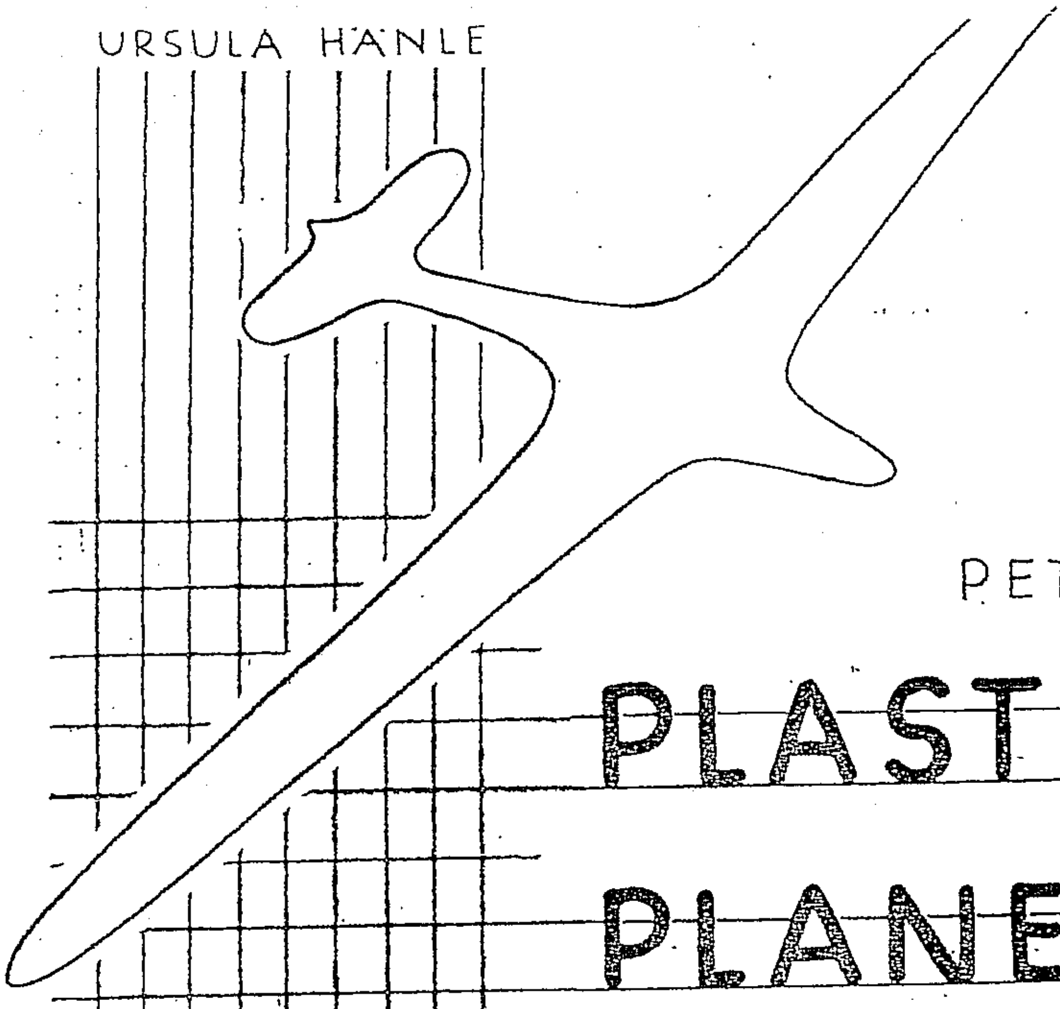
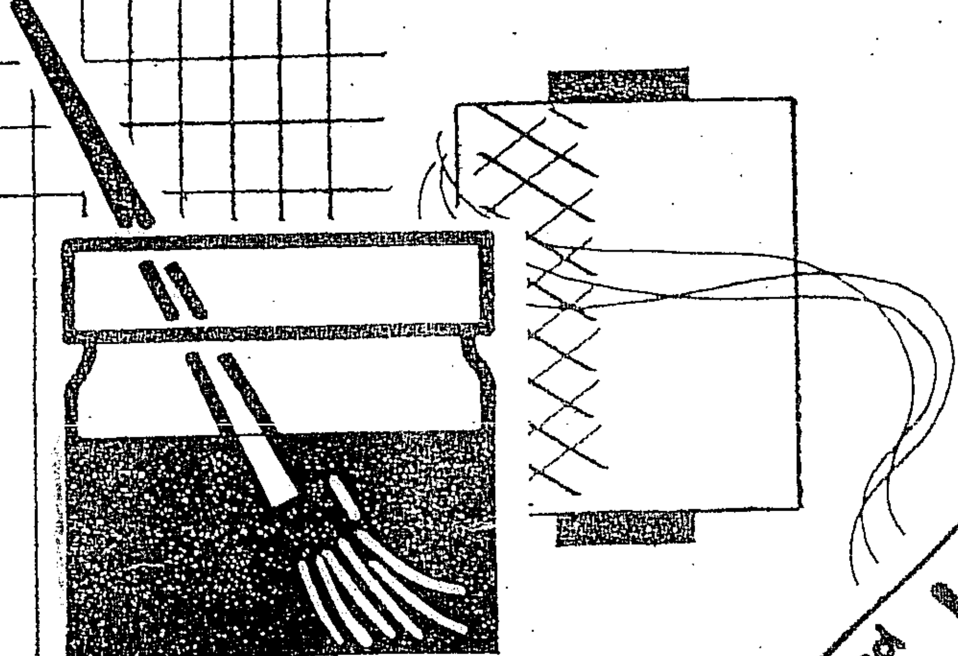
URSULA HÄNLE



PETITE

PLASTIC PLANE PATCH PRIMER



3rd ISSUE

F o r e w o r d of 3rd i s s u e

Grewing experience and enlarging of the plastic planes, also development of the basic materials required since long time a new-forming of the Patch Primer. Or, really radical: is this thing still necessary?

Not only that we know in the meantime other fibers, from what the slender birds are made; the manufacturers are pressed by the LBA to deliver maintenance and repair handbooks for each type of them. And these are responsible before all other papers because the manufacturer carries the responsibility, against you and the LBA.

Only if there is nothing to have from him, because he is no more present, f.i., jump into his part the LBA, his control organizations or an LTB (there are available a lot, also some with good quality). The necessary to explain a complicate repair method will be replace also by the lot of FRP - workshops which are arranged on many places.

The villages in possession of an FRP expert grew more numerous!

But what we miss in spite of this: a general introduction for new-comers in this territory. For instance: what I have to observe if I would like to buy such a plane? What I can do for to conserve it for a possible long time ? How I can help myself in case of little failures?
The new Patch Primer for this will have its C.G. more to this subjects. But it affords the luxe to transmit without change the introduction of the first issue from 30 years ago - a lot of this is no more utopic today.

When I wrote in 1967 the first issue of the booklet, I was nearly as a prophet in the desert.
Today we are in the position to k n o w , not by speculation but by experience, to say how is the behaviour of a plane with 30 years in action.

The new Patch Primer also will have the size and the arrangement which will allow you to insert this general basis into your advises of the manufacturer. The system of numbering the pages allows to insert them together with special tips for your plane on the correct place.

Strodehne, spring 1997

F o r e w o r d 2 nd i s s u e:

Many owners of a plastic plane which had the wish to learn more about the inner life of their bird have looked out for a PPPP without success in the last time.
I thought that another person would write a replacement for it with much more knowledgment, science and make-up.

However- this person was not found, sorry. And because under blind persons the one-eyed is king, so I was sitting down and writing all the informations from 10 years working and learnin on fiberglass sailplanes in this second issue.

Please would you connect during reading your pleasure to be able to help yourself in much cases with a moment of thanks to my husband, Mr. Eugen Hänle, because most of this recognizations were coming from him.

May 78 U.H.

Table of Contents

(Foreword to the first issue - 1967!)

Preamble

Pilots, especially glider pilots, have recently lived through a small revolution. It came from Germany, and it was happy and constructive:

> // An aircraft whose load-bearing elements are composed of reinforced plastic. //

As it was 50 years ago, when gliding was born, it was young people seeking the stars, who, without regard for finance or authority, opened a new way to aircraft construction.

Yes, very clearly: Aircraft construction. Even then no one knew the number and extent of the cicles which the new construction method would have the power to influence. Today the method is handicapped, in the sense of a large-scale industry, by the large amount of hand labor - but so were other branches of industry in their beginnings. It may be that in 50 years one will laughingly consider putting today's equipment of a fiberglass workshop in the Deutches Museum; it may be that one then will have no more the sticky fingers and the collar of glass dust - the beginning was here, today, with us.

The reinforced plastic aircraft has it roots in demands which are quite special for the sailplane pilot: Higher strength and stiffness with lower weight - one seeks the ultimate of materials - and higher aerodynamic performance.

The strength/weight ratio of fiberglass used in aircraft today is higher than that of good steel. The weights of pilots are more or less fixed, but cockpits can be fitted with lighter wings than with more conventional construction. Or, as the advantage is usually taken, the aircraft can have higher strength for comparable weight.

The conventional construction methods normally begin with partially fabricated material of limited deformability and are accordingly a compro mise between the form demanded by aerodynamics and its realization by means of a material which has essentially the form of sheets.

The reinforced plastic aircraft does not embodysuch a compromise. To be sure, some sheet-like material is used, but its fabrication is suited to itself from the beginning; it surmounts any limitations of surface - it can in practise take on almost any shape in the greatest detail, formed with so-called "lost" molds, or even without them. The builder is completely free to follow the laws of the streaming air.

These two distinctions: The unbounded formability, and the variability of the material, are at the same time its chief problems, because they require an entirely new approach in craftsmanship and design.

There is still a big item which both the builder and the pilot care about: The damping effect.

One means by this the capability of a material to absorb an impulse at its working conditions even though it is not permanently deformed. This damping effect for load-bearing fiberglass elements in an aircraft is very high, about 20 times as high as steel, if one takes into account the higher density of steel.

It follows that a fiberglass fuselage can endure much more than one of wood or metal before its contents are effected. This already applies to so-called fiberglass- sandwich shells; it applies even more strongly to solid fiberglass shells. And ultimately one is led to springs of fiberglass; we already find such springs under helicopters and aircraft, and also in the landig gear of the Libelle (E.g., the tail skid).

A further interesting point for the high- performance pilot is the quality and permanence of the wing surfaces. A fiberglass reinforced plastic object, once it is hardened, is, as we shall later clarify, fixed indefinitely to its original form. It changes no more, even if soaked in water. It does not chip, spall, or swell. Remedies, such as coatings, specially total paint- removings, should be spared on fiberglass aircraft - no well-equipped bird needs this either. One who cannot live without polishing something can use ordinary cloth and automobile polish, Plexiglass polish, etc.

No wonder then, that the love of fiberglass aircraft spreads like an epidemic. High performance pilots, and those who aspire to be such, cleave ever more to the swift, slender white birds. But a disquieting thought lurks in the background:

"Really now, what if the thing gets damaged, or goes kaputt? What then?"

The repair possibilities are basically about the same as for wood. However, the facts that almost any village holds a cabinetmaker, while must look a long way for a fiberglass expert, makes the outlook somewhat delicate... But as fiberglass aircraft become more widespread, fiberglas glass specialists will - must! - appear in flying clubs and workshops.

Small holes in the skin, or a nick in an edge - these can be fixed from the directions in the repair kits. And for perchance a damaged spar, - as with a wooden ship - one would use good sense, and take it only to someone with knowledge and experience. One should not overlook the fact that this misfortune is rarer with fiberglass, on account of its greater durability.

If any doubts arise during a repair, please ask your constructor, insteed of taking the risk upon yourself. In order to be complete, this manual must at least contain a fairly complete drawing. And in spite of this there would be the possibilits of added questions. Otherwise there will be something which you can't repair, either because special tools are necessary for it, or it would not be advantageous to do the repair work yourself.

For special questions, as when one perhaps needs to remove the ailerons, or where is the best place to put the oxygen equipment, it is again advantageous to have the answers in the standard format, so that you can make easy work to add this into the booklet. Then you will have repair instructions for your ship with the minimum trouble and in a smooth, continuous fashion.

The system of page numbering permits you to arrange things in the right place and provides spare also for special notices and sketches from your own practice in workshop.

General

A LITTLE SCHOOL ABOUT PLASTICS.

Plastics in aircraft are not new!

The most of the modern glues for wood or metal are plastic- based. In spite of this, you find in the operating manual for your aircraft a table which you have never seen for other birds. This does not imply that other aircraft do not follow the same laws. The question is only whether such a peculiary ought to be emphasized here. Plastics

Although one knows, for example, that some glues, upon being heated to 50°C, suffer a loss of strength wich is not recovered on subsequent cooling, there are no exact studies of the subject. And although it is generally known that all wooods "work", i.e., parts respond to changes in climate and thereby swell and shrink (metal parts, too!), the normal instruction manual contents itself with the brief remark: "Guard against excessive hot sunlight".

The fiberglass plane also could use the same term. But rather complate studies have been made on fiberglass materials and objects made from them. Accordingly, one can give quite accurate limits for safety. Thus one knows, for example, from studies made on complete fabricated articles, how a wing will behave after 9000 hours under load like in flight, or a fuselage in winch launch at 54°C (129°F).

The fiberglass sailplane, when first offered to the public, met with other suppositions. In the good old days when wooden aircraft made their appearance, one didn't know very much about flying and its associated stresses. One rattled the wings, and if nothing fell off, the pilot could start. The fiberglass sailplane made its debut under the surveillance of a testing bureau, many whom of were scientifically trained, and additionally, as the result of an accident, were inclined to be skeptical. This was in no way a disadvantage, for one approached the tests of airworthiness with foresight and an enormous amount of research results - for your benefit!

(And not only you and the fiberglass aircraft manufacturer; other faculties also profited from these studies: for example, it was found that the value of compressive strength in the fiber direction, according to correct assumptions, was almost equal to the tensile strength, not only for fiberglass. but also for fir. For years a smaller value had been taken.)

Even so, the studies showed that the strength of fiberglass articles did not fall, but instead rose, if one held it at a higher temperature and then tested it again after cooling. How does this come about?

Plastics are built by stimulate their molecules to knot nets or chains. They go together with regular repeated pattern, (the word "Poly" means "many-fold"). It is not uncommon for a molecular chain in a polymer to be made of several thousand links. For some nets it is possible to "de-knot" them. When such a polymer is warmed, the chains or nets vibrate more and become more free to move past each other. The plastic becomes soft and can be molded; when cooled, it hardens in this form. This can be repeated over and over. Such polymers are called "thermoplastic" because they become soft - plastic - when heated.

thermoplasts

Expensive machinery is needed to heat and mold such materials, and they are also not suitable for aircraft for other reasons. One exception is Plexiglass, used for the canopy.

duroplasts

Other polymers are made of nets which are tied together at a desired time by chemical reactions so that the entire collection form a rigid network. When warmed, the net remains firmly bound together, and may even form some new bonds. Such polymers, when they are fully hardened or cured (have many inter- chain bonds), do not dissolve easily in solvents, can not be molded again, and so are formed only once - hopefully in the right shape. This polymers are called "duro-plastics" or "thermosetting", because their shape endures, despite moderate heating or exposure to many solvents

Epoxy

The duroplastics are usually employed in aircraft construction and the principal type used goes by the name of "epoxy". There are slight variations in the kinds of epoxies available, but most of them have outstanding strength and tenacity, as plastics go. They are made by mixing liquid resin with hardener; these begin to react at once to build nets and tie them together, and before long one has the rigid article. The chemical reactions liberate heat, and the hotter the mixture, the faster the reactions go. (Never work with more than 2 pounds or 1 kilogram, in one pot, because the pot can get hot enough to fill a whole factory with fumes!)

To make articles with the resin, one needs also a mold, but one can make the mold himself. Repairs to such articles can usually be made more or less freehand..... one does not need presses or expensive machinery, steam, electric power, etc. If necessary, one can get by with 2 measuring cups and some pieces of wood.

And on top of all this, this simple mixture yet remains the best compromise for all plastics to be used with fiberglass!

Thus it becomes possible for you to repair your fiberglass sailplane quite simply.

Cleanliness

It is clear that the chemical reactions to produce the desired finished duroplastic will run properly only when one uses the right materials and mixes them in the right proportions. As with regular glues, one must not have foreign matter in the glue or on the surfaces to be joined. Especially deadly to strength are separating agents and substances which can act in this way: Fats, oils, greases, waxes, silicones - even a slightly oily finger which one absent-mindedly ran across his forehead a moment before. And also a drop of acetone in the wrong place can ruin everything for you.

We have to measure the components of the plastic precisely according to the directions. This is one of the very few points about which plastics are sensitive. Just imagine a party to which more women than men were invited. What long faces, when one girl must sit alone! Each molecule must find its partner, otherwise it remains out of the building process - to the detriment of the product. Thus it follows that your mixture is not completely joined together inside, or may not even harden, if you have mixed the wrong proportions. Chemica reactio

For to avoid bigger letdowns you should test the harding conditions of each charge. Prepare a paper sheet as follows:

sailplane LS1 D-4711

Nr	day	time	place	resin g	hardener g	test
1	14.11.	9^{33}	fuselage top pos. 3300	100	38	
2	14.11.	10^{15}	left wing, top pos. 4500 nose	50	19	
3	15.11.	10^{25}		50	19	
4						

From each charge you pick a little drop in the mentioned field of list. If you put the sheet on the central heating or a plate warmer, you will note very easy if the charge is o.k. (page 114: quality test) You may insert after hardening into the life act of the plane.

Consider very carefully during preparing the mix how long you will have to work. Thin layers of resin, especially if they are filled with fibers, will harden slowlier than the big pot in your hand. But in one time they will come the point that the resin will harden, equal if your work is ready or not! open time

For this you need a carefully work preparation. Play in your head the whole running of the work or, for a longer action, make notices. The last point is: resin mixture.

In a bigger work it may helpful that you prepare, perhaps on 2 tables, in order all necessary things: on the one all parts which are prepared for gluing, tools, brushes, - all what has to be exact cleaned; on the other all tools and auxiliary parts, which are prepared with separating fluid. It is not allowed to idle away any time during the work - the resin does not wait!!

You can use the mixture as long as it can thouroughly wet and penetrate the glass fibers, so that they become almost invisible; tough, stringy resin is useless; one can still smear it on unimportant places, like a nick in the garage; the toughness indicates that the molecular net-building process is well along, and the nets are torn apart by stirring and smearing.

As you know from other glues, it is not good to disrupt a chemical reaction by stirring, kneading, or premature removal of clamps and fixtures; the networks are thereby broken apart and don't join together too well again.

It is not possible to say exactly how long a resin mixture can be used. Large masses react more quickly than small ones; the reaction goes faster in warm rooms than in cold ones (and not linearly with temperature, but in a curve which goes up more steeply, the warmer the rooms. In summer you had better hurry!) and new, fresh materials harden more rapidly than those which have been stored for a time.

As a place to hang your hat, you can take it that 100 g, or 4 ounces of mixture in a coffee-cup in a room at 18° C or 65° F will begin to harden in about 20 - 30 minutes. If you hold the cup in your (warm) hand, it will harden sooner. When you place this resin on glass fabric or on your sailplane in thin layers, 4 to 6 hours may go before it begins to harden at 65°F.

Our epoxy then forms its molecular network at normal room temperatures, at least 15°C or 60°F. (Some industrial types require much higher temperatures). Lower temperatures lead to blocking of the hardening; they produce also a thick paste which is hard to work, so that you get too much resin in the article that you are making.

Heating

One can accelerate the hardening by warming. One must be careful with infrered lamps or so, because they may produce extrem local heating and damage may result. Hot air is the best; for small pieces, a hotpad will do. When the area is large, so that a hot air blower won't suffice one can make a temporary tent from plastic sheets, scrap material, wood, foam plastic, ect., so as to maintain a uniform temperature over the part. One can put a thermometers into an average part of the tent to observe the temperature.

Tempering

If it is difficult to lead the warmth to the wet resin area, one can warm the part after it has hardened at room temperature. The plastic may seem quite ready to you after a few days at room temperature, but it really is not. Its strength and hardness increase with time. This may take a month at normal temperature. Probably most of the active ends of the molecules are then bound, so that they can no longer find their partners so easily. But we can help them by warming. This is also done during construction; all parts are held at 50°C for 12 hours. The full strength of the plastic, which previously was guaranted to 40°C, falls somewhat during the warming; the networks become very slightly looser, and so the articles should not be subjected to stress during this warming. After this treatment, almost all of the last reactive moleculeshave become a part of the network, the network is stronger than before, and now we can fully load our article up to 54°C or 129°F without fear.

For this reason you will find the tables in the handbooks.

Nearly all "classic" fiberglass sailplanes are made from a resin type like this: the good old "Epikote- Laromin" combination.

(Libelle, SALTO, BS 1, ASW 15, Cirrus, LS 1 etc. etc.)

Note well: These sailplanes are made so that their outer surfaces are white. Other light colours also remain cool in the sun, but black or dark colours (e.g., numbers, decorations) can very easily reach temperatures of 70° C and more. At such spots the usual high safety factor of strength will not be available.

Because the manufacturers were angry about this low temperature strength (in spite of the feeling of the pilot if his cockpit has only a temperature of 40° C - have you tried? So it may be difficult to bring a sailplane under full load in flight conditions with a structure temperature of 54° C)
- so they have used in newer planes resin systems which are adjustable in open time and temperature strength by using different hardeners.

higher strength

adjustable

Hereby you can observe that, in general, a hardener which cure a resin slow has also a lower temperature strength then a hardener which works faster. In some systems you can even mix the hardeners and so obtain a sliding border between the asked requirements.

Sorry in normal case the fast working hardeners are more thixotrop then the slower ones.

In the new generation of gliders we have the so-called "interim - hardened" resins. This means: the resin cures in room temperature so that you can it put out of the mold with care, but it is not really harden for carry a strength. Then the part will be tempered, in temperatures up to 120° C, but in the most cases in such which can be reached with normal equipment (perhaps 80 - 90°). This resins have a strength in temperatures up to 80° C which may allow nearly coloured gliders...

interim

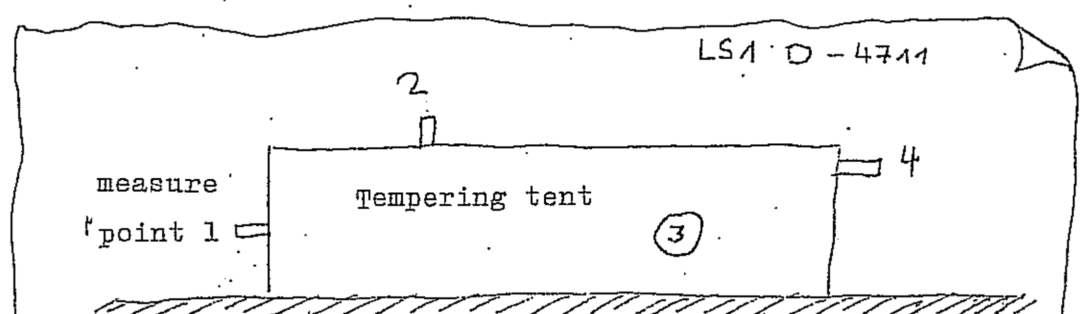
In no case you can harden any resin with any hardener. The systems react only in their borders and in the prescribed kind and quantity.

changeable

temper proof

In your manufacturer advise you will find from what kind of resin your plane is made, and with what kind of resin it may be repaired. One can think that you can repair certainly a plane from the good old Epikote/Laromin type with a resin system of higher strength, but not vice versa!

Certainly you have to fulfil this demanded tempering procedure also for each repair work. And it is important that this is documented. Do not be afraid if any government office require the use of sinful experienced aid tools as a temperature writer. Because our work is instslled for the use of hot air blowers so that is necessary to observe the area all time, it is possible to notice the teperature all hours and to inset them in a list as this:



tempering report from 30.11.68

time	M. 1	M. 2	M 3	M.4	
9⁰⁰ → 9^{00}	58°	57°	62°	60°	
10^{00}	60°	60°	64°	62°	
11^{00}			...etc.		

(With a lot of things it is similar: Either you can replace them with fantasy through others, or you search in your neighbourship to lean the expensive tool)

field repair

Some fast-curing systems can be used for "field- repairs". They harden in minute- times. Because their properties in regard of the conditions of these field- repairs are not definitable exactly, you should avoid to use them for main structures.

fire hazard

The components of the plastic, resin and hardener, are not as inflammable as, say, a laquer. The hardened resin does not burn easily and the fire goes out when the flame is removed. But it makes much soot when it burns. The white laquer is also essentially a resin (polyester), and falls into the same class. But its solvents are easily inflammable liquids such as acetone, laquer thinners, etc. The working with the chemicals from a fiberglass ship will need therefore as much or as little caution as with ordinary aircraft. (Cigarettes also should be put out before entering such a workshop!)

As for a room for working with resin, the same recommendations hold as you already know for glueing work: dry, moderate, constant temperature, grease-free working surfaces. The overall smell is negligible. Facilities should be provided for washing the hands with warm water. It therefore occurs to one that there should be no thoughts against using the rooms of one's own home for fiberglass repair, although, to be sure, one must, on account of the shameless stubborness of hardened resin spots on kitchen tables, etc., be prepared to reckon with political difficulties...

workshop

Tools

Some parts of tools are attacked by the liquid resin or especially by the solvents, for example, the beautiful red laquer on paint-brushes or putty-knives. Obtain unpaintened, rather cheap brushes for the work, raw sticks for stirring, and not colored rags but instead white goods.

The resin mixing can be done in vessels of glass or porcelain or tin-cans – – they must be unquestionably clean. If one often works with the resin, it may be advantageous to use small paper cups. They must be unwaxed! One can use them again when the previous batch of resin has hardened in them.

Dilution

If while stirring, you loosen the remnants of an earlier batch of resin, from the vessel walls, that's annoying. But dissolving is not possible for hardened resin, not at all. This hard realization may occur to you when you have let flecks of resin harden, unnoticed, on your sunday suit.

As long as the resin mixture appears soft, it can be dissolved in acetone, MEK, laquer thinners, etc.

Storage

The resin can be stored in clean tin- cans. The hardener must be kept in well-galvanized cans, but even better in glass and well- sealed, because it reacts with the oxygen in the air and crystallizes. After that it reacts only poorly with the resin.

If hardener in a well-sealed container nevertheless becomes loaded with crystals, like old honey, that's a sign that it's too cold. Put it in a warm place or in warm water, and at 85° F it should become all liquid.

Poison!

You must note well that the resin, and especially the hardener, is poisonous. Take care that it is kept away from food. Worst of all is to get it in the eye. Wash it at once with running water and go to the doctor, even if it doesn't seem so bad. A chemical description of the hardener is given on handbooks; the doctor will know from that what he can do.

Allergies

Many persons are allergic, or very sensitive to certain substances. The famous hay fever is nothing but an allergy to the pollens of plants. Some people will also be allergic to the resin. The symtoms fade away as soon as one no longer comes in contact with the irritating substance. In any case: avoid unnecessary contact of the skin with the chemical, wash the hands often with soap (you'll do that anyway because they get sticky), and if necessary work with rubber or plastic gloves.

Remember that hardened resin is chemically absolutely neutral. If you climb out of the ship after an eight-hour flight with a runny nose, or you don't feel well, it's surely for some other reason.

Glass

Now we've discoursed a long time about resin. But in a way, it's of secondary importance; it is a necessary evil which we must employ in order to hold the glass fibers in their places so as to direct their strength in the best ways. The fibers themselves have tensile strengths about twice that of good steel and about 20 times that of the resin.

The glass fiber is the real strong man!

Strength

This extraordinary strength of a material, which we used to regard as being brittle, springs from the surface tension of a very tiny fiber, about 9 microns or 0.36 thousandths of an inch in diameter. The tensile strength of such a fiber lies around 14,000 kg/sq cm, or about 200,000 psi; its compressive strength is almost exactly the same. Presumably, in order to put the fibers to the utmost use, one must orient them in the direction of the lines of force and anchor them under all circumstances in this position, specially when compressive forces are working and the fibers would like to prefer the way of bending or buckling.

Fiber-glass

To this now we need the plastic matrix. This combination we name "glass fiber reinforced plastic", "GFK" or "FRP", or Fiberglass". It is clear that the strength of the combination depends on two factors: The ratio by volume of the strong glass fibers to the weaker plastic matrix, and the lay or direction taken by the fibers.

A laminate made of parallel strands - "roving" - and plastic can possess a tensile strength up to about 8000 kg/sq.cm, or 110,000 psi. The approach to the maximum depends on how closely one comes to the optimal fiber volume fraction of 60%, and the line-up of the fibers parallel with the imposed stress.

Laminates made of woven fiberglass cloth are somewhat weaker on account of the weaving of the fibers and run from 2000 to 6000 kg/sq.cm.or 30,000 to 90,000 psi - in the fiber directions, naturally! Consider once a piece of fabric in the diagonal direction and you'll see why alignment is so important

Laminates made from random short fibers - "mat" - reach strengths of only about 1000 kg/sq.cm.or 15,000 psi.

We see that one can buy glass fibers in different forms:

Mats

Mats of unorientated short fibers - not too suitable for use sailplanes because fibers can't follow the lines of stress too well. And they use up a lot of resin in making the article.

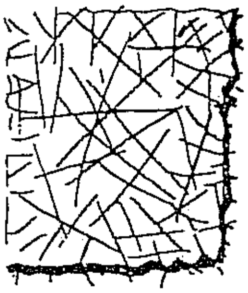
Cloth

Woven fabrics, including those with a great preponderance of fibers in one direction and only a few at right angles, are available in many types, weaves, finishes, weights, etc., for simple or highly curved shapes, for strongly directional or more equally divided stress patterns.

Prefabs

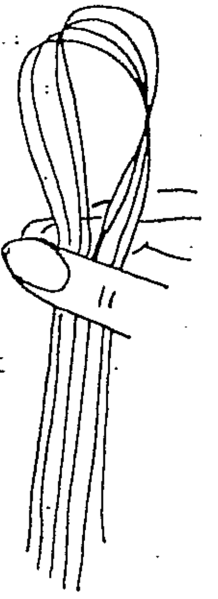
Pre- impregnated woven fabrics are made which carry resin in a soft state. When such material is shaped to the desired form and then heated, the resin hardens. However, such material is not very suitable for our hand work because the pressing and heating is difficult.

The threads should be in every case not or not hard twisted.



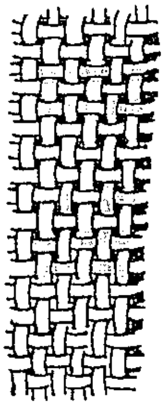
MAT

Unorientated fibers
held together with
a plastic binder

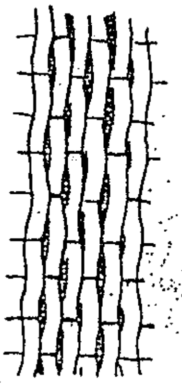


ROVING

CLOTH

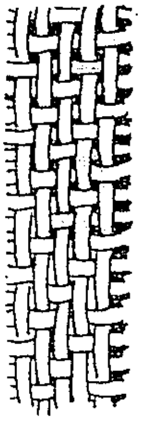


Plain weave:
over one,
under one.
Warp and weft
have about
the same number
of fibers and
strength.
Used for most
flat surfaces.



Unidirectional weave.

A special kind of plain weave. There are many fibers in one direction, but only enough to hold things together in the other direction. Such cloth is used in the outer wing skin of the Libelle, and in place of the rovings in the wing spars of some aircraft.



Twill weave.

This weave commonly has equal fiber content in warp and weft, but its special weave: over one, under two, makes it conform well to rounded places and compound corves.

Rovings — Rovings - long, long bundles of parallel fibers in various numbers per bundle, are about the hardest to handle, but once they are well placed, one can best satisfy the demands of following the lines of stress with fibers. With them one can span most directly between two points. One can reinforce edges with them or fasten down fittings. And it's not necessary to bore holes in the main spars; instead, using rovings one can attach the necessary assembly pins and sockets as firmly as a bough is fastened to a tree. The fibers are not cut off; there is no loss of strength.

Fiber coating — All glass fibers used for reinforcing are coated with a substance during their manufacture which results in a better bond between glass and resin. Furthermore, the glass would break easier without this protective coating. Do not permit the fibers to get wet or come in contact with thinners or cleaning materials. Do not heat it either. One should take care to keep the glass flat or smoothly rolled, so that it does not become weakened by kinking. It can be protected from dust by plastic sheets.

Fiberglass proportion — Because we build aircraft as lightly as we possibly can, we are concerned to develop the grip on the fibers with the least possible resin, exactly enough that the product doesn't show white spots from unwetted fibers, but not so much that there are "puddles" of resin. For the most part we are unable to reach the optimum standard of 60% glass to 40% resin in our hand-crafting methods. He who lays up spars, ribs, and skin with 60% fiber attains the highest strength with the least weight and space.

We find this optimum ratio in the BS and the Libelle in for example the wing spars.

In the most main spars are used rovings. In some cases they are made from unidirectional layers, but these spars are softer than they from rovings (lower amplitude).

Who gains a little more experience in the FRP technique will note that in the older fiberglass planes this system of following the stress lines is fulfilled more consequently than in younger ones. In this time the pressure of economic was still unknown...

carbon fibers — Sometimes we will find after remove the gelcoat black main spars or completely black interieurs of the planes!
We have to do with carbon fibers. They will be manufact from graphit or plastic material which will be carbonized.
The material has a higher strength than glass fibers. But their extension is not so high. Spares from carbon are very stiff; for this one can make very thin wings not from other material.
Carbon fibers have a different crash behaviour than fiberglass.
The long period of extend which we know from glass, or the long phasis of grewing white is not available in carbon. If they failure, they do it apruptly. (Watchers of a carbon crash are speaking about a "black explosion".

The high damping effect which we know from fiberglass is inapplicable.

Repairs of carbon fiber parts are in the system nearly the same than FRP parts. Caution: it is difficult to observe the througout wetting of all fibers!

Carbon fibers are in this time more expensive than fibers from glass. But all is relative: if you are so clever to go apart from a sandwich by using carbon - you have made a good business.

Also during working and repair we have to observe something:

basically are available the same kinds and clothes as from glass, also the same weaving sizes. But we are dependent of the statement of glider manufacturer what kind of carbon cloth is to find in what part of plane because this is nearly impossible to constate by eye-look.
Also there are mix clothes: chain from glass, shut from carbon.
Carbon fibers are no more inflammable than glassfibers. But they conduct electric stream! It may happen that your electric handtool may have a "short" and works no more. For this you should use air-pressure tools.

Kevlar

If under the white surface during remove it comes not green/or black but yellow, than we have to do with Kevlar fibers. (Aramid). Here we have also the same cloth types, but no rovings. This type of fibers has also a high tension strength, but a low strength for pressure. It will used on places who the material should be very light, and in constructions where the high tension strength came in play.

Aramid fibers are not resistent against UV- light. For this they must be protect against sun. Also you should remark that they do not like to be worked after curing, they fringe. It is nearly impossible to cut them with normal scissors.

It seems logical that it is impossible to repair one type of fibers with an other. Because we meet sometimes a combination material - f.i. 1 layer glass, 1 layer carbon or similar - it is indispensable to ask the manufacturer.

new fibers

The development of fibers is not resting on one spot. There were tests with bor fibers. Also thermoplast fibers are in the development. Concerning resin, also here we have tests with new polyester developments, or materials we know in the past as thermoplasts. For to be sure from surprises, it is necessary to contact the manufacturer. Each of them must record all materials used in the plane in its maintenance books.

Example: the stiffness of the carbon fibers provokes to use them in aircraft parts we had never think on it: there are pushrods or drivingshafts of them, for instance.

The fiberglass aircraft constructor therefore makes his own material as he goes along; he creates his aircraft from an embryo, out of the basic raw materials, so to speak. No one has looked into a metal spar, nor into the laminations of a wood structure. With fiberglass the construction is out in the open from the beginning; there are scarecely any casting flaws or resin lumps which can't be noted. And most parts can be thoroughly inspected after curing by simply illuminating them from behind with a strong lamp.

sandwich: balsa The first FRP sailplanes had balsawood as core inside between the FRP layers. In this time we had no other.

The balsawood has a really good strength for tension and pression; for this it takes part in this direction on the structure. Planes with balsawood cores have for this a bit higher wing oszillation.

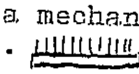
But the balsa supports not so good against buckling. Also it is the first which breaks when the wing is strongly bended, caused by its low extension.
If a balsa- sandwich is broken, you must slope it as normal wood.

conticell The most used sandwich material is "Conticell", a PVC foam. Its elasticity is good, but against buckling it's also not so very well. And in temperature strength it is not an optimum. But because it is manufactured in large plates, it is not so expensive to manufact the pieces for wing sandwich layers. If you are not very attentive the Conticell soaks a lot of resin, and your sailplane part gets very heavy.
If you have only a little repair spot, it is not necessary to slope it exactly. You place only the little spot with a mixture of resin and microballoon (see page 301)

Breaks in Conticell layers should be investigated with care. It is possible that you find under a little crack of a few cms nearly half a meter loosed inner FRP layer!

tubus Some sailplanes have sandwich layers from so-called "tubus" plates. They are made from a thermoplast material (polystyrol etc). We have learned that these materials may contact not so very good to fiberglass. This may be the reason that this construction method is not widely used. On the other hand these tubus and honeycomb- sandwich layers have a very good resistence against buckling.

Hexcel For this f.i. the "Airbus" is using in many parts a sandwich layer from honeycomb made of nylon paper which effects a really good connection to the FRP caused by a rough cutting of their thickness, but with some resin types you need "tricks". The material is called "Nomex" or "Hexcell". It is very light and to fit very easy in repair spots; but its price is really high.

For to obtain a good connection between Hexcel and FRP layer you should try to get little "feet" on the walls of the honeycomb. That means to try that the resin runs a little upward of them. Either you can use a special resin for this, or you can help yourself on a mechanical way: to wet the walls by using a brush, or a piece of carpet. 

Rohacell Under some FRP layers you will find a white sandwich material. This is a derivate from the Plexiglass of our canopies. ("Rohacell") It is very homogene, light and not so resin-greedy than Conticell, but more brittle. It is used in some tail faces.

Material list For newer FRP gliders you will find a register of all used materials of the plane in the maintenance book. If you cannot find such, please look for the so called "type attendant". The LBA will help you to find out him.

Each manufacturer delivers the materials used in his planes. But if you have a good reputable LTB in your area the buying there may be more cheaper because everybody knows what to buy minimum charges will cost today.
These LTBs are responsible also to a quality control.

Q U A L I T Y   T E S T S

Mistakes in a FRP part may have naturally two sources: glass or resin.

The glass portion has to fulfil the following requirements: it must have the predetermined amount and kind of glass in the right direction; the finished piece must be a translucent gray-green; hence it must not have white spots nor obviously visible glass structure. If these are seen, the glass was moist or had the wrong finish, so that the resin did not stick on it.

The piece is stronger, the higher the glass content and the more appropriate the lay of the glass fibers. Snarls, crooked or displaced fibers in the weave reduce the strength..

Imperfections in the resin component are more frequently as those in the glass. The parts must be clean, thoroughly saturated and cannot show any white spots.

The resin must be harden completely. Poorly hardened resin doesn't give enough support to prevent kinking of any fibers. One can check the hardening of the resin by the following tests:

Any little points sticking out of the piece must be as sharp as needles and break off in a brittle way. If you can merely bend them, the hardening is incomplete.
The left-over resin in the mixing pot should not be impressed by a finger nail by the next day (say after 12 hours)at 18°C. or 65°F minimum temperature. After about 24 hours, a hammer blow should split the mass of resin into splinters; the splinters should be brittle, yellowish, and clear like glass.

One can also detect inadequate hardening when he works on the piece: such parts, when filed, sanded, or drilled, are somewhat smeary. The loose particles cut off are like bread crumbs and not like powder. As one works in this soft material, the glass fibers may try to stand up or even tear loose. The sound of these parts is not bright and hard but dull. They do not resist against bending and don't break suddenly, with cracking and splitting, but more like soft plastic, e.g. polyethylene.

Often the trouble with a soft piece is simply that the resin hasn't had time to harden yet - perhaps it was kept too cool - and one can cure this by warming it up for a while.

We can establish whether this is the trouble by keeping the leftover resin in a warm place (baking oven!) and noticing latest after an hour whether it has gotten harder or not. Naturally we test it after it's cooled off.
If we have made an error in the preparation of the resin, or we used a brush wet with acetone in the mixture, then nothing can be done about it, exept to start over. But it is better to have that sinking feeling on the ground than in the air...

Help for Health

for FRP planes

You know that a plane is not able to fly without a minimum of paper. The system of these papers are different in the countries and continents. Here you find the system of Germany (Luftfahrt- Bundesamt = LBA).

piece

During its manufacturing, every plane will be observed by a licensed improvement person. He controls during the work of the plane if it s i accordance with its drawings, manufacturing advises and other papers which are important for its identity. Without this procedure the pla will not get its piece improvement certificate, and without this you will not get the C of A.

yearly

Every year - the date is caused by the date of piece improvement - the plane needs a yearly inspection. It is to be attested that the plane is airworthy by following the manufacturing documents valid in this moment.

We tell not a secret that the quality of this improvements is very different. For this it would be good for every owner of a plane if he would be able himself to check his plane. Undispensable will be this in case of a hard landing or other happenings.

The different manufacturers have in stock improvement lists of their designs. On the base of them you can check your plane. In doubt you should order a check list for the "Long Service Check"which is obligatory for every fiberglass plane after 3000 hours. This list will guide you through the whole plane. Also the little drawing on page 217 will help you.

Some sequences before you have read an important set: documents vali in this moment.

TB

The world is turning, and also manufacturers of sailplanes grew wiser (sometimes). If such a manufacturer notes that the part x should be replaced by the part y because this is easier to control, without a necessary of security, he amend his LBA for a "Technical Bulletin" (TM). This TM can be followed by the sailplane owner but must not. Both, the old and the new solution, are valid.

AD

If the manufacturer has the opinion that the security is in play, because any part of the plane may have a shadow to be not so sure as planned in design, he amends by the LBA an "Airworthiness Directive" (AD in English, LTA in German). Also the LBA can order an AD if doubts insecurity of the plane are shown.

An AD must be followed inside of the term decided in the AD, otherwise the plane is out of law. An AD of the LBA will be send to all Governments where the type of plane is flying, for the proposal that these officials will send the AD to all owners of the type and also to all licensed workshops.

Without a fulfilled AD you will not get a yearly CoA!

If you have the wish to change any little thing in your plane, you should be sure that this may not be a so-called "big change". This must be amended by the Government! self designs

For to clear this question you should ask the next improvement inspector or licensed workshop.

If an inspector will find such a change not identical with the plane's documents, he can refuse the CoA!

Herewith be spoken a word in favor of the improvement persons: certainly in the world we have bad peoples, perhaps also under us, but in the normal case you can be sure that the inspector is willing to protect you and others from harm. For this you should ask your inspector better one time more than less. (In our country we can say that inspectors and LBA are the best information sources you can find).

What is to do if it has "bumped"? damages

Every damage which injures the airworthiness eliminates the CoA.
My experience is that the state of airworthiness will be adapted very different by the owners of the planes.

Certainly the plane is no more airworthy if the tube of the ASI has removed from the instrument. But this will not bring in action an inspector, certainly.
In other cases an owner found his plane airworthy in spite of the gaps and crashes in the FRP surface.

That means: nobody until now was able to definate exactly what is a big damage of the plane, or in following a "big repair".

Here you see that there is a wide room of play for the responsibility of the owner. Principally you can say that every damage touching the structure or the controls of the plane should be discussed with the inspector.

To decide this you have the help of the check list of your manufacturer.

Sly peoples have try to eliminate this dilemma by setting up rules which separates the damages in classes (so called "Rosenheimer Regels", so named from a plastic institute at Rosenheim, Bavaria).

osenheim ules

class 1: big areas of distruction which demands a partial replacement of the aircraft part or a big repair. This means damages which interrupt main strength lines, specially if in primary or secondary parts strength connections are interrupt. Examples: tail broken away, wing main connection damaged, main spar damaged or broken, cockpit frame broken, control surface out of place (aileron, rudder, elevator).

class 2: holes and brakes in a laminate up to ca 200 mm in each direction: damages which have broken all sandwich layers top and bottom, f.i. transport damage, dropped wing.

class 3: little holes or damages in the surface without destructions of inner layer. Example: crashes or chamfers which cutted the outer laminate layer.

class 4: eroded spots, crashes and dents in the surface which have not damaged the FRP layer. Typical: crashed from placing in hangar.

Primary structures: this are such concerning main organs of the plane (wing, fuselage, tail)
Main secundary structures are f.i. control surfaces, flaps, airbrakes.
Auxiliary secundary structures are f.i. gear closing plates, canopy, inspection hole covers, baldachin parts.

In theory this seems very well, but in practice the border between little and big repair will be anywhere between class 3 and 4 - that means therefore fluidable. Why this is so important? Following the most government rules the little repair can do in border of maintenance of the plane, perhaps by such a "expert person", this may be the owner or a person which knows the plane since many years of maintenance. The big repair, contrary, must be done by a licensed firm (German: LTB = licensed repair shop).

For to avoid disagreable discussions, one should in principle all cases which touch in any kind the carrying structure or the control system of the glider, in advance clear with an inspector.

The following two pages are borrowed from the Long Time Inspection Program of the SALTO. Each who like to buy a FRP sailplane should be armed with this. They are helping also for each who will check such a plane by other reasons. check metho

After this follows4 pages of a check list, which allows to note after each question the reason of critism and later the restoration of them. If you have worked through this list, you can look for the visit of your yearly inspection with calmness.

If it has crashed, the list may help for checking: may I able to maintain the damage myself? What parts are necessary to order, and which material?

What means, properly, "Long Time Inspection Program? long ti check

When the FRP planes are just coming from their egg-shells, nobody knows how long this new material would beware its full strength, and if, perhaps during the time, may shown some objections.
For this the first types of the new material are designed and inspected for 3000 hours service time.
But, in most cases, it happen very fast that the 3000 hours are fulfilled. What now?
Manufacturer and LBA agreed that the white birds were subjected to a check through their whole structure all 3000 hours. If there were not found any mistakes on the FRP, they may work further 1000 hours. How the check will have its program is decided by the manufacturer. You may find notices around this temporary tests in the papers of the plane (one reason more for the axiom: the check of a plane I would like to buy begins at the papers!)

I regret that the most programs of this have their most weight on the plastic and less to other import parts of the bird. But we have the experience that there in still no case the time has nibbled on the plastic, but more that other materials of the bird are confounded. The catastrophic cases of pushrods which are rusted from inside belongs in this rubric! And such cases are not depending of the service time but of the life time!

(For this the Long Time Inspection Program of the SALTO demands a througout inspection of the bird, all parts equal what material, and each 1000 hours or 10 years, what may happen easier).

Drawing No	doktor fiberglas- check list SALTO- part	left ok	right ok	no, statement:	ok
	AIRPLANE ASSEMBLED: All main connecting parts should be clean and green, i.e. without paint. All parts of the airplane are to be washed and cleaned, the connecting parts are to be clean and lubricated. Spherical ball bearings and junction jaws are positionned accordingly. air brake handlever is in closed, but not in locked position				
	WING: Left and right are movable without problems (the use of an aluminum bar is allowed).				
middle attachment bolts	Left and right are movable by hand without problems (use of a small aluminum hammer is allowed) Remove again.				
	Left and right can be screwed without problems. There is no slackness. The screw-down bolts cannot be moved in the axial direction and are not and cannot be turned				
connection pins	The connection bolts have no slackness in the ball and socket joint. The distance between the junction pin and the ball and socket joint is not more than 1.5 mm.				
aileron and airbrake connection	The connection bolts of the ailerons and the air brakes have a distance of about 2 mm to the end of jaw gap Actuation shafts are not movable axially in the fuselage . Strong shake (neither tangential nor vertical) does not produce any noise.				
	TAILPLANE: The tailplane bushing and cones move together without problems (with only a slight push forward). The connecting screw can be screwed at least 3 threads before it is tightened. The U-plate is almost parallel to the safety stirrup. The safety mechanism can be inserted into the U-plate and removed without problems.				
	The tailplane is tight in the bushings, there is neither tangential nor vertical slackness. The tail control mechanism has no slackness in the rudder cavity. The rudder has no axial slackness in the tailplane.				
aileron airbrake	Control Surface Slackness Allowed: With the control stick and one aileron fastened: Maximum 2 mm at the outer end edge of the free aileron. With the control stick and pedal fastened: Maximum 3 mm at the tail rudder at the trailing edge at the fuselage (individual check of elevator and rudder). Not locked maximum 5 mm to one another. Axial maximum 1.5 mm.				

doktor fiberglas- check list

Drawing No	SALTO- part	left ok	right ok	no, statement:	ok
	Airplane steadily mounted on an even surface. Main connecting bolts and tail plane connection bolts fastened. Ailerons and rudders at zero. Air brakes closed, tire pressure 2,0 bar				
geometry	Connecting lines between wing tips and tail tips are parallel. Distances between wing tips and tail tips are equal.				
basic adjustment	Control stick in middle position- ailerons are at zero. Control stick in middle position- both tail rudders are at zero. In doing this, the square bar of the stick is nearly in the center of the rectangular opening of the knee board and the trim adjustment is neutral. If you move the stick forward and back, both tail rudders work nearly equal.				
passage freedom	All rudders are movable in each handling combination and each position of airbrake lever and drag parachute connections. No excessive chaff marks in the cockpit side tunnels. No minimum gap of less than 3 mm between two handling parts exeption: full pulled stick, full rudder against half pulled brake chute lever. suspicious places: (check all handling combinations): aileron control lever vertical under stick against rudder yoke; two leg rocker arm under the wing bridge right against aileron pushrod; tail control pushrod left against airbrake bell crank; tail guide lever against tail chute lever; airbrake lever in tunnel against tail pushrod in the tunnel				
	Control deflection declared in the inspection list can be realized.				
airbrake	The locked airbrakes need about 6-8 kg to be opened perceptible; (use a spring scale, positioned with a protection plywood piece at the trailing edge of brake)				
canopy	The canopy rocker arm does not touch the right wing root.				
vibration	The natural frequency is ok at __________ cycles/minute				
	All repairs found are faultless and are in the Logbook. All subsequent changes are standard. All inspection data are recorded. Weight and balance was done.				

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URSULA HÄNLE
doktor fiberglas

PRÜFLISTE Check List 1

2

Reason:

Date

RegNo

SNo

		left	right	to do	OK
Ail	state				
	hinges				
	gluing				
	end ribs				
	balance pl.				
	surface				
air brakes	state				
	end ribs				
	drive bear.				
	fit				
	play, fasten				
	surface				
ail lates	state				
	resin work				
	fittings				
	bearings				
	surface				
rudder elevator	state				
	bearings				
	inside				
	balance				
	surface				

+ in order - not correct o not aff.

		left		right		to do	OK
ings	state						
disconn.	clean						
	glue nose						
	" spares						
	bearings						
	ail. bridge						
	driv. ail.						
	" brakes						
	heads sec.						
	shaft play						
	surface						
	numbers						
aileron onnected	deflections						
	movement						
	gaps						
	noises						
	in sense						

		found	to do	erl
canopy glass				
frame				
fittings				
seal				
fusel. state				
resin work				
gluing				
hook nose				
" C.G.				
pitot				
feet contr				
rope conn.				
hamd contr				
tail contr				
ail. control				
airbrake c.				
main conn.				
bagg. comp.				
conn. comp.				
main gear				
tail wheel				
tail conn.				
canopy conn.				
trim equ.				
electric				

			found	to do	OK
Flz mont	main conn.				
	tail conn.				
	control conn.				
	ail. work				
	– deflect.				
	tail work				
	– deflect.				
	airbrake work				
	in sense				
Instr. panel	state				
	airspeed				
	altitude				
	Vario 1				
	2				
	Compass				
	radio				
	static press.				
Equipm.	harness				
	pocket				
	stick sack				
	covers				
	securies				
	plac. part				
	" date				
	" metal				
	" operate				

Self inspection

Sometimes it is not so simple to find damages. Put the parts so that daylight or sun may come in an angle to them. Certainly the part should be good cleaned from dust etc. Only then you will note little cracks or gaps - under which they may concealed reasonnable big crashes. FRP springs back in its starting position!

Added to this you should inspect the sandwich layers by "pick-pick" with the end of a pencil or so.

fuselage: try to insert a little stick lamp into the fuselage in a dark surrounding. You will see exactly each repair spot, each crash.

yearly inspection

Preparing of a yearly inspection:

For every inspection you need not only a prepared plane.

The plane's papers should be chronological in order,
all ordered AD's should be done,
all time limits of equipment should be observed,
the installed equipment should be in accordance with the equipment list
the weight and balance report should be valid for this equipment
the log book should be completed and settled up.

Time is money - this is specially an inspector's set!

buy a FRP plane

If you wish to buy such a plane for yourself or your club, please avoid the mistake which may cost you perhaps the life: to sit into the plane after a short explication by the owner and to take off!
The check of an unknown sailplane begins at the plane's papers. Without to know the weight of the plane, its present C.G. position, how big is the possible payload - without this the test flight will be a punishable carelessness!

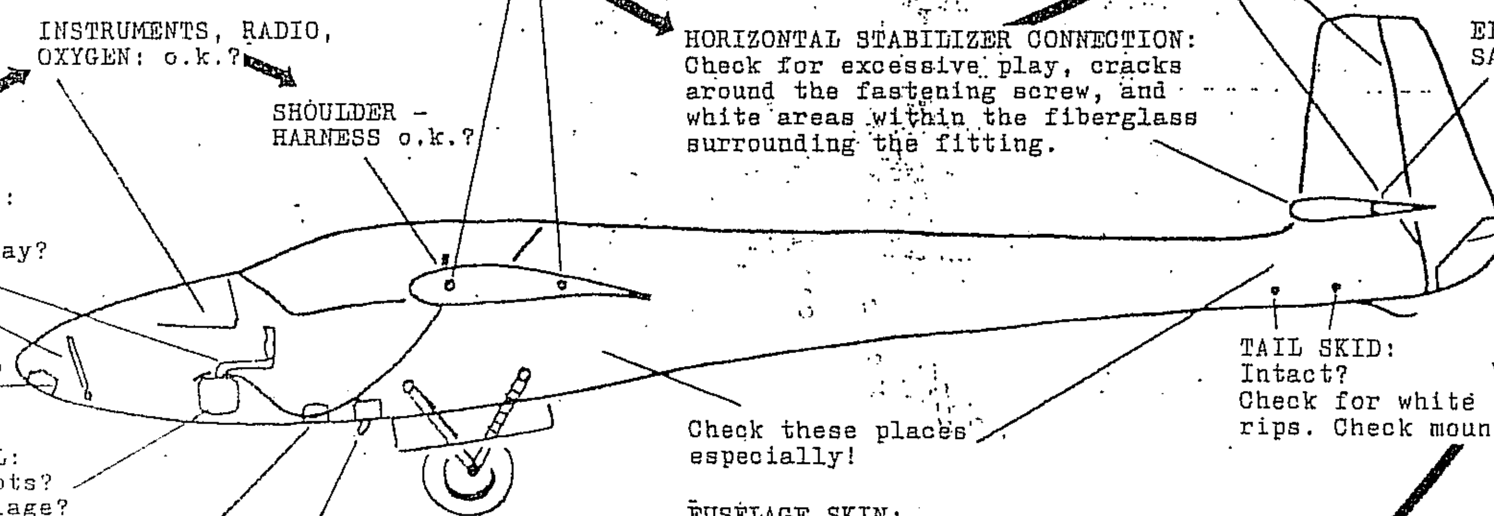
You should overthink that a bird with high performance in each case has also a high wing aspect ratio. This means a small area of possible C.G.-range. And a plane moving behind the allowed back C.G. may have an un-controlled behaviour.

Added to this, each plane will have its good or bad properties. Not only by type; each bird is manufactured by hand and a human hand is not an electronic control!

For this the first action of check is the study of the papers and the Flight and Service Manual.

Conscientious holders of a plane may demand you before a flight in their plane to confirm in writing that you have read the F.S.M and also understand it.

FUSELAGE



FUSELAGE-WING CONNECTION:
Check for white areas in the fiberglass, excessive play, loose or bent pins (hard assembly)

HORIZONTAL STABILIZER CONNECTION:
Check for excessive play, cracks around the fastening screw, and white areas within the fiberglass surrounding the fitting.

RUDDER:
Check for excessive play, white spots near joints.

ELEVATOR:
SAME AS RUDDER

TAIL CHUTE:
Works?
Casing fastened snugly and flush?

TAIL SKID:
Intact?
Check for white spots, rips. Check mountings.

Check these places especially!

FUSELAGE SKIN:
Check inside and out for dents, rips, white areas or lines in green fiberglass

TORSION TEST:
Hold fuselage near front and push sideways on fin.
Twist easier than usual?

LANDING GEAR:
Check for true axles and mountings, bent struts, free operation, broken springs, rips or white spots near attachment points to fuselage.

WHEEL BRAKE:
The wheel must be just turning free, the brake should respond in the last quarter of travel of the dive brake handle.

C.G.RELEASE HOOK:
Clean? Operate freely?
Check after hard belly landings!

SEATBELT LOOPS:
White areas near the attach points to the shell?

STEERING TUNNEL:
Rips, white spots?
Secure to fuselage?

NOSE HOOK o.k.?

FLIGHT CONTROLS:
Operate freely?
Not too much play?

INSTRUMENTS, RADIO, OXYGEN: o.k.?

SHOULDER - HARNESS o.k.?

ENTIRE SHIP

Check for proper position and fitting of wings, elevator and rudder.

Check the angularity of the axis (elevator and rudder).

Wing vibration must be the same as on the manufacturer's report.

For the annual checks, the datum points and other requirements are obtained from the flight and service manual.

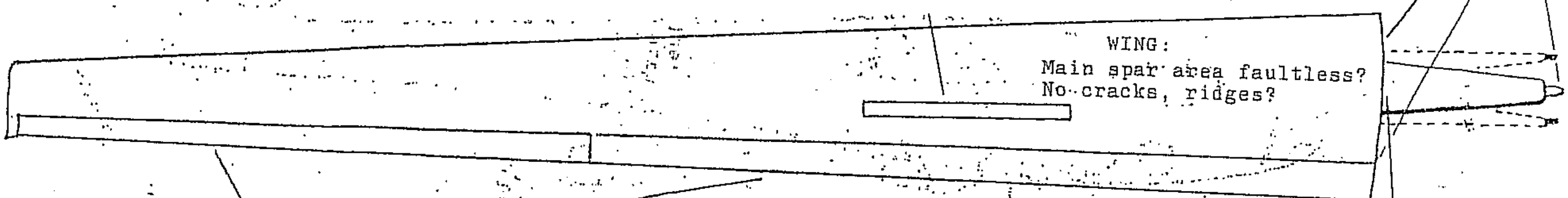
WINGS

DIVE BRAKES:

Full travel? Close well? Play in joints?

MAIN WING CONNECTORS

Check for hairline cracks along the front portion of the spar roots, condition of the pins, ball joints and the main pin.



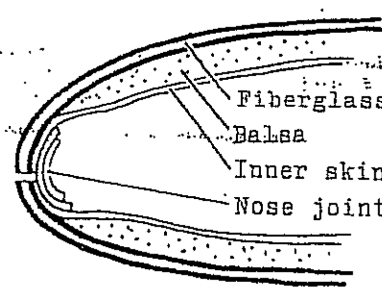
WING:

Main spar area faultless? No cracks, ridges?

AILERONS, FLAPS:

Full travel? No excessive play? Rips or nicks in surface?

HAIRLINE CRACKS at the WING ROOT EDGES where they butt against the fuselage are usually not important if they occur in the filler material used here for a good areodynamic fit. This resin-filler is not very elastic and often develops cracks from the normal working of the wings. The cracks do not grow when the wings bend, and the main spar is not affected. If a hard landing makes the cracks looking more doubtful, remove the putty and inspect the spar.



HAIRLINE CRACKS at the LEADING EDGE stagnation point: there is the same problem with the putty layer. The top and bottom shells of the Libelle wing are joined together at the leading edge by two layers of glasscloth inside, and the exteriar gap is filled with putty. The leading edge - see figure - has as many layers of glass as the rest of the wing, but the reduced thickness (no balsa sandwich) makes the leading edge more elastic, and the putty is not able to follow.

B A S I C   T E C H N I Q U E S

When it has happened...

Keep calm - even light a cigarette if you must. Your case is probably not as bad as many that came out fine.

Go through the checklist of the ship and establish exactly what is ruined.

Then you must determine from the debris what sort of glass material - weight, weave, and direction - went into these parts.
In most cases, you can do a little grinding to find this out; the layers are built up, like plywoods.
If you are in doubt, you can:

a) Ask your manufacturer of the ship,
b) For all cases, add another layer of glass reinforcement when rebuilding this area,
c) Burn a piece of the debris. After the resin is burned out, the glass fibers remain (if you didn't heat them too hot and melt the whole works into a lump), and then it's easy to tell fiber count and direction of layers.

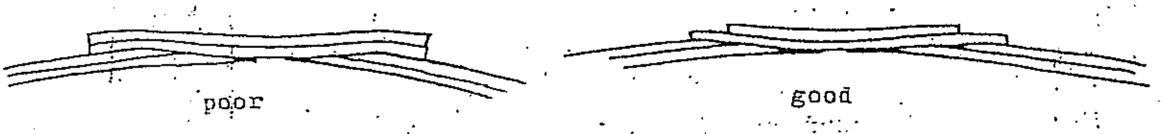
The golden rule says to always use one extra layer of glass than used before. Then you will have enough reserve for grinding and finishing, without fear of damaging critical fibers.

Lets look at the similarities to and the difference between working with fiberglass and with wood:

In general, one doesn't need to work so precisely with fiberglass because the fiberglass layers will squeeze together to a small degree. Usually no pressure clamping is needed, which makes things easier. Thereby one can often accomplish things in one session with fiberglass which would have taken several sessions with wood and glue.
But Fiberglass is more exacting in correct dosing of the components.

Both methods are equally sensitive to grease on the joining areas.

Fiberglass, perhaps more than any other material, allows one to re-build stronger and run closer to the original. Use this property, and don't build yourself a bunch of steps and sharp corners.



If you have not only holes, but also rips in the skin, first fix the rips; then these repaired parts will guide you in re-creating the right shape for the rest of the area.

Recall that earlier we noted that the strongest bonds are formed when the molecules of the wet, unhardened layers can join together. So we like to work "wet upon wet" wherever possible. Also by this we spare ourselves a lot of grinding. If you can't work "wet upon wet", then the next best course is "wet upon dry", i.e., laying fresh resin and glass on some which has already hardened. Good clean sanded surfaces are necessary then.

"Dry upon dry" is hardly ever done, for it places great demands on the exact fitting of the parts, as in wood glueing. Most of the time, we can get by with one layer of wet material between two hardened parts, which equalizes or levels any irregularities in the surface. If this is impossible, due to a precision fit, then we must consider: the highest strength is obtained by glueing two hardened fiberglass parts together with pure resin. But only with a very good fit! Pockets of the very brittle resin will disturb the strength of the connection. Where the exact glued surfaces are dubious, we can use a resin mixture "filled" with various kind of small particles.

Filler material

If one must fill in uneven spots or thick layers with resin, one must thicken the resin so that it doesn't drip or run. Usually one uses powdery fillers, to make the mixture thick, like putty, and also because our resin tends to be brittle. For our purposes the best are:

Aerosil - makes the resin stiff, so it won't drip. But the hardened mixture is brittle like pure resin.

Cotton fibers - the mixture is not too hard and is easy to grind. We use a mixture of aerosil and cotton fibers when we want a filled resin which should sustain a lot of pressure but must remain flexible as well.

Glass dust yields a very hard, strong mixture, which one should not use on top of wet-resin-fiberglass. Also this mixture is relatively dense.

Microballoons is excellent for making a very light putty for thick layers. It grinds well, but it is forbidden as an adhesive for joints. Its strength is not the best.

The normal microballoon material is brown (Phenol resin). it has also such in white, but this is very hard to obtain, if you wish such from plastic. There is also white material made from littel glass balls, but the mixture of them is very heavy, and hard to abrasive.

Separating material

Suppose that you had made a fiberglass part in a special mold, or you had used the origin surface of your sailplane as a mold for a spare part, and then after the resin had hardened, you couldn't pry, dig, or bl the part loose from the mold. That would be irritating.

Evidently the molds should be suitable isolated. Where thin plastic sheet won't do because the curvature, then one waxes the mold, and more often, rougher it is.

There are two main groups of parting agents: Water solutions of certai s thetics, and wax solutions. The water solutions part well, but the dry ig retarded and the surfaces don't get so smooth. Therefore we mostly use th wax solutions. Most suppliers of resins also have parting agents availabl The waxy solutions are brushed or mopped on; they dry in a few minutes. In simple little cases you can use floor-wax.

Any surface exposed to a parting agent must be carefully cleaned before puts resin or laquer on it. Even slight traces of parting agent in the. Sanding dust on the surface will ruin a good bond.

Seriously warned should be before any substance - separators or polishes - which contain silicone. This penetrates very deep into the FRP and cannot be removed. On this spots it is hardly impossible to set a reliable repair.

contact
no conta

The following material stick to fiberglass- resin:

Metal, wood, cloth, paper, rubber, concrete, clean glass, and some fiberboards (?)

The following material do NOT stick:

Polyethylene, Teflon, polyvinyl chloride (PVC), Cellophane, polyamid (Nylon), shiny phenolics, and probably polystyrene. And also linoleum and all fatty, greasy, or waxy stuffs, including silicones.

For the materials with a question-mark the behaviour is not clear.

Some people may end lamentable - because things which go into rooms or compartments very good in form of cloth with resin, may perhaps not to go apart in stadium of hardness...

Ball and roller bearings, and other link joints and rods must be well protected against the dangers of resin running into them, especially when the parts are heated and the resin becomes liquid like water. You never be able to clean epoxy out of bearings!

Steel parts which are to embedded in fiberglass should be well sanded and protected with primer paint; otherwise the hardener attacks them and rust builds up.-

If you wish to use some pressure while the resin is hardening, there are two reasons why the pressure should not be too strong: firstly, you won't be sure of the shape because the fiberglass will wander, and secondly, the repaired pieces should have the same thickness as the old to which they join, for although thinner, highly pressed sections have a higher glass fiber density, they also bend much easier.

During manufacturing, and also in bigger repair works, the pressure by vacuum is usual. Each LTB owned a vacuum pump. In adventurous cases of the begin of FRP sometimes aggregats of milking machines were used. Today are available special machines. One can, in rare cases, turn around a normal compressor.

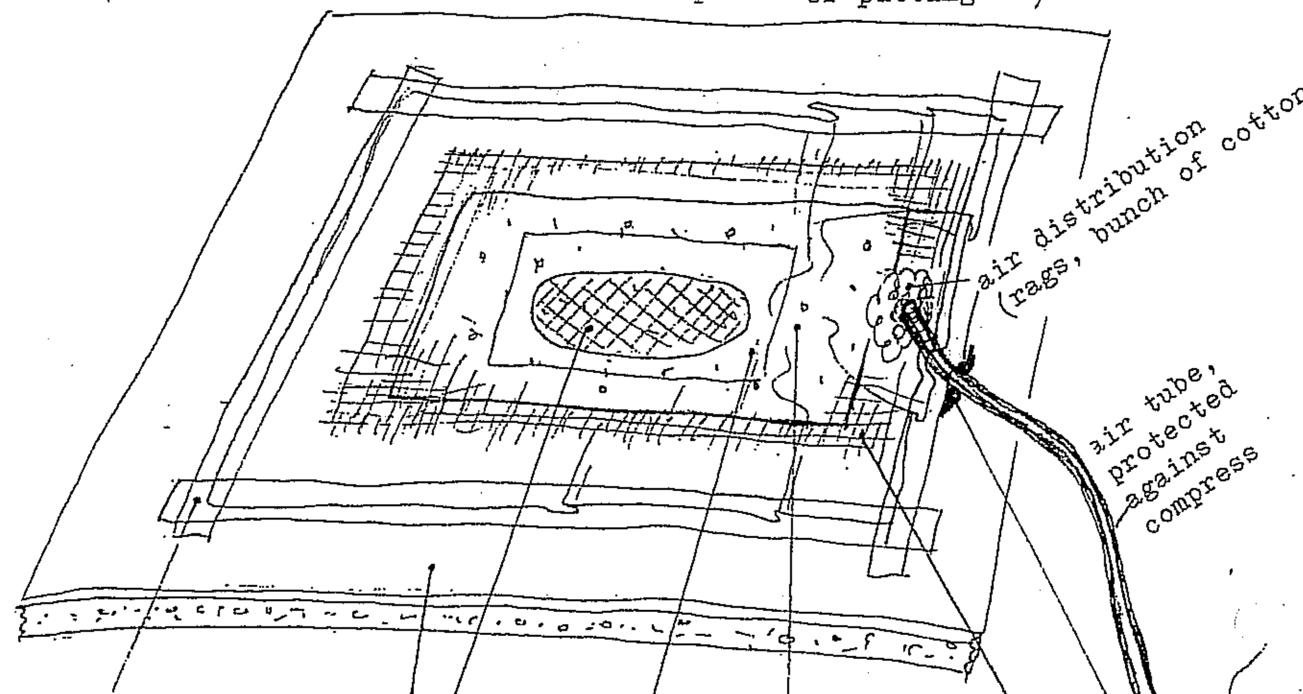
vacuum

A repair which was vacuum- pressed is more soft to even than a spot as described in page 300. And because the pressure of the vac cannot be more than 1 atue, there is no chance to displace the whole matter.

How is to do this in practice?

The trick is less to bring the spot really sealed, but to suck out as many air as possible. One should use for this no narrow valves, and not too little tubes.

A repair prepaired for vacuum pressure looks like this:
(the layers are listened in the sequence of putting-on)



1 sandwich shell
2 repair spot
3 tear off cloth if available
4 foil which have little holes (wood with nails)
5 air cloth (jute, fleece)
6 vacuum foil, sealed around with tapes

7 the wrinkles at the tubes are sealed with bathroom sealing

If it is to be apprehend that a lot of dust will be in the pump air, then defend your tube end with a filter of cloth.

If you have not many experience in vacuum technique, it may be worthwile to make a test in dry before using the resin. The vacuum is perfect if the little wrinkles which bulid up in the vacuum foil cannot be pulled up by hand, at no spot! Only really big holes in the foil you will hear to spit. The finer the whistle the more little the hole (and that means the more bad to find).

It is bad that all sharp spots, little resin needles etc. need often some time for to drill themselves through our carefully sealed foil...

The vacu foil should so loose bepositioned that it will not be separated from the borders when the vacuum is pulling on.

A little before we have read something about "tear off cloth": an invention which elaminates the burdensome abrasive after gluing. One put it as the last layer on the repair spot. After hardening it is simple removed - and ready is the abrasive!

When one has painfully learned to discriminate between places where something should be cemented and places where in no case should there be cement: - the one to be carefully prepared for the resin, the other to bear parting agent to reject the glue, and all this with the greatest economy of means - then it will seem like sport to juggle these two possibilities...

T O O L S

In addition to the usual tools of an aircraft shop, the following are especially recommanded for fiberglass work:

Clean vessels for resin, hardener, and mixing

Brushes with small bristles, and one big brush.

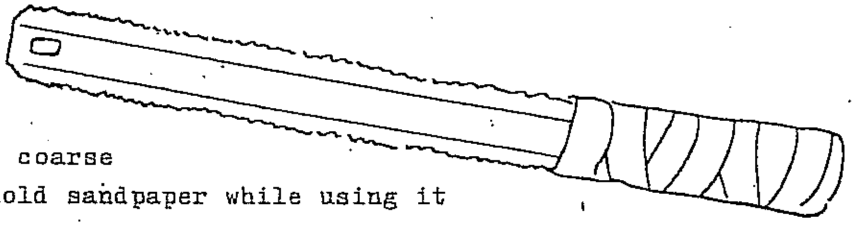
Sharp scissors

Sandpaper of varous grits

Abrasive paper 200, 300, 400, and 600 grits; 1000., 1500

Sharp chisel

A keyhole saw, a hacksaw blade with one end taped to make a handle



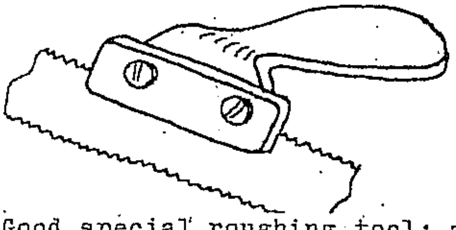
Files, half-round, coarse

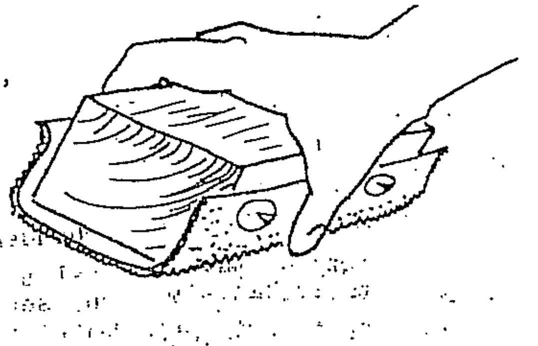
Sanding block to hold sandpaper while using it

Sanding lath: the working side of this must be exactly even! Rule: if you equalize a wing surface, the longer the sanding-lath the better the quality of the surface of your wing. For wet abrasive paper the lath should be in minimum as long as 2 blades of abrasive paper.

Vinyl (PVC) plastic electrical tape, clear cellophane tape, old newspapers,

Plastic sheeting, polyethylene





Good special roughing tool: a piece of a hacksaw blade fitted on a handle from fiberglass, or wood, or metal.

an old, bended pushrod which will be prepared on one end for insert a little brush. With this one can reach in to a fuselage f.i. very deep for resin works.

Parting agents for epoxies. In emergency, try paste wax or clear shoe polish, also a candle, However, never use waxes containing silicones because one can never remove traces of them from the work, and silicones will prevent adhesion of resin or laquer.

Solvents: Acetone or MEK (methyl-ethyl-ketone), laquer thinners, petroleum solvents, to clean the tools and remove traces of parting agents. Don't get them on the canopy!

A small hand grinder makes the work easier.

A disc sander with a 90° adapter is extremely useful for many works, but untrained people should use only small ones, - providing the danger of cutting holes very quickly!

These tool is really a little dust slinger - but no other tool is so multipurpose in our handicraft.

In the most cases these tools are delivered with hard grind disks. These are unsuitable for us. The best are these white elastic polyamide disks.

Grinding wheel for sharpening tools - fiberglass dulls them faster than wood!

Balance or scale which is accurate to about one gram (0,05 ounce) - a mail scale is not close enough in the most cases.

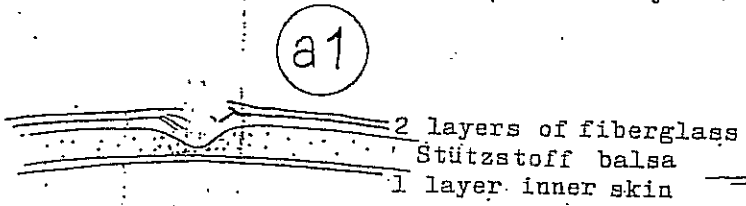
Repair of Fiberglass Parts

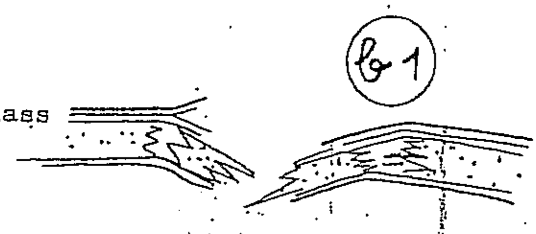
FIBERGLASS- BALSA- SANDWICH SKIN:
(Libelle and BS - Wings, Elevator, Rudder)

In these members we have a layer of balsa wood between two layers of fiberglass.

There are two kinds of damage:

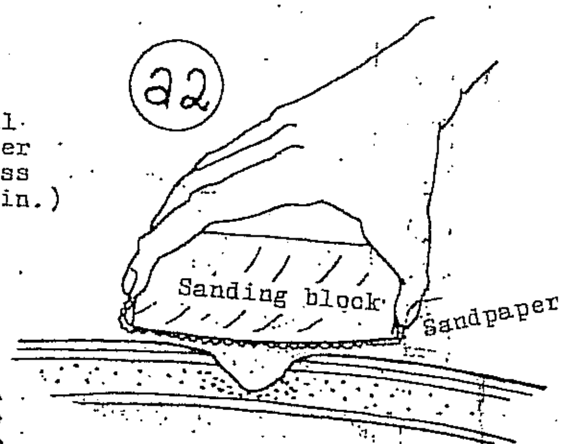
a) Only the outer skin and balsa is damaged, and the inner skin is sound;
b) The damage goes through all three layers.

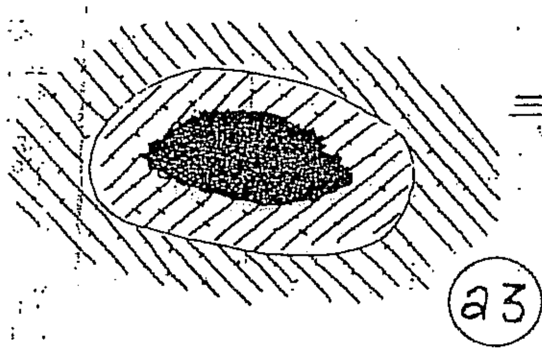




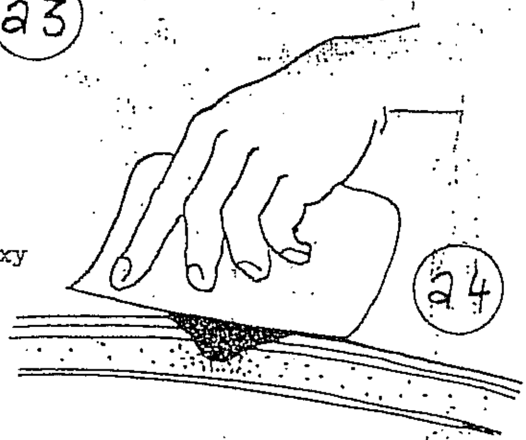
a) is of course simpler, so let's begin with it.

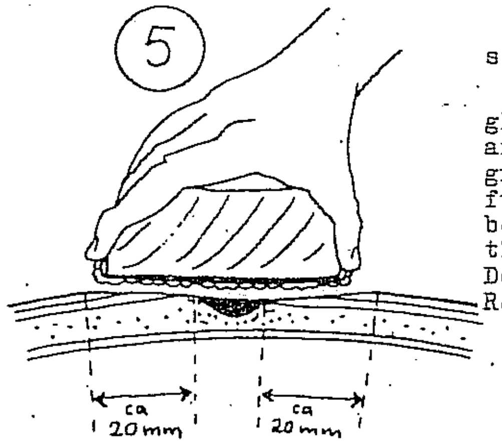
Grind off the afflicted area with 40 - 60 grit sandpaper, until the paint is removed from the outer skin and the structure of the glass cloth is visible about 6 mm (1/4 in.) around the rim of the hole.





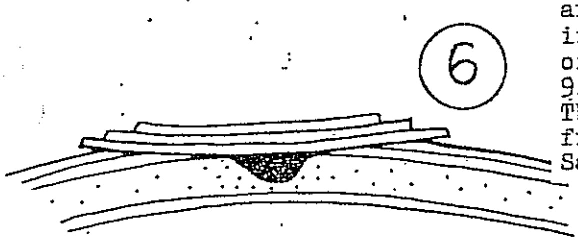
Fill the hole in the balsa with epoxy putty which is made from normal epoxy mixed with microballoon, cotton floc, sawdust, or even flour.
Let it harden.



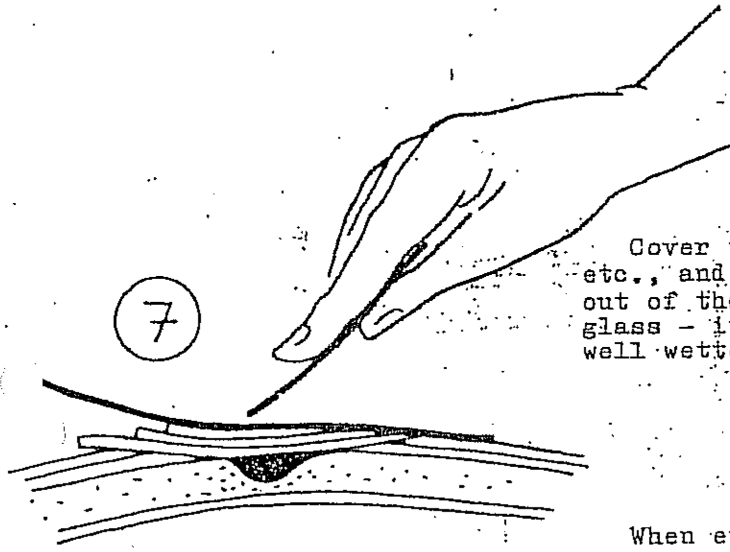


Grind off the excess resin flush with the sound balsa

Remove part of the outer skin so that the glass is exposed for about 20 mm (0.8 in.) around the rim. The exposed glass should be ground tapered so that it goes from zero to full thickness in the 20 mm. Note that it will be easy to unwittingly carve deep holes in the balsa while attacking harder stuff. Do not touch area with (greasy) fingers! Remove dust with clean brush.

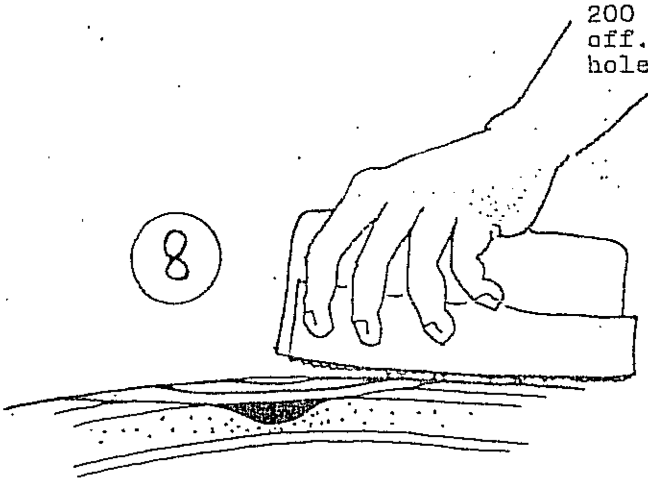


Cut some glass cloth patches to cover the area - use the same kind and lay as original in in that area (Exception: On wing skins, instead of 2 layers 92145, use 3 layers 92110. The 92145 weave can't be blended too well). Thoroughly wet the patches and the area with freshly mixed epoxy and lay them in place. Saturate all with epoxy.



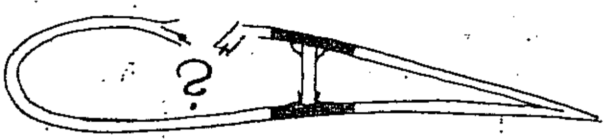
Cover the area with a film of polyethylene, etc., and squeeze and work the air bubbles out of the area. Be careful not to shift the glass - it will be nearly invisible if it is well wetted. Let harden.

When epoxy is surely hard, pull off the film and proceed to grind the area to shape, starting with coarse paper and finishing with 200 or even 400 grit, wet. Keep greasy fingers off. Epoxy putty can be used to fill tiny holes.



Certainly you can install glass cloth not only in flight direction but also diagonal. This is done in many places of your plane. In drawings this sign is used: ※

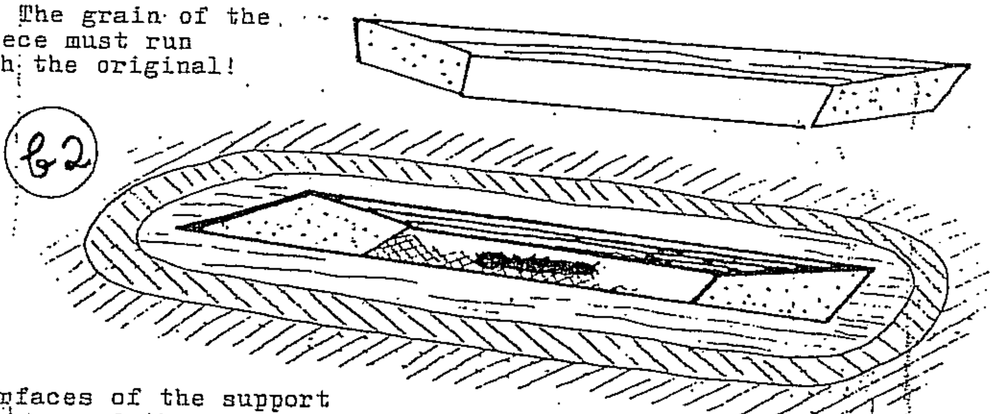
For newcomers it is not simple to remark the fiber direction. Helpful: to grip one fiber and pull on them.



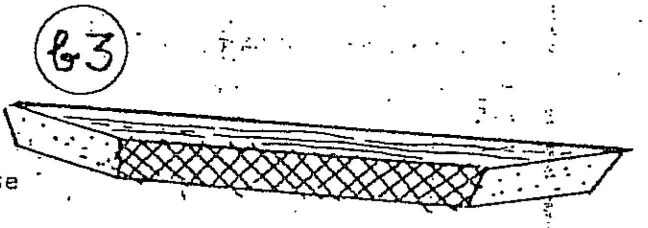
Now we consider case b), the awful hole through both the inner and outer skins. It will be necessary to rebuild the inner skin first.

Suppose that one can't reach the area from behind, and that the hole in the inner skin is small.

Prepare the hole as shown in picture b 2. The grain of the new balsa piece must run parallel with the original!

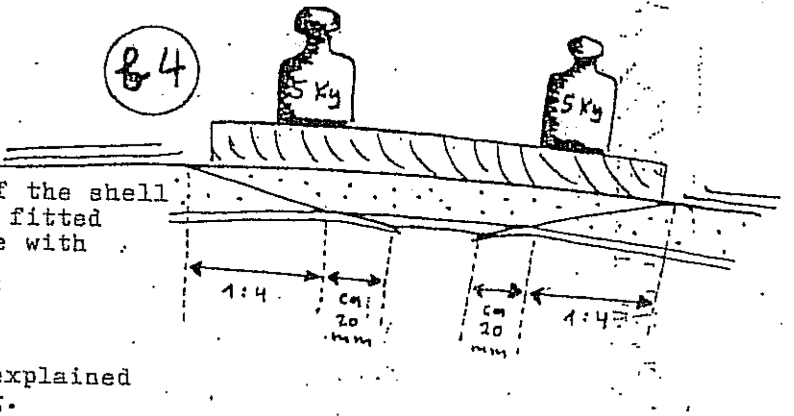


The inner surfaces of the support material are covered thoroughly with epoxy mixture



Then cover the bottom of the balsa piece with glass cloth and saturate it with epoxy

So it looks if the support material is balsa.
If we have foam, it has no fiber direction, certainly. We have only to watch that the material is shafted around with 20 mm. Tubus or Hexcel will not be shafted but insert simple stump and the edges will be glued with microballoon.



Cover the prepared area of the shell with epoxy and insert the fitted part. Apply light pressure with weights or sand bags.

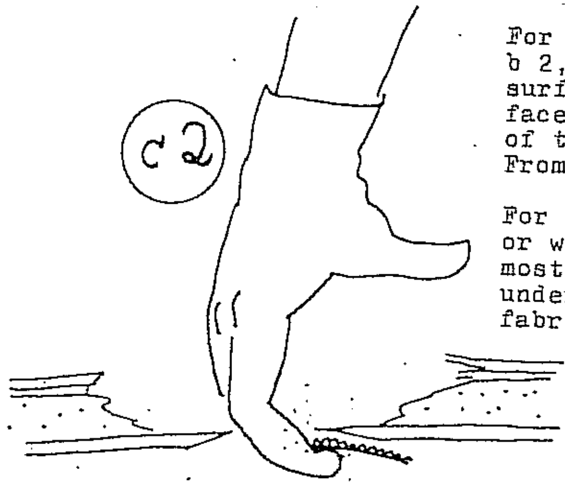
The next steps follow as explained in picture 5 and following.

The support material, balsa or foam, should be replaced every time in the described kind. It might be easy to make a foam support material in a round shape, but it will be very hard to fit it precisely.
But the glass cloth should be cut with round corners.
No bird comes apart if you substitute a foam in a little damage not exactly in its special kind, but only in an equal strength. Balsa should have a specific weight of .12 to .14.

But it is not allowed to put a support piece of foam into a shell of balsa!

This method in 2 steps will deliver the most qualitative result. If you have no time for a long work, it is also possible to repair the whole thing in one step: cover the support material with a glass piece which will reach ca 20 mm over the FRP material of the surface layer. For this the foam must be fit very well, not too high. Then continue like picture a 6.

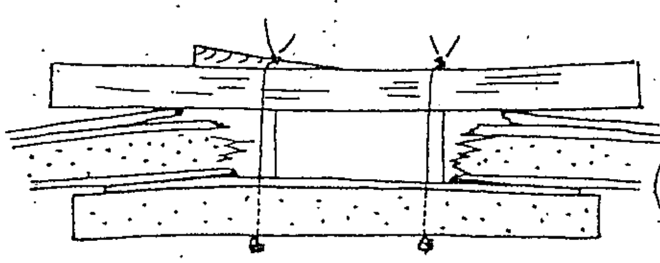
c 2



For larger damage: prepare as shown in picture b 2, but the weaving must cover the slanted surfaces and extend beyond those slanted surfaces. These "ears" lie on the spliced edge of the outer FRP layer.
From there follow as shown in picture 6.

For holes big enough to admit a couple of fingers, or where the inner skin hangs down and flops around most disconcertedly, one must build a light platform under the inner skin to hold it in place while new fabric is glued to it.

Dress the inside surface of the inner skin to a clean, tapered surface, as shown in picture c 2. Gloves will protect the hands from sharp edges!



c 3

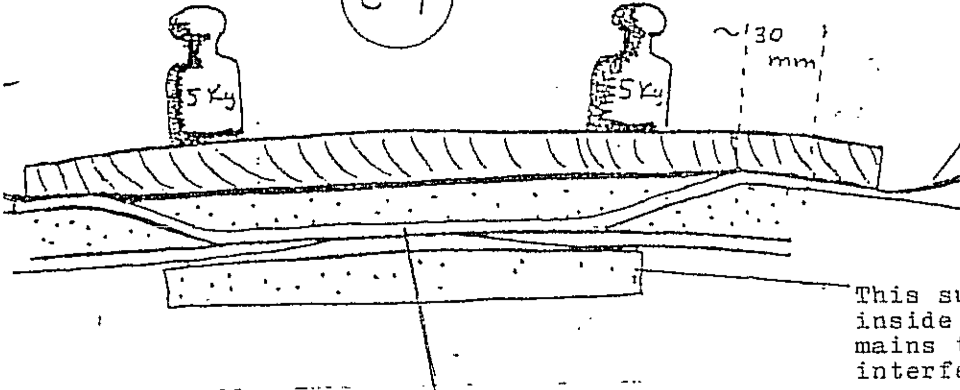
Cut out a platform piece of foam or balsa or other light material big enough to overlap the hole by abaut 50 mm (2 in.) all around. Sand off its top surface so that it is a fairly good fit to the ground surface of the inner skin. Then secure with wires or strings against the shell. The inserted part must fit shell contour exactly without distorting the contour.

Practice with a dry-run!

We cover the top side of this inserted piece with epoxy and glass cloth, so that it overlaps the splice of the inner FRP layer. After saturating exactly we tighten the wires or strings against the shell, and let it harden.

The reestablished inner layer is now sanded off and one can lay in a piece of balsa or foam and proceed as shown in picture b 2 - 4 and continued as in picture 5.

c 4



This support platform remains forever inside and we must insure that it remains there in fact, and also does not interfere with any steering mechanism.

In all cases where you are not completely sure to obtain a precise junction of the inner layers, you put under the

—.

bended parts

Sometime.: we will not come to a result, f.i. if the damage is positioned in the bended area of the nose. Then we should prepare a replace part, We stretch a foil in the neighbourship of the damage over the bended area, put on this a piece of inner layer FRP, good with wet resin, and on this a piece of foam. This will be pressed with tapes, tear off cloth or vacuum on the bended spot. Let harden. If you have tear off cloth, then this is the first layer before the inner FRP, so we have not to grind.
For this we have here the method "dry onto dry", it is necessary to glue in this replacement part with cotton fiber mixture.

roving ropes

Working with roving ropes

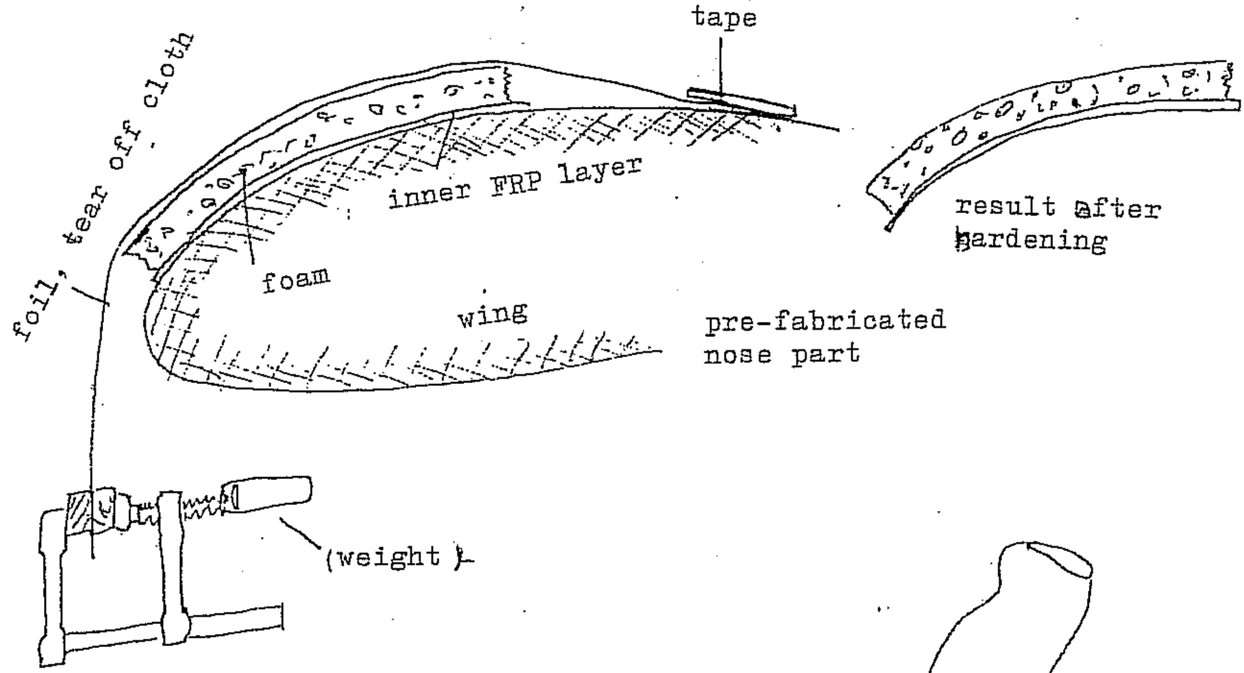
To this it is coming very easy. Example: a guide of a lever for airbrakes or flaps is wabbling; a landing gear cover is reinforced with rovings; the back rest of the ASK 21 is broken in top; etc. etc.
Certainly it is impossible for you to constate how many rovigs per rope and how many ropes are placed in the mentioned position, you can only estimate regarding the thickness of the layer.

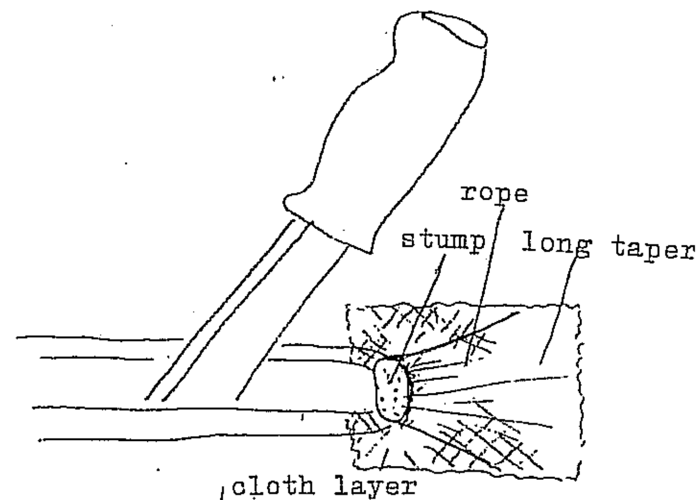
You can produce a roving rope as following:
cut some pieces of rovings, perhaps a meter or so. Then they are impregnated with resin. Work f.i. on an old newspaper (also foil is possible, but I personally prefer paper because it is to look where you have put resin, and also the paper absorbe the resin a little. the work grews less smeary than with foil).
The slipp- off of the most resin you can do in the simpelst matter with the fingers. More comfortable:
take a piece of tube 6 x 1 mm. This has a caliber of 4 mm. Therein 6 rovings can be slipped off. This results a proportion fiber/ resin of nearly 50%. A tube 10 x 1 has a caliber of 8 mm; can take 25 rovings for nearly equal proportion.
Certainly you should observe that the running of the rovings into the tube is prepared very soft, so the tube begins like a venturi tube. Profis put the tube into a turned mouth of steel, or alumin.

The area which you like to strenghten will be roughen, prepared with resin, the ropes positioned fine shafted and the layer covered always with glass cloth, otherwise the rovings may can crack under load.

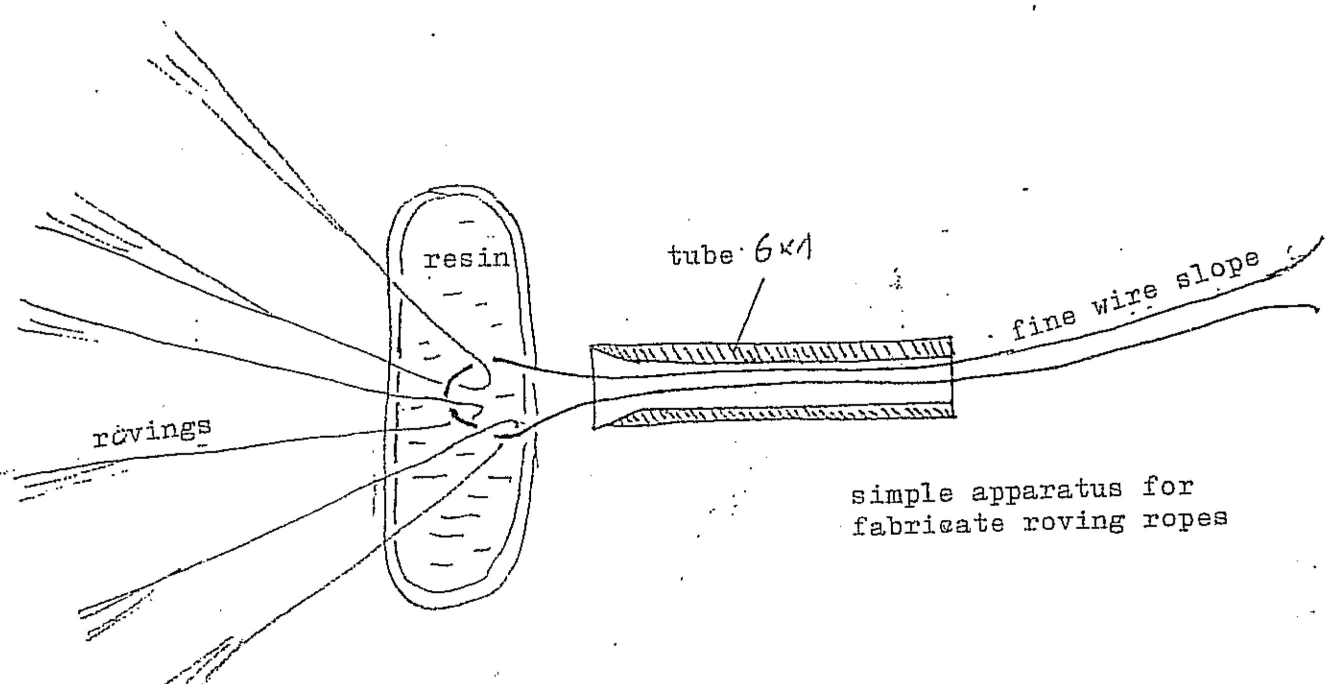
In case you like to repair a broken roving rope the shaft length must have a proportion of 1 : 40.

The stop position of the landing gear lever may be weaked in some planes by time. In all FRP guides we can renew this with a roving rope positioned against the lever (see picture).
If this is not possible screw or rivet a piece of polyamide against the lever.





stop of
landing gear lever



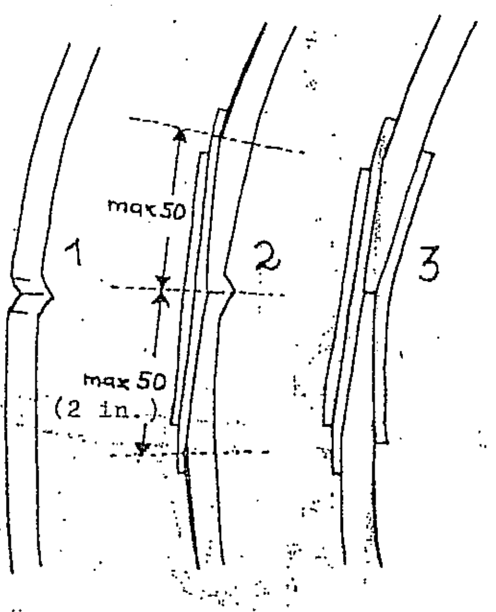
simple apparatus for
fabricate roving ropes

Repair of an all- fiberglass fuselage

(Libelle, SALTO, others)

In contrast to the wing a fuselage shell consists only of fiberglass. This design provides spring flexibility.

In case of a smaller damage do nothing but splice around the area, approximately 1 - 1.5 inches (20 - 30 mm). Observe the kind and direction of the glass cloth and replace accordingly. The first layer of glass cloth is the largest, and each repeated layer should be 7 - 10 mm (1/2 in.) smaller in circumference. Let it harden, sand it, paint it.



Rips in the shell or built-in parts are to be ground away (taper) on each side for a distance equal to the length of the rip, but at most about 50 mm (2 in.) on each side of the rip, and also at each end. Lay on resin and properly oriented glass cloth. After this is hard, grind off the inside surface of the rip and lay on a single layer of fabric inside, as shown in the picture. Observe the kind and direction of the glass cloth and replace accordingly!

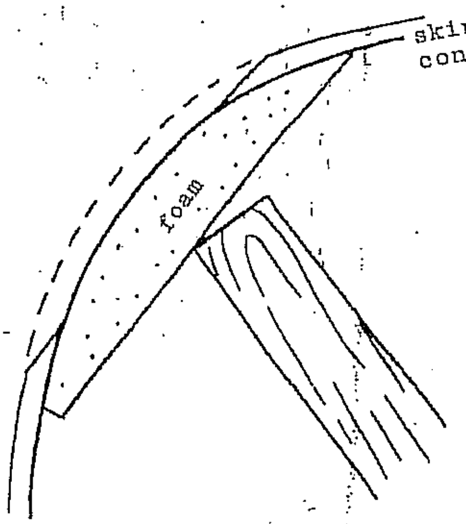
For larger damages it is difficult to establish the contour without a support.

Example 1: Fit a piece of foam, from the inside, so that it completely covers the open area and secure it with brace or other support

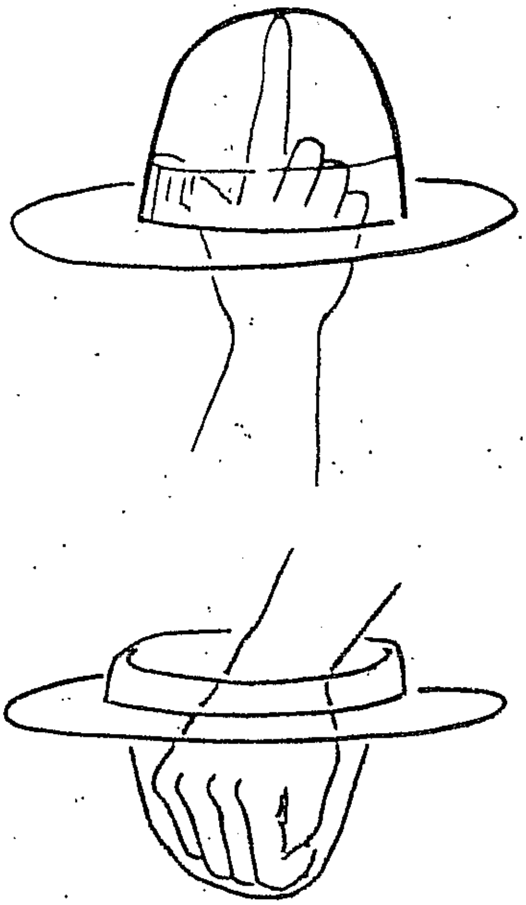
Remove the foam and splice the shell in a normal manner, cover the foam with a foil and insert it. Rebuild the shell as described earlier.

You can also work without the foil as long as the foam will not react to the epoxy. (Test a small piece!) Styrofoam has proven to work well.

But certainly this manner requires more effort to clean the patch.



And certainly you have the possibility to fabricate on a spot in the neighbourship a replacement part. (page 407)



Example 2: You make a mold on the outside. This is not too hard to make

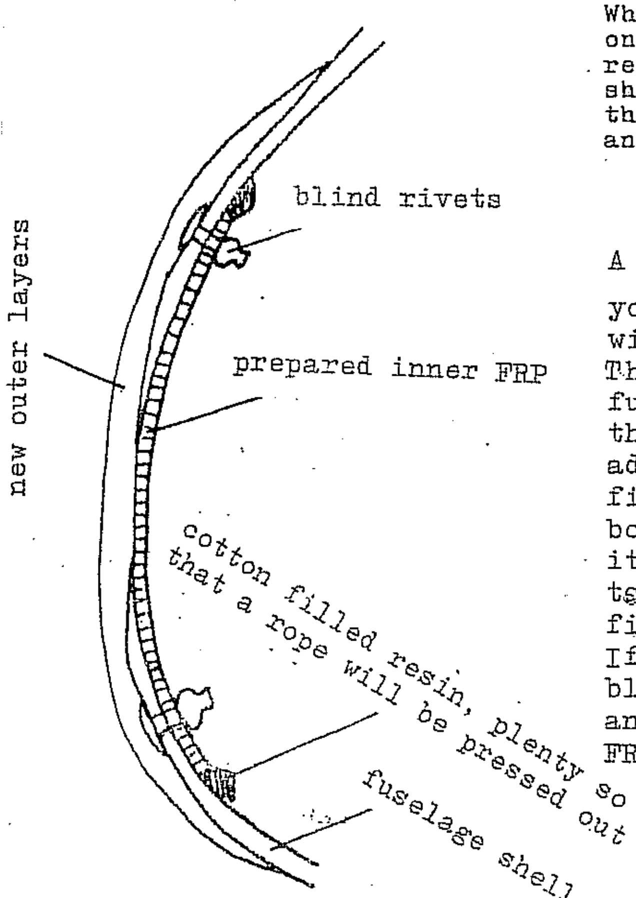
First wax the opposite symetrical side of the airplane perfectly (hoping this area was not damaged too!), lay on one layer of saturated glass cloth of 300 or 400 weight (12 oz./sq yd), let it harden and sand it as desired without removing from the plane's contour!

Then, after removing, bend it inside-out, like an old hat. Now the nicely ground surface, which used to be convex, has become concave. It can be waxed and used as a mold.

After preparing the damaged area as learned earlier under "little holes", wax the new mold and lay in the observed glass cloth. After saturating it with resin, stick the whole affair onto the damaged area in the right place. Hold it there very lightly, say with sticky tape. Heavy pressure will distort the shell contour or remove the wet fiberglass.

With small, curvaceous surfaces one may use modeling clay or typewriter cleaner or even Plaster of Paris to form a mold (but do not use silicones!) Remember that some of these molding materials may contain grease which ruins the epoxy bond. So after removing the molding material, clean the rebuilt area well with hot, soapy water and roughen it well after drying if you need to work with resin on this area.

Whenever it is possible, try to put one layer on the inside for safety reasons. Any separating material should be removed before inserting the inner layer. Wash with acetone and sand it.



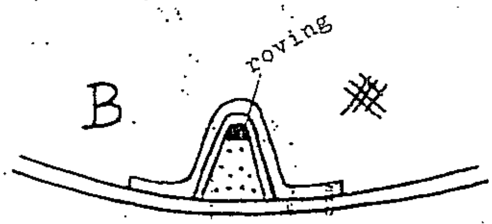
A HOLE

you can often not repair even enough with the wet FRP layers.
Then you prepare on a spot of the fuselage which seems adequate of the hole contour a fiberglass adapter of 2 to 3 layers, fit it with the good overlapped borders to the repair spot and glue it from inside, very well roughed, to cover the hole. Glue with cotton filled resin.
If you fix it with some little blind rivets, you can work without an interruption with the outer FRP layers.

WHEN A BULKHEAD IS DAMAGED:

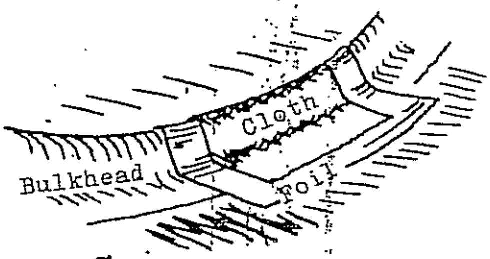
A Small places can be patched directly on the rib. Naturally one sands the spot as usual. One who is wise also patches little dents and bends, too.

B When a large portion of the rib is torn up, one will have to make a mold. One can form a rib core out of a foam plastic, glue it into the skin, and lay over it the necessary layers of glass cloth and roving, impregnated with resin.



B

C Or one can use an undamaged rib as a pattern. Lay a piece of thin polyethylene film over the good rib, and over this lay a single layer of cloth and resin. After it hardens, one uses it as a base for re-creating the damaged rib.



C

D If the prepared base doesn't curve quite right, saw some notches in it so that it will bend under light pressure. Here one is forced to repair the rib in two steps. First, glue on (epoxy!) just one layer of cloth over the deformed base and let it harden under light pressure in the right shape. Second, on this now perfect pattern, (naturally after sanding!) glue on the roving and outer fabric layers. Certainly, it is allowed to put the roving on the peak of the ring between the first and second layer.

D

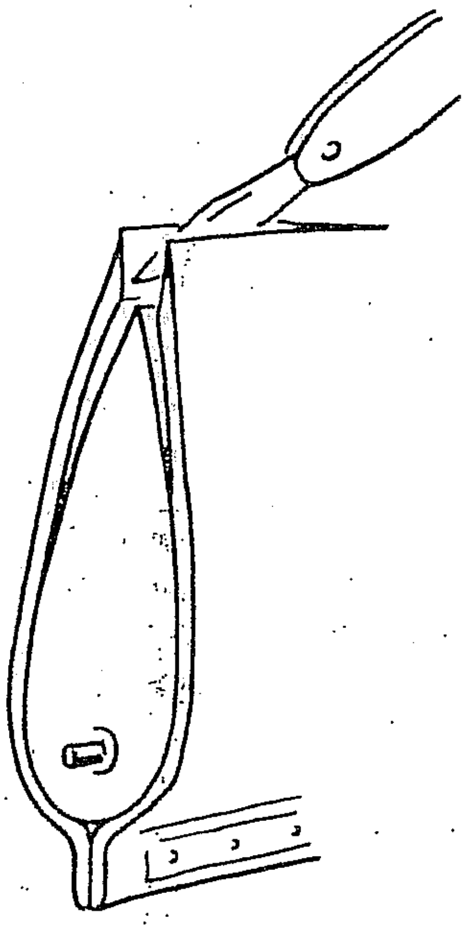
DAMAGED TRAILING EDGES ON AILERONS OR FLAPS:

If only a short length is split open, it often suffices to pry the two halves apart a little bit and squeeze some epoxy into the split. The two sides should then be squeezed together equally, as by spring clothespins or film clips.

However, if a piece of the edge has been hacked out, then you need to build it up again with resin and cloth. Sand off the paint until the glass fibers are visible, lay in 2 layers of 90070 fine cloth and resin in the proper way, and overlapping. Cover two straight pieces of wood with foil and clamp them to the upper and lower surface in a way that they line up with the trailing edge. Prevent any sliding, especially on large parts.

If the balsa has been damaged, then naturally you need to fix this first in the usual way .

Be careful not to add too much mass to the trailing edges, lest you upset the mass balance for flutter.



TORN-OUT END RIBS

on Flaps or Rudders.

If the rib is torn out clean, sand all around it first. Then split the rudder on the trailing edge and even coat the rib with thickened epoxy (aerosil and cotton flakes) and ram it back into position. Clamp it with tape-covered wood pieces. This freshly glued part has to be installed in its position so the bearings will line up again.

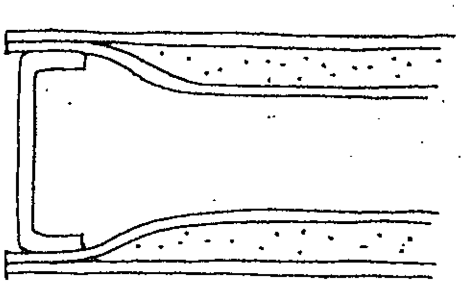
Usually, however, the rib is not torn out so gently, and a piece of the end rib or skin is damaged or distorted. The difficulty here is that the parts are built in female molds, which you don't happen to have handy. In spite of this the repair must match the original contour and the original strength must be regained. Therefore you'll have to make some kind of a mold, either by:

a) bending some smooth sheet metal exactly to the right contour, or
b) using the corresponding undamaged member on the other wing as a pattern for a mold (Ailerons, flaps, and elevator of the Libelle have symmetrical profiles!), or
c) Making an exact duplicate of the part, in softwood, cover it with 1 layer of glass cloth, sand it and fill it with putty, and make a female mold from this.

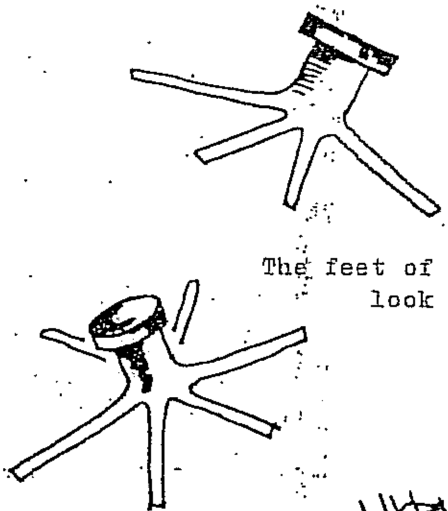
As in other aircraft repair, one must first obtain a good rib, either by repair or by purchase.

Then, with the aid of the mold prepared by one of the above methods, one can set in the rib and fasten the skin to it as described above.

Please note that in the neighborhood of all end ribs in the Libelle and BS 1, the balsa on the sandwich tapers off to zero, somewhat in from the rib, and the balsa is not called upon to carry any load in these places. See figure.



Diverse play of resin

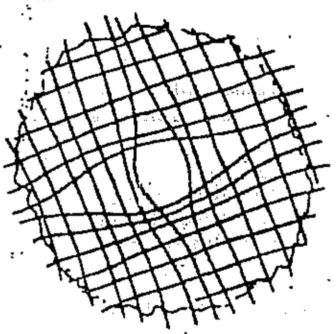


The feet of the bolts look like this

IF AN ASSEMBLY PIN ON THE WING ROOT IS BROKEN OFF:

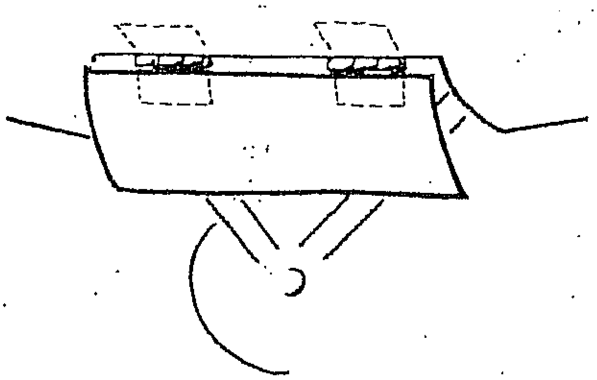
Relax. It's not like breaking a leg: The little pins have nothing to do with the stress portion of the wing. In fact, their strength is purposely limited to prevent damages by enthusiastic but misguided assemblers.

Grind away the remnants where the pin sat, until there's no hump left. Then lay 2 layers of glass cloth on the spot, and place a new pin on the spot. Cut out 4 circular patches of glass cloth, The patches should have different sizes, about 50 - 65 mm
Poke a hole in the center of each patch using something smooth so that no fibers are cut (perhaps a scissor's tip) Slip it over the head of the bolt so that they cover its feet. Orient the fabric so that the fibers crisscross, saturate all with resin, and let harden.



LANDING GEAR DOORS:

Here under the putty sit hinges and screws (fuselage side); or rivets (door side).



Damaged doors are disassembled by cleaning off the area of the hinges and removing the screws. If the hinge is damaged, it can be replaced with similar brass hinges..

The fiberglass doors are repaired "as is". If rovings are torn, proceed as with "Torn-out Fittings", and use new rovings with splices about 50 - 60 mm. (2 - 2.5 in.)long.

Badly damaged doors are usually replaced because it's too demanding to try to re-create their exact contours.

added equipment

A basic remark to the installing of added equipment parts:

1. each of these nice added parts costs weight. Very fast in this kind you can collect some kgs of weight, and this reduce the limit of payload.
2. The plane is licensed based on its type certificate. Going away from this line can interrupt the traffic license of the plane, with all consequences (insurance cover!) This is valid also for added equipment, Or the elimination of parts which are listend in the type designs.
If you find such a change very important you can apply for a "change on the piece" by the government. The for this necessary paperwork know the manufacturer or the LBA.

Extra Equipment

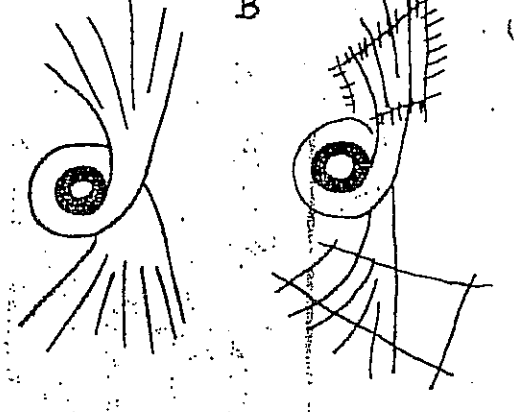
Attachment Point Reinforcement.

If you have to attach something on the shell, the same rules apply as in wood construction. The area must be strengthened before cutting any holes or inserting screws.

A

To accomplish this, roughen the place and put some layers of glass onto the area, each larger than the preceeding layer, and also changing the direction of the weave. The strengthening shall be in a realistic relation to the weight it must carry. A 1/8 inch diameter tubing does not need as much as an instrument weighing two pounds. In doubt you make some tests on a separate piece of wood or fiberglass.

B



A For loops, hooks, sockets, tubes: Sand the area, wrap the part with glass cloth around the tube and another layer lapping over to the skin, and let harden in position.

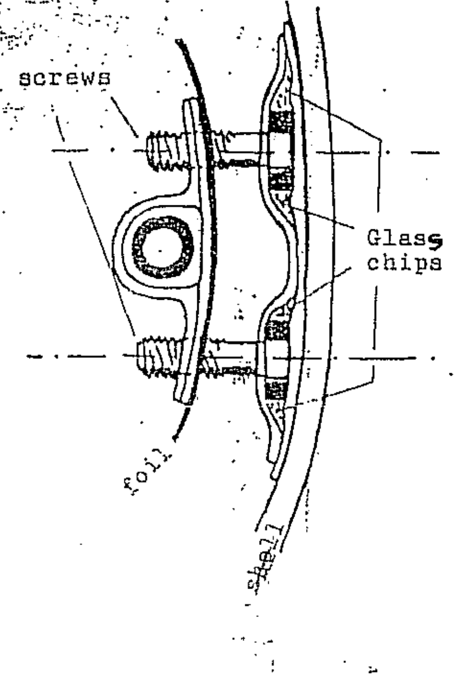
B Greater strength is achieved by wrapping the part with soaked strands of rovings. Spread the end out over the shell and secure it with an additional layer of cloth.

C You can also build a removable attach point:

1 First cover the shell with foil and then proceed as described above. After hardening remove the bushing including all the glass.

2 Cover the back side of this attachment plate with foil and drill the necessary holes for the connection bolts through the plate and foil.

C



3 Sand the area where the attach point should be located and cover it with the necessary layers of glass cloth.

4 Roughen the hexegons of the necessary screws with a file, the rougher the better. Protect the screws than against rust, by primer or by zinc or cadmium plating. Cover shank and thread of the screws with grease, but the head must remain clean.

5 Apply 2 to 3 layers of glass onto the prepaired backside of the attachment plate, clear the holes of weaving and push the screws through so that the heads come to rest on the wet glass.

6 Put resin-wetted glass fuzzles around screw heads

7 press the so prepared attachment plate against the glass spot in the plane and fix it with any suitable tool. For a conncetion between the plane and the fixpoint the screw heads should be

T h e S u r f a c e :

Equalizing

After repairs the equalize of the spot with putty is necessary. Rughen the spot well without injure the FRP. The structure of the upper glass layer should be not hurt. Abrasive paper 80 - 100.

Than you apply a white polyester putty with the japanese spatula. The plainer the putty area the lower the work to grind. It may be remunerative to donate a boddle beer to a friendly painter so that he will bring on the putty area - because he is able to do this in minutes and he reach a perfectly even area - instead the most laymen can only set relatively equal heaps .

Sometimes you need to apply the putty 2 to 3 times.Between the steps it needs to grind again. By time you feel a nearly even area which has no more differences to the environment.

The putty area is to grind a little deeper than the untreated area so that you have room for the later laquer. But in practice exactly the repair spot is the highest! Here hels only a wide spread-out of Schw. for to make invisible the buckle.

If you have to fill out a relatively little spot in a Schwabbellack surface, you can avoid somtimes a big action if you wait until the Schw. reaches nearly its polymerization point. Then he gets very thick, and you can fill more mm. Or you add some Aerosil (page 301). Then the spot gets perhaps not so shiny, but you have no colour difference to the environment - and save a lot of work.

In case of synthetic laquer surfaces (page 604) comes after the putty a thick filler, painted or sprayed, then a fine filler whichis to grind fine and wet, and then the laquer

Laquer and Finish

We know two methods to colour a sailplane:

a) on the beginning, b) on the end of its manufacturing.

The painting of the surface on the beginning, as the first step into the mold, we call "gelcoat" method. In all the first native time of the plastic plane one has known only the "Schwabbellack"; later there were developped special gelcoat resins. They are specially designed to get no "noses" on vertical surfaces.

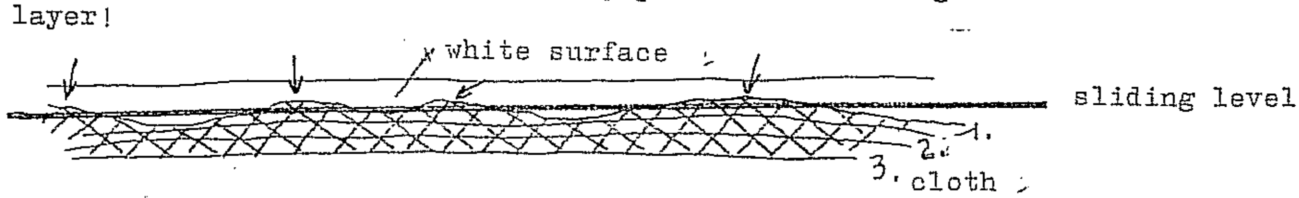
For the final laquer method you know the steps from a car; one uses also often the same laquers. So every clever craftsman for car- spraying can help and advise you.

It is clear that you should handle each kind of surface in its special manner. For this it is necessary to ask the sailplane manufacturer for the kind of surface before beginning every surface work.

Gelcoat resin is in the most cases a really thick layer; it is not to apprehend that you will grind "through" if you use a reasonable corn of sandpaper. But sometimes it is not so freindly to polish. If you have to apply some material it is necessary to grind the spot exactly. Caution is to be observe in the area of noses and other areas whre it is possible that we have glue gaps from manufacturing; there may be refitted and you may find thinner spots.
Gelcoat material is . harder than Schwabbellack.

Polyester- Schwabbellack ist also painted first into the negative mold, but it is more fluid and for this it can run from vertical walls so that the surface is not so equal than gelcoat. Also in former times (GLASFLÜGEL) one were avaricious with the weight of a plane so that we have often some trouble with a very thin layer of Schwabbellack.

Also the laying-on with a brush as it was done in former times of plastic planes that the white surface is not very even. This uneveness is followed by the first cloth layer. In such cases you should not have the ambition to remove each white little spot from the surface if you like to put a new gelcoat on this. In this case you would hurt on many places the first glass layer!



Before beginning with the work in Polyester, you should regard the part intensively in a slanting coming sunlight; then it is to see if there are thin areas. Then you have to decide: if you grind a repaired area you will necessary also grind the environment, and if this is thin from the first, you will risk there dark spots, so that you have to apply there new material . . . and so on until

lay on

If you have decided for "apply" - this is no question for repair spots - then you look good over the area and draw a pencil line aroun the area you will paint. This is grinded with abrasive paper 120, if you feel that the whole area has not so thick material, you take finer, 220 or 400. Never paint wider than the grinded area, this will result borders.
After this you paint the Schw. not too thin, grinding is relatively facile, also thin layers may harden slower and often not correctly.
Immediately after the laquer has polymerizated you can apply the next layer, if you have to paint vertical spots - so that you can reach also here a good thick surface.
Never paint over the pencil line or other uncleaned spots - they will come as dark spots after grinding.

reaction spot

During its reaction the Schw. is, for a very short time, really thick as putty so that you are able to apply it in this moment in millimeters thickness - if you have an uneven area too little for putty work.

sliding

If the Schw. is harden good and ready - you can help with a heating fan, but not so long it is wet! - than you grind. Only if you have to remove big hubbles than you take 120 paper, and only for the hubbles. Otherwise take no coarser than 360 to 400. This needs more time, but in other cases it may be possible that you can't remove the scrapes.

You use wet sanding paper, and span it over a good even piece of balsawood or other wood which is not too hard. For the wing the wood piece may be the longer the better. You please work never in direction of the wood's length, always rectangular or diagonal. Otherwise you fabricate channels.

This first grinding step decides over the quality of your surface; for this you colour the surface with a mixture of very little colour laquer and a lot of thinner - only so that you have a gleam of colour.
If you grind then with the even wood, you will note that on the higher places the surface get white and on the lower the coloured spots rest. So you have a check if you have grinded the whole area correctly.
If you see a dark shadow while on other areas still the colour rest unremoved, than you repeat the method of painting : line with pencil around the deep area, sanding and filling out with Schwabbellack, really thick.

After this you paint another time, thinner, also over the dark shadow - area.

This is to hear a little complicate, and of course it can be throughout a time- eating procedure, guided by your pretensions. Not without reason such planes are more expensive than such with a thick surface layer, but they are certainly lighter than them.

If the progress of the work cames on the spot that you have the feeling to have no more shadows or spots with colour - and also the feeling with your hand notes no more uneven spots - than you can dry the whole thing and regard it in slanting coming light. The surface than has already a light shiny looking, and you will see very good eventual scrapes or other mistakes.

fine finish

If you are satisfied totally with the 400 wet abrasion, you take the 600 and 800 paper. You can take a softer wood for it -(never you sand without an even base).Now no more material will be removed, only the channels of the former paper will be slided. The direction of sliding is now important: the wings in direction of flight, also the fuselage, only the ailerons can be done in length because their chord is too little.

The last step is a slide with the oldest, used-up fine 800 paper which brings only the last scrapes aboard.

Then comes the fine work with 1000 and the grey 1500 paper.

The dried surface has now a fine shiny look. We polish it with a good car polish. Not so experienced persons should not use a polish disk (angle-polisher): if the surface gets too warm on any spot then the structure of the glass come to see and all the work was for nothing.

If you have obstinated dark areas, there will help only a radical procedure: you should grind this spot deeper than the area around - without injuring the FRP! - and spread out your Schwabbellack over a good area around. Otherwise you will have on the critical spot a buckle for all time.

So complicate the whole thing seems - one can nearly do not really mistakes. If the dark shadow comes you will see. For this also laymen may try to help theirselves in following the described method.

Because Schwabbellack gets yellow a little after long time, it will be not to avoid sometimes to get"different colours of white"(as we say) But this means not a lack in straightness for the surface, which is the important point.

The procedure with gelcoat is similar to Schw.

spray

For some Schw. there are thinner or thinned hardener which allow to apply them with the spraygun. If you have larger areas you should prefer this. You can do it in a normal workroom which are prepared against dust by wetting the floor and covering the environment of the repair area.

Synthetical laquer (Polyurethane, Acrylic etc.)

Contrary to Schwabbellack this is a really laquer, with characteristical thin layer. The working method for this is basically different. The laquer should be sprayed with a gun, and it needsa dusty- free working room (cabin). It is more elastic and in spite more harder than Schw. and rest white for years.

build up steps

The method - let us regard the SALTO - is the same then on a car: first putty, than filler, than laquer. Because the laquer layer is thin you will come through easy when sliding, and you will note this not so fast because the underground is white.

The first putty, normally a sprayed one, will be slided with 80 paper. It delivers the straighthness of surface. The fine filler is to slide with wet 400 paper. It is soft and to slide fastly. After this workstep the part should not have heavy dark spots.

spray

Repair spots are to spray with a gun and with disappearing borders - not as Schw. with hard contours as from a brush. They will be prepared good with 600 paper. The sprayed area should be on end before the end of sliding.

To slide the ready work you will do after full hardening, otherwise you get scrapes. This harding procedure will go over days and weeks because we have not the possibility to heat as on a car.

How big the characteristic "orange surface" of spraying will be depends on the quality of material and sprayer.

If it is necessary to slide then you use no coarser than 600 paper, better finer, because channels are very hard to remove. Better to work a little longer with fine paper as to have the angry after using too coarse one.

Have you slided the sprayed part with 600 you should dry and look for the success. If you are content you take the old 800 or 1000 used-up paper and slide the whole area at once. After this there should not be to see channels.

Then you polish preferable by hand. Every good polisher is to use if you know it from your car - this laquer is a car laquer. With patience you can reach on your bird a diamond- like brigthness which makes pleasure for long time in fact of its better hardness.

SALTO and others:

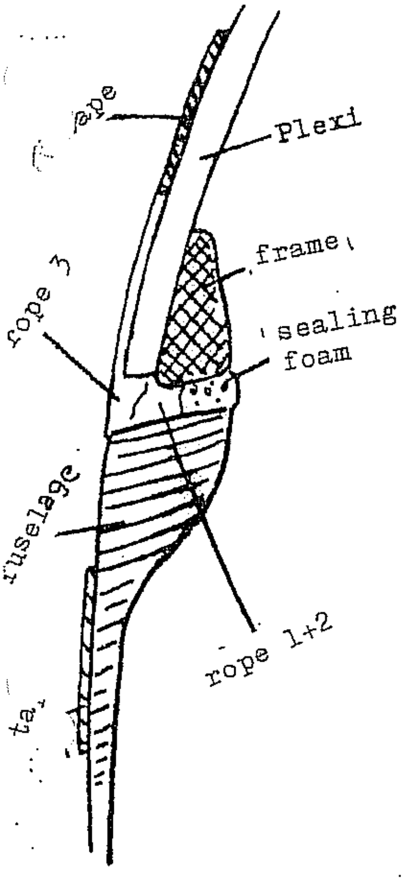
Canopy Tricks

1. Elastic Sealing:

elastic frame

If the sealing of the SALTO canopy is no more o.k., - this can be extended if you protect the sealing on the outside with a white plastic tape - than you should replace it by another system; for this you need some skill, but the result is a lot better in its aerodynamic effect

First remove the old sealing, clean the frame and rough it a little. Before working you should protect the plexiglass by a plastic tape on the outside directly over the sealing. Added to this use another tape over the first which overlapps the first some mms.



If you set the canopy on the fuselage you will note a gap between canopy and fuselage. This is the area for the damping element. We create it as follows:

in supermarkets you can buy silikone sealing paste, used normally for bath ceramics. We need 2 tubes of it, also the cartridge for to apply it, a roll of foam sealing for windows, ca 5 mm wide, a straight spatula from plastic, and a very weak base for the canopy (the best: an old mattress. Plexiglas is a weak material and earns scratches very fast!

Put the canopy on the weak base and glue the sealing foam strip around the canopy frame, towards the inside.

The fuselage frame should be insulated with fat so that nothing can be fixed there. Also use tape.

If you have prepared all materials and tools, you begin to press a fine equal rope of silicone around the canopy, close to the foam strip. It can be good thick. After this you press a second rope.

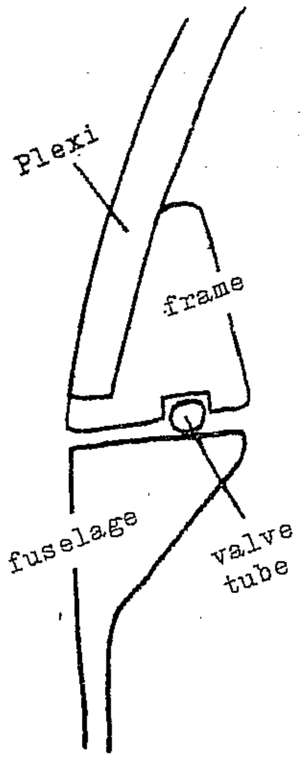
Then you set the canopy softly on the fuselage, and close the canopy levers.

After this comes the third rope. The silicone material should be plenty enough:

spread out the silicone around the frame, add material if it is not enough for the next step: take the sharp spatula and pull it in a single walk- around exactly on the frame, using fuselage and tape on the canopy as conduction.

The problem is: if it was not going to your satisfaction, then you have time in maximum for a second walk-around before the material begins to harden.

The whole thing must be storaged in silence during 1 - 2 days. Then you take a sharp fine knife and later a japanese spatula for to loose the canopy frame from fuselage.
This method you can use on all possible canopies and you can eliminate some whistling gap.



The sealing with the bycicle- valve tube is certainly not the newest; it was used almost in the first SALTO. It is only possible in massive frames from FRP:

with a little special tool you mill a groove into the basis of the frame, ca 3 mm deep. Fittings are surrounded softly. On a place which you can reach during flying, you place the ends of the tube, which will be installed in the groove with contact glue. The ends are imbedded into an instrument tube, on which you connect a rubber ball (blood pressure indicator). So you can adjust the sealing following the temperature necessary.

putty sealed canopy

The plastic putty sealed canopy is certainly the solution of the most comfort. But on the one side it needs the most perfection of worker, on the other hand it is relatively sensitive against hard closing (f.i. of the wind!).

In much cases the lot of patience when installing such a sealing will not be honoured, the larger the canopy the minder. Plexiglas is working much in temperature changes, so that your canopy will fit exactly only in a narrow area of temperature. If it sits proper in 20° C, you can get angry in - 5°.

Also a very strong installed canopy may not be undangerous. The necessary of working is present, and if the canopy has not the possibility to follow it, the tension gets possible uncontrolled so that you earn a crash!

polish

If your canopy is no more good transparent or has scrapes you should polish it.

In hard cases, if the scrapes are deep, you need in the begin of the procedure abrasive paper of 600 or 400. You take than the next finer, and so you will end at least at 1000 or 1200. Wet grinding is better than dry.
After this comes the special polish work. Only experienced people can take the angle machine with a fabric disk (not the normal angle grinder - its velocity is nearly 10 000 rpm, this of the special machine perhaps 2 - 300.) If you are not very attentive and the polished spot gets warm you can earn a buckle! So for not so trained people it is better to use a fine polish solution for cars and do it by hands.

In such cases if the unprotected canopy will be moved often on its base you can help with a cover of self-gluing plastic foil.

Sealing of a plastic putty frame:

(GLASFLÜGEL and others)

Suppose that you lost your canopy, or may be just want to have a spare. We'll describe the entire procedure, and thereby cover all the simpler cases.

You will need:

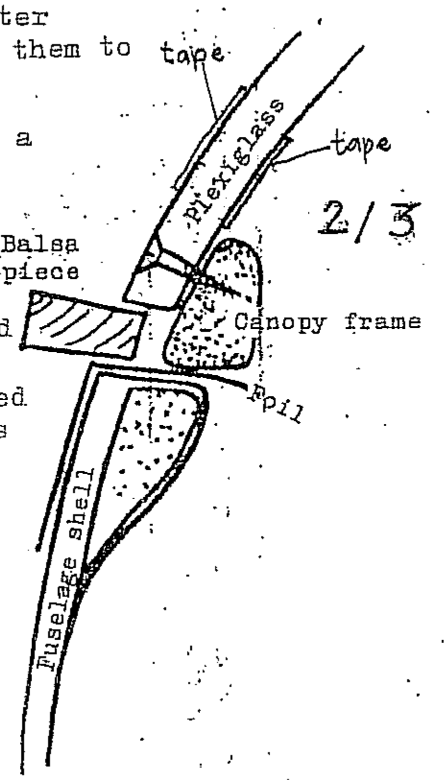
- A canopy frame,
- The untrimmed Plexiglass,
- Appropriate metal fittings and screws,
- Epoxy, glass fiber, etc. plexiglass glue

The Plexiglass comes with a protective layer on it; leave it on, wherever no glue need be applied, for protection.

1 First you have to fit the frame. Place all fittings and closing equipment on its place. Adjust the frame around so that it shows a distance of ca 3 - 4 mm around the fuselage contour (thickness of Plexi).

Caution: some later Libelle and the SALTO serial II have a frame with a step so that the plexi sits on the step and the step fits with the fuselage contour.

If the frame fits to your satisfaction, the fittings will be glued to the frame with fast polyester resin. Than you move it carefully and screw them to the frame.



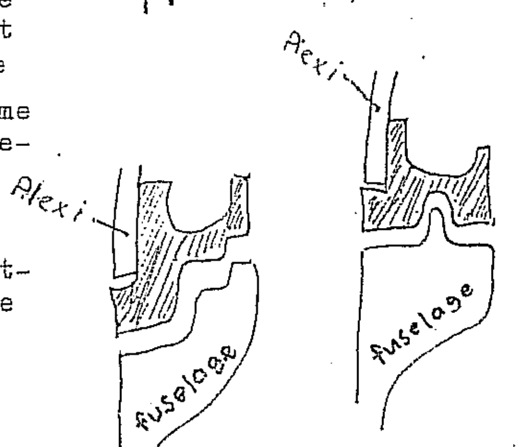
2 Now you adjust the plexiglass. Cut it raw with a angle cutter with a very little disk and equalize it with the anglegrinder.
Set the plexi on the fuselage. It must fit close to the frame when the glass is sitting on little pieces of balsawood ca 5 mm thick around the frame Never the plexi should be used as stroke on the fuselage.

During this procedure the frame must be fastened in its close fittings. Never put a canopy glass on a separate frame, this will never fit!

3 Drill first 6 to 8 holes for the screws, fix the plexi there and drill then the other needed holes (2,5 mm Ø for screws 2,9 mm Ø) Remove the canopy, light fixed on frame

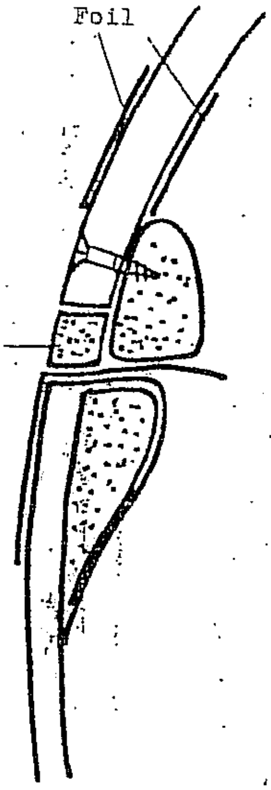
4 Protect the plexi on the inside with a tape directly on top of the frame. Cut with a sharp knife softly around the frame. If you remove then the screws you can loose this strip of protection foil. Here must be grinded the plexi. and also the frame

5 Protect the fuselage with a tape and some fat. Fix the frame correctly on the fuselage. Mix the glue following the directives and spread it out over the upper region of the prepared frame. Than you set up the plexi and screw it - but softly for to avoid crashes running from the screw holes.



Some newer canopy frames have a cross

The screws should be first fastened and then loose again for ca 1/4 turn. This will avoid the little cracks around the screws.



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6 If the thing is dry, you take a bunch of rovings, wet it with epoxy mix and place it into the gap between the plexi and the fuselage. With this you can fill nearly all the place so that on the one side you need not so much putty which is rigid and for this sensitive against shocks, on the other side you have protected the plexi too.

7 Now the outer contour of the canopy seems nearly o.k. The rest is done by putty and laquer. The claims to the fitting quality are different and so the time for the finish work changes.

When starting the finish work you place a protection tape outside of the canopy nearly parallel to the one of the inside. And then you need a quiet hand - take the sharp knife and follow the line of the tape around the canopy. After this you can remove this strip of protection foil and then you grind this area for to prepare it for good sitting putty and laquer.

8 If you are satisfied with the work you can remove all auxiliary and protection material. In some cases the protection foil is not moving very well; then you need water or spirit - never nitro thinner!

Tickling for Performance

Please do not await the deepest secrets of record fliers. Almost simple measures can bring notable better performance; for this they should be observed much more.

C.G. Position:

The most important mean to make more from your plane, and also the surest method to ruin a lot is the C.G position. Sometimes one's hairs are raising when observing the sins in this matter.

It is clear that a wing with a relatively high aspect ratio has a better performance than a not so wide one - but also a little possible area of useable C.G. If a modern airfoil will allow an area of let us say 30 - 45% reduced wing chord - so you have on a wing as SALTO and Libelle, both with nearly 630 mm reduced wing chord, not more than 100 mm. Inside of this little border you find all optimals, from best sinking to best glide ratio, and for this you have to balance really exactly if you wish to meet the for the case desired optimum.

So you should use the next rainy sunday and find out your personal flight C.G. - you will be astonished about the success!

You need: a place for the connected plane, with possible even ground, a wood showing the angle between fuselage surface and horizontal - this you find in your Flight and Servuce Manual - a scale for the tail weight, and two helpers.

First you have balanced exactly your plane, than yourself with all the equipment which you need during flying: hat, parachute, photo, breakfast etc., each on its place. Be clear that f.i. other shoes can reach a different C.G.!

In your FSM you find a drawing how you should adjust your plane for the C.G. ascertainment, also the formula. Sit in your plane, let held the wings horizontal with two fingers and let look the second helper for the tail weight.

Installed in the formula, you can calculate your C.G flight position in mms. For to change this in % of reduced wing chord, you need this from your sailplane manufacturer. He should tell you 1. the area, 2. the optimums.

Look that your personal flight C.G. is near of the optimum either for climbing or for gliding. With sitting position or equipment you should gamble a little; in the most cases you can avoid this lot of lead which I have seen in some planes.

The second check point you need is the zero position of your elevator. When a helper held the elevator in its zero position, you take a little ledge preferable from Balsawood for to adjust the delivered position of your stick referred to the instrument panel or another fixpoint.

The third is a little water balance which you can buy in hobbyworker's shops. You place it inside of the fuselage on a spot you can observe during flight. It shows you the exact horizontal position of your plane.

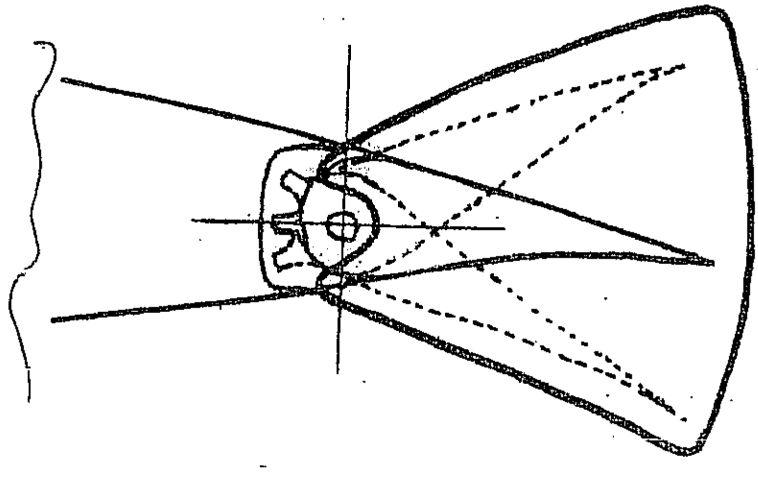
During the next flight in preferable quiet air you can check now if your plane is flying at the velocity of best gliding ratio with no redundant drag: straight fuselage, zero elevator.

Certainly the same for best sinking. Now you can calibrate your plane for the task you have in eyes. For aerobatic pilots specially it is indispensable to know his precise C.G. position because some figures, specially these with broken airflow, are only to fly exactly with the C.G. in a special precise position.

(Tip for SALTO pilots: the best gliding C.G. is at 300 mms, the possible area of C.G. is 235 - 335 mms, = 30 - 43%.)

Aileron endplates:

This penny cheap article can help you to circle for ca 8 km/h slower than without. You can do it yourself from a piece of stiff plastic foil, plywood etc.
They must be a little larger than the biggest aileron deflection for to avoid a blocking of aileron. After installing the plates the aileron must be to move fully free over the whole area and have a distance to the wing of ca 1,5 mms. You should colour the plates striking so that you avoid to catch on it.
The endplate is only effectful on the aileron root.



Cockpit airflow

You have pleasure if your cockpit is ggod airflowed on hot days. But are you sure that the incoming air can go out of the plane without redundant drag? If the air find no holes for to stream out through the fuselage and leave the plane behind the tail, it looks for other possibilities: press through the canopy gaps and disturb the airstream over the wings.
If you find necessary to drill holes for the leaving air, please be sure that you will not damage carrying parts. Better to ask the manufacturer.

Sealing

If you have a plane with through- going airbrake houses, you can reach only some success with silicone sealing paste. All other means may be payed with a bad fitting of the brakes.
But the most planes with an airbrake system Hütter (he was the inventor of these so-called Schempp-Hirth- brakes) have today separated houses so that you have no sealing problems.

Sealing of the aileron with inside tapes is only possible on ailerons with center hinging (GLASFLÜGEL, SALTO). In former times one used for this teflon tapes, which you had to remove if the aileron must be dismantled. Now we have this simple "V"- sealing tape from Tesa which you can buy in homeworker's shops, it is a sealing for windows but fits wonderful in our planes, also for tails.

It is also to use in some shell-hinging aileron systems.

Sealing with outside nylon buckled tapes: you should be sure that this is a win for your airfoil and not a lost; you should ask your manufacturer before using.
On SALTO's you should avoid to use this, specially on the tail!

Sealing the gaps between wing and fuselage: nobody has invented a better solution than these plastic tapes which move sometimes the laquer from the wings. The only method which looks acceptable is to use first a wider one, to cut it with a knife and rest it on the parts; on this tape is glued a smaller one which seals and will be removed when the plane gets disconnected.

Water ballast installing

is a "big change" and has to be licensed for this type of planes. The installing must be done under the eyes and with the confirming of a licensed person. The manufacturers held in stock parts for the installing.

The same is valid for adjusted wing enlarging.

Make a little gymnastique and look for the exact closing of your gear covers. The measures of a wind channel are related ever to really smooth fuselages!