TECHNICAL MEMORANDUMS NACA-TM-514

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 514

TECHNICAL REPORT OF THE 1928 RHÖN SOARING-FLIGHT CONTEST

By A. Lippisch

From Zeitschrift für Flugtechnik und Motorluftschiffahrt
February 14, 1929

Washington
May, 1929

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

19

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 514.

TECHNICAL REPORT OF THE 1928 RHÖN SOARING FLIGHT CONTEST.*

By A. Lippisch.

The gliders participating in the 1928 Rhön soaring-flight contest showed a general improvement over those of 1927, together with a strong tendency to the establishment of types. While only a few new designs appeared in 1927, the year 1928 brought forth a whole series of new gliders, nearly all of which represented an improvement over those of previous years.

Gliders of the R.R.G. (Rhön-Rossitten Gesellschaft) types "Zogling" and "Prufling" predominated. Twenty-two gliders of the former type and nine of the latter participated in the contest. A number of contesting groups tried more or less successfully to improve the performances of the simple "Zogling" type by enclosing the pilots. This year two 2-seaters of the "Djalar" type participated in the contest for the first time. These were A. Schleicher's "Poppenhausen" and the 2-seater "Rostock" of the Mecklenburg Aero Club. Both of these gliders, when flown as single-seaters, were far superior to ordinary training gliders, due to their considerably smaller wing loading, so that they both succeeded in making soaring flights with a fairly favorable wind.

*"Technischer Bericht des Rhön-Segelflug-Wettbewerbs 1928," from Zeitschrift für Flugtechnik und Motorluftschiffahrt, February 14, 1929, pp. 65-70.

The "Poppenhausen" (Figure 1) is a high-wing monoplane having a span of 15.2 m (49.87 ft.) and a wing area of 27 m^2 (290.6 sq.ft.). The rectangular wing with rounded tips has the profile 358 and the ordinary two-spar construction. The fuselage or nacelle has the form of a short closed boat, attached to the wing by struts and carrying a braced girder which supports the tail group. The empty weight of the glider is 120 kg (264.6 lb.), so that, when flown as a single-seater, it has a wing loading of 7 kg/m^2 (1.43 lb./sq.ft.). Its flight performances were excellent. It could soar even in a light wind and its sinking rate was scarcely smaller than that of the best performance gliders.

The "Rostock" (Figures 2 and 3) was smaller and more compact than the "Poppenhausen" and had a wing area of 22 m^2 (236.8 sq.ft.) with a span of 12 m (39.4 ft.). The two-spar wing had the usual wood structure, while the rest of the framework was made of steel tubing. The short fabric-covered nacelle and the tail structure were similar to those of the "Poppenhausen." The "Rostock" had a total weight of almost 100 kg (220 lb.) and was inferior to the "Poppenhausen" as regards sinking rate, due to its greater wing loading. Nevertheless, this type, because of its simpler construction, was better suited for training purposes than the heavier "Poppenhausen." It appeared to have better flying properties than the "Poppenhausen," while the latter had considerable inertia due to its low flight speed. For training purposes, soaring-flight ability is not worth striving for in itself, when it destroys the sensitiveness of the glider. It would therefore be a decided mistake to give up these slow and unsensitive gliders for faster and more sensitive single-seaters merely on the basis of the contest results. We must always bear in mind that a training glider has certain disadvantages in a contest, due to its special adaptation to training purposes. A smooth and exact functioning of the controls is an essential characteristic of training gliders, whereby, nevertheless, there must be a satisfactory degree of safety in extreme flight positions and the risk of rupture must be reduced by robust construction. Development in this direction always produces a glider with a small span and a medium wing loading, so that improvement in the aspect ratio (i.e., in the sinking rate) is not worth striving for. Gliders for beginners must also have a relatively large angle of glide, since otherwise the flight distance will make too great demands on the pilot.

The number of performance gliders was increased considerably as compared with the preceding year, 22 of these participating in the contest. Nine of these gliders were of well-known types which had previously participated in contests, 2 recently built but already tested gliders, and 11 new gliders. Of the older gliders which were still capable of excellent performances, we may mention the Fulda high-wing monoplane "Albert," as likewise the "Westpreussen" constructed by Hoffmann (Figure 4). The latter was based on the Darmstadt type and is a cantilever high-wing monoplane with a straight middle section and elliptical end sections. It has a span of 15 m (49.2 ft.) and a wing area of 15 m^2 (161.5 sq.ft.). The wing rests directly on the fuselage, which has an oval cross section. It has no fin nor horizontal stabilizer.

The "Wurttemberg" (Figures 5-6), designed by Laubenthal, stands next to the "Westpreussen." Two gliders of this type took part in the contest. The "Wurttemberg," flown by W. Hirth, had already demonstrated its excellent qualities in the French soaring-flight contest at Vauville and was also successfully flown in this year's (1928) Rhön soaring-flight contest. It is doubtless one of the best glider types thus far produced. The cantilever wing has a single spar ("Vampyr" type), a span of 15.2 m (49.9 ft.) and an area of 15 m^2 (161.5 sq.ft.). The fuselage has an oval cross section, pointed underneath with a "neck" or cabane to which the wing is attached. The fin and stabilizer are both very small. The empty weight of the glider is 160 kg (352.7 lb.), corresponding to a wing loading of 15 kg/m^2 (3.07 lb./sq.ft.). Nevertheless, its sinking rate was extremely small, so that it was able to soar in a light wind.

As a substitute for the 1927 "Darmstadt" which was sold to America, a new "Darmstadt" was built by the Darmstadt aviation group, which participated in the contest with Nehring as pilot (Figures 7-8). As compared with the old "Darmstadt," the aspect ratio was increased by increasing the span to 18 m (59.1 ft.) with a wing area of 16.9 m² (181.9 sq.ft.). The shape of the fuselage and the method of attaching the tail surfaces were similar to those of the 1927 type. The weight of the glider is 160 kg (352.7 lb.) corresponding to a wing loading of 13.5 kg/m² (2.77 lb./sq.ft.). The performance of the new "Darmstadt," however, did not prove to be much better than that of the old one. A flat Joukowsky profile of medium thickness was chosen for the wing. The smallness of the increase in performance, despite the improvement in the aspect ratio, may be due to the fact that, as Klemperer had already demonstrated, an improvement in the aspect ratio is of use only when it is possible further to increase the lift coefficient by choosing a profile to correspond.

The Munich academic aviation group tried to harmonize the profile and the aspect ratio in the design of their new S.E.3 glider. A brief statement of the reasons which led to this design, may be of interest. According to a calculation by Kupper, the effect of the weight of a cantilever wing on the sinking rate is so small between the aspect ratios of 8 and 22 that it can be disregarded in an approximate calculation. The best aspect ratio is then obtained from the formula

$$\Phi = \frac{\left(c_{w\infty} + \frac{f}{F} + c_a^2 \frac{F}{b^2 \pi}\right)^2}{F\ c_a^3}$$

in which f = the reduced drag area. It follows that, between the profile drag F and the lift coefficient c_a,

$$\frac{d\ c_{w\infty}}{d\ c_a} = \frac{c_{w\infty}}{c_{a_{best}}} = \epsilon_\infty\ \text{best (Fig. 9)},$$

from which the most favorable aspect ratio is

$$\Lambda_{best} = \frac{2\ c_{a_{best}}}{\pi\ \epsilon_\infty\,\text{best}\left(1 + \sqrt{1 + \dfrac{3\ \varphi}{\epsilon_\infty^2\,\text{best}}}\right)}$$

in which

$$\varphi = \frac{4f}{\pi\ b^2} .$$

Hence the most favorable sinking rate is

$$v_{y_{min}} = \frac{1}{b}\sqrt{\frac{G}{\pi\ \varphi}}\left[3 + \sqrt{1 + \frac{3\ \varphi}{\epsilon_\infty^2\,\text{best}}} + \right.$$

$$\left. + \frac{\varphi}{\epsilon_\infty^2\,\text{best}\left(1 + \sqrt{1 + \dfrac{3\ \varphi}{\epsilon_\infty^2\,\text{best}}}\right)}\right]\sqrt{\frac{\epsilon_\infty\,\text{best}}{1 + \sqrt{1 + \dfrac{3\ \varphi}{\epsilon_\infty^2\,\text{best}}}}} .$$

In this expression it is noteworthy that the profile drag, as such, is not determinative but that, for given values of the span b, weight G and reduced drag area $f = c\ f\ s$, the minimum sinking rate depends only on the profile coefficient of glide (or L/D ratio) ϵ_∞ best.

Thus Kupper demonstrates that there is a best aspect ratio for every profile and that, for the obtention of low sinking rates, one must, first of all, use profiles with a high absolute coefficient of glide. If the experimental results of the Göttingen laboratory be taken as the basis, it appears that the profile 652 designed by the Rhon-Rossitten Society is the most favorable (Figure 10). On the basis of Kupper's calculation, we obtain 21 as the best aspect ratio for this profile. The Munich group has performed an especial service, in that it succeeded in constructing a sufficiently strong cantilever wing having this aspect ratio. Of course, this can be accomplished only by giving the wing spar the form of a thin-walled square box girder and making all the necessary structural elements serve for strengthening and shaping. The wing structure was therefore a logical outcome of the structural method which had already been used in the "Münchner Kindl." On the other hand, it is entirely comprehensible that, in this new glider, not everything was as it would have to be, in order to attain the highest degree of perfection. The round fuselage, attached in the usual manner to the lower side of the wing, had a disproportionately large cross section in comparison with all other performance gliders and could not therefore be regarded as especially well shaped. Figures 11-12 are photographs of this glider being flown by Thöenes, while Figure 13 gives its principal dimensions. It is to be hoped that this glider will contest again next year in an improved form and with more success.

Kegel, of Cassel, also entered a very carefully constructed new glider. It is also a high-wing cantilever monoplane with a streamlined fuselage of the usual type. It has a span of 17.5 m (57.4 ft.) with a wing area of 19 m² (204.5 sq.ft.) corresponding to an aspect ratio of 16 (Figure 14). Especially noticeable in this glider was the unusually small fuselage cross section, which was made possible by the use of a very carefully designed hand steering wheel. The weight of this glider is only 110 kg (242.5 lb.), which is about 50 kg (110.2 lb.) less than the other similar types. Figure 15 shows this glider in flight. It did not do especially well in the contest, due principally to Kegel's lack of practice in flying this new type.

The same principles apply to the performance glider which Schleicher of Poppenhausen built this year (1928). The likewise cantilever high-wing monoplane (Figure 16) has a three-part tapered wing of the two-spar type. The use of the flat profile 549 makes it seem better not to choose too high an aspect ratio. This glider was therefore given an aspect ratio of 12 with a wing area of 20 m^2 (215.3 sq.ft.). The streamlined fuselage, of circular cross section, tapers to a vertical edge which carries the fin. As usual, there is no horizontal stabilizer. The glider weighs 150 kg (330.7 lb.), so that the wing loading is 11 kg/m^2 (2.25 lb./sq.ft.). The glider showed very good performance ability in several flights, though, according to the statement of the pilot, its tendency to yaw was so great as to make it difficult to hold to the course in lateral gusts. We cannot say as to how far this complaint was justified, since the glider was flown only by Schleicher. The Niederhessen Aero Club of Cassel produced the new glider "Hessenland." It was designed by Kirchner on principles similar to those of the 1927 experimental glider "Lapruvo." Kirchner endeavored, by a special type of construction of the wing spar, ribs, etc., to reduce the weight of the glider as much as possible. Instead of the ordinary plywood webs in the wing spars, he used, for example, crossed tie members or lattices of plywood with intermediate compression members. He also used rotatable wing tips in place of the usual ailerons, in order to save the weight of the aileron spar and the corresponding auxiliary spar. Instead of metal bearings, Kirchner often used wood, which does not appear to be entirely satisfactory as regards durability. Nevertheless, he thus succeeded in constructing the "Hessenland" with a span of 18 m (59.1 ft.), an aspect ratio of 15.4, a wing area of 21 m² (226 sq.ft.) and an empty weight of 81 kg (178.6 lb.). The wing alone weighed 45 kg (99.2 lb.) or 2.1 kg per m² (.43 lb./sq.ft.) of the wing area. The strong taper of the wings and the sweepback of their leading edges is especially noticeable in Figures 17-18. The location of the pilot in the leading edge of the wing is aerodynamically very unfavorable, due chiefly to the bad effect of the cutaway. The glider was flown from Magersuppe, Cassel, several times toward the end of the contest and, despite its small weight, showed no such improvement in the sinking rate as might have been expected. This was probably due entirely to the unfavorable position of the pilot. It is to be hoped that this glider will be rebuilt as a normal high-wing monoplane for the next contest.

In order to enable those who have not had the experience necessary for designing performance gliders to build practical gliders of this type, the aviation section of the Research Institute of the Rhön-Rossitten Society constructed a performance glider which was first entered in the 1928 contest. This is the high-wing monoplane "Rhöngeist" which was flown by Kronfeld of Vienna. This glider, which represents a fine type of performance glider, was built on principles recognized as correct for training gliders. It was designed with especial regard to ease of construction. In contrast with all other performance gliders, it has the braced type of wing and a fuselage with a hexagonal cross section (Figures 19-20). It has a span of 16.1 m (52.8 ft.), an aspect ratio of 14 and a wing area of 18.6 m² (200.2 sq.ft.). The braced central section of the wing is in one piece, and the end sections are tapered. The wing structure is of the single-spar type with a torsion-rigid leading edge. Light auxiliary spars serve for attaching the ailerons, which run the whole length of the outer wing sections. The hexagonal fuselage is very tapering toward the rear and carries a small fin. There is no horizontal stabilizer. As special features in comparison with other performance gliders, we may note the relatively large separation between the wing and the fuselage, the large angle of setting of the wing with respect to the fuselage axis, and the braced type of wing. The empty weight of the "Rhöngeist" is 156 kg (343.9 lb.), and its wing loading is 12 kg/m² (2.46 lb./sq.ft.). The flight performances of this type demonstrated that they were in no way impaired by its unusual structural features. On many flights it exhibited especially good soaring ability in light winds, i.e., an especially favorable sinking rate in comparison with other recent performance gliders. The working drawings of this glider, the same as for the "Zögling" and "Prüfling" types, are given out by the Rhön-Rossitten Society for reproducing.

The Mannheim chapter of the German Aviation Society had, for its first active participation in the Rhön soaring-flight contest, a two-seat performance glider made by Schleicher at Poppenhausen from a design by the Research Institute of the Rhön-Rossitten Society. This glider is, so to speak, the "big brother" of the "Rhöngeist." It is likewise a braced high-wing monoplane with a hexagonal fuselage. The wing was made in three sections, the middle one being rectangular and the others tapering. It has a single spar and a torsion-rigid leading edge. It has a span of 17.6 m (57.74 ft.); wing area 26 m^2 (279.9 sq.ft.); aspect ratio 12. The tail is like that of the "Rhöngeist." The empty weight is 210 kg (463 lb.), so that, with two occupants, the glider has a wing loading of 13.5 kg/m^2 (2.77 lb./sq.ft.). It did not do itself full justice in the contest, because the pilot could not get enough preliminary practice in the brief time available. Only after the contest, could the flight performance be tested by Nehring and Kronfeld, who found that the glider had good soaring ability in medium winds.

The 1928 gliders show an encouraging improvement in structural details. No marked innovations of a structural nature were made, however. In wing construction, the three-part "Vampyr" type is by far the most common. Short fuselages have been abandoned for the sake of improving the longitudinal or pitching stability, in the knowledge that reducing the inertia about the lateral axis does not improve the soaring ability and makes it more difficult to obtain the maximum flight performance. The previous arrangement of the tail surfaces was characterized by placing the rudder in front of the elevator (Figure 21), while the reverse is true of the 1928 types (Figure 22), in which the rudder is attached to the end of the fuselage, while the two-part elevator works on a steel or dural tube passing through the fuselage. This arrangement enables an easy and aerodynamically perfect construction of the rear end of the fuselage.

The excellent results of this year's contest were due not alone to the high development of the glider types, but also, in large degree, to the skill of the pilots. The further development of modern performance gliders has been greatly stimulated by these results, and it lies entirely within the realm of possibility to improve still further the sinking rate and the angle of glide by an intelligent use of the new methods of construction.

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


Fig.1

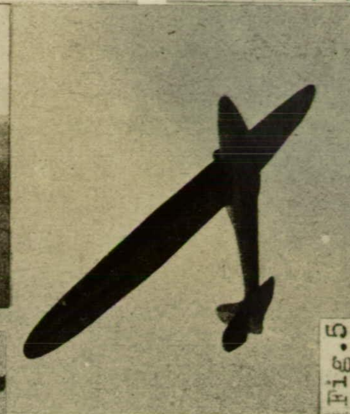


Fig.5

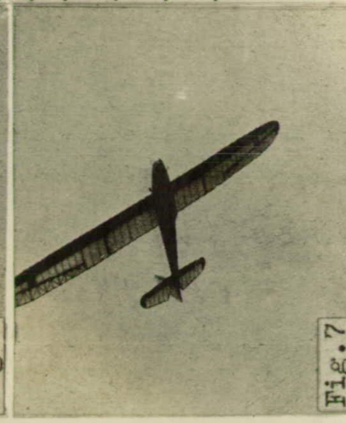


Fig.7

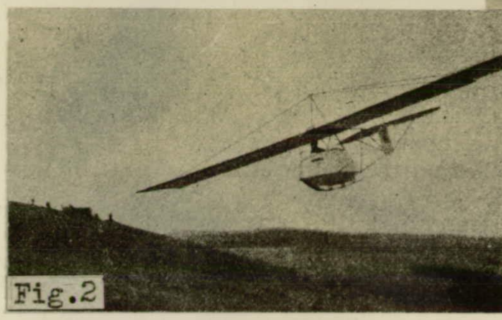


Fig.2

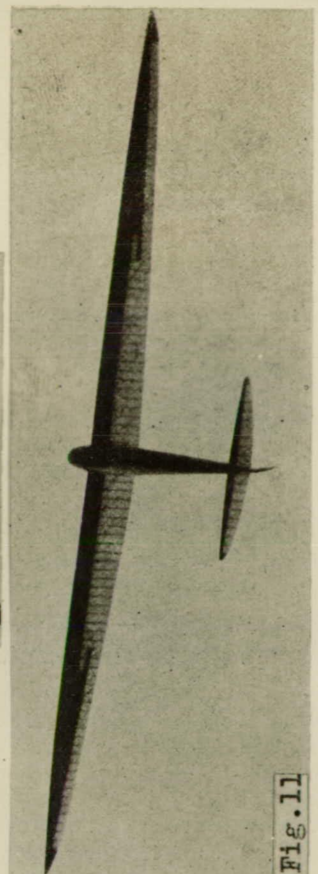


Fig.11

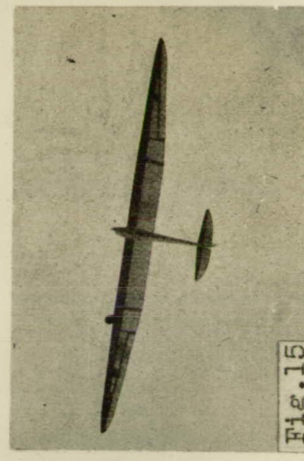


Fig.15

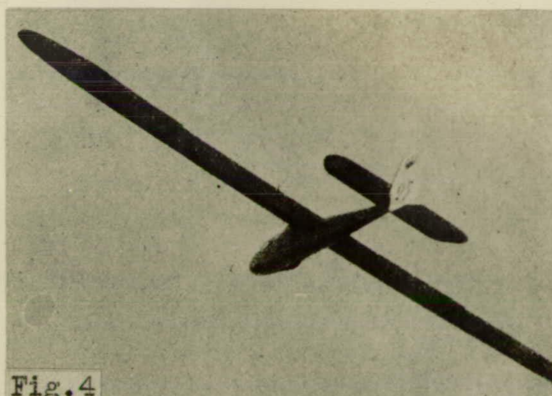


Fig.4

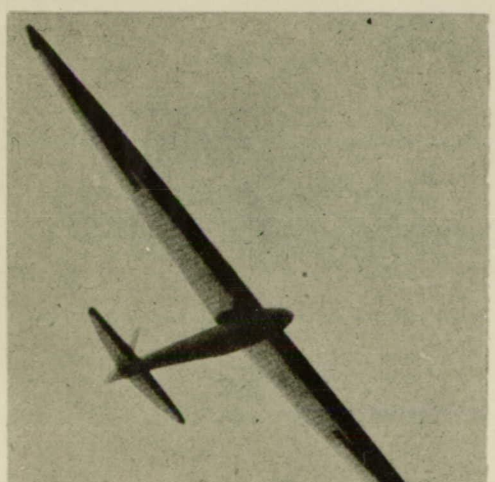
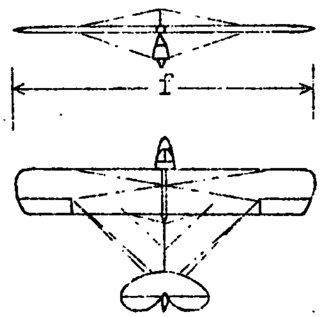


Fig.12


Fig.17


Fig.19

11336 A.S.



Rostock

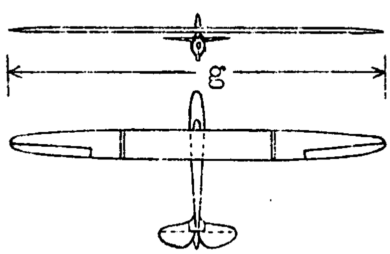
$\Lambda = 6.7$

$F = 22 m^3$ (236.8 sq.ft.)

$G_L = 100 kg$ (220.5 lb.)

f=12.1m (39.7 ft.)

Fig.3



Württemberg

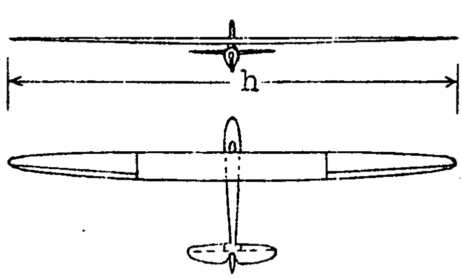
$\Lambda = 14.6$

$F = 15.8 m^2$ (170.1 sq.ft.)

$G_L = 160 kg$ (352.7 lb.)

g=15.16m (49.7 ft.)

Fig.6



Darmstadt II

$\Lambda = 19.2$

$F = 16.9 m^2$ (181.9 sq.ft.)

$G_L = 160 kg$ (352.7 lb.)

h=18.0m (59.1 ft.)

Fig.8

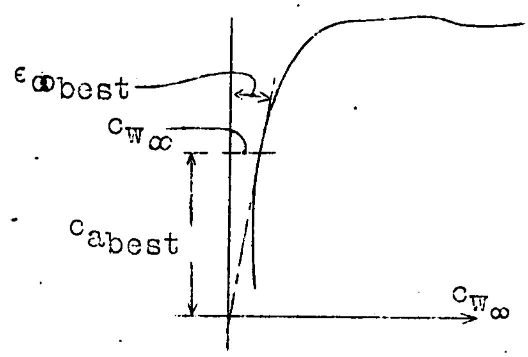

$\epsilon_{\infty best}$
c_{w_∞}
$c_{a best}$
c_{w_∞}

Fig.9

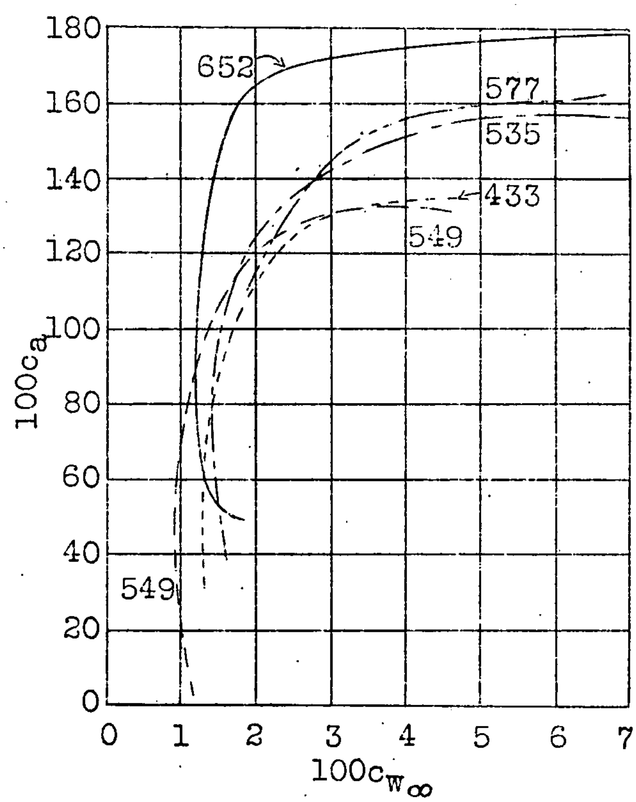
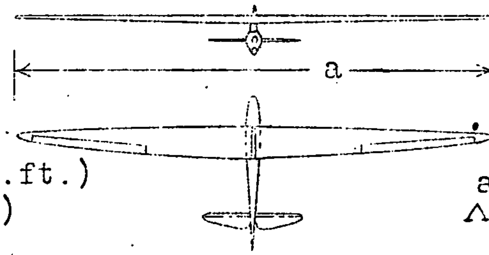

652
577
535
433
549
549
180
160
140
120
100
80
60
40
20
0
$100c_a$
0
1
2
3
4
5
6
7
$100c_{w_\infty}$

Fig.10

München

$F=17.6m^2$(189.4 sq.ft.)
$G_L=135$kg(297.6 lb.)



a, 19.21 m(63 ft.)
$\Lambda=21$

Fig.13

Kegel(Kassel)
$\Lambda=15.4$
$F=19.8m^2$(213.1sq.ft.)
$G_L=110$kg(242.5 lb.)
b=17.5m(57.4 ft.)

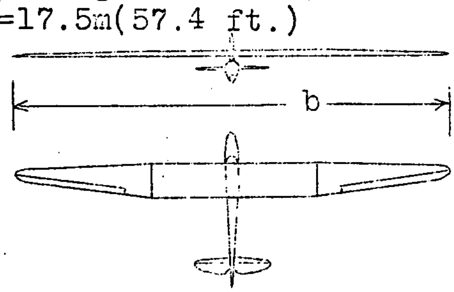


Fig.14

Schleicher
$\Lambda=12.5$
$F=20m^2$(215.3 sq.ft.)
$G_L=150$kg(330.7 lb.)
c=15.8m (51.8 ft.)

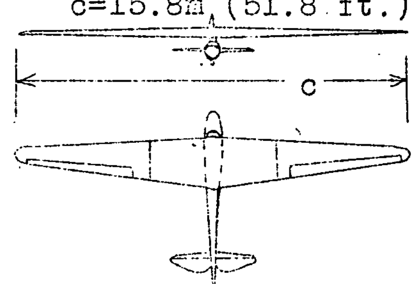


Fig.16

Hessenland
$\Lambda=15.4$
$F=21m^2$(226 sq.ft.)
$G_L=81$kg(178.6 lb.)
d=18.0m(59.1 ft.)

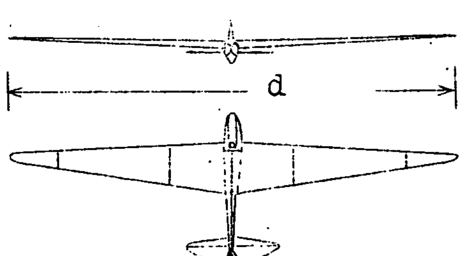


Fig.18

Rhöngeist
$\Lambda=13.9$
$F=18.6m^2$(200.2 sq.ft.)
$G_L=156$kg(343.9 lb.)
e=16.090m(52.8 ft.)

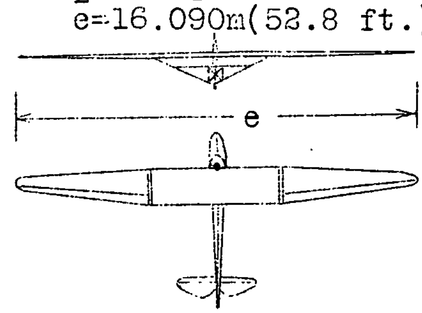


Fig.20

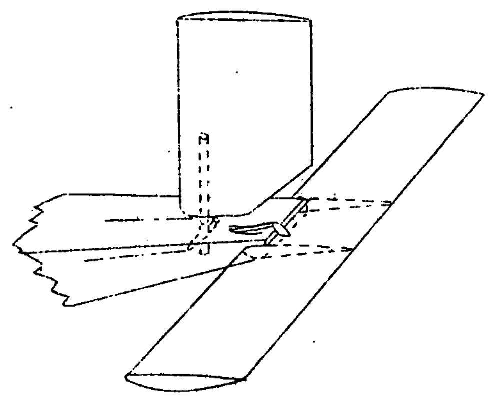


Fig.21

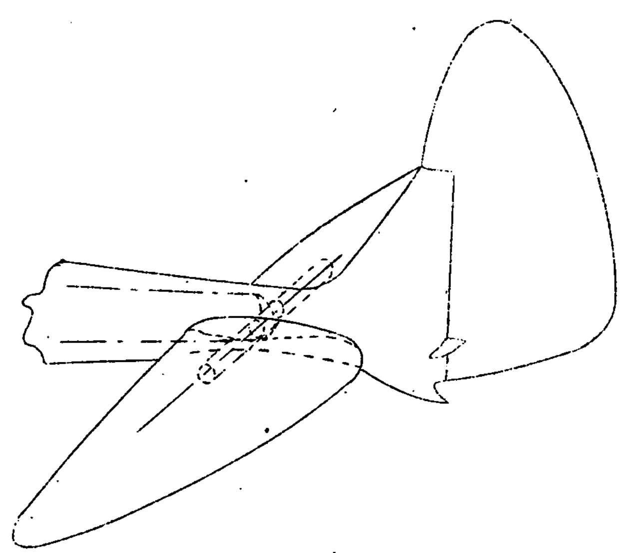


Fig.22