.

Further model tests varied the chord length and hence the solidity, and also introduced blade taper. With the tapered blade they obtained the highest lift coefficient ever measured on rotating-wing tests. Concluding, Klemin states that due to the smoothness of the rotor at any rotational speed combining the aircraft with stub wings would allow to carry the majority of lift in cruise condition by the wings while slowing down the rotor, thus decreasing its drag.

The W.R.K. Gyroplane

The wind tunnel tests at the Guggenheim School revealed lift coefficients for the rotor that surpassed existing autogyro capabilities, but also the need for design modifications. Klemin introduced Rieseler to Burke Wilford, director of the Pennsylvania Aircraft Syndicate (PAS), to introduce their principle with more success than experienced in Germany. According to Ref. 52, Rieseler and Kreiser moved to the U.S. in January 1930 with a low-wing aircraft on which a four-bladed rotor was mounted, equipped with a 62 kW [85 HP] Continental engine in the front.

However, that is the only source stating they carried their German-built vehicle with them. The story is told a little differently by W. Zuerl in Ref. 38:

Klemin had informed Wilford about the Rieseler patents and during a trip through Europe Wilford visited Walter Rieseler in Johannisthal (thereby surely he had seen the unsuccessful autogyro) and offered to take over the patents for an application in the U.S. Negotiations took their time until a contract was finished in 1928 that included a demonstrator aircraft to be built in 1929. Exhaustive wind tunnel tests followed at the Guggenheim School in New York that revealed 40% higher lift coefficients than ever measured there before [on other rotating wing models]. *However, some design modifications had to be made and a telegram at the end of 1929 called Rieseler to come over to the U.S., who arrived in January 1930. The demonstrator aircraft was immediately built in Keyport, New Jersey,* [just south of New York] *with the rotor blades modified according to the wind tunnel test recommendations. The vehicle still had stub wings attached to the fuselage and was pulled through the air by a 60 HP engine. Test flights followed the same year. Rieseler returned to Germany where he continued to improve the design of the "Wilford Gyroplane" as it was called in the U.S., and all results of test flights were reported to him. A second test aircraft was built* [by Wilford] *in 1931, equipped with a stronger 140 HP Continental engine. In 1932 it was again remodeled and its performance was improved that much that the U.S. Navy caught its attention and ordered two machines in autumn 1933. At that time Rieseler had an even better aircraft on the drawing board – now without stub wings and with swept-back rotor blades following his second patent.*

The Pennsylvania Aircraft Syndicate (PAS) also followed their own designs, one of them based on a normal Curtiss 19 R fixed-wing aircraft which was equipped with a three-bladed autogyro rotor of 11.6 m diameter. At a flight speed of 250 km/h the basic aircraft required a power of 150 HP, a stub wing combined with the autogyro rotor required 250 HP, and the autogyro rotor alone without stub wings required 350 HP. Another gyroplane, the XOZ-1 designed for the Navy, had floats, fixed wings and a four-bladed rotor atop the fuselage that could rotate or not at the pilot's will. This way it can be converted from a "bi-plane" to an autogyro and back, which was considered advantageous at slow flight speeds for taking photos, observation tasks or for shooting with machine guns.

Other designs of the PAS using the direct blade control were a small civil utility plane of the type Curtiss-Wright 19R converted to an autogyro with a three-bladed rotor and the XOZ-1, powered by a 114 kW [155 HP] Kinner R 5 motor. The XOZ-1 could be used either with wheels or with floats for take-off and landing on water, Ref. 52.

Yet another version of the "American Adventure" of Rieseler at the Pennsylvania Aircraft Syndicate is described in detail in Ref. 59:

A notable example [of the cyclic blade pitch control applied to autogyros] *in the U.S. was the promising Wilford Gyroplane, developed by E. Burke Wilford near Philadelphia; it was one of the advanced types tested by the Navy before WW II, built under a government research and development contract. Financially independent, Wilford was an aviation experimenter, designer and enthusiast in the tradition of Sir George Cayley and Juan de la Cierva. Besides his own work in the development of the rigid rotor gyroplane, Wilford's efforts stimulated thinking of others* [other rotary-wing aircraft designers] *in the Philadelphia area before WW II (then the center of U.S. rotating-wing activity); in his own words, he was a "technical counter-irritant". Much of its* [Wilford Gyroplane] *development was based on the ideas of two German experimenters, Walter Rieseler and Walter Kreiser (skilled mechanics, not engineers) taken to the U.S. by Wilford in 1930* [actually, they were invited by Prof. Alexander Klemin who brought them to Wilford's attention].

The design was unique in other ways: besides having a practical blade feathering [pitch control] *system for cyclic control, it also introduced a rigid rotor (sometimes called a "hingeless" rotor) that worked. In this system there were no hinges to allow the blades to flap up and down as they turned. Instead, the feathering ability of the blades was utilized – through a camming system – to change their pitch as they rotated, thus equalizing the lift as each blade advanced forward and then retreated away from the airflow from the front.*

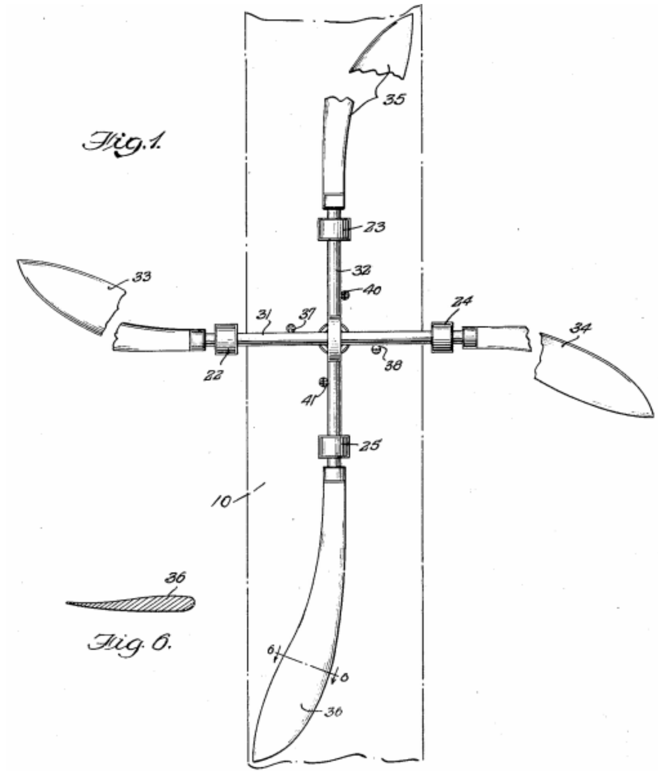
Designed with both wing and rotor, another feature of the Wilford Gyroplane was the fact that it could fly with much of the lift coming from the wing [thus unloading the rotor]. *An early version of the gyroplane flew in 1931; eventually it was developed into the U.S. Navy's XOZ-1, which flew beautifully in 1937. Ironically, these various improvements to the giro signaled the end of its superiority in the rotating-wing field* [because they paved the way for the successful helicopter].

A U.S. patent for a refined version of the blade feathering mechanism, now with pilot control interface to it introducing a spider control mechanism, was applied for in August 1930 and became effective 1934, Ref. 57. This novelty needs a more detailed explanation, and the patent drawings are shown in Figure 19. Again, the rotor blades are swept backwards for a larger lift offset with respect to the feathering axis, and thus a larger torsion moment. Therefore, the blade main spar, designed as a torque tube, has to carry a significantly larger torque between the opposing blades than with straight blades.

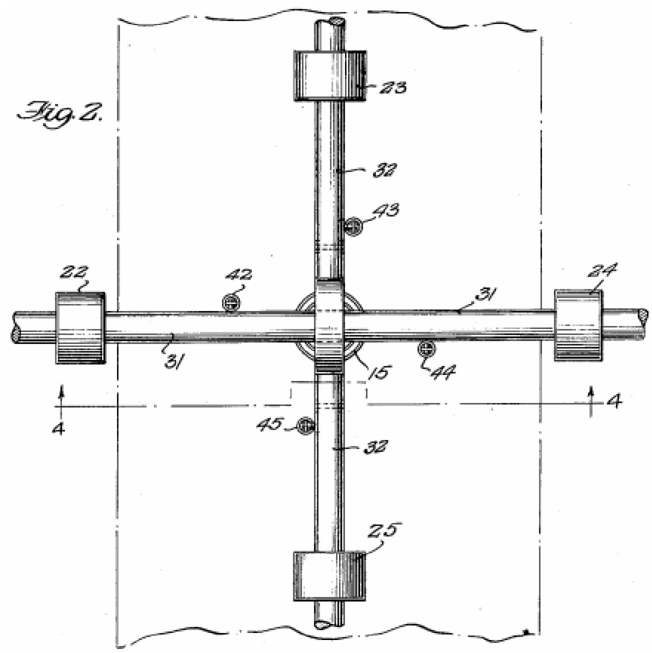
A significant difference to the German patents in Refs. 2 and 4 is that each of the two spars is now restrained near the hub by a pair of springs (part nos. 42-45 in Figure 19 (d)), whose bottom points can be vertically adjusted by the pilot. A feathering nose-up of one blade thus will relieve the spring tension of the spring at its root, but the opposite blade experiences a nose-down feathering and thus extends the spring attached to that blade's root. The pilot, by means of a control stick and a linkage mechanism, can shift a ball spherical bearing (no. 60) into any combination of lateral and longitudinal direction and thus can modify the feathering angle of the blades with zero moment from the pair of springs.

Effectively this represents a cyclic blade pitch control with pushrods replaced by springs. A small-scale model of the anticipated aircraft was built first, which is shown in Figure 20. It has the rotor with the swept-back blades, an aircraft-like fuselage and conventional tail surfaces with a vertical fin up to the plane of rotor rotation.

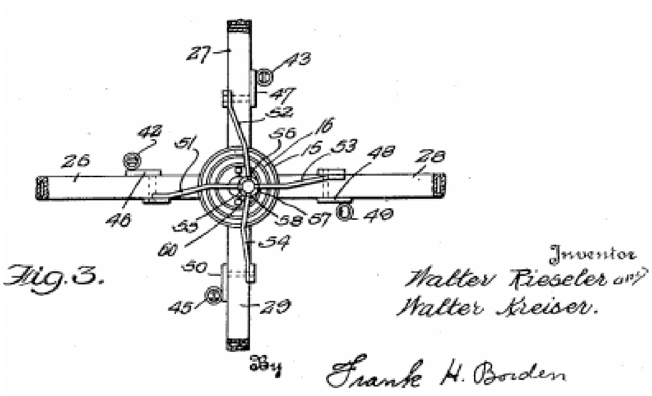
Some photos of the first actual aircraft at different states of assembly exist, Ref. 58. These are amended with several others and all are shown in the series of Figure 21 to Figure 25. Note the high, rounded rudder at the fin, the landing gear resembling the former German vehicle shown in Figure 17, the shorter rotor blades compared to the former German vehicle (only two installed yet), having a relatively large amount of dihedral (upwards bent blade tips), and the 4-cylinder in-line motor.



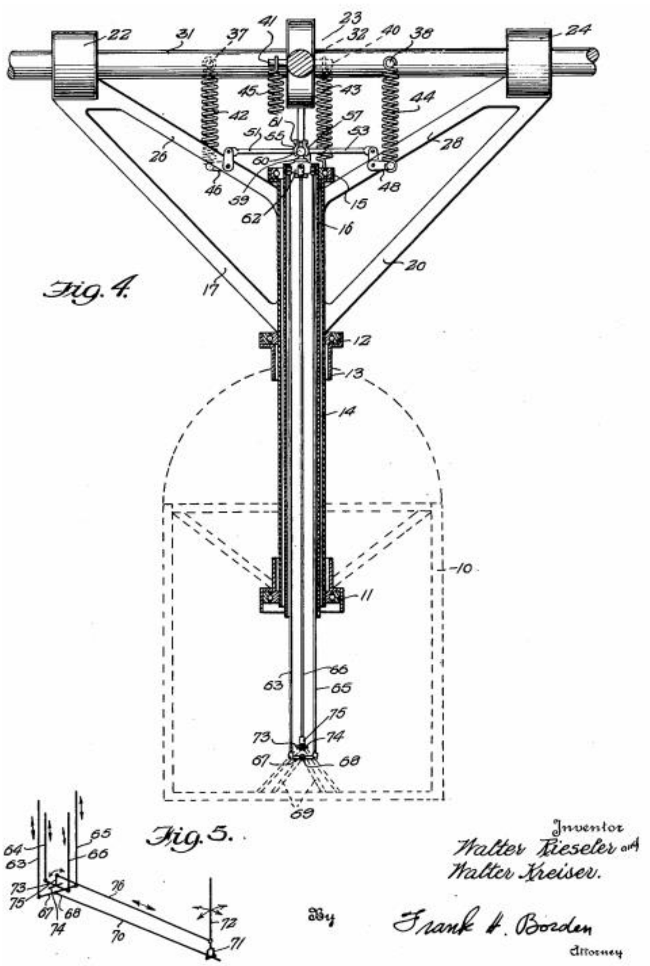
(a) Top view on rotor and rotor blade airfoil



(b) Hub construction



(c) Spider control at the hub

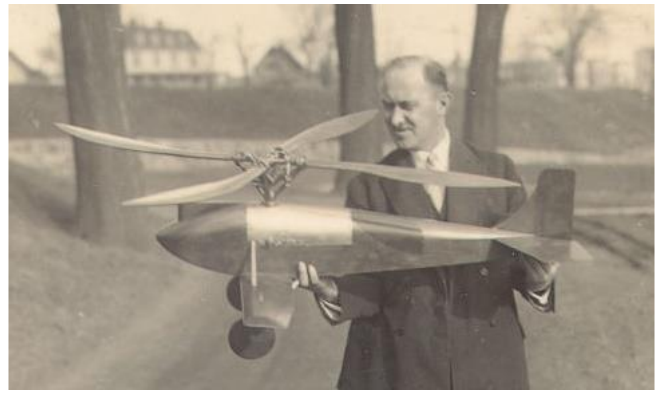


(d) Backward view of rotor blade control mechanism

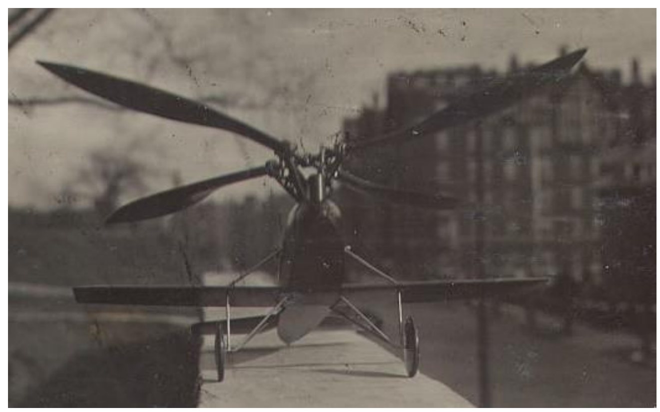
Figure 19. Rieseler & Kreiser patent drawings, Ref. 57.

The fuel tank appears to be arranged around the rotor shaft, which at some distance below carries a gear wheel for pre-rotation prior to take-off (connection to the engine not yet installed), and at the bottom some linkages can be spotted that connect the pilot's control stick to the rotor hub as indicated in Figure 19 (d).

Ref. 8 contains a close-up photo of the "rigid rotor" hub with the control mechanism shown in Figure 22. Apparently pushrods replaced the feathering springs of the patent description. The photo also shows the struts holding the blade spars and the spider control.



(a) Side view with Walter Rieseler holding the model



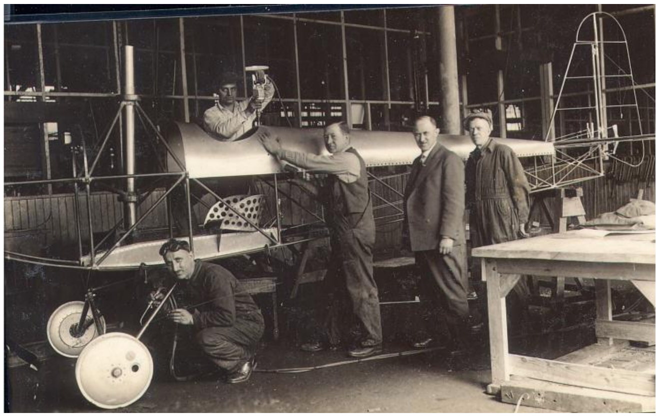
(b) Front view

Source: Hartmut Rieseler

Figure 20. Subscale model of the proposed autogyro.

A very brief description of Rieseler and his fixed-wing aircraft and autogyro developments is given in Ref. 60, but other sources provide far more details. A German journal reports that the rotor blades had an airfoil of type R.A.F. 34, were 50 mm thick and had a largest chord of 530 mm, thus about 9.5 % thickness there and more elsewhere, Ref. 61 (Note that the original RAF 34 airfoil has a thickness of 12.5 %).

Another source, Ref. 62, adds that a range of 5 deg [blade pitch angle] could be set, which apparently refers to the blade pitch control mechanism outlined before in the description of the U.S. patent, see Figure 19. The same source describes the aircraft as single-seater with an air-cooled Wright "Gipsy" 4-cylinder engine of 88 kW [120 HP], and equipped with elevator and rudder. The vehicle had a wide landing gear and balloon wheels.



(a) Fuselage frame assembly

(b) With tail section, engine and two rotor blades

Source: (a) Helicopter Museum Bückeburg; (b) Ref. 58

Figure 21. The W.R.K. Gyroplane under construction.

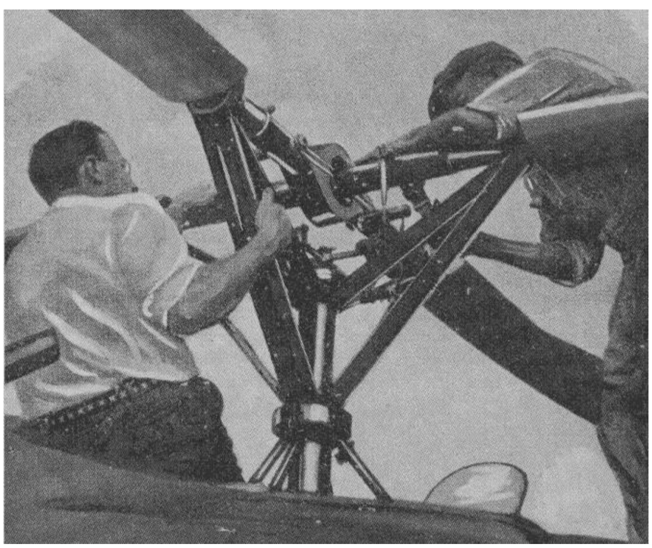
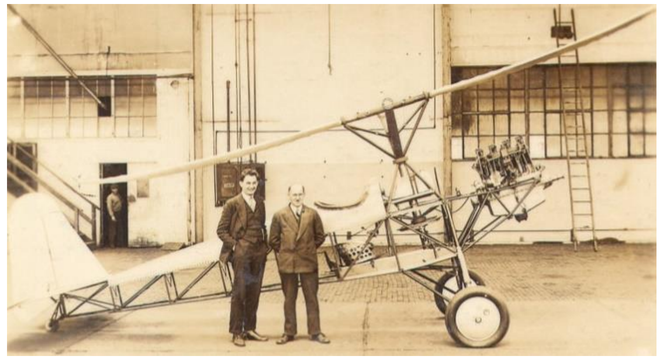
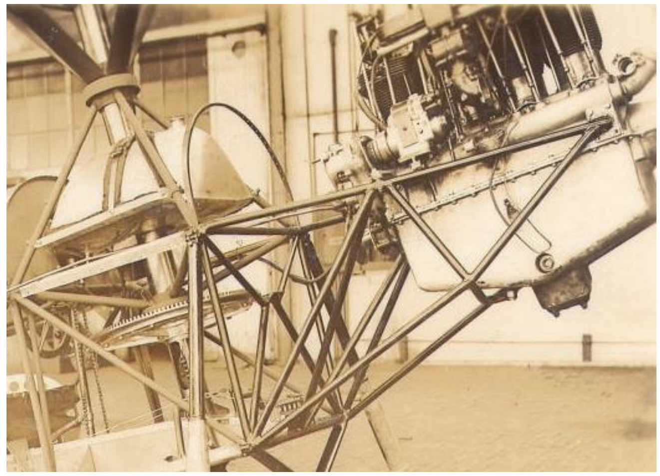


Figure 22. Rotor hub of the W.R.K. Gyroplane, Ref. 8.

The airfoil RAF 34 used on the rotor blades from Ref. 63 and the photo provided in Ref. 62 are shown in Figure 26. The S-shaped camberline reduces the aerodynamic moment caused by camber due to little movement of the center of pressure, but retains high lift capability.



(a) Same vehicle with the inventors



(b) Fuel tank arrangement, pre-rotator gear wheel, control linkages at the bottom of the rotor shaft

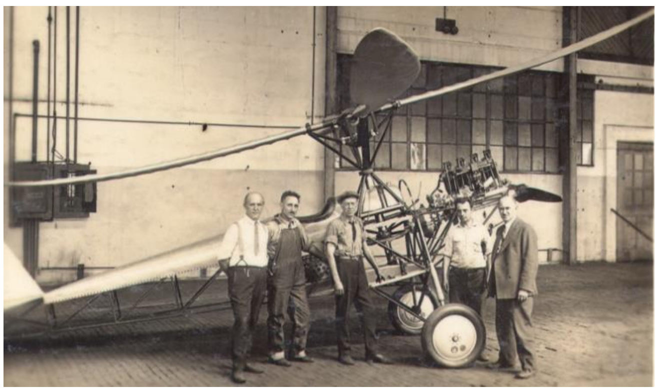
Source: Hartmut Rieseler

Figure 23. W.R.K. Gyroplane under construction (cont'd.).

The Wilford Gyroplanes underwent numerous modifications. It is worth noting that it actually was just one aircraft (tail number X794W) that was built and then underwent several modifications in a comparatively short period of time. An overview of the many variants of the W.R.K. Gyroplane is given in the Appendix. From the photos it is evident that only two engines were used: First an air-cooled inline 4-cylinder ACE (American Cirrus Engines) Mark III, built in the US under license from the British Cirrus Aero Engines Limited, then an air-cooled 7-cylinder Jacobs radial engine of the type LA-1. HP numbers for both engines vary a little bit in the literature, but are of the order of 90 HP and 170 HP, respectively. Note that in the following text the numbering of the aircraft is taken from the cited references, not from the Appendix.

The craft shown in Figure 26 was the third W.R.K. gyroplane built, as stated in two comprehensive articles authored by Alexander Klemin, Refs. 55 and 56. Compared to Figure 21 - Figure 25, this version had a bulky conical rotor hub fairing and a much wider landing gear, the wheels were replaced as well.

(a) Propeller and second pair of rotor blades mounted, pre-rotator clutch installed



(b) Inventors, Wilford and others proud of their vehicle

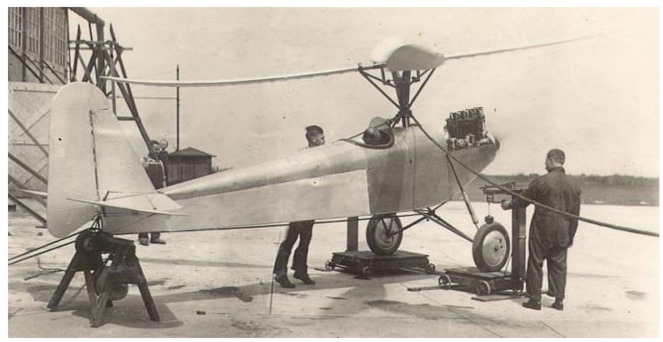
Source: Hartmut Rieseler

Figure 24. W.R.K. Gyroplane under construction (cont'd.).

Klemin in Refs. 55 and 56 reports about wind tunnel experiments executed at New York University and flight tests performed. In general the rotor hub design was seen as to facilitate ease of maintenance and reduction in cost of production. Also, because of no flapping and no lagging rotor blade motion it was seen as free from gyroscopic effects, in contrast to the Cierva system with individual articulated blades.

On August 5, 1931 the first flight of the W.R.K.-Gyroplane took place in Paoli, PA, (west of Philadelphia, just 7 miles away from today's American Helicopter Museum), piloted by the Lieutenant Frank P. Brown, U.S. Naval Reserve, Figure 27 (c), as indicated on the image, Ref. 64. In the hand-written notes on the photo some data of the aircraft and its operational parameters were given: 200 RPM [tip speed: 79.8 m/s]: minimum speed 30 to 2 MPH [13.4 to 0.9 m/s], estimated top speed 95 MPH [42.5 m/s; advance ratio 0.53]. 225 RPM: vertical or steep decent 30 ft/s [9.1 m/s], Cirrus Mark III 85 HP [63 kW] motor. Further data are listed in Table 1.

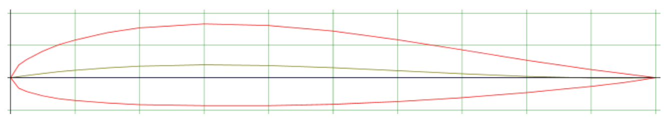
(a) Almost ready for testing



(b) First tests with aircraft tied down

Source: Hartmut Rieseler

Figure 25. W.R.K. Gyroplane during ground tests.

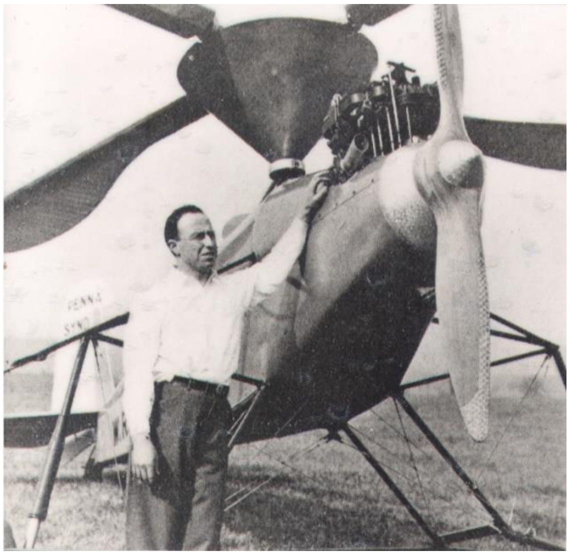


(a) RAF 34 airfoil geometry, from Ref. 63

(b) Wilford Gyroplane, Ref. 62

Figure 26. Third Wilford Gyroplane, 1931.

Finally, Ref. 56 also showed photos of the third experimental W.R.K. gyroplane built, Figure 27 (a), as well as the latest type built by the PAS, Figure 27 (b).



(a) Burke Wilford inspecting the third machine

(b) The latest type gyroplane, 1931

(c) First flight Aug. 5, 1931

Source: (a) Hartmut Rieseler,
(b) Helicopter Museum Bückeburg
(c) from Ref. 64

Figure 27. W.R.K. Gyroplane variants.

The "latest" type of the Wilford gyroplane differed with respect to the third type by removal of the hub fairing, modification of the rudder (top end cut off), the elevator and now wings with large ailerons attached to the fuselage. This opened the possibility to unload the rotor in high-speed flight to reduce its drag, because in such conditions a wing is a much more efficient lifting device compared to a rotor.

The *Aviation* journal closely followed and described the ongoing developments, focusing on "The Wilford Gyroplane", Ref. 65. This article starts by explaining correctly the difference in lift equalization of the Cierva and Wilford systems. Cierva's autogyros had fixed blade pitch but free flapping and lagging motion.

The Wilford system without these degrees of freedom had free feathering of the blades instead, with two opposite blades rigidly connected to each other. The feathering range could be limited, however, to obtain a certain degree of lateral control. Ref. 65 explained that an ingenious system of adjustable stops, interconnected with the ailerons on the stub wing, and operated by the pilot's control stick permitted the lift to be adjusted laterally so that the machine may be banked as desired in flight.

That source continued describing the rotor blades of the first vehicle as curved [following Rieseler's second patent], but the machine described [obviously the second vehicle] had rectangular rotor blades, anticipated to generate less drag.

The rigid rotor system – due to omission of all flap and lag hinges – was considered as having less weight than the Cierva system. Since the blades do not flap, the ground clearance was also much larger than in articulated rotors, and the fin also could be larger because of reduced danger of blade strike.

In addition, the rigid rotor could rotate faster than the articulated one, and thus its radius could be reduced. The vehicle was named "W.R.K. Gyro." and an early example of it as given in the article is shown in Figure 28 (a). Note the long straight blades sweeping over the tail, thus the flat fin to avoid tail strike, and the engine with cylinders still in a row. The article concluded with technical data as listed in Table 1; the engine power was given here with 66 kW [90 HP].

A month later, a report about the fifth annual Detroit exhibition was given in that journal, Ref. 66, and with regard to the Wilford developments:

Action was provided in the exhibit of the Pennsylvania Aircraft Syndicate by a revolving rotor system of the Wilford Gyroplane…. The show was devoid of new and unusual types, with the possible exception of the Wilford Gyroplane rotor which was not shown on any airplane but alone in a setup to demonstrate its principles.

In 1932 the W.R.K. Gyroplane was again modified in as much as the rotor blades got an elliptic blade tip and the engine was replaced by a Jacobs 7-cylinder radial engine, see Figure 28 (b) and (c). Most likely this motor was the type LA-1, the first Jacobs model certified in 1929 with a 140 HP rating, which was upgraded in 1931 to a power of 170 HP, following Ref. 67.

It also appears that the rotor now is turning in clockwise direction as seen from above, while all former vehicles had rotors with opposite sense of rotation. In addition, the fin height was further reduced and its length enhanced. Flight testing was performed at Wings Field northwest of Philadelphia, Pennsylvania, Ref. 68. The fixed wing now was to carry the major part of the lift in high-speed flight, while the rotor functioned as the principal lifting device during take-off and landing.

The photo shown in Figure 28 (b) with Paul E. Hovgard at the controls, author of several articles, is from Ref. 69 and includes some technical data that may be compared to the earlier variant shown in Figure 27 (c). These data are given in Table 1. Compared to the earlier variant, the rotor radius was enlarged significantly and the RPM reduced accordingly in order to obtain the same tip speed. This increased the rotor disc area more than the increase in gross weight, thus reducing the disc loading. The change of the engine with much more power significantly reduced the power loading.

Table 1 Characteristics of two W.R.K. Gyroplane variants.

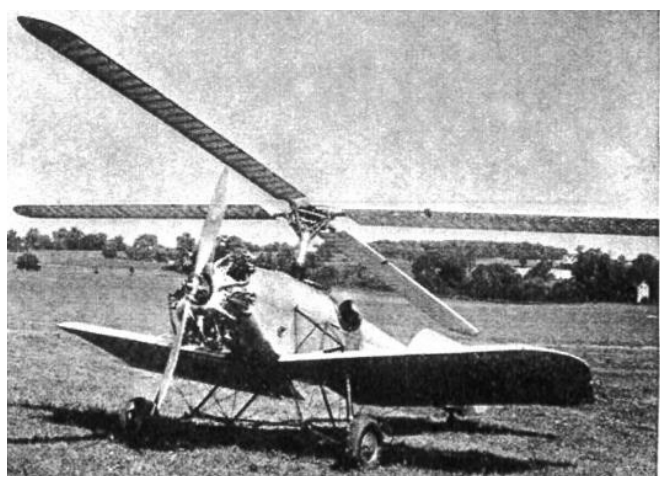
Characteristic	Refs. 64, 65	Ref. 69
Date of flight	Aug. 5, 1931	Aug. 5, 1932
Engine type	Cirrus Mark III	Jacobs LA-1
Engine power	63-66 kW [85-90 HP]	118 kW [160 HP]
Wing area	9.3 m² [100 ft²]	9.3 m² [100 ft²]
Rotor RPM	200-250	170
Rotor radius	3.81 m [12.5 ft]	4.88 m [16 ft]
Total blade area	4.46 m² [48 ft²]	6.69 m² [72 ft²]
Rotor solidity	0.0978	0.0895
Rotor tip speed	79.8-99.7 m/s [259-327 ft/s]	86.9 m/s [285 ft/s]
Gross weight	680 kg [1500 lb]	816 kg [1800 lb]
Disk loading	146 N/m² [3.05 lb/ft²]	107 N/m² [2.24 lb/ft²]
Power loading	106-101 N/kW [17.6-16.7 lb/HP]	97.2 N/kW [11.2 lb/HP]

The annotation in Figure 28 (b) also mentions the first flight without the fixed wings happened on October 1, 1932. During the hearings before the committee of military affairs in April 26-27, 1938 (Ref. 70), Burke Wilford himself stated that:

... we removed the fixed wing which was part of this machine, and made first flights in the world of a wingless giro in September 1932. The pilot on that flight was Mr. Paul Hovgard, now of the Curtiss-Wright Airplane Co….

(a) Vehicle on ground

(b) Further modified machine in flight



(c) The latest machine on ground

Source: (a) Helicopter Museum Bückeburg,
(b) Ref. 69, (c) Ref. 68

Figure 28. Refined models of W.R.K. Gyroplane, 1932.

A 1932 article of Paul Hovgard from the PAS also shows the vehicle status as in Figure 28 (b), highlighting the impact of wind tunnel model tests on the configuration changes of the full-scale vehicle, Ref. 71. He appears to be one of the first considering the rigid rotor capable of unloading it at high speeds to allow a considerable RPM reduction and to let fixed wings carry all the lift required, while keeping the unloaded rotor in a stable operating condition.

Another very good account of the Rieseler-Kreiser involvement with Wilford and their mutual benefit of the German brains with the American experimental and financial possibilities was given by Hale in Ref. 72. This article contained a very detailed description of how Wilford and Rieseler got acquainted with each other and explained the aircraft's design elements, accompanied by a photo as in Figure 26 (b). Purchasing Rieseler's German patent in 1928 was the first importation to America of basic patents for practical, operating rotary aircraft, following Ref. 72. The first Gyroplane built by Wilford started in 1930 in Keyport, NJ, within five months after work on it began.

Data of this first Wilford Gyroplane were reported in Ref. 72 as: Cirrus Mark III 63 kW [85 HP] engine, rotor radius 12.5 ft, airfoil Gö 429 with 2 deg incidence, blade backsweep 5 deg, spars with metal ribs 8 in apart, covered by fabric, no wings, cyclic blade pitch control applied at the hub. This craft never flew, however.

The wind tunnel tests outlined before demanded many design modifications that entered the "third gyroplane" whose construction started 1931 in Paoli, PA. It had the same fuselage and engine, but a modified rotor, wider landing gear, larger tail control surfaces and stub wings added. The rotor blade airfoil was changed to USA 35-B, the wheel control was changed to a stick control. The solidity is explicitly given with $\sigma = 0.12$; blade journals [feathering bearings] 15 inch outside of the hub center = 10 % of the radius. This craft flew with "wonderful results". No gyroscopic effects had been observed, flights were smooth and stable, and rotor RPM was around 200 (leading to a tip speed of 80 m/s = 262 ft/s).

In a photo caption in Ref. 8 the W.R.K. Gyroplane was called "Rieseler Autogyro" and shows the stub wings and the extended width of the main landing gear, the same as shown in Figure 28 (b). Remarkable is the flat fin underneath the rotor to allow for some elastic rotor blade flapping without the danger of collision with the fin. Ref. 8 also includes a section about the stability of rotating-wing aircraft with mentioning of the Rieseler autogyro:

Although the cyclic blade pitch control eliminates the lift unbalance caused by the uneven relative velocities [on advancing and retreating sides] *the large ailerons* [on the wings] *appear to be necessary* [for roll control]. *The further development of this type will show whether the wings and ailerons can also be omitted. As long as the center of gravity is placed at the right distance to the center of pressure a sufficient stability appears possible without wings.*

A review of 1932 developments in aviation included autogyros as well, with 70 in daily service, Ref. 73. Specifically, aside the Pitcairn and Kellett developments it is mentioned that a number of extensive flight tests were made with the feathering-blade Wilford Gyroplane, including a photo of it in flight, the same as Figure 28 (b).

Wilford's Further Development of the Gyroplane

After Walter Rieseler returned to Germany, Wilford continued on the design using Rieseler's feathering rotor system. Alexander Klemin summarized the experiences made until 1935 in a larger article, Ref. 74. He outlined the principle of the Gyroplane rotor and showed the four types of Gyroplanes built, beginning with the one in Germany 1926 (Figure 17), and those of Wilford in 1930 (Figure 25), 1931 (Figure 27 b) and 1932 (Figure 28 b and c). A sketch of the control linkage from the pilot to the rotor blades was as well given in Ref. 74 and is shown in Figure 29. Therein, the cross bar (8) represents the equivalent to the nonrotating part of a swashplate while element (7) represents the equivalent to the rotating part.

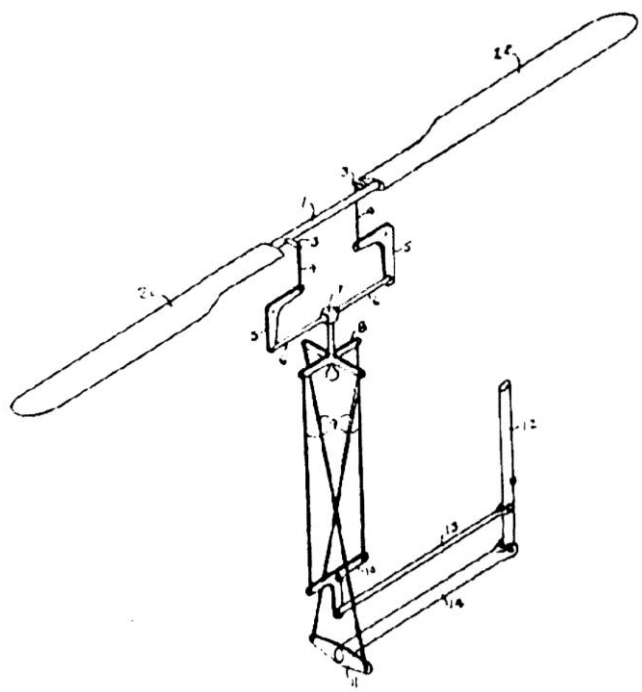


Figure 29. Elementary form of gyroplane control, Ref. 74.

The pilot's control stick has an upper pushrod and at the bottom a torque tube that tilt respective bars underneath the hub in longitudinal and lateral direction. In the rotating system this causes a 1/rev variation of the blade cyclic feathering angle that is used for controlling the rotor rolling and pitching moments. Klemin further outlines the various airfoils tested on the rotor blades with different mean incidence, different blade solidity, and the resulting lift/drag ratios of the rotor. The aerodynamic characteristics were adapted to slow speed and slow, short landings, even vertical landings were found entirely practicable. Depending on the rotor loading, blade tip speeds varied between 89.4 and 134 m/s (200 to 300 mph).

One characteristic of gyroplane rotors are the vehicle responses to gyroscopic forces, as Klemin outlines in Ref. 74. In autogyros, where the blades are free to flap and lag, these gyroscopic forces simply cause responses in these degrees of freedom. In the gyroplane rotor, which is “rigid” in flapping and lagging, these forces are transmitted to the airframe, and thus the gyroplane was found as not practical for violent maneuvers or aerobatics, but the control system can be adjusted to make these impossible. The blades would always be flexible to some degree to minimize the bending moments due to lift loads on them.

Klemin concludes in this article (Ref. 74) that structural problems need the most careful study, the rotor control system was judged very promising, the possibility of unloading the rotor in fast forward flight [with the wing taking over the lift] was well worth further study.

Wilford’s developments had caught attention of the Navy, resulting in the XOZ-1 Gyroplane, which was initially tested on wheels in 1935, Ref. 75. In 1936 announcement has been made that the first flight of this gyroplane with floats replacing the landing gear was made at Frank Mill’s Seaplane Base at Essington, Pennsylvania, on the Delaware River, Ref. 76, with a photo shown in Figure 30. Flight testing continued in 1936 and 1937, Refs. 77 and 78. Wilford’s flight testing activities were supported by the NACA with the aerodynamic analysis of the gyroplane rotor, Ref. 79, and consecutive wind tunnel tests of a 10 ft diameter gyroplane model, demonstrating the capability and usefulness of that system, Ref. 80.

Paul Hovgard acted as flight consultant and flights were witnessed by Elliot Daland, chief engineer, and Mr. Wilford, Ref. 76. The XOZ-1 was considered a compromise between an aircraft and the autogyro, since the fixed wing carried 60-80 % of the load in cruise. Its gross weight was close to 2.000 lb and it had 900 ft² of lifting surface. The specifications were given as: radius 16 ft, fixed wing span 28 ft, wing area 100 ft², the engine as a Kinner R5 with 114 kW [155 HP]. Further developments aimed at a minimum flying speed of 40 mph and a top speed between 150 and 200 mph with a reasonable power loading. A photo of the vehicle standing at the shore was provided.

In 1938, chief engineer Daland published an article about the Wilford Gyroplane’s performance, Ref. 81, which in condensed form was also published in Germany, Ref. 82. Interestingly the article starts with a justification for unconventional aircraft and that they shall not be compared with aircraft optimized for a specific purpose. Nevertheless he made use of the modern Curtiss-Wright 19R monoplane as basic aircraft, fitted with a 3-bladed rotor of the feathering type, retaining both gross weight (4.400 lb) and power plant (309 kW [420 HP]).

(a) Preparation for start

(b) Ready for take-off

(c) The aircraft in flight

Source: (a) Ref. 76, (b) Hartmut Rieseler, (c) Ref. 81

Figure 30. XOZ-1 Gyroplane.

Three cases were considered:

1. Convert the machine to a Gyroplane with 11 % reduced fixed wing area and a wing inclination such that at 150 mph the rotor is fully unloaded and in idle condition.
2. Conversion to a wingless gyroplane.
3. Same as case 1, but with the ability to stop the rotor in flight.

Performance characteristics of these configurations were calculated and the results shown and compared to the available horse power, see Figure 31, in terms of power required versus flight speed, Ref. 81.

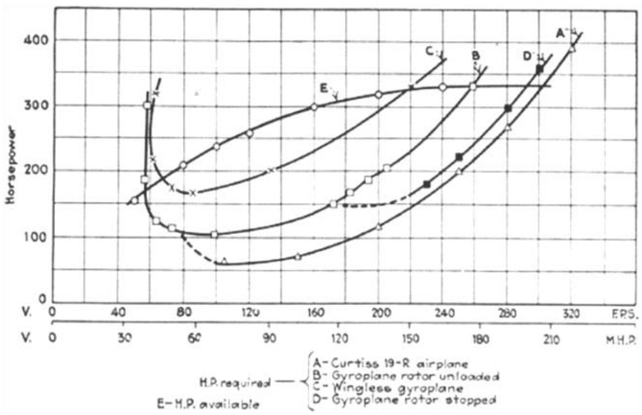


Figure 31. Power estimate of different gyroplane configurations, Ref. 81.

As expected, the basic airplane alone has the highest flight speed and minimum power requirements, but the highest minimum speed as well (curve A). Case 2 (pure gyroplane, curve C) requires the highest power throughout the flight regime and has the smallest range of achievable flight speeds, especially limited in maximum speed. Case 3 (curve D) with stopped rotor comes closest to the basic aircraft at high speed, but this configuration is found very limited in its minimum speed. Case 1 (curve B) appeared as best compromise if minimum speed is of high importance at the price of some penalties in power and maximum speed.

Further Information about Gyroplane Developments

During the first Rotating Wing Aircraft Meeting held at the Franklin Institute in Philadelphia in 1938, Ref. 83, a couple of presentations were given with respect to the Wilford Gyroplanes. In the first session, Burke Wilford reported about the development and improvement of the vehicles. He emphasized that the gyroplane was “the rigid blade adaption to a rotor that flew without hinges, which Cierva said was impossible” and that the XOZ-1 was performing “the first flights in America, with the help of the NAVY, off the water.” Rieseler and Kreiser were mentioned by him once in the beginning, but that their first machine in Germany 1926 had no lateral control and that “it cracked up by the first puff of wind.” He continued that the first machine built in his company was flown by a volunteer who was short in money to marry his fiancée and was offered $ 500 to make it fly 100 yards in line in 1931. He survived the flight, got married and Wilford “doesn’t know whether he is sorry or not that he made the flight.”

In another session of that meeting Bailey reported about NACA tests of a gyroplane model in their wind tunnel described in the report NACA TR 536 of 1935, concluding that “The promise shown by the gyroplane rotor in the tests so far conducted appears to warrant a full-scale experimental investigation of this type of rotor.” NACA TN 492 of 1934 elaborated on the aerodynamic analysis of this type. Paul Hovgard outlined future types of gyroplanes, Ref. 83, emphasizing their operation as a helicopter with a rigid rotor powered by the engine in hover and at low speed, operation in autogyro mode for moderate speeds, and operation as a fixed-wing airplane at high speed, the wing taking over all lift with the rotor only in idle mode as unique capability of this gyroplane system.

In 1939, Alexander Klemin published a big summary about the “Principles of Rotary Aircraft” in the *Journal of the Franklin Institute*, Refs. 84 and 85. He addressed all existing types of autogyro, gyroplane, and helicopter developments with details of their principles and control existing at the time. However, he did not mention Rieseler or Kreiser in the section about the Wilford Gyroplanes.

Walter Rieseler’s Last Autogyro Patent

It is not exactly known when Rieseler returned to Germany. Some sources state 1934, others an earlier date. However, there is proof that Walter Rieseler became member of the NSDAP (National Socialist German Workers' Party) already on May 1, 1933, Ref. 86, with address in Berlin Johannisthal, Wernerstr. 22 – just one house number next to the address he had before, see Figure 6. Membership in the NSDAP was necessary to acquire German government contracts, especially from the military, and Rieseler’s helicopter developments described in the next chapter were all funded by the Reichsluftfahrtministerium (RLM, Reich Ministry of Aeronautics).

Rieseler initially continued work on the design of his feathering rotor blade control system and applied for another patent, Ref. 87. First, he emphasizes the need for a hub fairing to cover the control devices like pitch links etc. in order to protect them from outside influences.

This protection, at the end, is the sole claim of that patent. In contrast to the second patent’s control mechanism shown in Figure 19 (d), here (Ref. 87, drawings see Figure 32) the pilot control stick motion was translated by inclining the nonrotating control tube 11 in any direction. Due to bearings 12 and 13 the extension of the control tube can rotate with the rotor and its spherical end 14 can be displaced from a center position into any direction.

Then a system of pushrods and linkages transmits the motion to the pitch link pushrods, with one going up and the opposite down, such that a blade pitch is introduced into an opposing pair of blades. In harmony with the earlier patent, these pitch link pushrods are described as a combination of a spring and a damper. During the revolution of the rotor this results in a 1/rev excitation of the blade feathering.

No word is spent anymore whether the blade center of pressure should be behind the feathering axis or not. This seems to end Rieseler’s activities on autogyro design, as there are no further records of any activity. No vehicle following this patent was ever built.

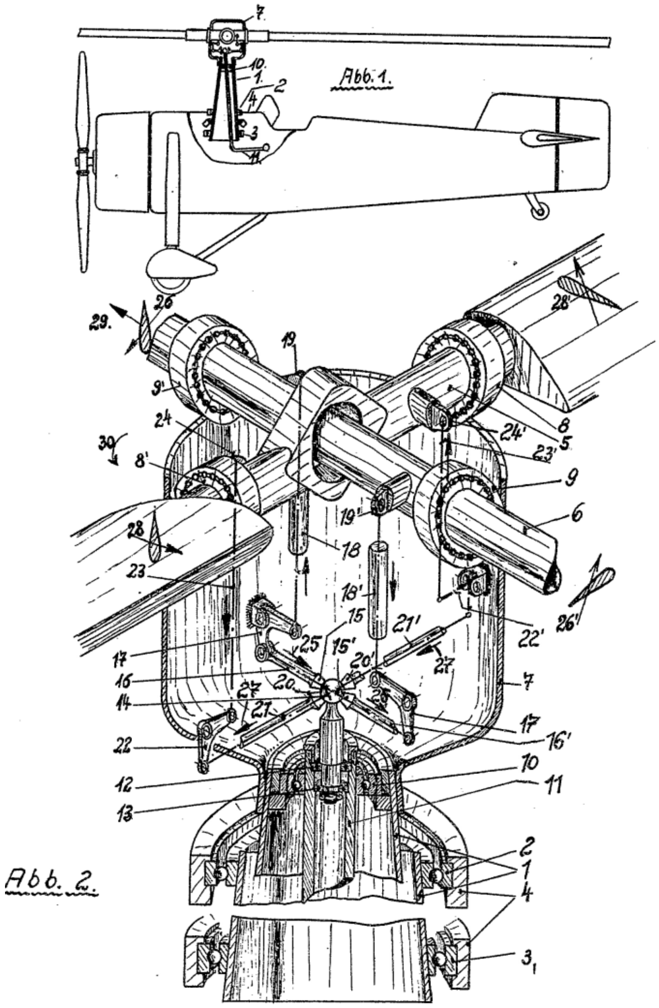


Figure 32. Rieseler's last autogyro patent, Ref. 87.

Walter Kreiser and the Weltbühne Trial

Walter Kreiser, shown in Figure 33, wrote a critical article in the journal "Die Weltbühne" in March 1929, Ref. 88 with the full text of it in Ref. 89.

Die Weltbühne

Der Schaubühne XXV. Jahr

Wochenschrift für Politik · Kunst · Wirtschaft

Begründet von Siegfried Jacobsohn

Unter Mitarbeit von Kurt Tucholsky
geleitet von Carl v. Ossietzky

Inhalt:

Carl v. Ossietzky: . . . . Gänse und Krieger
Kurt Hiller: . . . . Kelloggiana
Heinz Jäger: . . . . Windiges aus der deutschen Luftfahrt
Karl Plättner: . . . . Sexualnot der Gefangenen
Ernst Toller: . . . . Henri Barbusse
Rudolf Arnheim: . . . . Lubitsch, Dupont, Czinner
Harry Kahn: . . . . Giftgase
S. J. . . . . Adalbert Matkowsky
Erich Kästner: . . . . Gebet keiner Jungfrau
Bemerkungen — Antworten

Erscheint jeden Dienstag
XXV. Jahrgang — 12. März 1929 — Nummer 11
Versandort Potsdam

Verlag der Weltbühne
Charlottenburg · Kantstrasse 152

Source: Helicopter Museum Bückeburg

Figure 33. Walter Kreiser and the title page of Ref. 88.

He unveiled the beginning of the secret installation of a German air force that violated the Versailles regulations. He was accused of treason and treachery of military secrets in August 1929, thus the move to the U.S. could be mistaken as an attempt to circumvent the trial. This so-called "Weltbühne trial" took place in November 1931 and Kreiser returned to Germany for it. Together with the journal's editor Carl von Ossietzky he was sentenced to 18 months of prison in 1931, but he could escape to France and in 1934 he was officially expatriated from Germany. More information on that trial can be found in Ref. 90. When France was occupied by the Germans Kreiser moved to Suisse and in 1941 to Brazil, where he died in 1958.

THE RIESELER HELICOPTERS

Unsatisfied by the inherent disability of the autogyro to vertically take off and to hover, Rieseler in 1934 began concentrating on the problem of the helicopter and designed a coaxial aircraft called "Steilschrauber", that actually is a hybrid machine with characteristics of both the autogyro and the helicopter, as described in Ref. 91. Today we would call it a compound, because the engine could be used for either turning the rotors only (helicopter) or only the propeller in the front with the rotors turning freely in the wind (autogyro), or in a mixed mode, Ref. 92.

This is worth a closer look at the patent drawings in Figure 34 (Ref. 92) and explanations given hereafter, since especially the rotor blades reveal some interesting design features. The rotor consists of two pairs of now counter-rotating blades with each pair rigidly interconnected by a common spar. The blade tips (5) are rigidly connected to the spar with an incidence as needed in autorotation. The inner part of the blades (4) can either be rotated about the spar as a whole, or by elastic twisting between the outer and the innermost end as indicated in Figure 34 (a). This nose-up pitch changes the rotor operational setting from an autogyro's to a helicopter's. Rieseler suggested also the opposite design: fixing the inner blade part for autogyro operation and the blade tips to be pitched up for helicopter mode.

Figure 34 (b) is helpful for understanding the blade pitch control. Two hollow shafts drive the two rotors: shaft (8) the lower rotor with spar (6) and the inner shaft (9) the upper rotor with spar (7). Bearings between the shafts and blade feathering bearings on their respective shafts are not drawn. The lower ends of the shaft are connected to the engine (1) by a bevel gear and a clutch (3). The pilot control stick motions (fore-aft or right-left or any combination) are transmitted to the control rod (11) that is tilted into arbitrary directions.

Above the lower rotor there is a spherical bearing such that the part above it is moving out of the rotational axis of the rotors into an eccentric position, thus shifting the ring 10, which may be interpreted as a swashplate, into any direction. This introduces a periodic feathering motion to the spar of a pair of opposing blades, as was the case in the earlier described autogyro designs. The inner parts of the blades can change their pitch relative to the spar by rotation of a control tube 19, Figure 34 (a). The actuation of the control tube 19 was considered by means of an electric motor mounted rigidly on the blade spars.

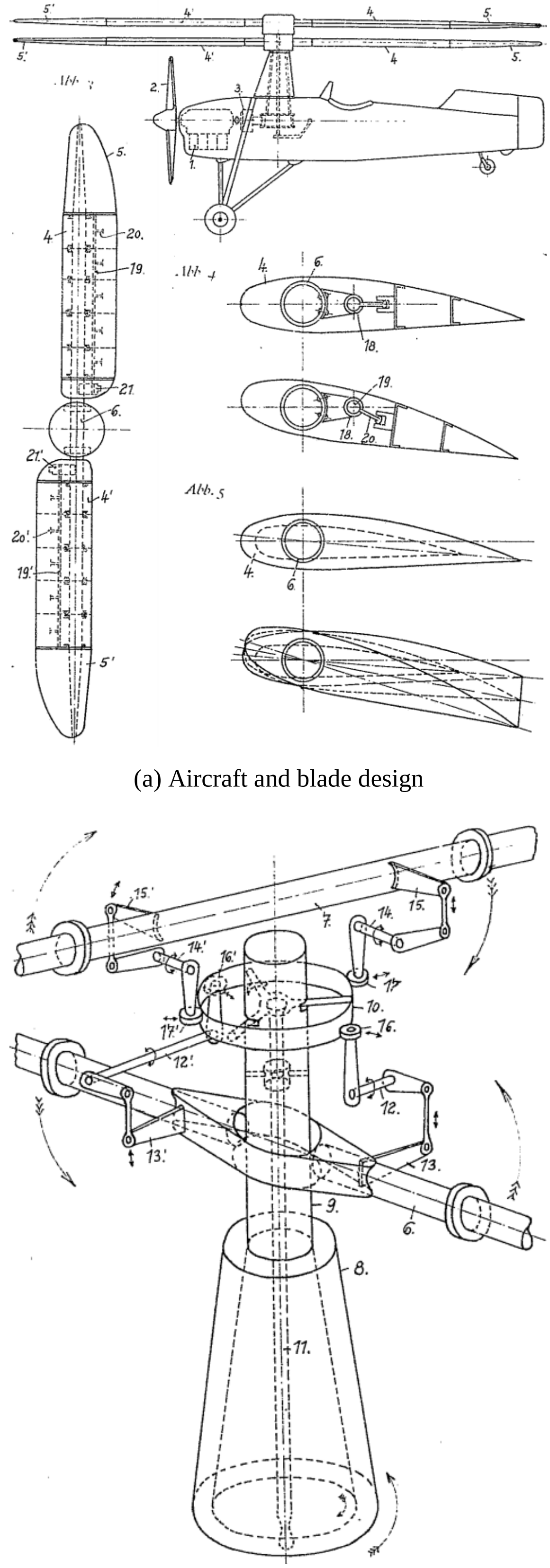
The propeller in front of the aircraft has a variable pitch such that in hovering flight no propulsive force would be generated and the helicopter would stand still in the air or climb or descend vertically as desired by the pilot. The claims of the patent are:

1. an aircraft to be used as helicopter or as autogyro with parts of the blades able to change their pitch angle in a common sense;
2. blade tips with a fixed incidence accounting for the needs of autorotation and the inner blade parts movable between helicopter and autogyro position;
3. the movable inner part of the blade may be elastically twisted instead of being rotated as a whole.

Based on this patent, Rieseler was able to spur interest and also to obtain funding by the Reichsluftfahrtministerium (Reich Ministry of Aeronautics, RLM), and got a contract for development, construction and flight testing of a vehicle. It is remarkable that at about the same time Focke and Flettner became interested in rotorcraft developments. Also, the National Socialist German Workers' Party had just taken over the Government in 1933 and strongly pushed aeronautical development in all aspects. The Versailles contract rules had been violated already before. Initially, this happened in utmost secrecy.

It is noteworthy that there are some remarkable similarities to the Hungarian von Asboth coaxial helicopter that was successfully tested from 1928-1931, featuring vertical wings in the rotor downwash for steering. von Asboth formerly got some experiences as a researcher with the Petróczy-von Kármán-Žurovec helicopters, which were tethered coaxial rotor designs during 1917-1918. A comparison of both vehicles is given in Figure 35.

Ref. 60 reports about the political background of the time: The Third Reich opened new possibilities to those, who so far designed their aircraft on private funds, by provision of government funds in order to establish a new aeronautical industry [thus by intent violating the contract of Versailles]. The RLM and its military offices provided the money but kept all projects top secret. As camouflage [of the Versailles contract violations] the "Reichsministerium für Volksaufklärung und Propaganda" (Reich Ministry of Public Enlightenment and Propaganda) made proper use of publicly disseminating the technical achievements only, but hiding the true goals of these.

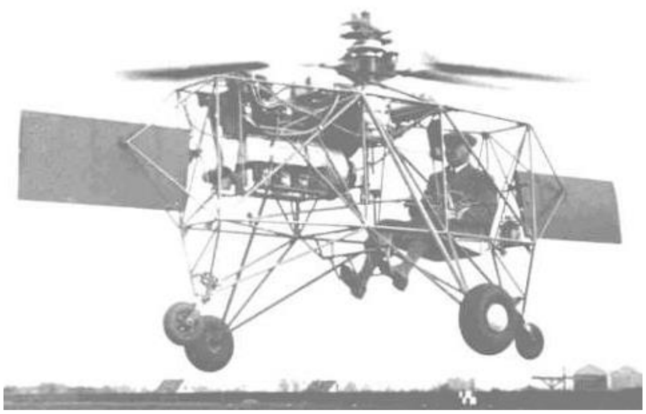


(a) Aircraft and blade design

(b) Blade pitch control mechanism

Figure 34. Rieseler's helicopter patent, Ref. 92.

(a) Asboth AH 3 helicopter, ca. 1929



(b) Rieseler R I helicopter, 1936

Source: (a) Népszava Könyvkiadó,(b) Hartmut Rieseler

Figure 35. Asboth AH 3 and Rieseler's first helicopter.

For the purpose of manufacturing, Rieseler found a new design engineer Otto Steue and founded the "Rieseler & Co. Apparatebau" at the airport Berlin-Johannisthal. Initially, Fritz Kempter was co-founder and in February 1937 Otto Skuras joined the team, Ref. 93.

Again, the home address and the company address could be found in a telephone book of 1937, Ref. 94 and Figure 36.

Rieseler Walter Flugz.-Kon-
strukt. App.-Bau Johtal Flugpl.
Westhalle 1 **63 16 80**
Wohn.Johtal Segelfliegerdamm 32
63 46 47

Figure 36. Rieseler's company and home addresses, Ref. 94.

Much information about the airport Berlin-Johannisthal and its history from the beginning to the end of WW II can be found in Ref. 19. The airport Berlin-Johannisthal and the DVL (German Aeronautical Testing Establishment) in Berlin-Adlershof were in immediate neighborhood. At Johannisthal many established companies were located, such as the Albatros-Flugzeugwerke GmbH (started before WW I), Focke-Wulf Flugzeugbau AG (since 1932 after their fusion with Albatros; 1939 converted to Flugzeugwerk Johannisthal GmbH), Henschel Flugzeug-Werke AG (since 1933), Bücker-Flugzeugbau GmbH (since 1933, until 1935), Anton Flettner Flugzeugbau GmbH (since 1935).

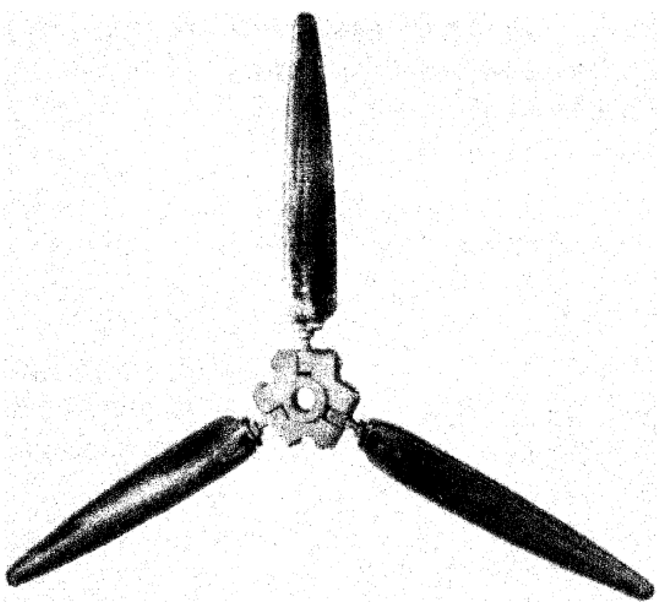
Within this group the "Rieseler & Co. Apparatebau" found empty space for his designs of helicopters, right next to the officially named "Fliegersportgruppe VII des Deutschen Luftsportverbandes (DLV, founded 1933)" (Aviator Sports Group VII of the German Air Sports Association), but in reality members of the Fliegersturm (a branch of the SA and of the SS merged into the DLV in 1933) performed flight training. 1937 the DLV was dissolved and the Nationalsozialistisches Fliegerkorps (NSFK; National Socialist Flyers Corps) was founded as its successor. At this location, the NSFK Sturm 7/27, Hauptstützpunkt VII, continued what formerly was the Fliegersportgruppe VII of the DLV.

Here Rieseler designed, built and flight tested his R I and R II helicopters, and with his fixed-wing pilot license he also helped out the NSFK, where he had a function as "Oberscharführer" (group leader).

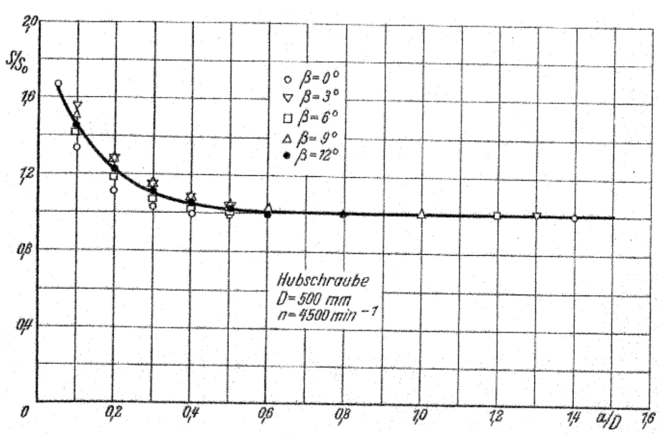
Rieseler's start on helicopter design (as those of Focke and Flettner) appears to follow an article in the "Flugsport" magazine published in 1935, Ref. 95, complaining about a standstill in rotating-wing developments. This article was in response to a more scientific lecture from a strong German propagator of the rotating-wing idea, Martin Schrenk working at the DVL, Ref. 96. He was deeply involved in autogyro theory and published 15 scientific and popular articles about it between 1932 and 1934, covering aerodynamic theory, designs, its performance and flight dynamics. Two have been translated into English and published as NACA TM, Refs. 97 and 98. Schrenk died in May 1934 during a ride on a gas balloon for very large heights and the reasons of his death remain unknown. The scientific gap he left at the DVL was soon filled by G. Schoppe and by Flettner's chief engineers Gerhard Sissingh and Kurt Hohenemser.

Because Rieseler's helicopter project was funded by military sources his development was also practically supported by the neighboring DVL right from the beginning. The test pilot Johannes Mohn, also employee of the DVL, who flew Rieseler's helicopters, supported flight testing and the laboratory experiments of Schoppe helped to get a better figure of rotor aerodynamic performance and power required. Experiments of Schoppe at the DVL reported in 1935, Ref. 99, and 1936, Ref. 100, made use of a model rotor and investigated the thrust-power relationship in hover (figure of merit curve) with and without ground effect; both reports were translated by the Allies immediately after the war into English and published as one post-war translation report, Ref. 101.

The model airscrew used in Refs. 99 and 100 had three blades of variable pitch angle, hyperbolic twist, a radius of 250 mm, a solidity of $\sigma = 0.09$, and operated at 4,500 RPM (tip speed 117.8 m/s, tip Mach number of 0.346). Ref. 99 describes Figure of Merit experiments for a range of different RPM and ground effect experiments with constant RPM and variable distance to a ground plate, down to a distance of only 20 % of the radius. A thrust increase of up to 20 % relative to the out-of-ground condition was documented and the results led to the conclusion that ground effect practically vanishes for distances greater than about 1.2 rotor radii. These results and the airscrew used are shown in Figure 37.



(a) Airscrew used for the experiments



(b) Ground proximity results. D = rotor diameter, a = distance to the ground plate

Figure 37. Model scale hover tests, Refs. 99 and 100.

The Rieseler R I - First German Helicopter?

As reported in Ref. 91 the first Rieseler helicopter R I was finished in summer 1936 and soon after was flight tested, Figure 35 (b). Its two coaxial rotors with opposite sense of rotation consisted of two blades each that were made from light-weight metal and attached to the hub without articulation, just with a pitch bearing, Ref. 52. The rotors were driven by a 44 kW [60 HP] Hirth HM 5 engine, also reported in Ref. 50. Cooling of it was performed with a fan but remained a severe problem, and test flights often had to be ended prematurely due to engine overheating.

Climb or descent was controlled via the engine throttle, i.e., via variation of the rotor's RPM, because the collective pitch was fixed. Pitching and rolling motion were handled by the control stick that was operating the cyclic blade pitch control.

The type of engine installed in the R I helicopter often is in question. Refs. 11 and 12 report about a HM 504 with 66 kW [90 HP], which appears more likely than the HM 5, which was a prototype only, while the HM 504 was the second series production motor from 1934 on, succeeding the HM 60. It is likely that HM 5 was used synonymously for the 5-series of Hirth engines: HM 504, 506, 508, 512 where the last two digits indicate the number of cylinders. The power of 45 kW is about the minimum power required to lift off the R I helicopter in hover out of ground, see power estimate given in Table 2 later on. Because of weak cooling and quick overheating of the engine its maximum power is unlikely to be obtained, requiring sufficient excess power for performing the flights executed. A protocol written during an inspection in 1938 by an expert from the Deutsche Forschungsanstalt für Luftfahrt in Braunschweig (German Aeronautical Research Institute, DFL) noted a HM 60 motor with 44 kW [60 HP], probably the most reliable source, Ref. 102.

Both Refs. 52 and 60 report in almost identical wording about the first test flights performed by the pilot, aircraft captain Johannes Mohn, in the summer of 1936. In a letter to the Helicopter Museum Bückeburg Bückeburg in 1967, Johannes Mohn, who then lived in Buenos Aires, Argentina, reported about his involvement with the Rieseler company, Ref. 103. He lost all his related documents during an air raid in 1943. Since May 1925 Mohn was a member of the branch T 2 V(L) of the Reichswehrministerium (Reich Ministry of Defense), acting as engineer and test pilot. That branch was secret at the time, because it was the technical test branch of the air force.

Anton Flettner also approached Johannes Mohn for test flying his helicopters, but he denied because of the accidents with the Rieseler helicopters he had to experience before. [After Mohn's denial Flettner approached Richard Perlia, promising him (or whoever volunteered) 1000 Reichsmark for the first successful flight of the new Fl 265 helicopter. Perlia accepted both the challenge and the risk, performed what was asked for, took the money and became chief test pilot for Flettner, Ref. 104.]

Mohn had been the head of pilot schools of the DLV and the later National Socialist Flying Corps since 1933. He was imprisoned 1945 in Hamburg and interrogated by British intelligence officers, showing him photos of the R I and R II helicopters with him at the controls of higher quality than he ever has had, and asking for technical details. Because he acted as volunteer pilot for Rieseler, not as designer, and never had been hired by that company, he could not provide details they were seeking for and was released soon after.

In that letter he also told about the funding. Rieseler's helicopters were solely designed for military purposes, completely funded by the RLM and thus their flight testing was under secrecy. The goal was to develop a vehicle that could be carried with any motorized division, take off and land vertically in any terrain and – with an observer standing – could hover or fly forward with up to 160 km/h at any height. All this was achieved during his test flights.

In an article entitled "Germany's First Helicopter" about his experiences with the Rieseler helicopter Johannes Mohn told his stories in 1951, Ref. 105. However, he did not provide an exact date of the first flight, only stating "in the summer of 1936". For example, the Focke-Achgelis Fw 61 helicopter had its first free flight on June 26, 1936, after a year of tethered flights, Ref. 106. The other competitor, next door to Rieseler's company, Anton Flettner's Fl 185 helicopter, had its first flight a year later in the summer of 1937, after some experiences with the helicopter "Gigant" in 1934 (but only in tethered condition) and the autogyro Fl 184 from 1935-1936. Mohn continued his experience report about the first flight:

He [the pilot] *could hover the aircraft* [R I] *in about 5 m height with slight oscillations like a pendulum, but reactions to the controls were satisfying and the vehicle could be safely landed even in side winds of up to 7 m/s. Hover flights with external loads were carried out as well. However, flights exceeding about 15 min could not be performed due to overheating of the engine. Also, handling qualities in forward flight were not satisfying and required design modifications and also demanded a redesign of the empennage. The chief designer Otto Steue is reported to have jumped about 1 m up into the air due to his excitement and almost broke his own gear during landing…*

Due to the proximity of the Flettner company at the same airfield, their engineers were also witnesses of Rieseler's R I flight trials. Kurt Hohenemser commented later, Refs. 11and 12:

The helicopter went up and down like a yo-yo toy. Its rigid rotor blades combined with the sensitive cyclic blade pitch control meant that forward flight was not yet strived for.

On September 3, 1936, in front of a commission from the RLM including Ernst Udet as new Chief of its technical branch the vehicle was demonstrated. During the second part of flight demonstrations the overheated engine quit its duty and the helicopter crashed. The pilot, flight captain Mohn, escaped with broken ribs and his report about this experience was published in the aeronautical journal "Der Flieger", where he described the accident as follows, Ref. 105:

The wind blew with 3 m/s and some drizzling rain fell down. I climbed vertically to a height of 60 m, made a full turn left and right, and touched down after 16 min at the starting point. The engine had become alarmingly hot. After a cigarette I took off again for a full circle flight. When I was about to throttle down the engine for landing it quit entirely. The rotors lost their RPM, the vehicle fell down, and I found myself trapped in the crooked frame of the fuselage and the kinked rotor blades. After I was freed with some broken ribs and gasped for breath, Ernst Uded commented that mishap: "You cannot impress me with that; I made crashs by my own more than enough. Come on; let's drink a Cognac because blood of pilots is no butter milk."

The overheating problem caused the nearby DVL to design a specialized cooling fan to help solve that problem, Ref. 107 for the R I and Ref. 108 for the R II helicopter. The first of these reports clearly denotes the motor as HM 504, which should clarify the issue once and forever. A photo taken during ground runs of the R I measuring temperature at different engine locations (note the bundle of cables at the left) is given in Figure 38.

Figure 38. Test of engine cooling fan, Ref. 108.

To prevent the helicopter lifting off the ground, several sand sacks had been attached all around and additional persons were hanging on the frame. Many spectators in the back are watching the experiments at a respectful distance.

While the Focke, Flettner and von Doblhoff helicopters had a fuselage that essentially resembled that of a conventional fixed-wing aircraft, Mohn described the design of the R I in Ref. 105:

In contrast to the classical shape of normal aircraft a cone-shaped steel tube frame served as fuselage, supported by a strong two-wheel landing gear with an additional wheel in the front and the rear, respectively. For the purpose of *vertical descent and landing a vertical rotating hub was mounted in the middle of the craft, carrying two airscrews of opposite sense of rotation. This ensured that the fuselage would not rotate about the vertical axis after lift-off. The motor was a 60 HP HM 5, which was mounted inside the fuselage, as was the pilot seat. This engine was air-cooled and designed for fixed-wing aircraft in forward flight. A specially designed ventilator was attached to it to provide cooling in hovering flight.*

Flying forward, backward, or sideward and keeping position in gusty weather was achieved by [cyclic] *blade pitch control. Pushing the control stick caused a forward tilt of the airscrew disks and the vehicle gained speed. Any other stick deflection caused an according vehicle reaction. A rotation about its vertical axis was obtained by large vertical control surfaces subjected to the rotor downwash and operated by the pedals, as in a normal aircraft. Take-off, i.e. vertical climb, was controlled by the engine throttle.*

These control devices can best be seen in Figure 39, where Walter Rieseler is sitting at the controls. In his right hand he has the stick for cyclic rotor blade control, a push rod extending horizontally to the left (front of the machine). From it a vertical arm passes into the hollow rotor shafts which can be moved inside to any direction by some amount, causing the cyclic blade pitch variation as described before. The lever standing vertical in (a) and in the left hand in (b) is the motor throttle, regulating RPM and thus rotor thrust. The pilots feet are resting on pedals, best be seen in (b), which are connected to the vertical control surfaces by steel wires and links.

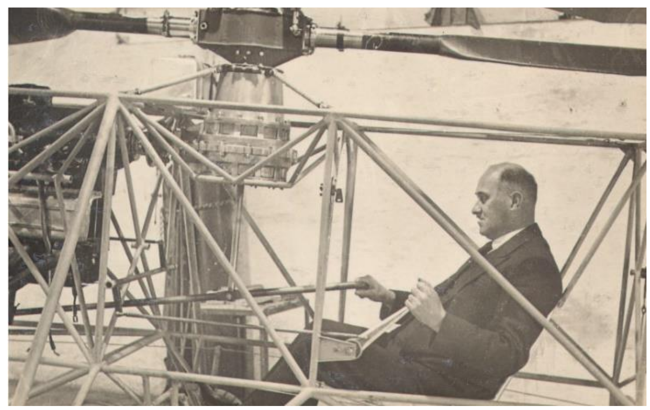
Flight testing continued, partly in the hangar suspended by a rope from the ceiling, Figure 40 (a). The helicopter is also loosely tied to the ground in order to allow it some height above ground. Note the deflected control surfaces, obviously this is a tethered test run for checking the effectiveness of these surfaces. Next, flight tests took place on the airfield, initially with courageous men assisting to stabilize the vehicle, Figure 40 (b).

This was followed by free flights in front of the company's hangar Figure 40 (c), which is considered the left building in the back, whereas the right building is of the aforementioned "Fliegersportgruppe" in its immediate neighborhood. From Figure 40 (a) it is also immediately apparent that the pilot's field of view is significantly obstructed by the engine in front of him.

It is important to note that the mechanism of switching from autorotative to helicopter mode inside the blade as described in the patent Ref. 92 is not mentioned anywhere as feature of the R I helicopter, because it was not installed.

As in Focke's helicopters Fw 61 and the later Fa 223, the Rieseler R I had a fixed collective, and thrust control could only be achieved by operating the engine throttle. However, although full controllability was given, pilots of the Focke helicopters often complained about the slow reaction of the throttle control, and only late models of the Fa 223 were tested with a collective blade pitch control instead, which provided a much more direct response.

(a) Details of pilot controls



(b) Different perspective on pilot controls

Source: Hartmut Rieseler

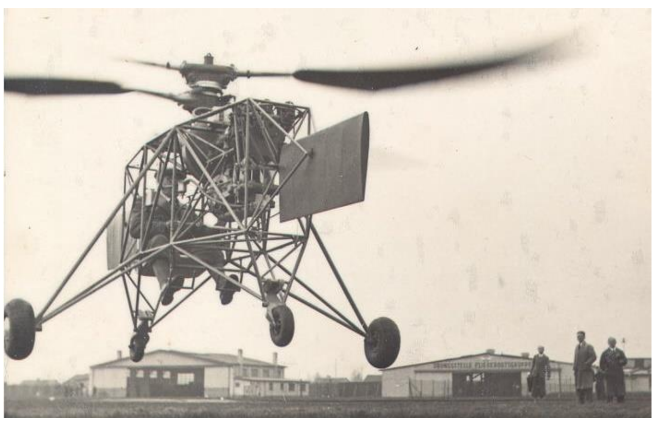
Figure 39. Details of R I helicopter controls.

For reasons of safety, all Focke helicopters had an automatic switch from default "lifting" collective control angle setting into the autogyro mode with a much lower value. Rieseler's helicopters were missing this safety feature, and in case of engine failure the helicopter would fall like a stone. In this case the open frame construction allowed the pilot to escape with a parachute, at least theoretically. In reality, this required sufficient height, and it remained Rieseler's secrets of how to escape the rotor blades above.

In contrast, Flettner's Fl 185 single rotor helicopter had a fixed collective pitch combined with cyclic control. Switching to autogyro mode was done manually. The later models, such as the Fl 265, all carried intermeshing rotors, similar to the coaxial rotor, but with separate shafts inclined relative to each other. Again, manual switching to autogyro mode was installed, but an accident made it necessary to introduce an automatic switch as in the Focke designs, Ref. 9.

(a) In the hangar, suspended from the ceiling

(b) First trials in free flight



(c) Flight on the airfield.

Source: Hartmut Rieseler

Figure 40. Flight testing of the R I, 1936.

The construction of the Rieseler R I was also in some detail described in 1946 in Ref. 9 (German original, its translation is published as Ref. 10):

The machine featured a coaxial arrangement of two counter-rotating, two-bladed lifting propellers of the same size that were placed some distance from a fuselage of welded steel tube framework that contained the engine and the cooling fan. The rotor blades were made of aluminum alloy and were connected in pairs that were stiff in bending and could be tilted about their longitudinal axis [blade pitch control].

The first machine [R I] *was equipped with a 110 kW (150 HP)* [Siemens & Halske] *Sh 14A* [seven cylinders] *radial engine* [This engine definitively refers to the R II. Other sources state that the engine was a Hirth HM 5 with 44 kW, barely sufficient to hover the vehicle.] *with a vertical crankshaft such that no transmission with a bevel gear was needed. Power transmission was performed in a very clever way by a hydraulic coupling that ensured power delivery free of shocks and vibrations.*

With this machine, hover flights were performed up to 100 m high with climb velocities of about 10 m/s. The flight characteristics in forward flight, however, were not satisfying and caused some redesigns and different shapes of the empennage. A fully automatic switching of the blades [into autorotation condition] *in the case of engine failure also was not installed, such that the machine crashed during a test flight, fortunately from a low height of about 40 m.*

Some technical data of the R I were also reported in Ref. 9, but these actually must refer to the R II helicopter, because: (a) the year given there was 1938 and (b) the R I was always reported to have an engine that was operated closely to its limits, and 110 kW was by far oversized for the R I. Table 2 summarizes the data given in Ref. 9, estimates data for the smaller and lighter R I and performs a simple hover power estimate.

Table 2 Rieseler Helicopter Characteristics.

Characteristic	R I[a]	R II[b]
Year of first flight	1936	1937
Begin of constr.	July 1, 1935	June 18, 1936
End of operation	Aug. 10, 1937	April 7, 1938[c]
Passengers	1	2
Number of engines	1	2
Engine type	Hirth HM 5	Sh 14A
Single Engine Power	44 kW [60 HP]	110 kW [150 HP]
Rotor RPM	350	300
Rotor Radius	3.1 m	4 m
Rotor Solidity	0.09	0.09
Rotor tip speed	113.6 m/s	125.7 m/s
Empty weight	400 kg	700 kg
Gross Weight	475 kg	850 kg
Blade loading C_T/σ	0.108	0.095
Disk Loading	154.3 N/m²	165.9 N/m²
Induced Power	38.8 kW	72.0 kW
Profile Power	6.1 kW	13.7 kW
Total Power	44.9 kW	85.8 kW
Power Loading	103.7 N/kW	97.2 N/kW

[a]Data estimated, engine from Ref. 50
[b]Data partly from Ref. 9
[c]Date of inspection by DFL Braunschweig

Other features of the vehicle are described in Ref. 109:

The fuselage was supported by a four wheel undercarriage. Pedal actuated control surfaces were located at the front and rear. The control stick was used to tilt the disks of both *contra-rotating rotors* [This description is not correct because the stick operated the blade pitch control, which generates the rotor blade flapping motion that finally represents a disk tilt]*... The helicopter had good maneuverability, in level flight it attained speeds up to 160 km/h* [86.4 kts, or 44.4 m/s – with the data given a realistic advance ratio of $\mu = 0.35$]. *However, the engine was not powerful enough, it overheated in flight, and as a result the R I prototype was heavily damaged in an accident after a few flights.*

The Rieseler R II Helicopter

It is remarkable that the coaxial rotor design of Rieseler was tested in the DVL wind tunnel in model scale with respect to its autorotation capability in 1937, with a model rotor of 0.6 m diameter provided by the Rieseler company. Probably as a consequence of the crash of the R I they considered this autorotative capability a need for future vehicles. The aforementioned DVL scientist G. Schoppe was associated with that work and a research report was published at the end of 1937, Ref. 110. The goal was to answer two questions:

1, are counter-rotating rotors capable of autorotation at all, which is decisive for development of a coaxial helicopter [Note: the autorotation of a single rotor was thought of as understood at this time, but the capability of coaxial rotors to autorotate was not];

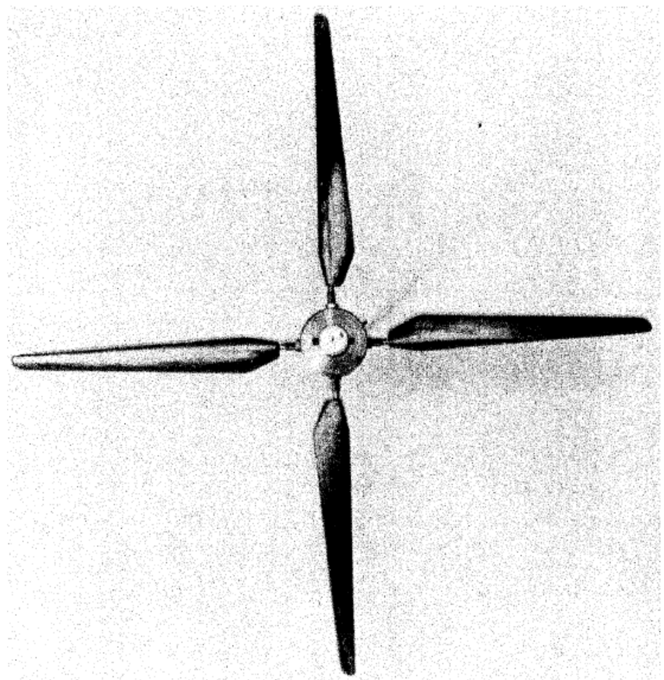
2, does an equilibrium condition exist where both rotors turn at the same speed, which drives the need for a mechanical coupling between both rotors to enforce the same speed of rotation.

This report contains a photo of the model from the top, Figure 41, which is probably the only source providing a realistic planform of Rieseler's rotor blades, while all available photos taken of the full-scale vehicle do not reveal a perspective of the blades that allows an estimate of their geometry. Both rotors had two blades of 0.3 m radius, they were untwisted and had adjustable pitch angle, set at the hub. A simple bevel gear allowed for either free run of either rotor, or both rotors coupled via the gear.

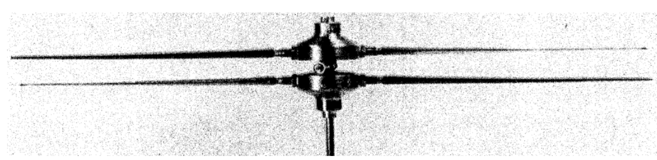
The linear blade taper is clearly visible with a blade root to tip chord ratio of 2.5:1 and the root chord located at 25 % radius. The chord at 75 % characteristic radial section can be estimated therefore to be about 7 % of the radius, therefore the rotor solidity based on four blades results into approximately $\sigma \approx 0.09$, like the full-scale rotor of the R I helicopter.

First, individual rotor tests in vertical descent were performed in the DVL 1.2 m x 1.2 m cross-section wind tunnel (the model diameter was therefore half of the width and height of the tunnel test section) and autorotation was achieved at blade pitch settings of up to +2 deg. Both rotors in free run did not show any condition where both obtained the same RPM, even when different pitch angle settings were used in the upper and the lower rotor. The upper rotor (always in the decelerated air of the lower rotor) always had a significantly lower RPM than the lower rotor.

Both rotors coupled by the gear and thus forced to have the same RPM were found to autorotate in a stable manner, as long as the pitch angle setting is not exceeding +2.5 deg. It was concluded that autorotation was possible at considerably small blade pitch angle settings, just as in autogyros, and therefore coaxial rotor helicopters also were able to land safely by autorotation.



(a) Top view



(b) Side view

Figure 41. Rieseler's coaxial rotor model provided to the DVL, Ref. 110.

Based on the experiences made with the R I, immediately a larger and more powerful design R II was built as a two-seater, Ref. 91. For the first time in history two engines of the type Siemens-Halske Sh 14A with 110 kW each were installed in the helicopter for purposes of safety, following Ref. 91 [that's not really true; the Rüb helicopter of 1918 also had two engines for the same purpose, but it never lifted off the ground, see Ref. 111]. Another remarkable design feature was the hydraulic coupling in the drive train of the two rotors. Ref. 9 also reports about the R II design:

As a replacement [of the R I], *a machine with twice the* [needed] *engine power was planned with the two Sh 14A motors placed opposite to each other, facing each other's fronts. The cooling was performed by a centrifugal fan and the power transmission was again provided by a hydraulic coupling. In this second design the lower lifting screw had a larger diameter than the upper one and different speed of rotation* [This is the only source stating different diameters. An expertise of a German Research Establishment states the diameters were the same.]. *After the sudden death of the inventor* [on May 6, 1937] *the development stopped in 1939 and was never resumed.*

Also, Ref. 52 adds to the design description:

The two engines had a common drive shaft with a hydraulic coupling to the two rotor shafts that eliminated any shocks or vibration in the drive train. The different rotor diameters resulted in different rotor RPM. The fuselage had a closed cabin for two persons and the engines were mounted right and left of the fuselage. The engine cooling was improved. In autumn 1937 test flights began with satisfying results. Due to the sudden death of Walter Rieseler on May 6, 1937, attempts to build a third helicopter R III found an end.

Ref. 109 adds to the R II description:

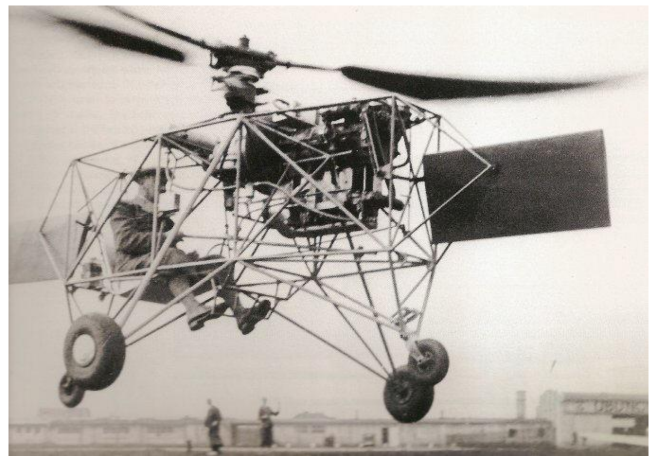
Higher power and increased diameter of the rotors resulted in markedly improved performance of the helicopter, with flights lasting up to 20 minutes, and the maximum altitude was 60 m. Unfortunately this helicopter was heavily damaged too, when the test pilot made a violent dive recovery immediately above the ground. Construction of a third version of the helicopter was terminated in 1938 by the sudden death of the designer.

The R II (data see also Table 2) was finished in 1937 and flight tested with great success, Figure 42. The pilot Johannes Mohn in Ref. 105 stated that all foreign helicopter records were broken with the R II in 1937 (note: the foreign, not the national ones! These at the time were all kept by Focke's Fw 61). Ref. 91 also reports about a crash with the R II during a test flight on December 18, 1937:

Pilot Mohn at the controls tried to pull up the vehicle during a recovery from a steep dive, which caused overload and rupture of struts and bolts connecting rotor hubs and the fuselage. Again, the pilot escaped the crash with minor damages.

After the crash, and without Walter Rieseler as brain of the development of this type of helicopter, the future of the company and its developments was at risk. An expertise was needed and the DFL in Braunschweig was ordered to investigate the case, Ref. 102. Only a five-page hand-written manuscript of a Dr. Braun exists, written in the German Kurrent handwriting, similar to the Sütterlin. This expertise was ordered by the RLM, branch LC I (aeronautical research), and Dr. Braun's visit took place on April 7-8, 1938. Three findings have been proven by the test flights of the R I and R II helicopters:

1. coaxial rotors are not unstable without wings in the downwash;
2. the need of individually hinged blades for a very precise balancing and tracking appears not necessary in coaxial rotors of the Rieseler system;
3. the aircraft weight does not appear higher than that of helicopters with articulated blades, despite the heavy hub construction.



(a) Rieseler R I helicopter, 1936

(b) Rieseler R II helicopter, 1937

Source: Hartmut Rieseler

Figure 42. Rieseler's helicopters, 1936-1937.

A work schedule developed by the Rieseler company at the end of January 1938 aiming at further developing the system, especially introducing collective blade pitch control instead of changing thrust by motor RPM, was seen as a step into the right direction. It was thus recommended to continue the work until a comparison with the articulated type of helicopter could be made. A necessity – also derived from the accidents experienced – was the demand to introduce the switching to autorotation mode. The fact that both motors were mounted to one drive train was judged as irresponsible by G. Schoppe of the DVL and at least elastic elements or shock absorbers should be introduced.

How much of this work plan was actually executed is unknown, but work stopped in 1938, the remainders of the R II were given to the DVL and never reappeared. The Rieseler & Co Apparatebau, established 1935, was dissolved in 1938, Ref. 112, and Rieseler's accomplishments started to become forgotten.

A further German patent was filed and made public in 1942, its effectiveness starting in November 1937. Its inventors are Hermann Rieseler, who was an uncle of Walter Rieseler, and Emil Fischer, Ref. 113, but their involvement in the Rieseler company is not mentioned anywhere and this remains uncertain. They claim both cyclic and collective blade pitch control via a centralized swashplate between the two rotors of a coaxial rotor that can be moved by the pilot in vertical direction for change of collective and tilted to any direction for cyclic control. One of the drawings is shown in Figure 43. It is remarkable that now a blade coning is introduced into the hubs and all four blades are individually connected to it. It is still a hingeless type of rotor hub.

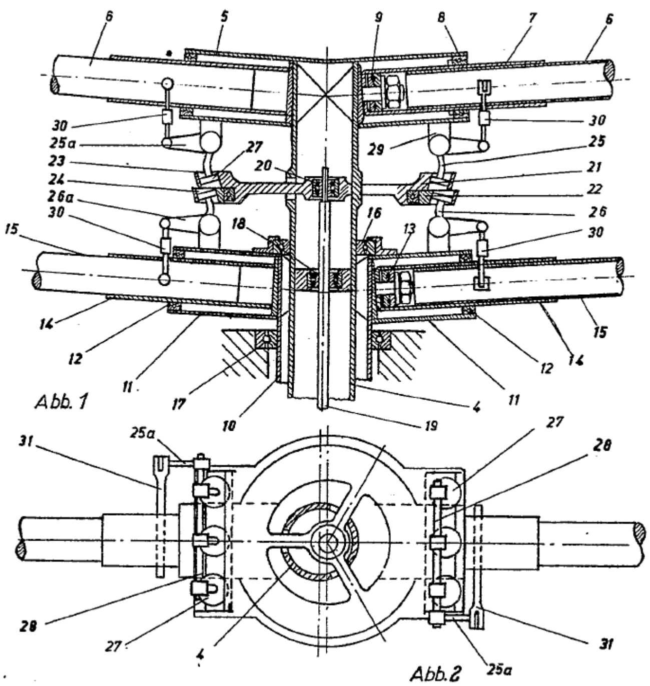
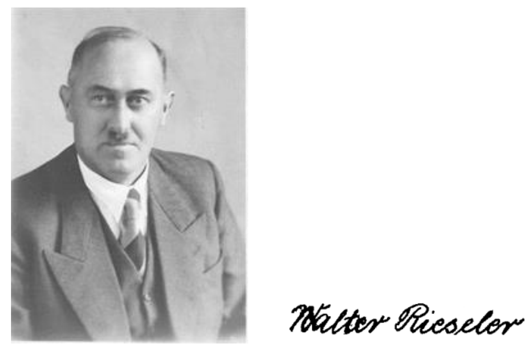


Figure 43. A last patent on a coaxial rotor blade pitch control mechanism, Ref. 113.

CONCLUDING REMARKS

Walter Rieseler – in Figure 44 shown at an age of 43 (ca. 1934) – was a successful fixed-wing aircraft designer and pilot first, then turned to rotating-wing aircraft and invented and patented the direct control mechanism for autogyros. This was successfully flight-tested in the U.S. at the Pennsylvania Aircraft Syndicate under Wilford. After having returned to Germany, Rieseler focused on the design of a coaxial helicopter that was supported by the RLM.

It was claimed that his second design R II surpassed all foreign helicopter records in 1937 and only his sudden death ended a promising career. The designs of Rieseler were advanced and demonstrated remarkable flight performance. As long as his work was based on private funds frequent reports can be found in related aeronautical journals that covered his fixed-wing and gyroplane work



Source: Hartmut Rieseler; Helicopter Museum Bückeburg

Figure 44. Walter Rieseler, ca. 1934.

His helicopter activities, in contrast, were funded by military sources and were thus under secrecy, therefore very little is known of that and that's the reason why he kind of vanished from being mentioned in textbooks on the subject. Nevertheless, his last R II design was very capable and with respect to flight performance could compete at least partly with the successful helicopters of Focke and Flettner.

Rieseler's contributions to vertical flight technology with a rigid, coaxial rotor design round up the range of German helicopter developments of the side-by-side articulated blade configuration preferred by Focke, the intermeshing rotor concept with articulated blades of Flettner, and the Austrian tip jet concept of von Doblhoff. Therefore, Walter Rieseler deserves an honorable mentioning in a row with these.

Walter Rieseler died unexpectedly due to a heart attack on May 6, 1937, and without his genius the work on the helicopter stopped. The R II was given to the DVL in Berlin-Adlershof, but nothing is known about its fate. The death notice of the local newspaper is given in Figure 45, Ref. 114.

Although Walter Rieseler left his hometown Burg long ago, he was well known there as one of their aeronautical heroes, and on May 10 a short obituary was published, Figure 46, which is translated next, Ref. 115:

Burg's aeronautical pioneer Walter Rieseler died

These days Walter Rieseler, known to many of Burg's residents, died in Berlin following a heart attack. Together with the well-known Flieger-Schulze he was one of the aeronautical pioneers that were very active particularly in Burg. About 10 years ago Walter Rieseler moved away. His latest activity was aircraft designer and director of a test aircraft company in Berlin-Johannisthal. The deceased has

entered into the history of Burg's personalities; he will not be forgotten by his hometown.

The city of Berlin named a street after him at the new BER airport near Schönefeld.

Author contact:
Berend G. van der Wall, berend.vanderwall@dlr.de.

Plötzlich und gänzlich unerwartet wurde unser Mitarbeiter und Betriebsführer

Walter Rieseler

aus einem erfolgreichen tätigen Schaffen am Auf- und Ausbau unserer Firma uns entrissen

Ein grausames Schicksal hat ihn die letzten Erfolge seiner langjährigen Arbeiten nicht mehr miterleben lassen

Wir werden stets seiner gedenken!

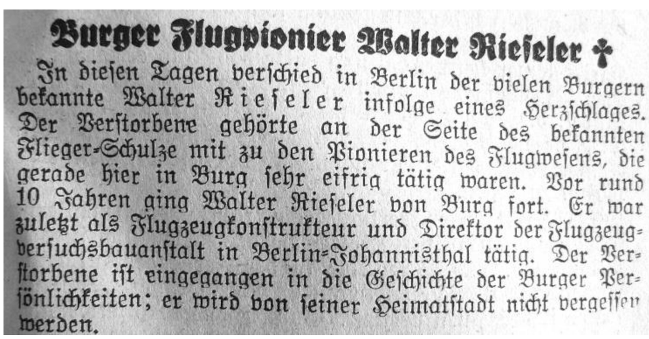
Die Betriebsführung und Gefolgschaft der Firma

Rieseler & Co., Apparatebau

Berlin-Johannisthal, den 6. Mai 1937

Source: Helicopter Museum Bückeburg

Figure 45. Death notice in newspaper.



Burger Flugpionier Walter Rieseler †

In diesen Tagen verschied in Berlin der vielen Burgern bekannte Walter Rieseler infolge eines Herzschlages. Der Verstorbene gehörte an der Seite des bekannten Flieger-Schulze mit zu den Pionieren des Flugwesens, die gerade hier in Burg sehr eifrig tätig waren. Vor rund 10 Jahren ging Walter Rieseler von Burg fort. Er war zuletzt als Flugzeugkonstrukteur und Direktor der Flugzeugversuchsbauanstalt in Berlin-Johannisthal tätig. Der Verstorbene ist eingegangen in die Geschichte der Burger Persönlichkeiten; er wird von seiner Heimatstadt nicht vergessen werden.

Source: Helicopter Museum Bückeburg

Figure 46. Obituary in Burg's local newspaper.

ACKNOWLEDGMENTS

The contributions of Hartmut Rieseler, Günter Frost, Alexander Kauther, the Helicopter Museum Bückeburg, and the German Museum Munich are greatly appreciated.

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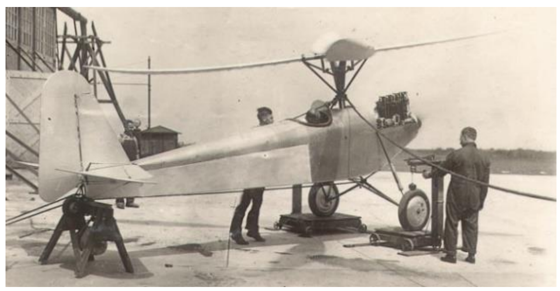
APPENDIX

The Rieseler/Kreiser “Windmill Plane” of 1926 represented the starting point of the Rieseler “rigid rotor” system, but it never made it to flight. Note the similarity of the landing gear, fuselage, rudder and elevator with the first variant of the W.R.K. Gyroplane below. Source references are given next to or below the images.


Hartmut Rieseler

Based on this first development, many variants of the W.R.K. Gyroplane were built from 1931 on in the U.S., initially with the help and presence of Rieseler and Kreiser. The following overview was prepared by Wulf Mönnich, DLR Institute of Flight Systems. Descriptions refer to visible modifications relative to the former variant. Many more fotos, many of them in excellent resolution, can be found at https://digital.klnpa.org/digital/collection/wcuburke/search.

Variant 1: narrow landing gear, wingless, no hub fairing, backward swept rotor blades with dihedral, long rounded rudder, engine with cylinders in-line.




https://tehistory.org/mla/mlapix.html; Hartmut Rieseler; https://digital.klnpa.org/digital/collection/wcuburke/id/25/rec/84

Variant 2: wide landing gear, hub fairing

Ref. 62

Variant 3: wing with larger ailerons, rudder and elevator with rectangular tips

Hartmut Rieseler; Ref. 64; Helicopter Museum Bückeburg

Variant 4: straight, unswept and longer rotor blades with rounded tips and without dihedral, rudder of low height but extended length

Helicopter Museum Bückeburg

Variant 5: further reduction of rudder height and extended rudder length, radial engine

Ref. 68; https://digital.klnpa.org/digital/collection/wcuburke/id/48/rec/68; VERTIFLITE Summer 2007/Courtesy of the Smithsonian Institution National Air and Space Museum. Negative number 9A01102

Variant 6: extended rotor blade radius with wider root cutout

https://digital.klnpa.org/digital/collection/wcuburke/id/65/rec/66

Variant 7: fatal wreck of final variant at Essington Field on July 16, 1934: rudder height increased again, no root cutout


https://digital.klnpa.org/digital/collection/wcuburke/id/35/rec/98