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THE 1929 RHÖN SOARING-FLIGHT CONTEST

By Alexander Lippisch

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Soaring-Flight Coefficient as the Performance Coefficient for Soaring Gliders

The limitation of the 1929 contest to performance gliders necessitated the establishment of a formula which would make it possible to distinguish between performance gliders and school and training gliders. The sinking speed was therefore adopted as the basis for such a distinction, and the requirement was made that the sinking speed of a performance glider should not exceed 0.8 m/s (2.62 ft./sec.).

The question now is to find the simplest possible approximation formula for calculating the sinking speed from the easily determined data of a soaring glider. These data are:

Wing area	=	F (m^2),
Span	=	b (m),
Aspect ratio	=	$\Lambda = b^2/F$,
Flying weight	=	G (kg).

These data can be easily obtained even at the time of entering the contest, thus enabling the calculation of the sinking speed

*"Technischer Bericht des Rhön-Segelflug-Wettbewerbs 1929." From Zeitschrift für Flugtechnik und Motorluftschiffahrt, Feb. 28, 1930, pp.92-98.

with the aid of a simple formula, while the statements of the builder, as, for example, the data of the customary aerodynamic calculation on the basis of wind-tunnel tests with consideration of the always inaccurate residual drag of the fuselage and tail, afford no guaranty of a correct conclusion. In the latter case, it would be necessary for professional examiners to work out all the calculations and to establish a fixed scheme. This method is not practicable, however, because there would not be enough time available for the technical examination of the contest gliders. The following method was therefore adopted for the development of the formula to serve as the basis of the determination.

Instead of the polars of all the different profiles, a mean polar is used for the calculation of the sinking speed. This mean polar of the wing was established as

$$c_w = \left(\frac{1}{\Lambda \pi} + 0.010\right) c_a^2 + 0.007 \qquad (1)$$

In Figure 1 the polar obtained for $\Lambda = 5$ is compared with the polars obtained from the tests made in the Göttingen Aerodynamic Laboratory. In order to allow for the structural drag $c_{w_s} = \frac{\Sigma c f}{F} = 0.013$ was introduced. Any grading according to the different fuselage shapes and wing sizes was omitted due to the difficulty of determining accurately the coefficient c and the cross section of the fuselage. The polar serving as the basis of the calculation is then written

$$c_{w_{tot}} = \left(\frac{1}{\Lambda \pi} + 0.010\right) c_a^2 + 0.020 \tag{2}$$

The theoretical sinking speed of any glider is then

$$v_y = \sqrt{\frac{G}{\frac{\rho}{2} F \frac{c_a^3}{c_w^2}}}.$$

The minimum value of $\sqrt{\frac{c_w^2}{c_a^3}}$ can then be determined with the aid of formula (2). With $\frac{1}{\Lambda \pi} + 0.010 = a$ and $0.02 = b$, we have

$$\frac{c_w}{c_a^{1.5}} = \frac{a\, c_a^2 + b}{c_a^{1.5}}$$

Differentiation according to c_a gives the minimum value of $\frac{c_w}{c_a^{1.5}}$, which, after several transformations and the introduction of the numerical values, becomes

$$\frac{c_w}{c_a^{1.5}}_{min} = 0.658 \sqrt{\left(\frac{1}{\Lambda \pi} + 0.010\right)^{1.5}} \tag{3}$$

If we call the air density 1/8 and remember that the limit of the sinking speed is 0.8 m/s (2.62 ft./sec.), we obtain the following relation between the wing loading and the aspect ratio

$$\frac{G}{F} = 0.514 \frac{\Lambda^{1.5}}{(1 + 0.0314\ \Lambda)^{1.5}} \tag{4}$$

This formula characterizes the wing loadings on the one hand and the aspect ratios on the other, which would necessarily yield a sinking speed of 0.8 m/s (2.62 ft./sec.). The ratio between the wing loadings and the corresponding aspect ratios is given by the formula

$$\frac{G/F}{\lambda} = \frac{G}{b^2} = 0.514 \sqrt{\frac{\Lambda}{(1 + 0.0314\ \Lambda)^3}} \qquad (5)$$

The solution of this equation shows that the curve of G/b within the range of the customary aspect ratios approximates a straight line. The following table shows the calculated results in the region of normal aspect ratios, and Figure 2 represents the course of the function $\frac{G}{b^2} = f\ (\Lambda)$.

Λ	6	8	10	12	14	16	18	20
G/b^2	6.97	1.04	1.08	1.10	1.11	1.11	1.10	1.09

Therefore the requirement was made that the types to be recognized as performance airplanes must satisfy the condition that the quotient of the wing loading and aspect ratio shall not exceed 1.1. Eventually this requirement means, therefore, a limitation of the load per unit of span, if we understand by the expression "span loading" the load corresponding to a surface equal to the square of the span. It has previously been demonstrated that the span loading is decisive for the determination of the sinking speed. The use of this simplified method, on the other hand, for calculating the sinking speed from the wing loading and aspect ratio yields the following expression:

$$v_y \cong 0.762 \sqrt{\frac{G}{b^2}} \qquad (6)$$

It is obvious that a strict application of this limiting formula is not necessary for such an approximation formula.

The New Glider Designs

For the contest there were 36 entries in all, but 10 of them did not appear. Of the remaining 26 gliders, we shall mention only the ones which are especially noteworthy as new designs.

The winner of the contest was the high-wing monoplane "Wien" (Vienna), which Kronfeld had had constructed according to a design by the writer. This glider was a further development of the "Professor" type of the R.R.G., which had made such a good showing the year before. The development of this type as a high-performance glider required considerable improvement in the aspect ratio, which was increased to 20. With the same wing area as the "Professor," it had a span of 19.1 m (62.7 ft.), which presented no particular difficulty for this braced type (Figs. 3-4). The wing is made in two parts, in order to avoid the weight of the extra fittings required for a three-part wing. In consideration of the increased aspect ratio, the rectangular middle portion is given a more strongly cambered profile, which was developed from the Göttingen profile No. 549. The outer portions were strongly tapered, with a decrease in camber and thickness, in order to increase the effectiveness of the ailerons. The junction of the strut with the main spar was purposely made eccentric, so as to relieve the compression flange of the inner portion. It is a V strut, the same as on the "Professor."

The fuselage had an oval cross section and showed, in the side view, the downward-slanted nose, which had proved so satisfactory on the "Professor." The manner of mounting the tail surfaces was the same as on the original type. An interesting feature of this glider was the use of a differential aileron control, which greatly improved its flying qualities, a circumstance which doubtless had much to do with its excellent performances. Further details are given in the table at the end.

In the opinion of most of the experts, the improved performance glider "Kakadu" (Cockatoo) of the Munich group was the best glider in the contest. The only change in the wings was in the ailerons, which included the wing tips as balancing surfaces. The fuselage, however, was entirely reconstructed. The new fuselage is longer and has a smaller cross section. The latter was almost too small, so that the pilot's head projected above the wing. The glider was flown by the Munich pilot Krebs and this time fully met expectations. Unfortunately, the wing bent considerably in normal flight, so that it could not be flown in very gusty weather. Figure 5 shows the "Kakadu" just after the take-off. The wing weighed 6.9 kg/m² (1.41 lb./sq.ft.), while the wing of the "Wien" weighed only 4.5 kg/m² (.92 lb./sq.ft.).

W. Hirth had a new glider, "the "Lore," from Laubenthal, which the Württemberg Aero Club had had built by Klemm. The "Lore" was a further development of the "Württemberg" type of the preceding year (Figs. 6-7). The cantilever wing was made in three parts. The central part, with the Göttingen profile No. 535, had a rectangular plan form, while the outer parts were tapered and elliptically rounded at the tips. This shape is peculiar to nearly all the gliders of the Darmstadt school. The wing has only one spar and a torsion-rigid leading edge, with no auxiliary spars. It is attached to the fuselage in the usual manner by fittings on the spar and leading edge. The pilot sits directly forward of and below the wing. The fuselage has an oval cross section pointed at the bottom. The lateral projection of the fuselage is larger than of most gliders. The fuselage is covered throughout with plywood over a framework of three longerons with transverse frames. It terminates at the rear in a vertical wedge with a small fin and a balanced rudder. The fixed portion of the horizontal empennage is hardly large enough to be regarded as a stabilizer. With W. Hirth as pilot, this glider was one of the most successful in the contest.

Engineer Hofmann brought out the "Schloss Mainberg" (Fig. 8), as an improvement on the "Westpreussen" type. It was built by the Kegel Company in Kassel. The cantilever wing has the Göttingen profile 535. It was made in three sections, with a single spar. Like the "Westpreussen" it is attached directly to the top of the fuselage without any cabane. The pilot's head comes directly in front of the wing. The plywood fuselage has an oval cross section, sharp at the bottom. It has three longerons with transverse frames. The rudder is attached in the same way as on the "Lore." The attachment of the elevator proved insufficient, so that it had to be reinforced during the contest. It was piloted by Dittmar of Schweinfurt, but this slight defect prevented the "Schloss Mainberg" from making many appearances.

The Darmstadt aviation group brought to the contest, along with their glider "Darmstadt II" (Fig. 9) of the preceding year, the new glider "Starkenburg" (Fig. 10). The dimensions of the latter are almost the same as of the "Schloss Mainberg." It differs from the latter, however, as regards the wing profile, the attachment of the wing to the fuselage and various other details. The construction was refined and exhibited a series of interesting novelties. The Darmstadt group had gone back to the device of coupling the rudder and ailerons, as on the "Consul," so that the operation of the former automatically operated the latter. This differential coupling worked very well on the "Consul." Unfortunately, the "Starkenburg" crashed in starting and was not repaired during the contest.

The Kegel Company made from its own designs the performance glider "Elida" and the two-seat "Hercules" for the lower Hessian Aero Club. The "Elida" is a cantilever monoplane of large aspect ratio and flat profile (Fig. 11). The wing has the Göttingen profile 549 and is made in three parts, the middle part being rectangular and the outer parts having a strong elliptical taper. The wing is constructed differently from the usual way, in order to increase its rigidity with its small thickness in relation to its span. The main spar at the thickest part of the wing is almost square and strengthened by three webs thus forming, as it were, a double box girder. Aft of the main spar there is a light auxiliary spar at about 2/3 of the wing chord. Forward of this auxiliary spar the wing is covered on both sides with plywood. This manner of construction makes the wing rather heavy, so that the advantage of the cantilever type was not apparent with a good aspect ratio. The wing loading of 6.9 kg/m² (1.41 lb./sq.ft.) is as great as that of the "Kakadu." The oval cross section of the fuselage is similar to that of the "Wien." It is smaller, however, and the nose of the fuselage is slimmer. The weight of the fuselage is relatively small, thus offsetting the extra weight of the wing. The shape and mounting of the propeller corresponds to the "Professor" type, but the very short bearing of the rudder is a little weak. The glider was disappointing in its flight performances, when it is considered that, with an aspect ratio of 17.5 and a wing loading of 12.8 kg/m² (2.62 lb./sq.ft.), its sinking speed should have been smaller than that of most other gliders. Obviously, its controllability was impaired by the heavy wing and the correspondingly great inertia moment about the vertical and lateral axes. On the other hand, it might be advisable, with such a good aspect ratio, to increase the camber of the middle portion of the wing.

The two-seat "Hercules" was designed more as a school glider. It might be designated as an enlarged "Prufling" (Figs. 12-13). The two-part wing is of the normal two-spar type and is braced against the fuselage by two parallel struts on each side, the struts being braced by diagonal wires. The middle of the wing rests on two supports projecting above the fuselage. The forward support (between the first and second cockpit) and the after support (behind the second cockpit) are firmly joined to the corresponding fuselage frames. This method of installing the wing is very favorable as regards the air resistance (drag) and visibility and has also proved satisfactory from the structural viewpoint. Since the ailerons were hinged to the rear spar, the latter had to be made rather wide, so that it produced considerable stresses on the control cables. On similar gliders, the method had already been adopted of balancing such large control surfaces both with respect to the weight and the aerodynamic forces. The fuselage was hexagonal and resembled in shape the fuselage of the "Professor." It terminated at the rear in a vertical wedge, prolonged above and below to form the fin. The stabilizer, which was supported by struts, was mounted on the upper part of the fin, so as to remove the horizontal empennage as far as possible from the ground and thus render it less liable to injury. This glider is provided with dual control in order to make it available for training purposes. It did well in the contest under the piloting of the Kassel glider pilot Hurtig.

The Berlin Glider Club also participated successfully again with a performance glider. The "Luftikus" (Figs. 14-15) was designed by the president of the club, O. Hohmuth, and constructed by the members of the club. The shape of the whole glider corresponds to the earlier "Vampyr" with improved and refined lines. The wing, with the Göttingen 535 profile, comprises three single-spar parts, the middle part being rectangular and the outer parts tapering. The middle part is reinforced, however, by an auxiliary spar and is supported by a raised "neck" and two short steel struts. The plywood fuselage has a hexagonal cross section in front and a square one at the rear, similar to the "Vampyr." The greatest width of the fuselage is only 0.48 m (18.9 in.) at the pilot's seat, so that the pilot has too little freedom of motion for long flights. The fuselage ends at the rear in a horizontal wedge which is broadened to form a small stabilizer. The high pointed rudder is attached to a small vertical fin in front of the horizontal stabilizer. This arrangement of the tail surfaces was formerly common. The elevator and rudder are extremely light and strong. Despite the angular fuselage, this glider excelled many performance gliders, so that the "Luftikus," flown by the youthful pilot

Bedau who had only just obtained his license as a glider pilot, was one of the most successful gliders in the contest.

The Aachen Club, after an intermission of several years, again entered a glider in the contest. The semicantilever school glider, "Aachen MI," (Figs. 16-17) of the Aachen Aero Club was designed by Engineer Mayer as an improvement on the "Prüfling" for training purposes. The wing has two spars, is made in three parts, and has the same chord and profile (Göttingen 535) throughout. The middle part rests on the top of the fuselage and is supported by V struts at its points of junction with the outer parts. The struts therefore use the same fittings which serve for attaching the outer parts of the wing. The fuselage has a hexagonal cross section. It is covered with plywood in front of the rear wing spar and with fabric back of this spar. It ends at the rear in a vertical wedge which is extended into a fin at the top. The rudder is rectangular and narrow from front to back. Each of the two parts of the horizontal stabilizer is attached to one side of the fuselage and supported underneath by a strut. The elevator is rectangular with a cutaway for the rudder. The performances of this glider were very satisfactory. Under the piloting of its constructor, Mayer, it made very creditable flights during the contest. It constitutes a noteworthy contribution to the development of the school-glider type.

The Mecklenburg Rostock Aero Club has been devoting its attention to the further development of the school two-seater. Under the supervision of Krekel, the well-known type "MI" in the 1928 contest was improved and entered in the 1929 contest as "Rostock M II." The wing, improved in its aspect ratio, is made in two parts and has two spars with brace wires in the inner panels and rigid diagonals in the outer panels. All the details, such as the fittings, ribs, etc., were carefully gone over again and standardized so far as possible. All the other parts of the glider, such as the fuselage and tail surfaces, have steel-tubing framework. The roomy fuselage is longer and higher than the "MI." It has dual control with removable control sticks. It is covered with doped fabric. The removable cabane is constructed of streamlined steel tubing. The attachment of the four brace wires is so effected that they can be tightened or loosened by a single turnbuckle, which simplifies the assembling and disassembling and renders it possible to tighten the wires without the expenditure of much energy. The tail girder is likewise constructed of steel tubing in the usual manner and braced to the wing. The tail surfaces comprise a stabilizer, elevator, fin and rudder, likewise constructed of steel tubing. The stabilizer is adjustable. Both elevator and rudder are elliptical. This glider had the smallest weight per unit wing area of any in the contest, namely 5 kg/m² (1.02 lb./sq.ft.).

The "Rostock M III" (Fig. 18) was built with the purpose of improving this two-seat type still further. In this glider the fuselage and tail of the "M II" are retained even to the smallest details, but the wing is developed more in the direction of soaring ability. The semicantilever wing of the "M III" is made in four parts, the two inner parts being rectangular with two spars and diagonal wood braces, while the outer parts, which are attached at the junction points of the supporting struts, are tapered and have rounded tips. The two struts run together in a point and are likewise braced by wood diagonals in the inner panels. The ailerons cover the whole length of the outer panels. Outside of the wing, all the structural parts are made of welded steel tubing hardly differing from the "M II." As special features, this glider has ailerons with differential control and the possibility of varying the dihedral of the outer panels of the wing. In doubling the aspect ratio of the "M II" the weight of the "M III" per unit area was only increased to 5.8 kg/m² (1.19 lb./sq.ft.), so that this glider may still be regarded as exceptionally light. It showed very good soaring ability, both as a single-seater and as a two-seater, and is far the type best adapted for school purposes.

The Schleicher-Poppenhausen Airplane Construction Company also entered in the contest a two-seater designed by the writer, which more nearly approaches the form of a performance glider. The "Rhönadler" (Rhön Eagle) (Fig. 19) has a three-part, semicantilever wing with rectangular middle part and tapered outer parts.

The profile of the middle part is the R.R.G. No. 652, the same as used in the Munich glider "Kakadu." In the outer parts this profile is uniformly tapered to a thin, slightly cambered profile, in order to increase the maneuverability and controllability.

In the internal structure of the wing, an attempt was made to improve the method with a supporting outer covering, as already variously used by the Munich group. Two thick I girders at 10 and 35% of the wing chord, form, together with the wing covering, a large box girder resisting both bending and torsional moments. Between these two girders, whose flanges serve only for connecting the supporting skin with the webs, there are, in addition to the ribs, for reinforcing the plywood covering, light T strips parallel to the spars. The full cross sections run through the ribs whose flanges are reinforced at these points, and through the junction points. The two main spars are stiffened by the vertical rib webs, due to the fact that these webs are glued directly to the plywood wall of the spar.

Furthermore, the ends of the ribs are stiffened by a light auxiliary spar at 68% of the wing chord. The attachment of the strut to the wing spar was likewise remodeled. Through the neutral axis of the box spar there ran a strong tube, which was rotatable between the spar webs. Over this tube was slipped a band which was drawn downward in the form of a tube into which the strut was inserted and rigidly secured by bolts. This provided a simple method for installing the strut and good transmission of the stresses to the wing covering. This main strut, together with a light auxiliary strut to the rear spar, formed a V, which was braced fore and aft by cables connected with the fuselage.

The wing rested on a long "neck" with the main spar between the two cockpits. The front part of the fuselage had a regular hexagonal cross section which tapered aft into the frustum of a cone. It had, correspondingly, six light longerons. This type of construction was adopted, in order to simplify the construction of the fuselage as much as possible. The fuselage terminated in the fin, while the stabilizer rested on short supports over the fuselage and was braced by two struts.

The wing proved to be exceptionally rigid, so that no deflections were noticeable even in strong gusts. The strength of the fuselage "neck" was not satisfactory, however, as was evident during a soaring flight of the two-seater up to an altitude of 1275 m (4183 ft.) under the piloting of Groenhoff. In this altitude-record flight, Groenhoff also broke the distance record for two-seat gliders, with a flight of 33 km (20.5 miles).

Schleicher's 1928 performance glider was likewise flown by Groenhoff, only the rudder being slightly changed. He made several successful flights with it in the early days of the contest. In a steep bank over the wooded southeast slope of the

Eube the glider sideslipped and crashed.

The Dresden Academic Aviation Group also entered two gliders in the contest. The cantilever high-wing monoplane "Dresden No. 8" has a two-spar, strongly tapered, three-part wing. The wing is covered with plywood back to the rear spar in order to give it torsional rigidity. This method of construction is similar to that of the "Elida" and results in a wing loading, at an aspect ratio of 21, of 7.3 kg/m² (1.5 lb./sq.ft.), which is greater than that of any other glider in the contest. The fuselage has a rectangular cross section with a tall vertical wedge at the end, so that the side view of the tail shows a considerable keel effect. The cantilever stabilizer is attached to the top of the fuselage. The elevator is surprisingly small. The liberal use of plywood covering made the glider exceptionally heavy, and, since the heavy outer wings produced considerable inertia moments about the longitudinal and vertical axes, the Contest Committee entertained doubts at first regarding the advisability of admitting it unconditionally to the contest. Several flights near the end of the contest, however, showed satisfactory controllability even in very gusty weather. Due to its great wing loading and the sagging of the long cantilever wing, the glider was remarkably stable.

The table at the end gives the data of the gliders participating in the contest, in so far as we were able to obtain them.

From the examination of the barograms of several high-performance gliders in long flights, the actual sinking speeds were found to exceed the computed values by 10 to 20%. Since the coefficients of glide (lift-drag ratios) show a better general agreement, it must be assumed that the profile drag appears smaller in the tests at large lift coefficients and that roughness considerably impairs the results. It will be possible to explain the discrepancies only by numerous tests.

Despite the excellent performances in the 1929 contest, which are certainly due in part to improvements in construction, a further improvement in the flight performances is still possible through the systematic improvement of the most successful types. The semicantilever type, e.g., enables the use of considerably greater aspect ratios. The tapering of cantilever wings throughout their whole length will yield greater bending and torsional rigidity with a greater span and also reduce the weight. We should not overlook the possibilities still open to soaring flight. For their attainment the constructor must continue his work of improving and refining.

T A B L E

Name of glider	Total wt., kg	Weight of wing	Wing area, m	Wt. of wing per unit area, kg/m^2	Span, m	Aspect ratio	Wt. of glider per unit area, kg/m^2	Wing loading kg/m^2	Coefficient of soaring flight	Profile
Lore	161.8	102	16.6	6.1	16.0	15.4	9.8	14.0	0.91	535*
Stadt Stuttgart	140.6	87.2	16.0	5.4	14.5	13.1	8.8	13.2	1.00	430*
Hugo	153.1	97.2	15.5	6.5	15.0	14.5	9.9	14.4	1.00	
Wangen i. Allg.	143.8	90.8	18.1	5.0	15.7	13.6	8.0	11.8	0.87	535*
Elida	186.2	139	20.0	6.9	18.7	17.5	9.3	12.8	0.73	549
Schloss Mainberg	142.8	92.2	17.0	5.4	16.0	15.0	8.4	12.5	0.84	535
Kakadu	168.6	122	17.6	6.9	19.2	21.0	9.5	13.5	0.65	652
Wien	158.1	81.6	18.0	4.5	19.1	20.0	8.8	12.6	0.63	549*
Kassel	140.0	100	20.5	4.9	17.5	15.0	6.8	10.2	0.68	549
Starkenburg	145.2	99.6	17.5	5.5	16.0	14.8	8.05	12.3	0.84	
Luftikus	143.0	82	15.4	5.3	15.0	14.6	9.3	13.9	0.95	535
Aachen M I	120.4	69.6	16.8	4.1	14.5	12.5	7.1	11.3	0.90	535
Dresden No.8	227.4	139.5	19.0	7.3	20.0	21.0	12.0	15.6	0.74	527
Rostock M II	121.5	60.0	24.0	2.5	12.1	6.1	5.0	10.9	1.78	
Rostock M III	153.2	97.6	26.5	3.7	18.0	12.2	5.8	11.3	0.90	532
Rhönadler	207.0	123.2	27.0	4.4	17.5	11.3	7.7	12.8	1.14	652
Mannheim	200.4	101.6	27.1	3.7	17.3	11.0	7.4	12.6	1.14	533
Herkules	193.5	108.0	27.0	4.0	15.5	8.9	7.2	12.4	1.38	549

*Modified.

T A B L E (Cont.)

Name of glider	Wt. of elevator per unit area, kg/m²	Wt. of rudder per unit area, kg/m²	Wt. of fuselage per unit length, kg/m	Flying weight, kg	Flying wt. of two-seaters, kg	Calculated sinking speed, m/s $v_y = 0.762\sqrt{\frac{G}{b^2}}$	Calculated sinking speed, m/s $= \frac{\sqrt{G}}{1.315\ b}$
Lore	3.30	2.65	8.8	231.8		0.724	
Stadt Stuttgart	4.25	4.45	7.2	210.6		0.763	
Hugo	2.63	2.45	8.2	223.1		0.759	
Wangen i. Allg.	3.17	3.20		213.8		0.710	
Elida	2.65	2.80	6.0	256.2		0.653	
Schloss Mainberg	3.80	3.72	7.3	212.8		0.695	
Kakadu				238.6		0.613	
Wien	2.14	2.60	8.1	228.1		0.600	
Kassel	2.79	2.66		210.0		0.629	
Starkenburg	2.95	3.00	6.8	215.2		0.697	
Luftikus	1.00	1.00	10.0	213.0		0.742	
Aachen M I	4.40	3.20	5.5	190.4		0.726	
Dresden No. 8	6.50		10.0	297.4		0.656	
Rostock M II	2.20	1.88	13.8	191.5	261.5	0.871	1.017
Rostock M III	1.82	1.90	12.8	223.2	293.2	0.633	0.725
Rhönadler				277.0	347.0	0.725	0.811
Mannheim	2.95	2.70	9.7	270.4	340.4	0.725	0.812
Herkules	3.30	3.57		263.5	333.6	0.798	0.898

Translation by Dwight M. Miner,
National Advisory Committee for Aeronautics.

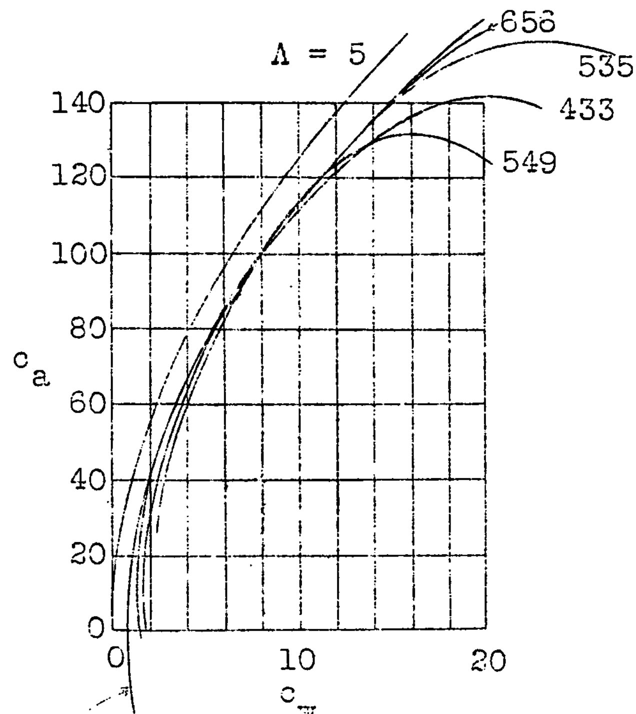

Fig.1 Comparison of the substitute polar with the polars obtained in the Gottingen Aerodynamic Laboratory.

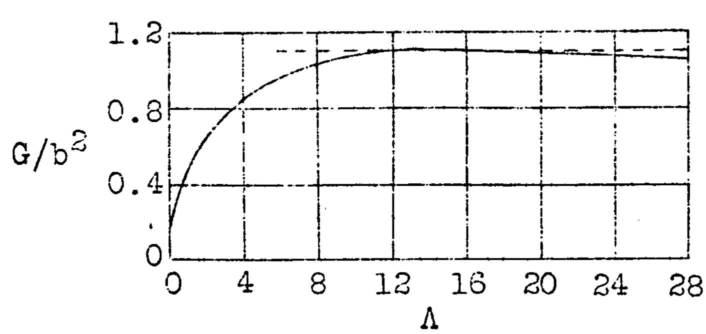

Fig.2 Span loading plotted against aspect ratio according to formula 5.

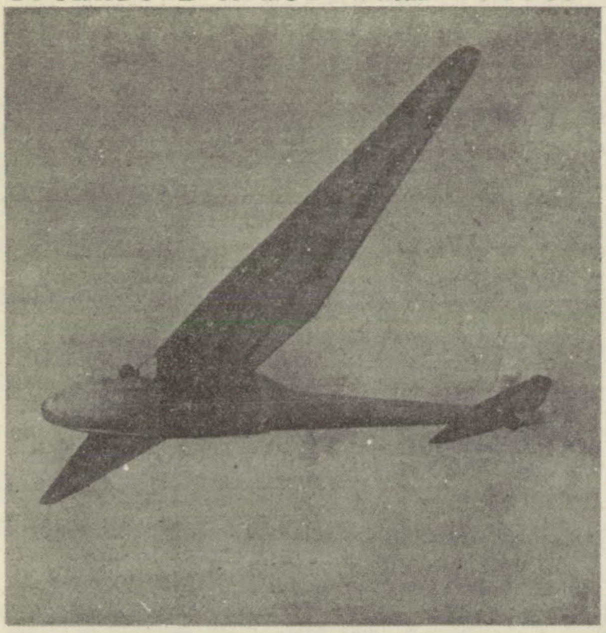

Fig.3 The glider "Wien".

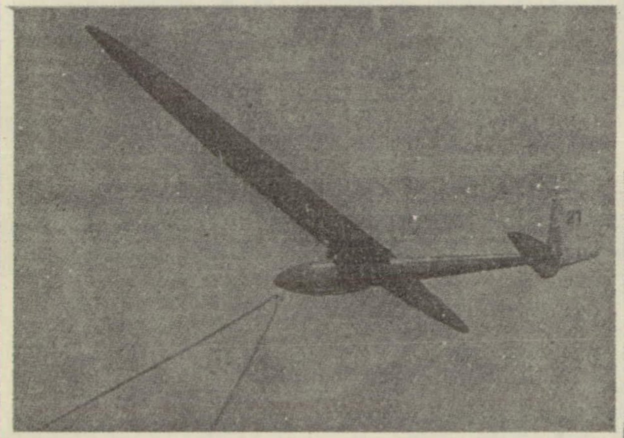

Fig.5 The glider "Kakadu".

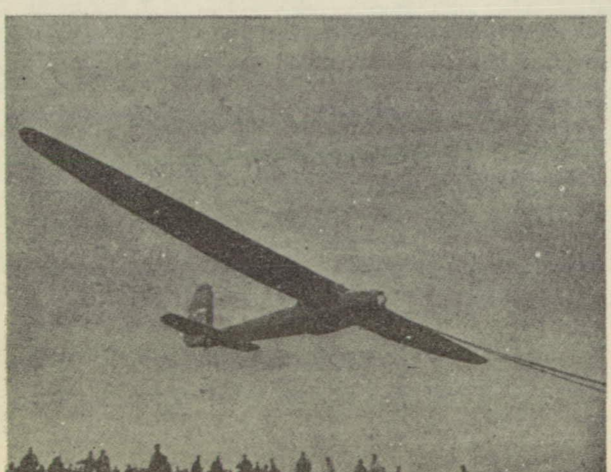

Fig.9 The glider "Darmstadt II".

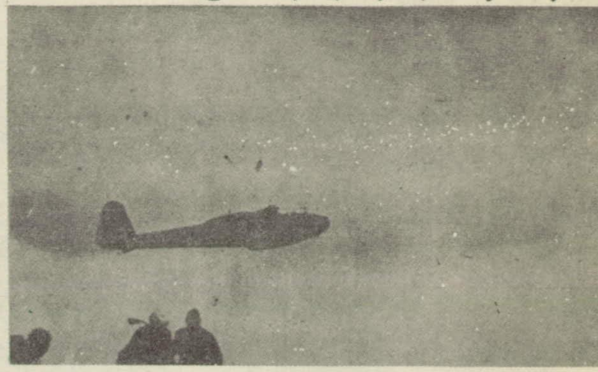

Fig.6 The glider "Lore".

Fig.12 The glider "Hercules"

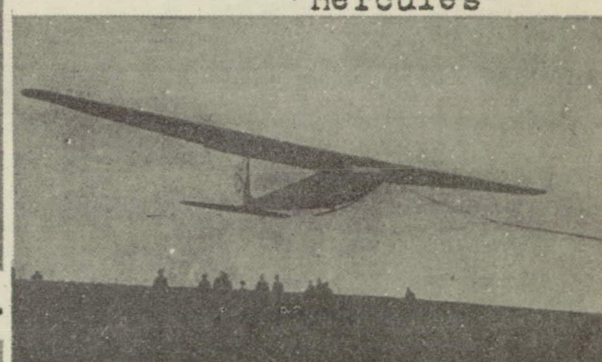

Fig.14 The glider "Luftikus".

Fig.16 The glider "Aachen MI".

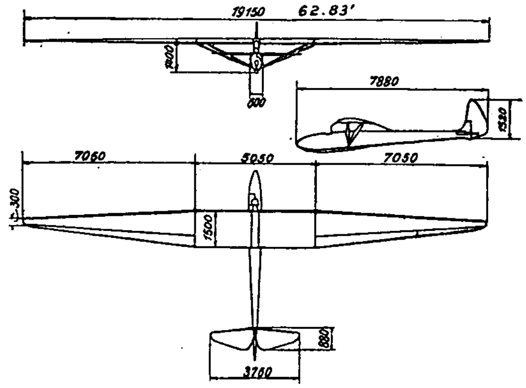

Fig.4 The glider "Wien".

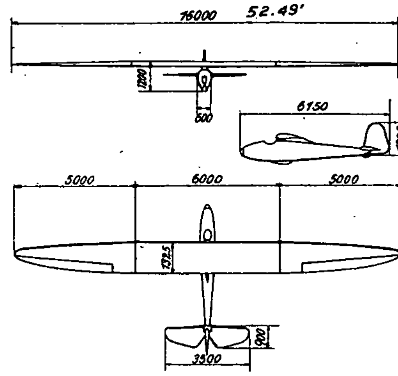

Fig.10 The glider "Starkenburg".

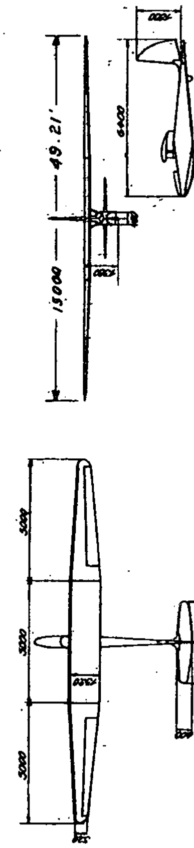

Fig.15 The glider "Luftikus".

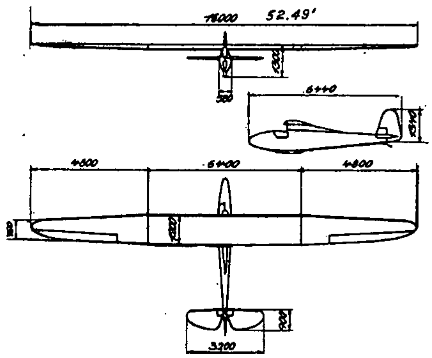

Fig.7 The glider "Lore".

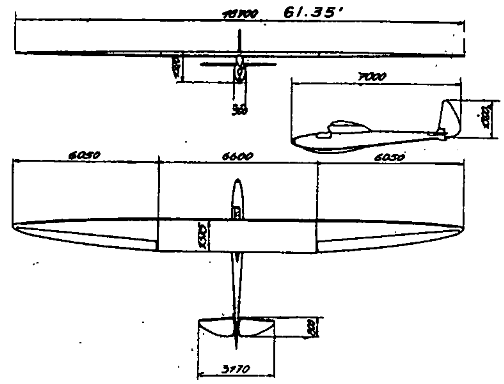

Fig.11 The glider "Elida".

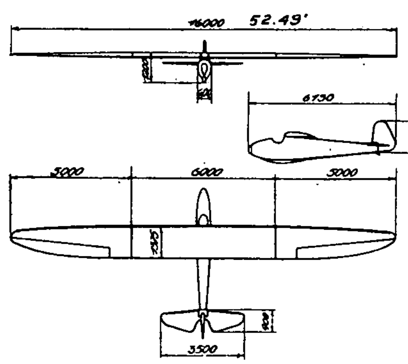

Fig.8 The glider "Schloss Mainberg".

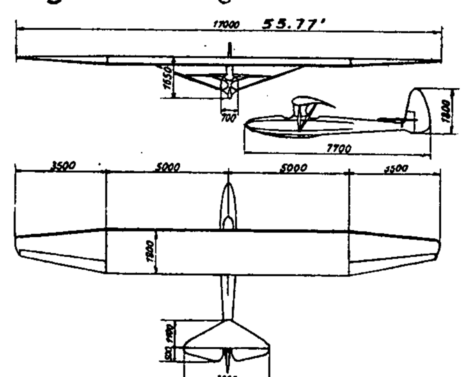

Fig.19 The glider "Rhonadler".

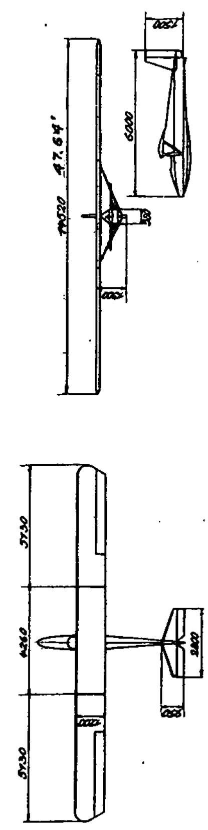

Fig.17 The glider "Aachen MI".

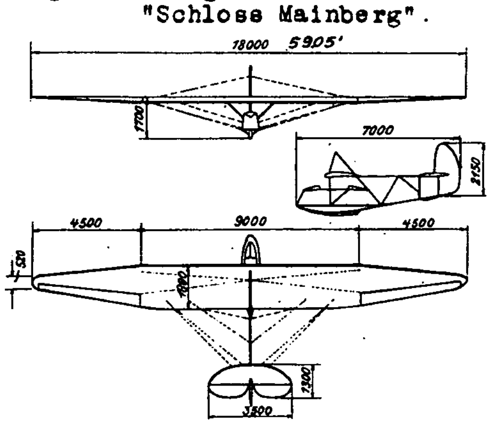

Fig.18 The glider "Mecklenburg MIII".

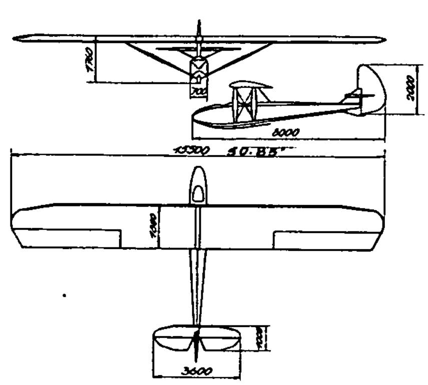

Fig.13 The glider "Hercules".