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REVOLUTION IN AIRPLANE CONSTRUCTION? GROB G110: THE FIRST MODERN FIBER GLASS COMPOSITION AIRPLANE SHORTLY BEFORE ITS MAIDEN FLIGHT

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Translation of "Revolution im Motorflugzeugbau? Grob G 110: Das Erste Moderne GfK-Motorflugzeug Kurz Vor Dem Erstflug", Aerokurier, No. 12, December 1981, pp. 1550-1555.

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16. Abstract

This magazine article introduces a new single engine two-passenger airplane. It is constructed completely from fiber reinforced plastic materials.

The cockpit, controls, wing profile, landing gear are all discussed. Further development of this airframe is also presented.

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REVOLUTION IN AIRCRAFT CONSTRUCTION?

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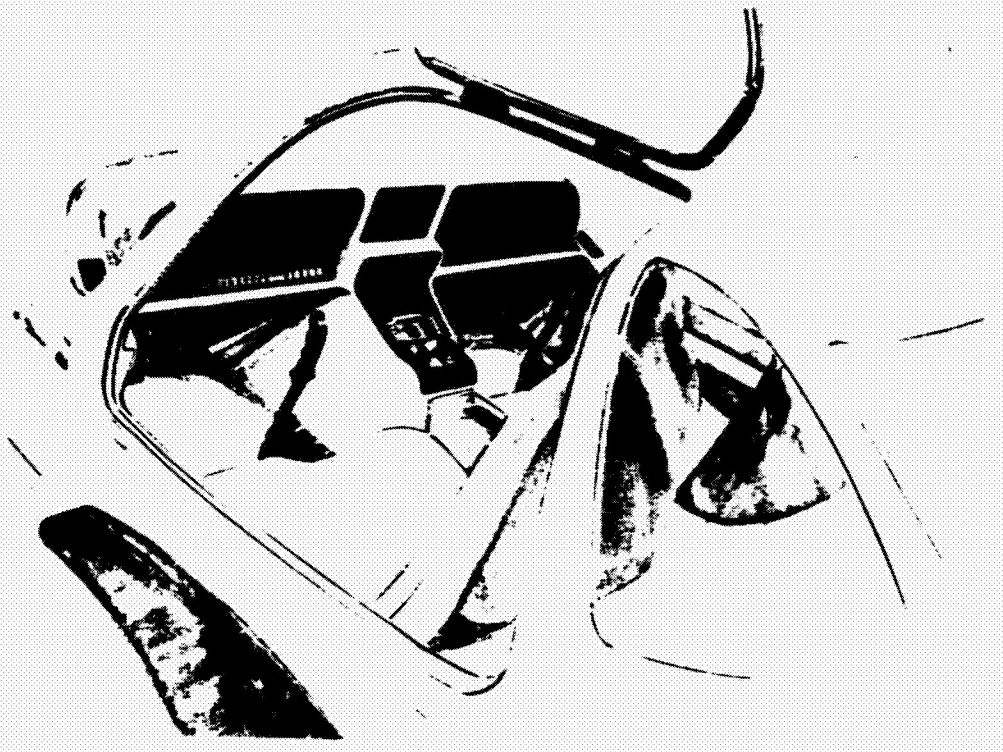
Grob G 110:

The first modern fiber reinforced plastic motorized aircraft just before its maiden flight



The cockpit of the G 110 is as comfortable as a medium sized car

Is a revolution imminent for motorized aircraft construction? The Grob Aircraft Manufacturing Company in Mindelheim is now pursuing something that has been due for a long time: the first motorized aircraft in the world made completely using the modern GFK (fiber reinforced plastic) shell construction method, the two-seat G 110. If everything proceeds according to schedule, the beautiful twin seat aircraft will start on its maiden flight at the turn of the year. According to positive experiences with the GFK motorized glider G109, the Grob company hopes that the bird-type acceptance

*Nos. in margin indicate pagination of foreign text.

testing of the G 110 will occur rapidly, so that in the following year, serious production can start.

The G 110, we would like to state, is only the first precursor of an entire series of motorized aircraft now being planned by Grob, extending from a light two-seater aircraft up to a 200 HP four-passenger aircraft with retractable landing gear. Grob has designed a peak speed of far above 300 km/h for this aircraft. Because of the GFK construction method, this new motorized aircraft family will offer an attractive performance spectrum which was difficult to obtain using conventional materials up to the present.

Already for the two-seat G 110 an 87 kW (118 HP) engine has a designed speed of 250 km/h for 75% power. In order to also offer the G 110 as a pulling aircraft, probably a 120 kW (160 HP) version will soon appear, and a rope retraction system (Stolle system) is planned for it in order to save having to overfly airports where one cannot land with the rope.

The G 110 represents a long overdue development. Finally, it seems possible that the know-how of the German GFK (fiber reinforced plastic) glider aircraft construction method known everywhere in the world will be transferred to other regions of aviation. If the Grob GFK motorized aircraft family is successful, and there is every indication of this, then during the 80's there could be a technological revolution which occurred during the 70's in the area of glider aircraft construction. The Grob G 110, in any case, is a development, the effects of which cannot yet be foreseen for future motorized aircraft construction.

As Burkhart Grob stated in a discussion with the Aerokurier Magazine, the G 110 will be priced about in the range of aircraft having the same power with conventional construction. /1551

Has any pilot who has run his hand over the beautiful surface of a modern GFK glider not asked himself whether this wonderful material could not be used for motorized aircraft construction? The well developed aerodynamics of modern gliders always posed the question to motorized pilots, why it was not possible to expend some aerodynamic effort for motorized aircraft, and thereby improve the performance which has stagnated for a long time, in order to reduce drag and then reduce fuel consumption, using the improved surface quality of the GFK construction method.

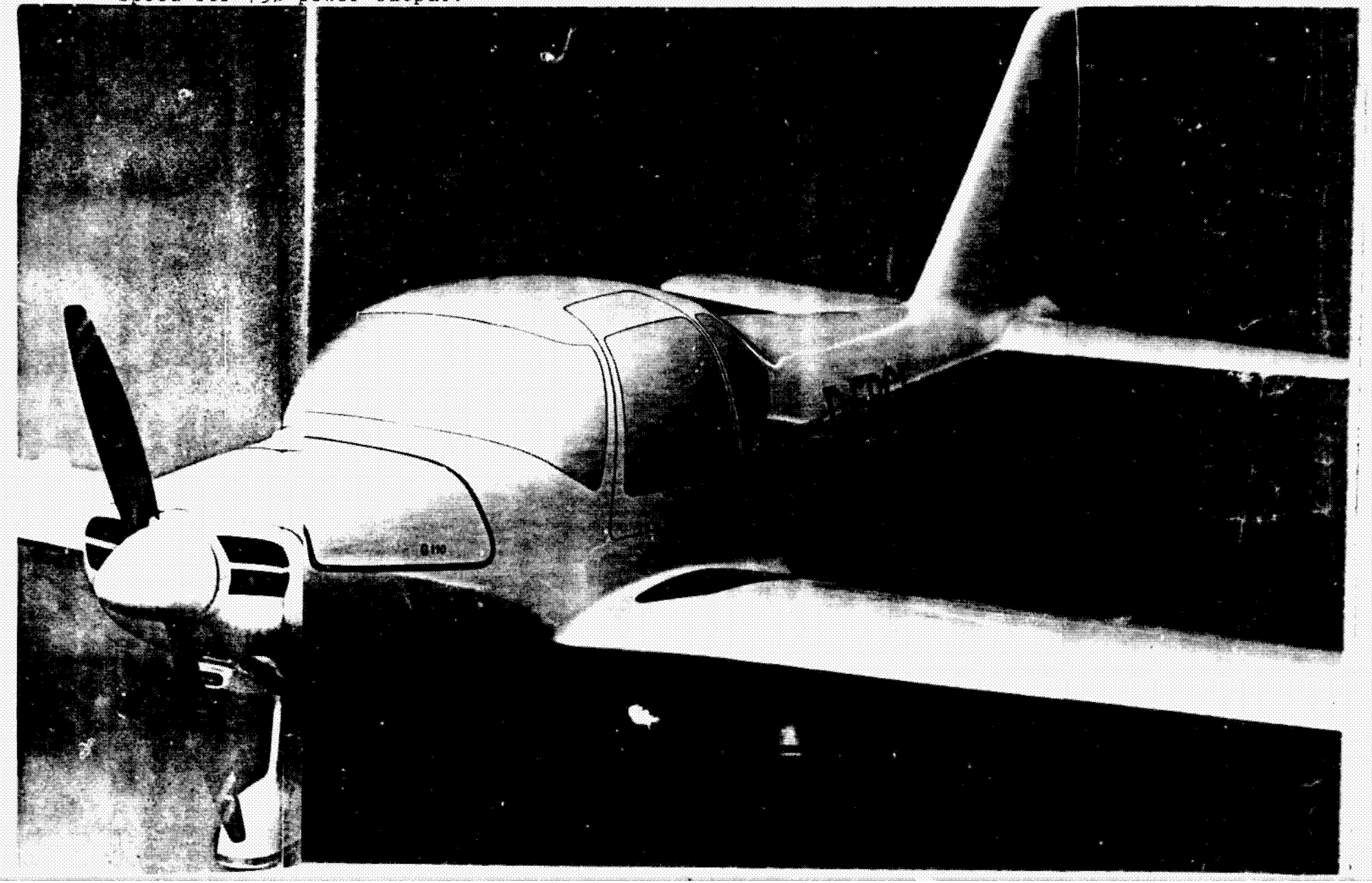
There have been many attempts to use GFK technology in motorized aircraft construction in the past. We only have to recall the LFU 205, the prototype of Wassmer Aviation, and in the USA, the Windekker Eagle. All of these attempts had one feature in common, even though they were different: starting with the design, for these aircraft only previous materials, usually metal or wood, were substituted by GFK. It was only in a few cases that attempts were made to develop a new shell construction method appropriate for the GFK material, which would completely exploit the advantages of this new material.

This is the area in which German glider construction has progressed substantially over the last few years. What has been happening is equivalent to a revolution in aircraft construction.

The Grob Aircraft Construction Company was the first German manufacturer of gliders who decided to exploit the highly modern know-how of glider aircraft construction in the area of motorized aircraft construction. While this Aerokurrier Magazine edition was being delivered, the prototype of the first German motorized aircraft designed for mass production is being finalized in Mindelheim Mattsies. If no unexpected difficulties occur, then the G 110 probably will experience its maiden flight in this year.

The G 110 is more than just the first German GFK motorized aircraft developed for mass production. At the same time, it is

The cockpit of the G 110 offers the space of a comfortable middle class automobile. The performances are exceptional: only 87 kW (118 HP), the G 110 reaches 250 km/h cruise speed for 75% power output.



the first motorized aircraft in the world which uses the most modern GFK shell construction method. Everything that the Mindelheim company has developed over the last few years (improving and simplifying the manufacturing of gliders), for the first time is being applied for motorized aircraft. The results are impressive: Using an 87 kW (118 HP) engine, the G 110 with only 75% power will reach a cruise speed of 250 km/h (calculated). For a maximum departure weight of 900 kg, the G 110 after takeoff will achieve an ascent performance of barely 5 m/s. The payload is designed for an increase. The empty mass of now 560 kg results in an additional payload of 340 kg for the twin seater aircraft, which for full tanks and pilot weight already considered of 80 kg, still allows a payload of 160 kg. It is a well known secret: the G 110 is the precursor 1552
of a large motorized aircraft family. The new GFK twin seater has been developed as a prototype, and the development division of the Grob company has for a long time been working on the further development of a four-passenger aircraft which will probably be called the G 111. At the end of November the Aerokurrier Magazine editor visited Grob in order to inform himself about the motorized aircraft development. Our report follows:

First of all, it looks very elegant and crisp, the G 110. The concept is completely tuned to the technical possibilities of GFK construction. First of all, we have the very slender wings with large aspect ratio which is unusual for motorized aircraft. The body is also slender in height but rather voluminous which means that there will be no reservations about the space requirements of twin passenger aircraft. It tapers in an elegant manner into a conventional control surface assembly. Of course, the G 110 has a three wheel landing gear.

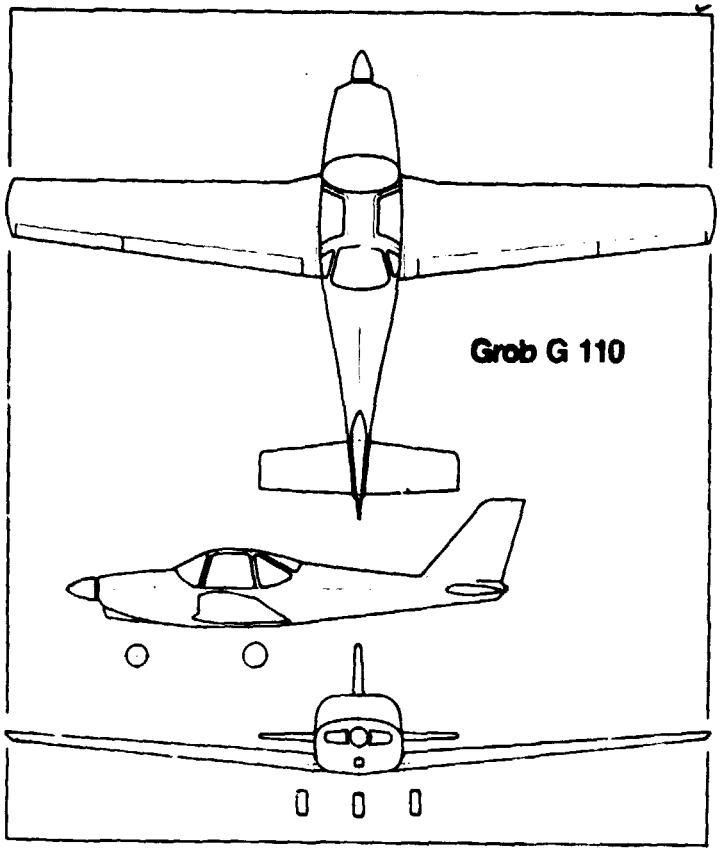
The motor fairing may seem rather large at first glance, but it is also designed for growth.

For the engines, Grob selected the Lycoming 0235 MI with 87 kW (118 HP) power at 2800 rpm. It is unusual that this motor has an adjustable airscrew. This screw was developed and has the name HO-V72G by the propeller factory Hoffman in Rosenheim. Use of an adjustable airscrew is one condition that the performance potential of the G 110 can actually be exploited because of the high aerodynamic quality of the airframe.

As is usually the case in aircraft in this category, the G 110 is entered from the side. The pulpit cockpit is entered through two wing doors on both sides, which open upwards. As already done earlier in the design of gliders, Grob again oriented itself in a design of the G 110 cabin using standards of the automobile industry. This first of all starts with the dimensions of the cockpit. The previous type conditions have been overcome which exist in many training aircraft. The queer width of the G 110 cockpit inside is not less than 1.28 m, a value which corresponds to the space in a comfortable medium class car.

Burkhart Grob: The seats have headrests in the G 110 and have only little in common with the dimensions of conventional seats in aircraft in this category. Instead they remind one of first class seats in a Boeing 747. In order to adjust to individual body size, the seats can be displaced and the armrests can be adjusted. They are turned forwards to load the luggage area so that the luggage compartment of the G 110 is easily accessible.

One of the interesting design features of the G 110 is the relatively steep front windscreen. Using model investigations, it was found that they not only provide a very good viewing condition in the flight directions, but during roll-out it makes it possible to see the runway at a distance of only about 10 m in front of the aircraft.



STICK CONTROL

According to its presumable use as tra ining, sport, light-work and cruise aircraft, the G 110 has a stick control system. Experience has shown that motorized aircraft pilots of light aircraft classes do not object to a control stick instead of the control horn which is sometimes not appropriate for this size aircraft. The four-seat aircraft will have the control horn used in cruise aircraft today, according to Grob.

PANELS

Because of the large cabin width, the G 110 will have a very generous panel which would offer no difficulties to incorporate extensive IFR avionics in a logical and appropriate manner in this aircraft. In the design of the instrument board, Grob did not want

to install a "clock factory", but to have a panel appropriate for modern ideas.

As is done today, the G 110 panel will have three area elements containing the instrumentation and control elements for the pilot and copilot in the front at the seats and there will be a vertical avionics panel in the center. The panel surface has an artificial leather-like material and is very beautiful.

The other operating elements must harmonize with the category and the purpose of the aircraft according to Grob. This starts with the foot tip brakes and includes the mechanical operation of the flaps and friction trim. This simple type of trim is made possible because Grob decided for a flettner trip rudder which as is well known does not exert any large forces on the operating elements. A trim lever damped by the friction brake will certainly be sufficient for this aircraft.

As far as can be seen from the present cabin layout, all of the operating elements will be arranged in an appropriate ergonomic way. This is also true for engine operation which in the usual way, including propeller adjustment, is arranged in a center power console. Just above this console there are the important instruments for engine monitoring. There is the tank selection switch in the center for switching among the area tanks.

We should also mention the wing doors when describing the cockpit. As already stated, they open upwards and are supported by gas springs. Grob realized that difficulties had occurred previouly in similar designs. In many cases there were problems with ceiling so that both rain water could penetrate and whistling sounds were heard. Grob considered this in the development of the G 110. Starting with the realization that the airframe complex is deformed in flight and twists, it was decided to not have the wing doors of the G 110 fit tightly but instead, they were designed so that they would be

stretched when they were closed over the airframe arc which provides a rigid connection. This makes it possible to transfer twisting forces to the door as well without having leaking points. Before that, these leak holes were so large that they could not be covered with the usual rubber lips.

A new kind of door construction has evolved at Grob which it believes is sufficient for traveling speeds of up to 350 km/h.

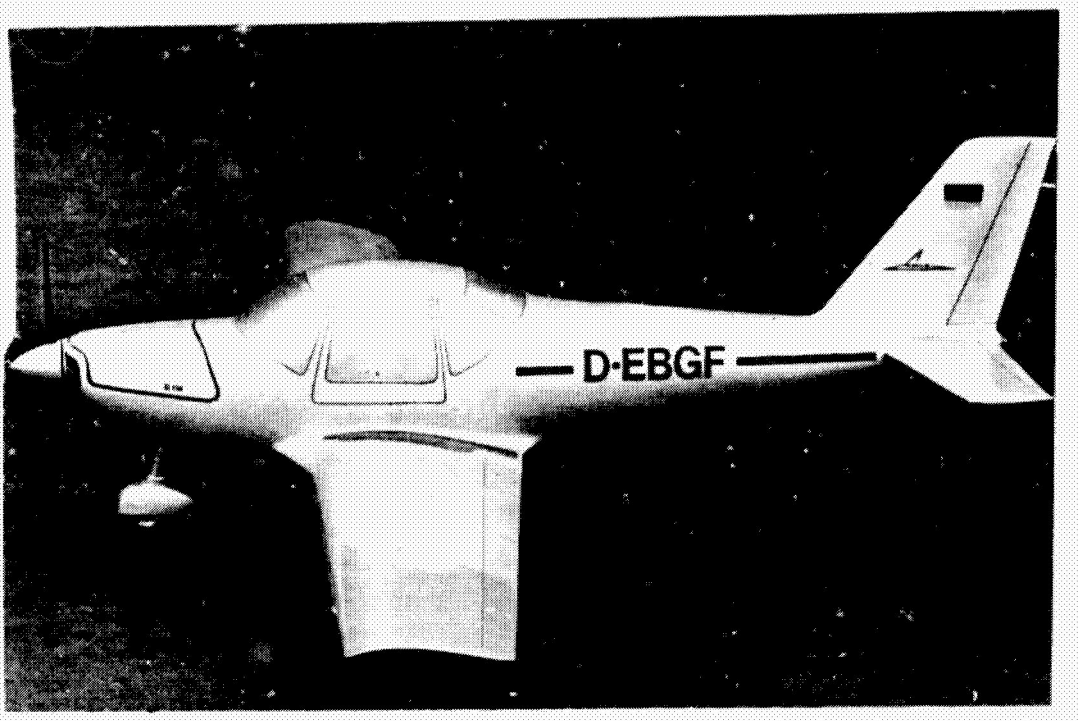
In order to operate the doorlock, there is a lever which is about at the height of the upper leg of the pilot and copilot and by turning it by 180°, the two part doorlock is locked or opened. The same handle passes through an access outside and is connected with an aerodynamically structured handle. It is designed so that the door of the G 110 can be opened with one hand. This overcomes one problem which was encountered previously in wing doors. If one stands on the ground and opens the door, then it always closes by itself because it cannot be lifted up high enough to maintain its position. On the other hand, if one stands on the surface, then it is difficult to open the door because one is in the way of the door.

Since the wing door only has a small width in the area of the wing root, in the case of the G 110 it should be possible to also open the door when one is already standing on the wing.

Burkhart Grob: "In aircraft construction, comfort should be offered as is known from any better medium class car. In the 1554
design of the G 110 we exploited the possibilities of a very low drag GFK airframe. In other words, because of the overall more favorable airframe in terms of drag it was possible to make the cabin volume very large without running into the danger of increasing the total drag of the aircraft to an unacceptable degree".

VISUAL CONDITIONS

Today there is no longer any debate of designing an aircraft so that it offers optimum viewing conditions in the flight direction as



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The G 110 concept has exploited the technical possibilities of glass fiber reinforced plastic construction. The exceptionally wide and spacious cockpit also offers exceptional seating comfort and viewing possibility

as well as to all sides. The G 110 will be an example in this regard. In addition to the large and steep front windscreen already mentioned, there are two large side windows in the doors. The G 110 has three further rear windows which overall give a good 360° visibility during flight and on the ground. We should also mention the fact that in Mattsies at the present time there is a design for equipping the G 110 with a second seat bench so that a third adult or two children could be seated there. Such a 2 + 2 seat aircraft would be very interesting if it were equipped with a stronger power plant. Such a version is already being planned at Grob. Let us consider the innards of the airframe: all of the rotors and flaps including the vertical control surface are operated with push rods. There is not a single control rope in the entire aircraft. The entire control rod assembly is supported with ball-bearings in order to have the best operation possible.

Also Grob no longer wishes to use cast elements for this. All the parts of the control are made of steel-welded design. Of course,

the support blocks are also welded and Grob has developed a kind of universal solution which was used in the entire G 109. In this area we have the greatest technical relationship between the motorized glider G 109 and the new motorized aircraft G 110. Even though there are some differences in detail and dimensions, the design principles which were used in the G 109 and which proved themselves were also incorporated in the G 110. The Grob firm admits that Germany was the first GFK motorized glider with prototype acceptance and it will be the same for the G 110. Even though both aircraft are slightly similar, technologically they are very closely related.

In Mattsies, one often speaks of the building box principle. In other words, vast areas of the internal installation are designed so that they can be connected with one another with screws in building blocks during manufacturing.

The real advantage of this design principle will be exploited in the design of the four passenger aircraft as Grob firmly believes. The building block principle has two advantages: First of all, the design which is then relieved from a large amount of detail work. Also during the later manufacturing, expensive equipment is avoided and individual elements can be manufactured in large numbers at chepaer price. During final assembly, the parts are only screwed together just like in an Erector set. It is then possible to then completely avoid erroneous assembly work. The parts simply do not fit when assembled the wrong way. In parallel to the development of a building block system, there is also the development of a standardized system which will establish harmony between all of the designed elements. After this preliminary work which was very extensive, it is now believed that the development rate in motorized aircraft construction will be substantially accelerated. The four seat cruise aircraft will profit from this the most which will be developed in record time and may be presented in 1982.

WING

The construction and conception of the G 110 wing is derived directly from experiences with glider construction. Nothing else was expected from the Grob company and the G 110 has an Eppler profile. Consider the high expected cruise speeds, it is believed as Grob that this profile is optimum. According to Burkhart Grob, the advantage of the Eppler profiles was always the top speed range. The G 110 is, therefore, an aircraft which will completely exploit this possibility.

In the past an impression has been created as though the development of new profiles for motorized aircraft had stood still. On the other hand, in gliders and in the area of fast large aircraft, there has been much development. New profile developments show that it in fact pays off to carry out extensive work on profile aerodynamics, considering the high fuel costs of today, in order to exploit all possibilities of reducing drag.

EPPLER PROFILE

The Beech Skipper and the Piper Tomahawk are two aircraft which are new developments of the most recent past and these had a new profile. Both aircraft used the GA(W)-1 developed by NASA especially for general aviation. This profile then led to intensive profile research for motorized aircraft construction.

Grob decided on the Eppler profile as could be expected, more precisely, the E 789. There are especially two important properties of this profile which were advantageous: Its favorable drag coefficients for fast flight and its harmlessness for slow flight. As previous experience shows, in practice it seems impossible to make the flow separate in this profile. Grob was, therefore, able to avoid one restriction for the wing of the G 110. The wing of the G 110 is restricted neither geometrically nor aerodynamically.

In addition to the advantages of th Eppler profile, Grob also selected a lifting surface of 12.25 m^2 which is a relatively large wing area in order to have a relatively low area loading and uncritical flight properties, as well as low takeoff and landing speeds. This is very important because typical central European airports in comparison to the USA, are short and usually poor. Therefore, one would expect that a European aircraft would take these restrictions into consideration.

The shortest possible takeoff distance, however, is not only advantageous in terms of safety, it is also environmentally friendly. The faster an aircraft is in the air, the faster it will reach altitude after liftoff and the smaller will be the noise load on the population.

The landing flaps of the G 110 extend over 2/3 of the span. 1555
The landing position is 15°. For landing approach a range between 45 and 60° could be used but Grob does not wish to use a flap position which is too steep in order to avoid difficulties when going around again. Flight testing will decide this. The flaps are operated manually through a lever between both feet. Because of the relatively thick Eppler profiles, there are no problems with wing installed components especially not for the area tanks which both hold 70 liters. The thickness of the Eppler profile does not have a negative effect on the drag balance of the aircraft which is not generally known.

In order to not influence the aerodynamic quality of the wing, there are closure covers which are carefully integrated into the surface.

Thanks to the Eppler profile and a favorable area loading, the G 110 is flown with an approach speed of about 100 km/h (60 kts).

LANDING GEAR

Grob uses the experiences with the motorized glider G 109 for the landing gear of the G 110. In other words, the G 110 does not have GFK but instead steel spring legs. Burkhart Grob: "It does not make sense to use the material which is only conditionally suited if other materials are available which completely satisfy the application".

Of course, the G 110 has a nose landing gear because it is a motorized aircraft. On the ground, the nose wheel is controlled with springs. Starting with a certain sideways deflection, the nose wheel, however, will disengage so that close maneuvering is made easier.

Because of the high cruise speed, the main and nose landing gear wheels will be supplied with wheels cowlings in mass production. According to Burkhart Grob, an attempt is being made to offer a complete aircraft at a fixed price. The usual option lists will refer for the most part to avionics and additional equipment.

CONTROL SURFACE

For many people it will be surprising that the G 110 does not have a T or cross control surface system, however, but has a conventional control surface system, as has been used many years ago and has been called old fashioned. An aircraft control surface is such a serious matter in terms of handling and flight properties, that only design and never fashionable aspects are to be considered. Previous aerodynamic analyses have shown that conventional control surfaces of the G 110 are superior to other kinds of control surface systems. Therefore, it is correct that Grob has selected this system and is not following any fashion.

In an earlier design stage the G 110 was planned with a T control surface but it was dropped during the development.

The final decision ab ut the optimum control surface design, of course, can only be done during flight tests, which will start shortly.

Disregarding aerodynamics and flight mechanics, the conventional control surface has many design advantages. It allows a great savings in weight especially for fast aircraft by reducing the design weights for the side control surface and the elevator control surface.

CARBON

The G 110 will also profit with experience with carbon fibers, as have been attained for glider construction. Even though the material KfK (carbon reinforced plastic) has only been used seldomly. This is especially true for the rudders which are equalized by 100% in mass. In this way it is possible to reduce the rudder weight to about one half.

The door frames are also made of KfK (carbon reinforced plastic) in order to save weight and to achieve sufficient stiffness. A mixed use of GfK (glass fiber reinforced plastic) and KfK (carbon reinforced plastic) is not advantageous because of the different elasticity conditions.

GLIDER TOWING AIRCRAFT

Grob plans to offer the G 110 with engines of various performance classes. In the simplest design, the G 110 will have an 87 kW (118 HP) Lycoming O-235-M1 engine, and in conjunction with the Hoffman adjustable airscrew, this will be a rather fast cruise aircraft. The G 110 will become a small rocket if as planned it is equipped with a 160 HP motor. Rather attractive performances for glider towing will be expected from this version and the 160 HP engine will limit the fuel costs as well. Grob will equip the

glider towing version of the G 110 with a rope retraction system if desired, which will roll into the aircraft after the glider has separated. This will make it unnecessary to drop the rope which is not possible at many airports.

The GfK aircraft G 110 is offered in white, but accent colors for the side and wing end strips are possible. Basically, the GfK motorized aircraft can also be delivered in bright colors but no experiments will be made in this regard in the G 110 and later motorized aircraft will only be delivered in white.

If one considers that most motorized aircraft made of metal are sprayed in white as a basic color, then there will hardly be problems with desired colors. Burkhart Grob: It does not make sense to paint our aircraft in metallic colors. Otherwise, some people will think we are offering a metal aircraft.

R. Doerpinghaus

GROB G 110 data
Status November 1981

Manufacturer	B. Grob Flugzeugbau Mindelheim
type	G110
engine	Avco Lycoming O-235-M1 TC 223
power kW	87
HP	118
rpm	2800
for airscrew	HO-V72G const. speed
crew	2
span m	10.6
length m	6.9
wing area m^2	12.2
aspect ratio	9.2
profile	Eppler E 789
cabin dimensions	
length m	1.7
width m	1.28
height m	1.15
empty weight kg	560
fuel, max l/kg	140/100
payload kg	240
addl. load kg	340
takeoff wt. max kg	900
area loading kg/m^2	73.5
baggage, max kg	40
max allowed speed kts	189
km/h	350
max speed for normal flight kts	ca 156
km/g	ca 290
maneuver speed kts	118
km/h	220
travel speed 75% (2000m) kts	135
km/h	250
range for 75% power NM	648
km	1200
fuel consuption for 75% power l/h	25
consumption for 100 km range	10

type	G110
stall speed flaps retracted km/h	95
flaps deployed km/h	82
ascent performance max m/s	4.8
landing roll distance at altitude NN concrete m	210
grass m	250
takeoff distance over 15-m obstacle m grass m	530
concrete m	470
landing distance over 15-m obstacle m	420
landing roll distance m	200