SECTION 3

REPAIR OF WOODEN COMPONENTS

Chapter 3.1

TIMBERS AND PLYWOODS COMMONLY USED

It is essential that a repair should be made with material that is identical as regards strength and weight with the original structure and, therefore, it is necessary that an Inspector be able to recognise the various timbers used in glider construction with no possibility of error. All materials used will of course be of aircraft Specification and will have Release Notes issued with them so that there is no question as to their suitability for use in aircraft. If the Inspector has a set of drawings for the machine he will have the materials quoted on the drawing. However it frequently happens that the drawings are not immediately available and the Inspector will then have to decide for himself what materials have been used. Fortunately this is not very difficult.

Timber

Spruce

The main load carrying members of gliders are almost all made of spruce to Specification V 37. This is a light-coloured softwood of great strength/weight ratio. When broken, good spruce breaks with a fibrous fracture and all along the broken surfaces will be found tiny whiskers of grain that have pulled up. Bad, dry spruce breaks 'short' or snaps like a carrot and the whiskers are absent.

While spruce is more or less universal in this country, be on your guard against finding other substitute timbers in foreign gliders, particularly the older machines. Firs and pines of various types have been used, but if in doubt check with the manufacturer.

Ash

A white hardwood with characteristic flecks in the grain. Its great merit is that it has good resistance to bending and is therefore used for skids and occasionally for the keel of gliders.

Beech

A hardwood used for re-inforcing blocks in certain places. Some years ago it was used for making ply when Birch was in short supply, but this seems to have disappeared now. In colour it is a white-ish wood, darker than Ash and contains short flecks in the grain.

Birch

A hardwood used mainly in the manufacture of plywood but used on its own in certain applications. It faintly resembles Beech but is of a darker colour altogether. It is used for reinforcing blocks, tailskid spring-carrying members and in many aircraft where the fittings of the wings are attached to the spars.

Mahogany

Rather a generic term this, as there is a whole family of timbers which go by this name. It is a dark timber which comes from various places in the world (Honduras, Africa and other places). It varies in hardness but it has one great merit and that is its great resistance to shock, hence its use in places like wheelboxes and, in the Power Flying Sphere, for propellors.

In any workshop a lot of wood will be required for such things as jigs and, of course, this can be of any origin. However, the most important point to ensure is that this scrap timber can never be muddled up with the aircraft timber. A Bonded Store is an excellent idea if you can run to it. Basically it means a store where nothing but aircraft materials is stored and from which nothing is ever issued except with its Release Note. It does mean a more or less full time storeman and this is probably beyond most gliding clubs or repair organisations.

Plywoods

Plywoods can be divided into two basic types: High strength to Specification 6.V.3, and Low strength to Specification V35.

High strength ply to Specification 6.V.3 is almost always made of BIRCH laminations, though in years gone by, beech was used occasionally. It is always glued with waterproof synthetic glues. It is used in places where strength is of vital importance such as spar webs, leading edges. Consequently, when repairing members containing this material, only ply of the correct Specification may be used. It is obtainable in many thicknesses from less than 1 mm. up to almost any thickness, but ply thicker than 3/16 in. is not much used on gliders these days (1966).

Grain direction is very important and any replacements or insertions must follow the grain direction of the original structure if the strength of the repair is to be maintained. It is often applied to leading edges and to spar webs so that the grain lies in a diagonal direction to cope with the heavy shear stresses.

Low strength ply to Specification V35 is used in many applications where stiffness rather than strength is required. It is made usually of GABOON which is a soft, very light wood of the Mahogany family, darkish brown in colour. Waterproof synthetic glues are used for gluing the laminations. It is found in leading edges, fuselage skins and similar applications where accuracy of form is required. It must *never* be used to replace ply of the High strength 6.V.3 variety.

All ply repairs must be made to the correct Specification, of identical thickness to the original structure, and following the exact grain direction of the original.

All ply tends to suffer from a phenomenon known as 'case hardening'. The exact causes of this we need not go into, but the result is that in the manufacturing process, the ply surfaces may acquire a hard skin which interferes with the proper adhesion of glue. In consequence, before gluing ply, it must be *thoroughly sanded* to remove this hard skin. Failure to observe this precaution may result in very poor adhesion. One hardly need stress the disastrous possibilities.

There is a further application of ply that has been seen in certain gliders and will possibly become more popular. This is the ply sandwich, where two thin layers of ply are used, and the space between them is filled with a foamed plastic which is attached to the ply. It is perhaps a little early to try to lay down hard and fast methods of repairing these sandwiches, but as a general principle it can be said that if both layers of ply are repaired and new foam filling is inserted, properly attached to the ply surfaces, the repair will be satisfactory. The ply sandwich does enable the designer to produce exceedingly light but stiff shapes with the minimum of internal stiffening structure, and so is very valuable when forming leading edges to wings and suchlike parts of a glider.

Defects of Timber and Ply

While timber and ply can be assumed to be of Specification standard when new and purchased with Release Note, there are several factors which reduce the strength and quality if allowed to do so. These can broadly be divided into two categories, natural and mechanical...

The natural enemies of timber are moisture, either too much or too little, and insect attack. The moisture content of the timber is carefully regulated when the timber is inspected for approval and if the protective coating is properly maintained this should not alter very much. Possibly we should qualify the last statement by saying that, in the United Kingdom, the moisture content should not change very much. In tropical climates there is strong evidence that drying out of timber does tend to occur. In the United Kingdom however, if timber is allowed to become water soaked or even oil soaked there is always the danger of rot starting up. This is usually quite obvious. It starts with bacterial attack, discolouration of the timber and the deterioration can be quite easily detected by probing the timber.

Drying out of the timber is liable to occur if the machine is operated in very hot climates. In theory, the drier the timber, the stronger it becomes, but unfortunately the drier it becomes, the more brittle it becomes also. All one can say in this context is to keep the protective coating intact and protect the machine from unnecessary cooking in the sun or in the trailer. Should drying out be suspected it is probably wise to take a sample of the timber and have the moisture content checked and then consult the manufacturer.

Insect attack is not very common in this country but it is, of course, possible to get woodworm in a glider. The dopes that are used seem to discourage this activity, but if it should ever be found, then the entire machine is suspect, until every part has been checked and passed as free from damage. Overseas this may well be quite a problem but this is perhaps better left to those who have expert knowledge of the methods of dealing with this sort of thing in the various territories.

Mechanical damage to the timber is due either to mishandling on the ground, or to overstressing the timber. When timber fails in tension the failure is obvious, because the timber is broken quite clearly, and the damage can be seen. When, however, it fails in compression the damage is often much more difficult to spot. Frequently all that is visible is a 'compression shake'. FigureA. illustrates a typical compression shake. What

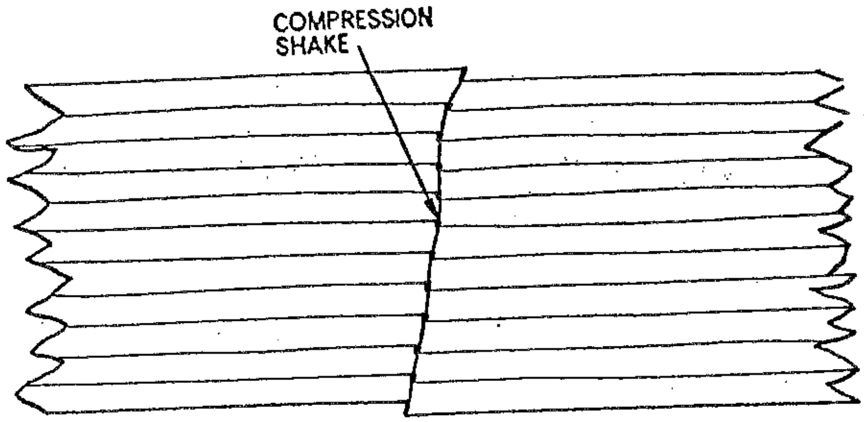

Figure A

has actually happened is that the fibres of the timber, instead of lying parallel to each other, have collapsed at one point and have folded over on to themselves, or 'telescoped'. The timber is useless and must be replaced by new timber. All that may be visible of this damage is a small hair line crack or fold in the paintwork. Some compression shakes are easy to see but some can be very tricky to detect. If you have any doubt whether a line is a compression shake or not, simply apply a small amount of bending to the member in question. If there is a compression shake in it the member will bend at that spot almost as if there were a hinge there.

There seems to be some evidence now that timber which has been repeatedly stressed to near its ultimate strength develops what is referred to as a 'Brash' condition. In this state the timber loses a lot of its resistance to shock and when broken it breaks 'short'. Some authorities regard this state as being the early state of the formation of compression shakes.

Apart from failure in tension and compression, timber may become bruised. If this happens, except in the case of the very smallest bruise, the damage must be cut out and new timber scarfed in to replace it. There is one other form of damage that cannot be left out. This is damage by lightning strike. A number of machines have been struck by lightning in the air but none so far has been damaged so as to require abandonment in the air. However, examination of some of the cases shows that lightning strikes can destroy timber in a most remarkable way. What appears to happen is that the charge of electricity follows metallic paths in some cases but, where it passes from a metallic path to a surface track, it often generates intense heat locally. This local heating is sufficient to vaporise the moisture in the timber, with the result that the timber is literally blown apart. This is not always obvious on a casual inspection, but as soon as the timber is prodded it is clear that the nature of the wood has gone and that all that is left is a spongy mass of wood fibres. This form of damage has only recently made its appearance in gliders, but should a machine have been taken anywhere near an electric storm, the most minute examination must be made for any signs of a strike. Should this be found then all the timber must be checked for this sort of damage. Also all the cables will have to be removed for inspection.

Chapter 3.2

GLUES AND GLUING

All gluing on gliders at the present time (1966) is done by synthetic resin glues. The day of Casein glue and animal glues is past and the synthetic resin glues have shown themselves to be infinitely superior in every way.

Three types of glue are commonly used. The first is ARALDITE which can be used for many purposes. In repair work its main application is for gluing timber or ply to glass fibre components. The glue is in two parts, the resin and the hardener. Both are liquids and are mixed together, in the correct proportions as given by the manufacturer, and then applied to both surfaces. The surfaces are then cramped in contact and the glue is allowed to set. It sets by chemical reaction and the time taken depends on the ambient temperature. Setting times are given by the manufacturer.

The second type of glue is AERODUX. This is also in two parts. The two liquids are mixed together in the correct proportions and then applied to the two surfaces, which are then cramped together in the same way. It is used for gluing timber to timber, or ply, and forms an excellent bond. It is an admirable glue for construction work, but it does suffer from disadvantages for repair work, in that the setting time is rather long. To be exact, it sets fairly rapidly, but it does not develop its full strength for some days, and this can be awkward in repair work. Again the manufacturer supplies full instructions for the use of this glue.

The third and most usually used glue for all timber and ply work is AEROLITE. This is also in two parts but the application of the glue is somewhat different. The glue proper is a treacly resin known as Aerolite 300 and the hardener is an acid. The hardener is made in three strengths: rapid, medium and slow. Each contains a stain to identify it, the rapid being stained amber, the medium green and the slow,* purple. The method of application is to apply the resin to one of the surfaces and the hardener to the other surface. The two surfaces are then brought into contact and cramped together to set. The hardener and the resin must *never* be brought into contact except in the manner just described as setting commences as soon as the two meet. The time taken for the joint to set depends on the temperature and can be made quite short: of the order of one hour, by the use of heat on the joint. Which hardener to use depends on the temperature and the speed of setting desired, and the manufacturer supplies tables of setting times for various hardeners and temperatures.

Aerolite 300 has a shelf life of three months from the date of manufacture. After this time slow setting of the resin takes place and the glue must not be used on aircraft, though it may be quite satisfactory for odd jobs. Clubs and repairers may find that it is more convenient to buy the resin in powder form in which case it is known as Aerolite 306. The powder is mixed with water to form the resin, again following the manufacturer's instructions, when the resin becomes Aerolite 300 and is treated in exactly the same way. In the powder form Aerolite 306 has a shelf life of two years provided that it is kept dry and airtight. When Aerolite 306 is used, sufficient time must be allowed after mixing with water to clear the mixture of air bubbles and this may take one or two days. Therefore it is a good plan to mix up the resin for a job several days in advance If kept airtight the mixed resin will remain in good condition for several weeks. If a skin should form on the resin this must be removed as it will not re-dissolve.

At the risk of being repetitive, let it be emphasised again that no glues may be used on any aircraft work unless those glues have been made for aircraft and a Release

*Recently the makers have been using a dark blue stain in place of the purple stain.

Note has been issued with the glue. This is vitally important as every batch of aircraft glue is tested to ensure that it is up to Specification. If you use glue without a Release Note you are asking for trouble.

The hardener of Aerolite is an acid and it is absolutely necessary that the hardener is wet or damp when the two surfaces meet. If the hardener is allowed to dry then the chemical reaction with the resin will not take place and the glue will not set. Anything that interferes with the acidity of the hardener will have a similar effect. This brings us to one very important point. Casein glue which is found on quite a number of older gliders is very alkaline and, if a joint has to be re-glued on a glider of this type, then special precautions must be taken. First clean off all the old casein glue and then paint hardener on both surfaces and allow it to dry. Repeat the painting with hardener and allow it to dry again. You will now have killed the alkalinity and can go ahead using the glue in the ordinary way: resin on one surface and hardener on the other.

This point cannot be overemphasised since there is no way of ensuring, once the joint has been made, that the hardener has done its job. The joint will look all right and the stain will prove that the hardener has been used but, if the casein were not properly killed, the joint will be worthless.

Another vitally important point must not be overlooked. A recent development in the construction of gliders is the use of metal-to-timber bonded components, notably the booms of spars. These are made up by bonding to the metal a thin lamination of timber, usually by the Redux process. The metal with its lamination of timber can then be glued to the rest of the timber structure in the ordinary way. Now Redux and the acid hardener of Aerolite do not agree and if they are allowed to come into contact, there is a real danger of the Redux bonding being destroyed. Therefore it is absolutely vital that if any repairs have to be done anywhere near a metal-to-timber Redux bond, Aerolite glue is *not used*. The only permissible adhesives are Aerodux or Araldite. Experiments are going on at present to determine if Araldite can be satisfactorily used for the metal-to-timber bond but for the present it is safer to assume that all these bonds are of Redux and to avoid the use of Aerolite anywhere near them.

Gluing

All this part of Chapter 2 refers to the use of Aerolite glue whether in the form of Aerolite 300 (the ready mixed resin) or Aerolite 306, the powder form of the resin mixed by the user. At the present time this is the usual glue used for repairs on timber to timber joints.

Glue must always be used in shear. Glue has not much strength when used in tension, but used in shear it is simple to obtain a joint that is far stronger than the timber. Figure B. should make this clear.

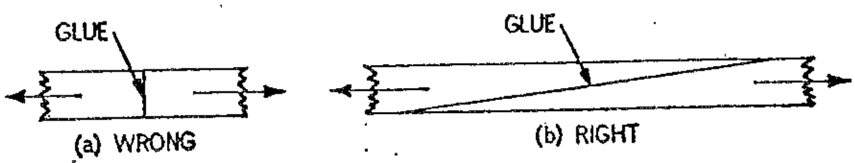

Figure B

The essential points to observe when gluing are the following:

1. The surfaces must be clean and this means that there must be no fingering of the timber after the final sanding of the surfaces, as even traces of perspiration from the fingers can spoil the adhesion of the glue.
2. The surfaces must fit accurately. It is difficult to express this in a quantitative manner by saying that a feeler gauge of such and such a thickness should not go through the joint since timber is a springy material, but the joints must fit over the whole area to be glued. If there is any doubt then the surfaces must be scraped, sanded or otherwise adjusted until they do fit.
3. The adhesive or resin must be spread on one surface covering it completely, and the hardener must be spread over the other surface and the two must be cramped together *while both surfaces are still wet.*

4. The joint must be kept cramped and not allowed to shift until the setting time has expired. If these points are observed Aerolite glue can be relied upon to produce a joint that is far stronger than the timber.

The setting time varies enormously depending upon the hardener used and the ambient temperature. At the bottom end of the scale do not attempt to glue at temperatures below 50°Fahr., though this can be done if measures are taken to heat the glue area. At the other end it is possible to cure a glue joint in something of the order of an hour at 90°Fahr.

For all joints, unless the workshop temperature is 65°Fahr. or above, it is advisable to use heat to cure the glue. This is not so complicated as it might at first appear. For a small ply patch the humble hot water bottle can be very useful, while an old electric blanket suitably covered with any scrap cloths or blankets can heat quite a large area. Radiant electric fires or infra-red heater bulbs of the type used by poultry and pig farmers can often be arranged to heat a setting joint, or, at a pinch, paraffin heaters with deflectors to send the heated air over the work will do the job well. As a rough guide, if the work feels warm to the touch the heat is sufficient. In all these methods do not forget the elementary fire precautions as the average workshop presents a fairly serious fire risk at the best of times.

When using Aerolite the joints should be cramped up until the surfaces are held in contact over the whole area to be glued. Excessive pressure should be avoided and nothing is gained by cramping up tighter than this. In the old days, using Casein and animal glues, the idea used to be to cramp up as tightly as possible, short of damaging the timber fibres, but tests have shown that this is definitely injurious to the strength of a glued joint made with Aerolite.

The resin can be spread most conveniently by means of a short stick of wood. The hardener, being a thin liquid, requires some sort of absorbent spreader. This is most easily made by wrapping a piece of felt or cloth round the end of a stick and tying it with string. Do not use tacks or nails to fasten it on as the acid will attack these. Alternatively a polythene bottle with a felt wick makes a good hardener spreader.

Some people may find that these synthetic resin adhesives cause skin troubles if allowed to remain in contact with the hands for any length of time. Water will wash the glues away quite easily provided that they have not been allowed to set on the hands, but if you do find you have trouble in this way, rubber gloves can be worn for the gluing operations.

Keep the resin and the hardener separate at all times. They must never be allowed to meet except in the manner described for making a joint. Should any of the hardener come into contact with the resin accidentally, then the resin must be thrown away as it is now contaminated.

Keep the two constituents of the glue in a cool dry place and if using the Aerolite 300 form of the resin always throw away any glue which is overdate. This overdated glue may, of course, be used on odd jobs if required, but it must *never* be used on aircraft work.

Whenever possible quote the batch number of the glue or the Release Note number in the log book of the aircraft. This is in your own interest, since it enables the glue to be traced back to the tester should there ever be any question as to its integrity.

Joints must be held in contact while the glue sets and there are two main ways of doing this. Firstly by cramps and secondly by tacks and tack strips. When using cramps do use pressure pads of odd pieces of timber to spread the cramp load, otherwise you may well damage the fibres of the timber with the serrated feet of the cramps.

When closing joints by means of tacks and tack strips, use a thickness of ply for the strip, something like the thickness of the ply on the repair. This will spread the load evenly between the tacks. Use the thinnest tacks that will do the job. Japanned gimp pins ½ in. or ⅝ in. long and of 20 or 22 gauge seem to cover most glider jobs. When the glue has set, remove the tacks and strips. The removal of the strips is made a good deal easier if strips of cellophane, or polythene, or even paper, are used between the ply and the strip, to prevent the excess glue from sticking the strip to the ply.

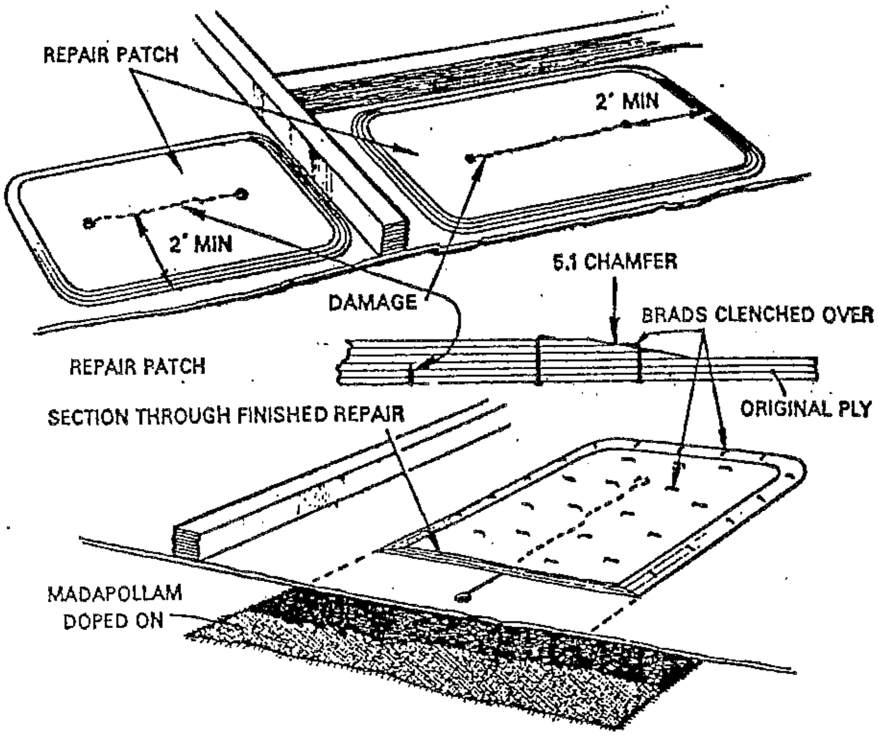

Illustration 3.3.1. Internal Ply Patch over Crack

Although you will always remove the tacks and strips where possible, there are a few jobs where it is necessary to tack up and leave the tacks in place. In these cases the tacks must be brass tacks. Apart from these special cases, japanned steel gimp pins work as well as any and they do not bend over so easily under the persuasion of the tack hammer.

When removing tack strips after the glue has set take care not to damage the surface of the newly glued joint. If you lift the tack strip off most of the tacks will be drawn with it, but a few may be left behind. These must be pulled straight out and not twisted out with pliers, or the ply surface will be dented by the edges of the pliers and the tack holes will be stretched. Both these defects mar the appearance of the joint and make the job of restoring a good finish much more difficult. Be particularly careful when dealing with gaboon ply as it is very soft.

Chapter 3.3

PLYWOOD REPAIRS

General Considerations

At the outset, let it be understood that in any wooden structure, if all the damaged timber is cut away and new timber scarfed in, using 12 : 1 minimum scarfing angles (or 15: 1 in the case of solid members) and all dimensions are as in the original structure, and assuming good workmanship and satisfactory gluing, the final result will be as strong as the original.

While it is almost impossible to compile a repair scheme to cover every possible form of damage that the repairer will ever have to cope with, a number of typical repair schemes are set out below and if the above paragraph is borne in mind, it will be found possible to work out a repair scheme for almost any sort of damage, though in many cases it will be necessary to use part of one scheme and part of another.

The schemes are numbered for easy reference, the first number referring to the Section, the second number to the Chapter and the third number indicates the Scheme in question.

Ply can be glued to ply in two ways, either by a Lap Joint or by a Scarf Joint.

Examples of the use of Lap Joint

Scheme 3.3.1. This is a plain ply patch to repair a crack in a ply panel. Use this method where:

1. The crack is not longer than 6 ins. (Longer than this it will be easier to replace the panel).
2. You can obtain an overlap of at least 2 ins. all round.
3. The ply is ⅛ in. or less in thickness.
4. The damage is accessible from both sides.

See illustration 3.3.1 and go ahead as follows:

1. Clean up fabric on the outside if necessary.
2. Drill ⅛ in. diameter holes at the ends of the cracks to prevent spreading.
3. Cut a patch (a) From the same grade and thickness of ply.
   (b) With the grain in the same direction as the panel.
   (c) Having the required overlap.
   (d) Corner radii of ½ in.
   (e) With all outer edges chamfered to 5 : 1.
4. Clean the surface of the damaged panel, sanding well, and thoroughly sand the patch.
5. Glue the patch centrally over the damage on the inside face of the damaged panel, bradding or stapling through if necessary on to pieces of scrap timber, to ensure that the patch is held down all over its surface. Alternatively fold the brads over.

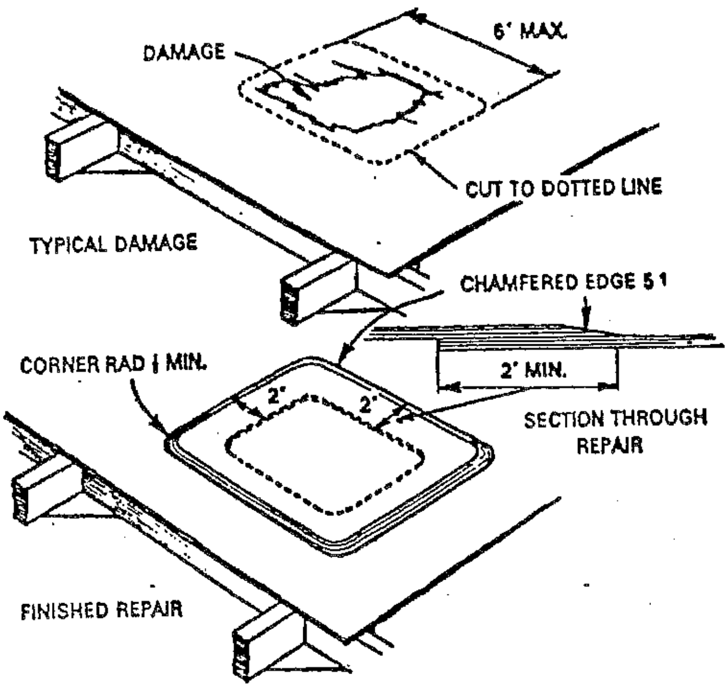

Illustration 3.3.2. Raised Patch Repair

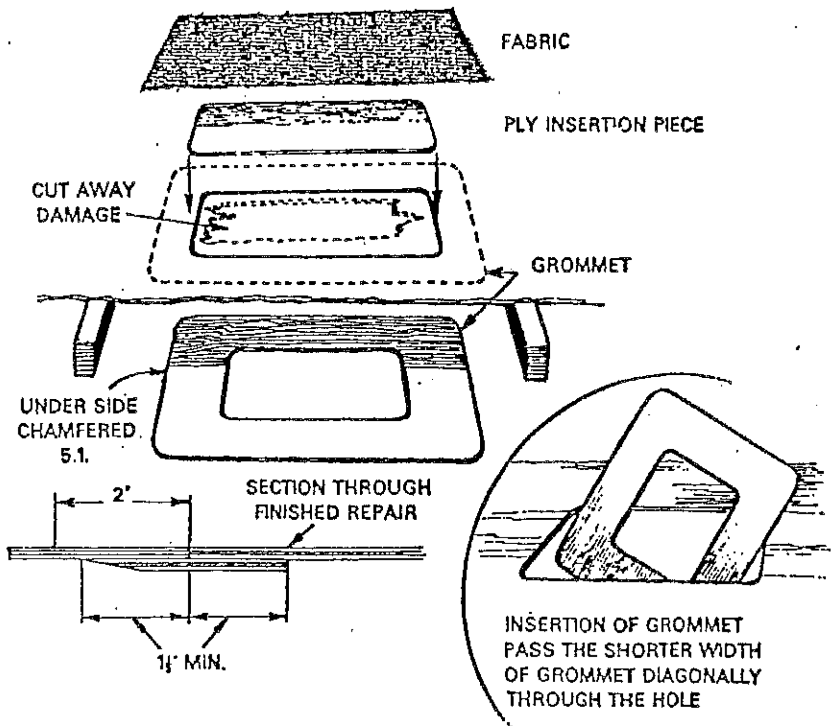

Illustration 3.3.3. Flush Butted Insertion Repair

6. Clean off excess glue
7. When the joint has set, remove the tacks, brads or staples and sand the repair smooth.
8. Apply a fabric patch (Madapollam DTD 343) over the outside of the repair, if this is an external surface, and make good the dope work.

Scheme 3.3.2. Raised Patch for internal ply panels. Use this method where:

1. The ply is ⅛ in. thick or less.
2. The repair is not exposed to the airflow.
3. The damage is not greater than 6 in. square.
4. Both sides are accessible.

See illustration 3.3.2 and go ahead as follows:

1. Cut away damaged ply leaving corner radii of ½ in. minimum.
2. Cut a patch: (a) From the same grade and thickness of ply as the original.
   (b) With the same grain direction as the damaged panel.
   (c) Having an overlap of 2 ins. all round.
   (d) With corner radii of ½ in. minimum and having outer edges chamfered to 5 : 1.
3. Clean all the surface to be glued.
4. Glue the patch in place closing the joint with brads, tacks or staples if necessary driving these through in to pieces of scrap timber to ensure that the patch is held down securely over its whole surface. Alternatively fold the brads over across the grain.
5. Clean off excess glue.
6. When the joint has set remove tacks, brads or staples and any tack strips, odd pieces of scrap timber and sand the repair smooth.

Scheme 3.3.3. Flush Butted Insertion repair. Use this method where:

1. The ply is ⅛ in. or less in thickness.
2. Not larger than 5 ins. across the grain or 7½ ins. along the grain.
3. Exposed to the airflow.
4. Accessible from both sides. (Note: this repair can be done even if only one side is accessible. In this case, though, special means will have to be taken to cramp up the grommet and the ply insertion patch may have to be held in place by straps.)

See illustration 3.3.3 and go ahead as follows:

1. Cut away fabric and clean up the hole to a rectangular shape with corner radii ½ in. minimum. (Note: diagonal of hole must be greater than shortest side of grommet, if the repair is accessible from one side only.)
2. Cut a plywood grommet:
   (a) From the same grade and thickness ply as the panel.
   (b) To give overlaps of 1½ in. minimum and corner radii of ½ in.
   (c) Outer edges chamfered to 5 : 1.
3. Cut a plywood insertion piece to fit the hole accurately, grain and thickness as panel.
4. Clean up the inside of the panel and the grommet and glue the grommet on the inside of the panel. Allow the glue to set.
5. Glue the insertion piece into the hole.
6. Clean up the job when the glue has set, apply stopper if necessary, rub down smooth and dope on a fabric patch (Madapollam DTD 343) on the outside of the job.

NOTES ON THE USE OF SCHEME 3.3.3: This is a very useful repair scheme for many jobs. However, think before you use it. It is often as easy to replace a ply panel complete to the next frame and this is a lighter job. For small jobs, the grommet can be solid and not cut out, but this makes gluing in a little more difficult, as you cannot put cramps through it to hold it in place while the glue is setting.

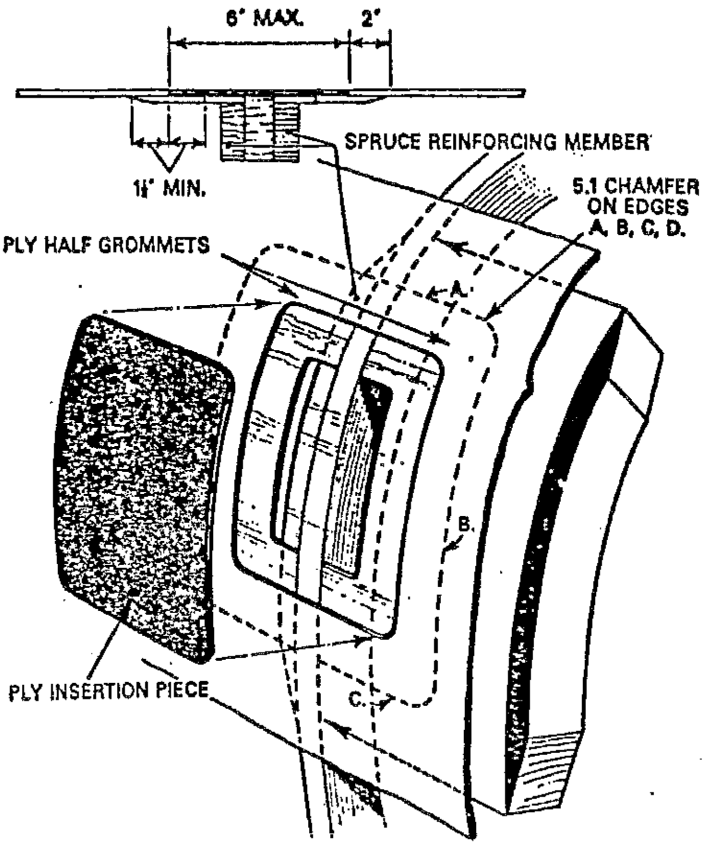

Illustration 3.3.4. Flush Butted Insertion Repair across Member

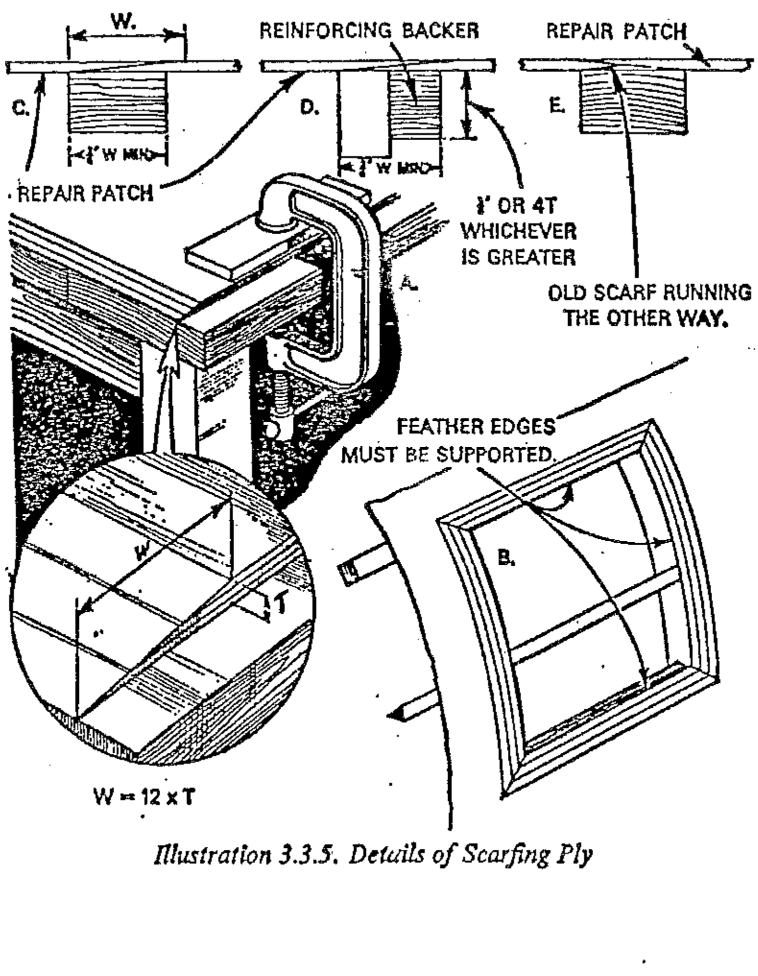

Illustration 3.3.5. Details of Scarfing Ply

The shape of the hole can also be almost anything you like, provided you can get the required overlap and that you can get the grommet through the hole. A straight sided hole with semi-circular ends is easy to shape, as the ends can be cut with a sharpened pair of dividers. Properly done this flush insertion repair is quite invisible after cleaning up, stopping and doping.

Scheme 3.3.4. Flush Butted Insertion Repair across Member

1. This is the same job as Scheme 3.3.3, except that it is adapted for use where the damage is over a member.
2. The member must be less than 1 in. wide and, if damaged, must be repaired by scarfing in a spruce insert at 15 : 1 splice angle before the ply repair is started.
3. The grommet is made in two pieces so that it fits on each side of the member.
4. Spruce reinforcing members are glued to each side of the member so that they support the edges of the half grommets. These members are ¼ in. thick, extend beyond the ends of the half grommets and have their ends chamfered off at 5 : 1.

For general instructions see Scheme 3.3.3 and read in conjunction with illustration 3.3.4. Do not use this Scheme for damage over 6 ins. square or the weight penalty will be considerable. In these cases it is better to replace the panel with new ply. Do not use this scheme on ply over ⅛ in. thick.

Scarfing Repairs in Ply

See illustration 3.3.5

The basic rules for scarfing ply are as follows:

The panel and the insert to go in must be scarfed accurately to an angle of 12 : 1 (Sketch A). The scarf must be supported over at least three quarters of its width but preferably over the whole width. This is necessary to allow the brads, tacks or staples to hold the scarf closed while the glue sets (Sketch C). Failure to ensure this will result in poor gluing. Reinforcing backers must be glued in if necessary to provide this support. It is, of course, possible in some cases to fit temporary backers to scarfs which can be removed after the glue has set and this is quite acceptable practice. It means that the joint must be accessible from both sides and care must be taken to ensure that the temporary backers are absolutely rigid otherwise they will not do their job (Sketches B, C and D).

When cutting away ply for the replacement of a panel, do not cut right back to the frames or ribs without thought. First cut away enough ply to enable you to measure the width of the frames, ribs, etc., and then you will know if you need to fit reinforcing members to give you the support over the three-quarters width of the scarf. If you need to fit these members it is much easier to fit them on the side of the frame or rib that you can see, rather than to have to fit them round at the back.

The support for the scarf must run right up to the edge of the inner feather edge, otherwise it is almost impossible to cut a good scarf, and it is equally difficult to ensure proper closing of the joint. (Sketch B). Make plenty of trial fits of the patch and do not glue it in until you are satisfied with the fit.

To glue the ply in, it must be held in position and the best way to do this is to use tack strips. These are strips of scrap ply of about the same thickness as the panel to be glued and the width of the scarf or thereabouts. If using tacks it is best to tap the tacks into the strips, so that all that is needed is to put the strip in place and drive the tacks home. Alternatively if you are using a stapler you can put the ply strip in place and staple it down. The tacks or staples must run into timber behind the ply. It is no use whatever trying to hold scarfs together by driving tacks or staples into thin air. Try to get the scarf closed with as little hammering as you can. Too much hammering tends to pump the glue out of the joint and let air in, both of which should be avoided.

Note the shuffling time allowed by the hardener and the temperature. This gives you a clue as to the best hardener for the job. Large jobs need slower hardeners generally, as you will take longer to tack them up. In extreme cases think whether it would not be

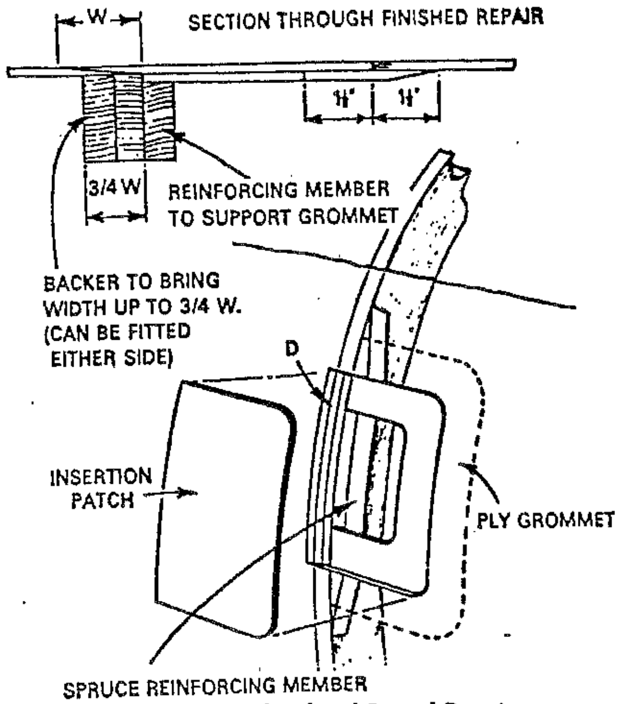

Illustration 3.3.6. Spliced and Butted Repair to Ply Panel

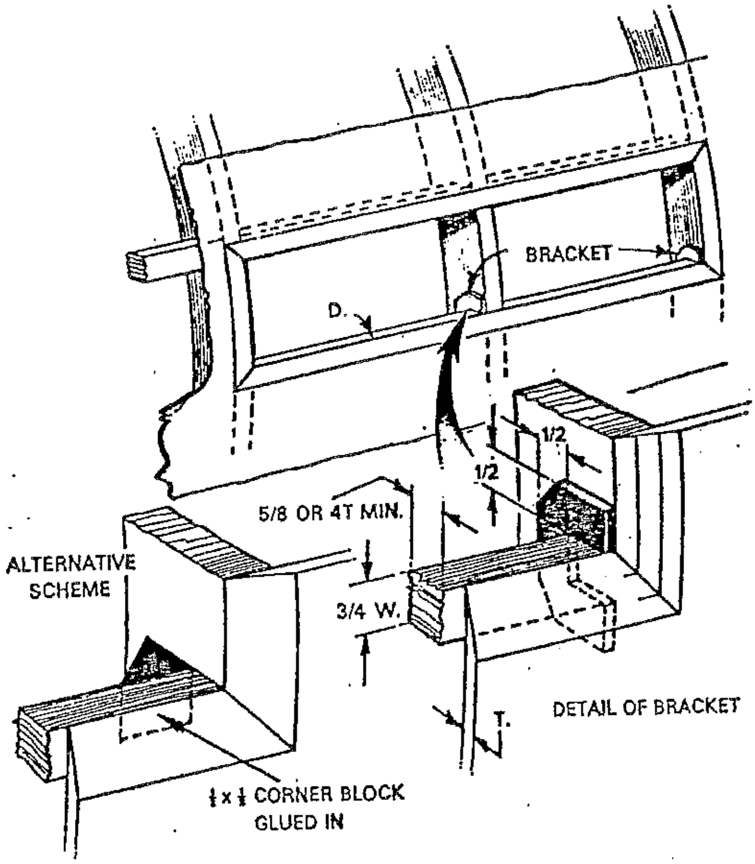

Illustration 3.3.7. Renewing a Portion of a Large Panel

better to recruit help in tacking up. Two or three people can tack in a large panel in a very short time and this may be necessary in the heat of Summer.

Frequently you will have to scarf at a point where there already is a scarf joint. If the direction of the new scarf is the same as the old then there is no problem. Cut down the old glue line, clean off the glue to raw wood and fit the patch. If the old scarf runs in the other direction simply ignore it and go ahead as if the old scarf were not there. The resultant joint will be amply strong (Sketch E).

When scarfing the patch to be fitted, secure it to the bench with cramps or tacks, with the edge to be scarfed exactly flush with the edge of a piece of planed wood, preferably hardwood. This will enable you to cut the scarf without damaging the feather edge (Sketch A).

These points are shown in the various sketches of illustration 3.3.5.

Scheme 3.3.6. Spliced and Butted Repair to Ply Panel.
This is a variety of Scheme 3.3.3 and Scheme 3.3.4, and is useful where the damage is close to a member. The same general considerations apply.

Remember that the thickness of the member must be at least three quarters 'W', where 'W' is the width of the scarf. If necessary the member must be built up to this thickness by means of spruce re-inforcing members. These re-inforcing members, if used, must have their ends chamfered off at an angle of at least 5 : 1.
See illustration 3.3.6 and go ahead as follows:

1. Clean out the damage and measure the thickness of the ply.
2. Measure the thickness of the member and if this is less than three quarters the width of the scarf, then make and fit a reinforcing block to bring the thickness up to this. (This is easier to fit on the side that you can see, so do not cut right back to the member without thought).
3. Scarf the ply at edge 'D' to 12 : 1.
4. Make the grommet as in Scheme 3.3.4 and glue it in, fitting spruce reinforcing members to support the edges. Make the plywood insertion piece as in Scheme 3.3.4, scarf the edge and glue it into place.
5. When set, remove tack strips, stopper up the repair as necessary and dope on a Madapollam patch as in Scheme 3.3.4.

NOTE: Any damage to the member must be repaired by insertions of spruce at 15 : 1 splicing angle before the ply repair is begun.

Scheme 3.3.7. Renewing a Portion of a Large Panel.
Use this method for extensive damage which:

(a) does not involve the whole panel.
(b) Requires a portion of a panel to be removed to obtain access to damage behind it.

See illustration 3.3.7 (and 3.3.5) and go ahead as follows:

1. Cut away the damage, and examine the thickness of the members surrounding the hole, to determine if any reinforcing members are needed to bring the thicknesses up to ¾'W' (the width of the scarf).
2. If any re-inforcing members are needed, glue them into place before cutting back the edges of the hole.
3. Make and glue in the support member of the edge 'D' of a width of '¾W', the width of the scarf, minimum and T in. deep (or 4'T' whichever is the greater, 'T' being the thickness of the ply). Fit support brackets or corner blocks to the ends of this member.
4. Scarf all the edges to 12 : 1 angle.
5. From ply of the same thickness and grade as the original panel, cut a patch to fit the hole and scarf all the edges to 12 : 1.

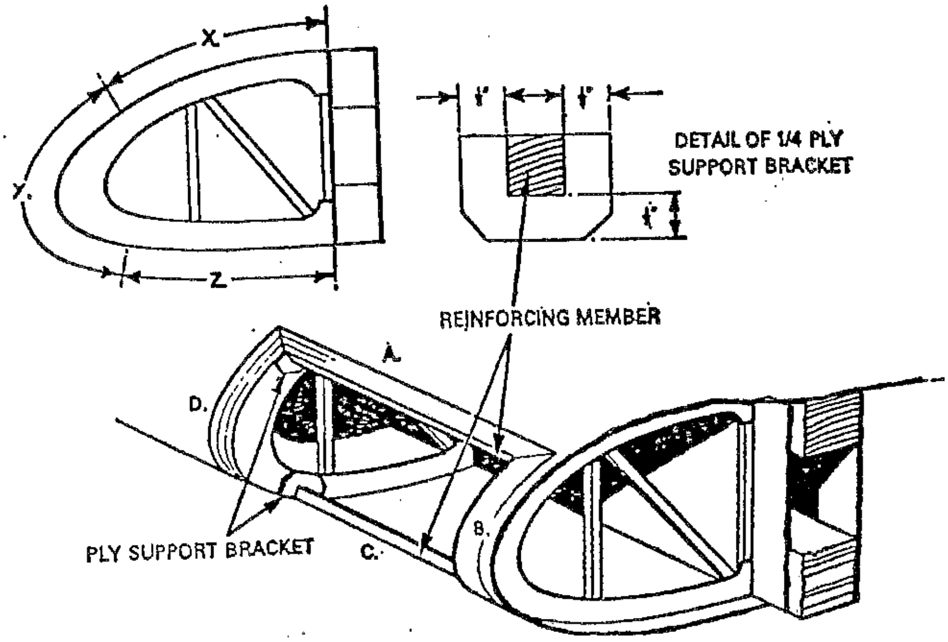

Illustration 3.3.8. Ply Leading Edge Repair

6. When satisfied with the fit of the patch, glue it in.
7. When set remove all tacks, tack strip and dope a fabric patch (Madapollam DTD 343) over the repair.

Scheme 3.3.8. Ply Leading Edge Repair.
Use this method where the damage does not warrant replacing the ply round the leading edge from the top to the bottom boom of the spar.

Do not try to make the scarf joints in the sharply curved portion marked 'Y' in the sketch. All scarf joints should be in the portions 'X' or 'Z'.
See illustration 3.3.8 and go ahead as follows:

1. Cut away fabric and damaged plywood to ribs such as 'B' and 'D' spanwise and to lines such as 'A' and 'C'.
2. Clean up the edges 'B' and 'D' and pack the ribs out to ¾W, if the ribs are not already this thickness.
3. Cut reinforcing members ¾W wide and ⅜ in. thick of spruce and make the support brackets or corner blocks. Glue these in to support the free edges of the ply at 'A' and 'C'.
4. Scarf edges 'A', 'B', 'C', 'D' to an angle of 12 : 1.
5. Cut an insertion panel from the same grade and thickness of ply as the original structure and with the *same grain direction*. This is particularly important. Many gliders have diagonal grain ply on the leading edges. Scarf all the edges to an angle of 12 : 1 and fit the panel accurately.
6. Glue and brad or staple the panel into position.
7. When set remove all tacks, brads or staples, clean the repair up, and dope a fabric patch Madapollam DTD 343 over the repair, with an overlap of 2 in. all round and edges frayed for ¹⁄₁₆ in.

NOTES ON SCHEME 3.3.8: If the curvature of the panel is great, it may be necessary to preform the panel. This is best done by steaming the panel or soaking in hot water and then strapping in place and allowing to cool. Do this before scarfing the edges 'A' and 'C' of the insert or you will ruin them. When dry and formed roughly to shape, scarf the edges 'A' and 'C'. Make sure that the panel is quite dry before gluing in.

If the wing has a leading edge member, you can scarf on to it only if the curvature is gentle enough to allow it. This must be judged taking the thickness of the ply into account and also whether you are working on a straight grain or diagonal ply.

You may cross several ribs in this repair if necessary. The only limitation is the size of the sheet of ply from which you cut your repair panel.

If the damage is fairly extensive, consider whether it would not be easier to scarf right back to the spar boom on one or both edges. This avoids the operation of fitting the reinforcing members on edges 'A' and 'C' but uses up more ply. Note that if a large piece of leading edge ply is removed, care must be taken to ensure that no twisting of the spar is permitted while the wing is open. It may be necessary to put the wing into a jig to prevent this, and a clinometer should be used frequently to make sure that no twist is being built in, as the leading edge ply is replaced.

Scheme 3.3.9. Renewing a Large Panel.

A large panel can be replaced by using Scheme 3.3.7, with the exception that the damage is cut away to existing members that are undamaged or which have been repaired. In this case there is no need to fit a reinforcing member to an unsupported edge, but care must be taken to ensure that there is ¾'W' thickness at each of the edges. If the members are not of this thickness, then backers will have to be fitted to bring the thickness up to this. No illustration is provided for this scheme as it uses the techniques of illustration 3.3.7.

NOTES: Think well how long it is going to take you to tack or staple up the panel. If the temperature is high, it may be necessary to recruit help to get it tacked up within the permitted shuffling time. Do remember too, to make sure that the panel is glued to any members that cross the hole. The position of these must be marked on the panel and tack strip must be prepared for all these glue lines. As a help, when fitting a large panel, to getting the scarfs accurate, drive in a few tacks half-home, say one at each corner, and then clip off their heads. The panel can then be lifted off the tacks for adjustment and then refitted carefully, by slipping it back over these tacks into exactly the same position. Two or three trials and you can get the fit right. These 'positioner' tacks also guarantee that the panel goes into exactly the right position when you glue it in. They can be drawn easily enough when you come up to them with the tack strip.

Chapter 3.4

SOLID MEMBER REPAIRS

General Notes

In gliders built of wood, the main load carrying members are usually made of spruce or one of the spruce substitutes, and if there should be any doubt in the repairer's mind as to which timber has been used, he should refer to the manufacturer. In many cases it will be found that apparently solid members are, in fact, laminated out of several thicknesses of spruce. This has two advantages: one, in the case of large sections, the final result is less likely to contain any local weaknesses and two, it is easy to obtain sharply curved shapes by building up with laminations, and to keep the grain direction running along the member.

Now when repairing solid members, laminated or not, bear in mind the angle of 15 : 1. This is not only the angle at which you must scarf the joints, but it is also the maximum angle at which the grain direction may lie to the length of the member. Any repair must satisfy both these requirements.

It is often not easy to determine the direction of the grain in a piece of spruce. Do not be misled by the 'flower', or pattern of the sections of the annual rings as they appear on the surface of a piece of cut spruce. This can be very misleading. If there is any doubt in your mind, put a spot of ink on the wood surface and watch for the lines that show up as the ink runs along the grain.

Laminated members can usually be treated as solid and repaired by solid inserts if necessary, but you must always check to see that the 15 : 1 rule is not being broken. By this is meant that, when you come to splice in an insert of spruce, into the curved surface of a frame in a fuselage, you will find that there is a limit to the length of insert that you can put in. A short insert will give you your 15 : 1 scarfs and the grain direction can be arranged to run more or less parallel to the scarf line. Try to fit a longer insertion in, and you soon find that it is impossible to keep within the 15 : 1 limit on both scarfs, and the centre line of the member. The grain direction is bound to run shorter than 15 : 1 somewhere. In this sort of case the easy way out is to laminate a piece of spruce to make a short length of member of the right curvature and the right section. The rest is simple. Cut your 15 : 1 scarfs and glue the insert in. Since the insert itself is laminated the grain direction will run along it everywhere, so there is no question of finding a place where the grain inclination is less than 15 : 1. To make the laminated piece is not as difficult as it might seem. It is not necessary to get *exactly* the right curvature or section when laminating up. If you will allow yourself a little extra when laminating the thing up, when you come to clean the job up after gluing, you can true the thing down to size. Often when making a piece for a frame insertion, you can strap the bunch

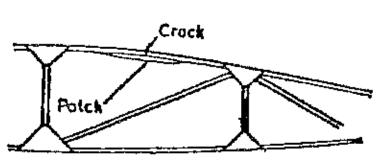

Illustration 3.4.1. Lap Joint Repair to Rib Boom

of laths, that you are using to laminate the new insertion, direct to the old frame and thus take the shape for the new piece from the old. Care must be taken, of course, to ensure that plenty of greaseproof paper is used in this case, so that the new piece does not adhere to the structure while it is setting.

In general, all repairs to solid members are made by the use of scarf joints. Very occasionally there are some trivial repairs which can be dealt with by lap joints. Illustration 3.4.1 shows a case of this.

The patch piece is made of the same section as the rib boom, the parallel portion being at least ten times the thickness of the boom, and the ends of the patch piece must be chamfered down at an angle of 5 : 1. This is a satisfactory sort of repair for this job, but its disadvantages are obvious. The job is heavier than before, and the boom stiffness has been greatly increased at this spot. Not very important points, perhaps, in a rib boom, but we must not allow this sort of thing in the more important structural members of the glider.

When closing and gluing the scarfs in solid spruce members, the same rules apply as in the case of ply scarfs. The joint must be held in contact all over the joint and not allowed to move until the glue has set. For this purpose you will need to use some sort of cramp, and most workshops have a large selection of various sizes of 'G' cramp. When using these 'G' cramps never put them straight on to the timber. If you do you will almost certainly crush some of the fibres, and this is the equivalent of putting in a compression shake. Always put a piece of scrap timber between the cramp and the job. This way you spread the load and do not damage the timber of the repair. You will need a lot of these 'G' cramps as they are most useful, and many jobs cannot be done without them. Do not try to tack up solid splices. Tacks are just not up to this sort of work, and if you try anything heavier, you stand a good chance of damaging the timber. Tacks can be useful for another purpose though. Frequently the job of positioning the bits is difficult while gluing up, and a tack or two can be helpful here. Preferably use them as described above when discussing ply repairs, i.e. drive them lightly in and then clip off their heads. The insertion pieces can then be lifted off, and replaced, as often as you like, while fitting up and adjusting the scarfs, and you do ensure that they go back into exactly the same position every time. When you are satisfied that the fit is correct, you can cramp up the glued joint and draw out the positioner tacks as you come to them.

In the past it has been the practice to reinforce over the uncovered feather edge of a splice, by gluing on a spruce member of ¼ T thickness (where T is the thickness of the member) to carry the load over the feather edge. There was also the idea that the feather edge might start to lift and allow a crack to run in. Modern experience has shown that this practice does more harm than good. Present day adhesives have such a vast gluing power that these reinforcers are quite unnecessary. More, they do actual damage, since they form local stiffenings at the places where the splices are made and this simply asks for compression shakes to start up at the ends of the splices. Several cases of this happening have occurred recently, yet in no case has a properly made 15 : 1 splice shown any sign of opening. Indeed, it would be surprising if one did, since all tests show that Aerolite glue has a strength far in excess of that of timber.

The workmanship in making these splices must be good. This does not mean that a repair man has got to have some fantastic skill to make a good scarf. Anybody can do it provided that he is prepared to take trouble over it. The scarfs must really fit and they must be scraped, chiselled and sanded until they do fit. The only real difference between the skilled and the unskilled repair man is that the skilled man is so used to the job that he can produce a splice with three or four strokes of a plane which takes the unskilled man a whole morning to produce.

In the case of ply scarfs we saw that we may cross an old scarf with a new one. This is *not* permissible in scarfs in solid spruce members. In solid members we can place the scarfs anywhere we like so there is never any trouble in avoiding previous scarfs: while ply scarfs have to be made at frames or other places where there is sufficient support. Scarfs in solid members must never overlap other scarfs and this is where a little study of the log book of the glider may save you a lot of trouble. If you are going to scarf something which is ply covered, have a look in the log book first. Somebody may have already scarfed the piece you are going to repair and, if you can find out where the scarf is, you can avoid a lot of work. If you wade in without thought, you may well find that this old scarf comes right in the middle of your repair, and you have then to do a lot more cutting back to get your scarfs clear of the old one. When you have done the job, think of the next man, and write up the particulars in the log book, specifying where you have put the scarfs. In the case of spar booms, it is a very good idea to glue on to the web a tiny diamond shaped piece of ply, about $\frac{3}{8}$ in. long, over the centre line of the splice as a further reminder. This of course applies to box spars where the splice cannot be seen until the box is opened up.

Finally, at the risk of being repetitive, let it be said again that nothing, except approved materials, glue, timber and ply may be incorporated into the structure of a glider, and the proof of the use of approved materials must be supplied, in the form of the Release Note numbers in the log book when the repair is written up and signed by the Inspector.

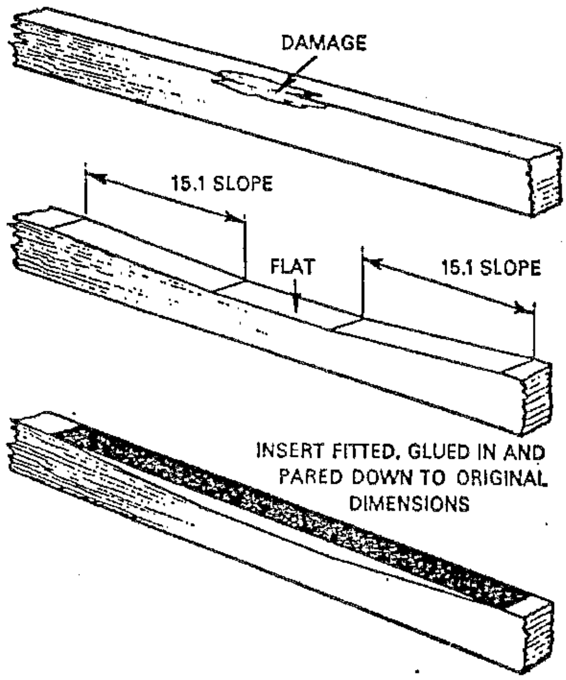

Illustration 3.4.2. Repair of Minor Damage to Solid Members

Scheme 3.4.2. Repair of Minor Damage to Solid Members.

Use this method where:

1. The member is not ply covered.
2. The bruising or damage is not more than $\frac{1}{8}$ of the minimum depth of the member.
3. There is no sign of compression shake.
4. The 15 : 1 rule can be complied with.

See illustration 3.4.2 and go ahead as follows:

1. Pare down the damaged area to a flat surface.
2. Taper out the step in the member to 15 : 1.
3. From a piece of spruce prepare the insert with splices running out at 15 : 1 at the ends and fit this accurately to the prepared surface of the member. Do not, at this stage, cut the insert down to size.
4. Glue and cramp the insert into place.
5. When the glue has set, remove the cramps and carefully shape the insert down to the original dimensions of the member.
6. Restore any protective treatment to the same standard as the original member.

NOTES ON SCHEME 3.4.2: In certain circumstances this repair can be used on ply covered members. The ply must be removed, to enable the member to be repaired, and after this is finished, new ply must be scarfed in at an angle of 12 : 1 to restore the ply panel to its original state. The important thing is to see that spruce does not replace ply or vice versa. The ply will have to have backers fitted to all the scarfs, unless it can be cut back to members which supply the necessary ¾ width of scarf support. The latter course frequently saves time and weight though it does mean a larger piece of inserted ply.

Scheme 3.4.3. Insertion Repair to Solid Members, Longerons, etc.
Use this method where the damage is greater than can be dealt with by Scheme 3.4.2. Remember that frames must not be cut away to accommodate repairs. Frequently you will have to make the splices in two separate bays to get the necessary 15 : 1 splices. See illustration 3.4.3 and go ahead as follows:

1. Cut away ply as required to gain access to the damaged member.
2. Cut out the damaged part of the longeron, making sure that all the damaged timber is removed.
3. Scarf the ends down at 15 : 1 angle.
4. From a piece of spruce of the same section and grade as the original longeron, make an insertion piece with ends scarfed off at 15 : 1 angle and tool this to fit accurately.
5. Glue the insertion piece into place, using cramps and pieces of scrap timber as load spreaders. Note particularly that cramps must not be applied directly to the joint, or the feet of the cramps will crush the timber fibres.
6. When the glue has set, remove cramps and scrap timber, clean the joint up and replace the ply, if any, using a suitable scheme from Chapter 3.3.
7. When any ply repairs have set, clean up the repair and make good any fabric work with a patch of Madapollam DTD 343.

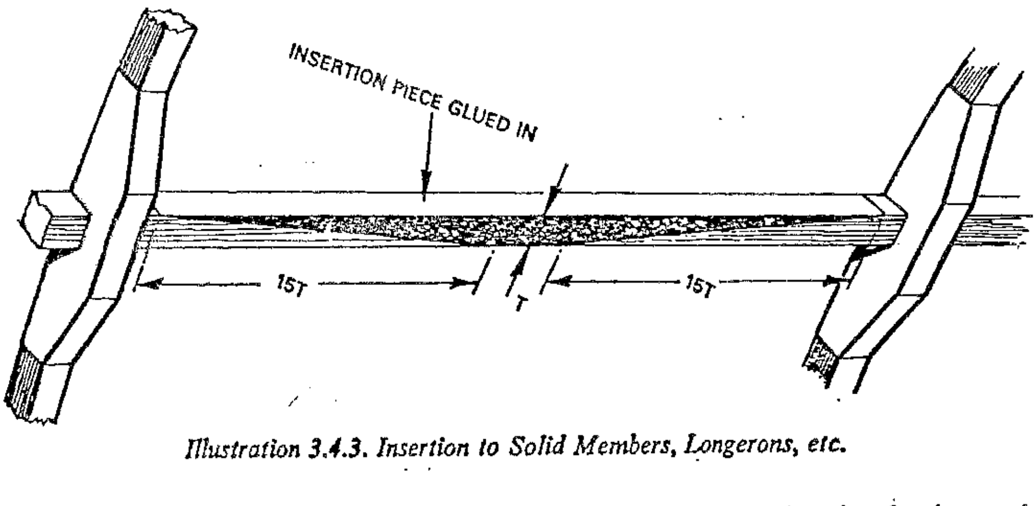

Illustration 3.4.3. Insertion to Solid Members, Longerons, etc.

NOTES ON SCHEME 3.4.3: Sometimes it is convenient to glue in the insert before finishing it to size. This applies where the insert does not run through a frame. If it does run through a frame then, of course, it must be finished to size and accurately fitted to the notch in the frame before gluing up. It will need to be cramped or otherwise held into the frame while the glue is setting. Thin pins, preferably brass, may be used for this but in general avoid pinning if cramping can be used.

Do not fit reinforcing blocks. They cause more trouble than they save. Rely on accurately fitting splices and make sure that the joint is correct for cross section all over the repair. A small caliper gauge of the vernier type is useful for this.

To avoid the possibility of the scrap timber sticking to the repair, it is sometimes helpful to wrap the scrap pieces in greaseproof paper or newspaper. Any adhering bits of paper can easily be sanded off.

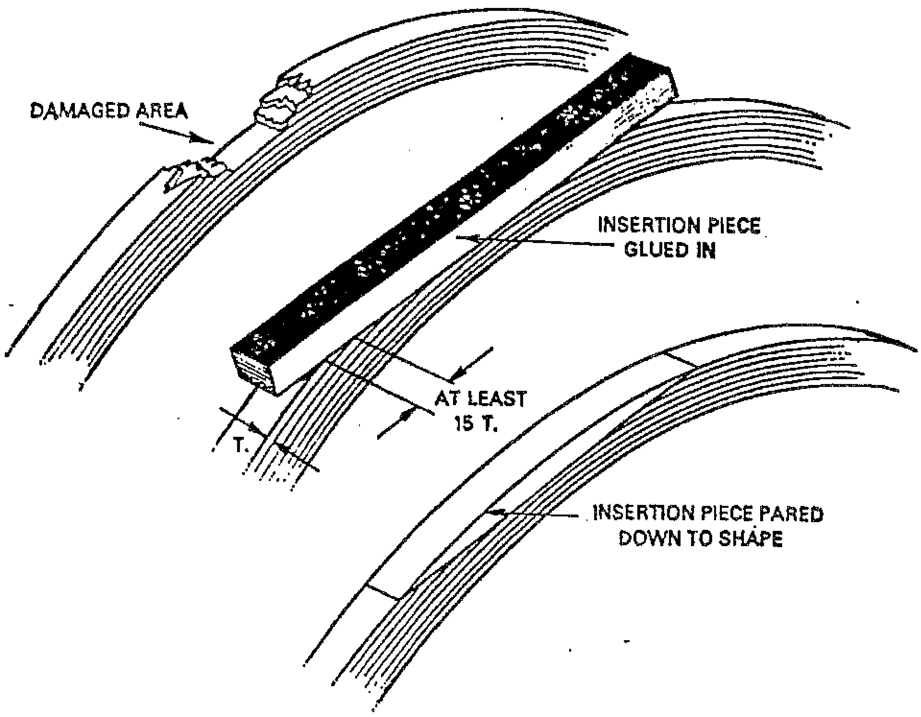

Illustration 3.4.4. Repair of Minor Damage to Laminated Member

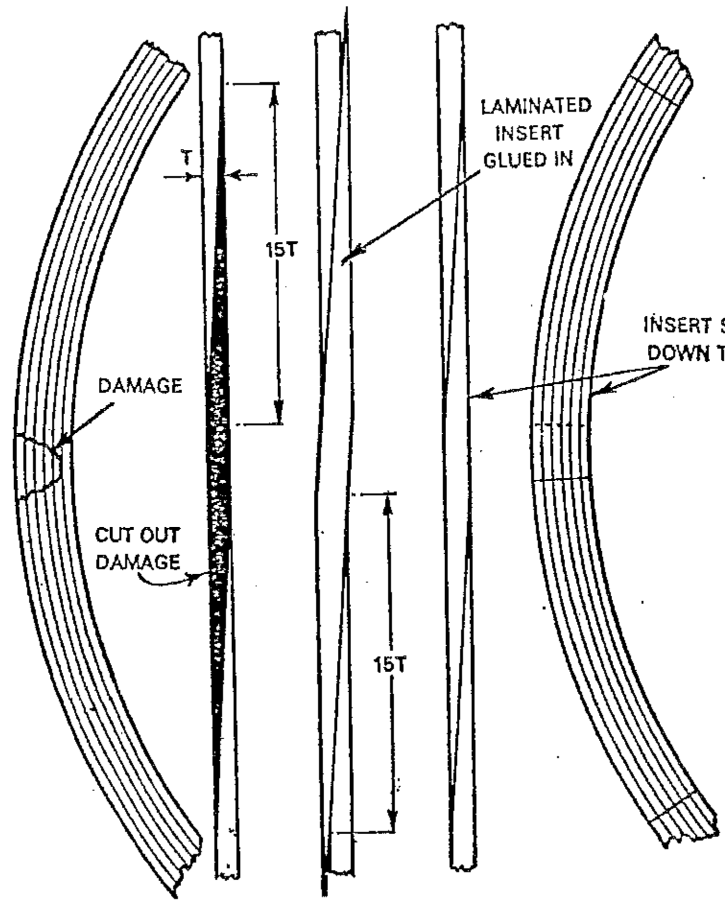

Illustration 3.4.5. Insertion Repair to Laminated Member

Scheme 3.4.4. Repair of Minor Damage to Laminated Member.
Use this method where cutting away the damage to the member in a straight line crosses the glue lines of the laminations, *and* the grain of the timber at less than 15 : 1.
See illustration 3.4.4 and go ahead as follows:

1. Remove any ply necessary to get at the damage.
2. With a straight edge, pencil the line which will remove all the damage.
3. Examine the angle at which this line crosses the laminations and if less than 15 : 1 plane down to a straight line to give a perfectly flat surface.
4. From a piece of spruce of the same grade as the original prepare an insertion piece and tool the surfaces to fit. Do not at this stage shape the insertion piece to exact size.
5. Glue in the insertion piece, cramping as necessary and using scrap timber load spreaders.
6. When the glue has set, remove cramps and carefully pare down the insertion piece to the exact size of the original member.
7. Replace any ply removed using a suitable scheme from Chapter 3.3.
8. Clean up the ply repair and patch with Madapollam DTD 343.

NOTE ON SCHEME 3.4.4: This scheme can only be used on the outside of frames, i.e. the convex edge.

Scheme 3.4.5. Insertion Repair to Laminated Member.
Use this method where the damage is such that scheme 3.4.4. cannot be used, either because the member is broken or the 15 : 1 rule cannot be met.
See illustration 3.4.5 and go ahead as follows:

1. Remove ply as necessary to get at the damage.
2. Cut out the damage to the laminated member and scarf the ends to an angle of 15 : 1. This scarf may be made in either plane but it is easier generally to scarf in the direction of the flat surfaces of the member.
3. Make up a laminated insertion piece. Sometimes a jig must be constructed to glue up the laminations, but frequently the insert can be glued up, using a piece of the adjacent structure of the glider to get the shape required. Make the insertion piece somewhat oversize to start with, unless it has to pass through or fit any other parts of the structure. Scarf the ends at 15 : 1 and tool the scarfs until they fit.
4. Glue in the insertion piece, using cramps and scrap timber load spreaders.
5. When the glue has set, remove cramps and pare the insertion piece carefully to size.
6. Replace any ply removed, using a suitable scheme from Chapter 3.3.
7. Clean up the repair and patch with Madapollam DTD 343.

NOTES ON SCHEME 3.4.5: Often you will find that one side of a laminated frame member is glued to a ply web. If this web is undamaged then you can go ahead as above, but you will have to fit the edge of the laminated insertion piece to the web, as well as fit the scarfs together before gluing up. This should not present much difficulty. If the web is damaged, it is usually easier to repair the frame first, and then repair the ply web afterwards, using any suitable scheme from Chapter 3.3. If the frame should have a ply web on both sides, then one side will have to be cut back sufficiently to let you get at the job. Obviously if one web is damaged then you will cut that one away, so that you do not have to repair both webs. Unless the curvature is very small, it is better to scarf the parallel sides of the member. Otherwise you will find that the scarf angle runs steeper than 15 : 1 at one end. Reference to illustration 3.4.4 should make this clear. At the middle of the insertion piece the scarf angle is zero, but it increases steadily towards the ends of the scarf and, of course, the maximum angle permitted is 15 : 1 at the ends.

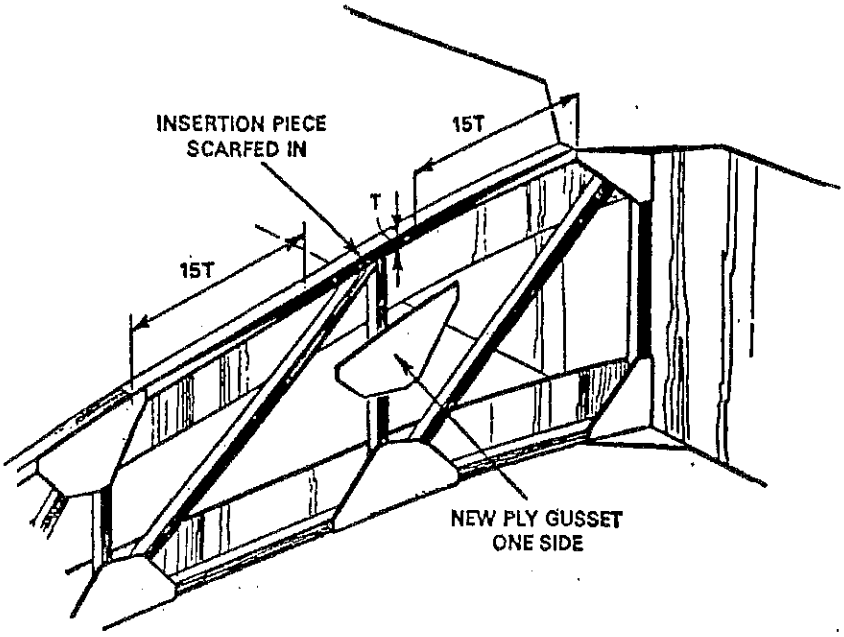

Illustration 3.4.6. Rib Boom Repair

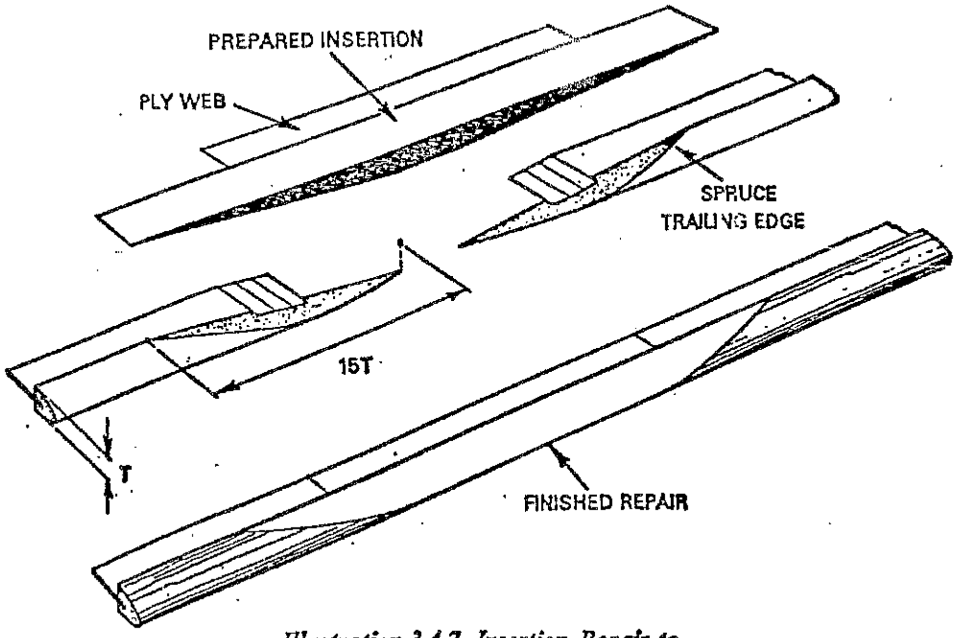

Illustration 3.4.7. Insertion Repair to Trailing Edge Member

Rib and Trailing Edge Repairs

The ribs in the wings of most wooden gliders are simple lattice work girders, made of small section spruce members joined by ply gussets. Should any of the diagonal members of a rib be damaged, the repair is obvious and requires no illustration. Simply remove the gussets as necessary, cut a new spruce member of the correct section and length, glue it in and glue on a new gusset of ply. When doing any rib repairs it is important that the correct shape of the rib is preserved and to ensure this, it is often a good plan to place a straight edge across the damaged rib and several good ones. This at once shows up any fault in the shape of the damaged rib and the fault can be corrected before gluing in the new members and gussets.

In the general notes at the beginning of this Chapter we did touch on the repair of ribs, when discussing the occasional use of lap joints in solid member repairs, and illustration 3.4.1 shows a lap joint used to repair a rib boom. The disadvantages of this sort of repair were pointed out in the text. The craftsman will prefer to make a proper job of this kind of damage and the following scheme gives an example of how to do it.

Scheme 3.4.6. Rib Boom Repair.

Examine the damaged boom to make sure how far the damage extends. Frequently a compression shake in the middle of a boom member is accompanied by similar shakes at the next gusset.

See illustration 3.4.6 and go ahead as follows:

1. Remove sufficient fabric to let you get at the damage.
2. Cut out the damaged section of boom, removing ply gussets as necessary. Note that if there is a gusset on each side of the boom, you can often get away with only removing a gusset on one side, and this has the advantage that the rib retains its shape because the diagonals are still glued.
3. Scarf the ends of the boom to 15 : 1 angle.
4. From a piece of spruce of the same section and grade as the original, prepare an insertion piece and scarf the ends of this to 15 : 1 angle. Tool the scarfs to fit.
5. Glue in the insertion piece, and glue on any new gussets, and check the rib for shape with a straight edge across the neighbouring ribs. Pull the rib into shape if necessary before the shuffling time allowance of the glue expires. Cramp up.
6. When the glue has set, remove cramps, clean up the joint and make good the fabric and dope work, patching the hole with the same grade of fabric as used on the rest of the wing and doping up to the same doping scheme.

NOTES ON SCHEME 3.4.6: This is frequently fiddling work, as the section of timber used for ribs is often quite small. However, to hold these scarfs while the glue is setting, you will find that the office type of Bulldog clip can be very useful. Also the spring type of clothes peg can be used for these jobs and this has the merit that it can be bought anywhere at about 6d. per dozen. Care has to be taken when scarfing these tiny sections as the ends are very easily broken. A really sharp chisel will, in skilled hands, produce the scarfs very quickly with one or two strokes.

Scheme 3.4.7. Insertion Repair to Trailing Edge Member

On some aircraft the trailing edge member is a simple shaped piece of spruce, and in this case the insertion repair presents no problems and is identical to Scheme 3.4.3. More usually, however, the trailing edge member consists of a spruce member into which is glued a strip of ply. The ply is set into a saw cut in the spruce, and gives great stiffness in the direction of the pull of the fabric. To make a satisfactory repair, both the ply wood and the spruce must be repaired and the two must be properly glued together. Any length of trailing edge may be scarfed in, but if there is much damage, consider well whether it is not quicker to renew the whole trailing edge member.

See illustration 3.4.7 and go ahead as follows:

1. Cut out the damaged portion of the trailing edge, removing it from any ribs carefully to avoid damaging the ribs.

2. Scarf off the ends of the member at 15 : 1.
3. Make up a section of the trailing edge member by sawcutting a piece of spruce and gluing in a strip of ply. Leave the spruce a little oversize for the time being.
4. When this glue is set, scarf off the ends, spruce and ply, to 15 : 1 angle.
5. Glue and cramp the insertion into position, gluing it into any intermediate ribs.
6. When the glue has set, remove the cramps and pare the spruce down to size.
7. Make good any fabric and dope work.

NOTES ON SCHEME 3.4.7: An alternative to this plan is to make the spruce section in two halves. One half can be spliced in, and then the ply can be repaired, by cutting back the other half of the spruce to allow a 12 : 1 ply scarf. When this has set, the second half of the spruce can be scarfed off, and an insertion piece prepared and glued in. This method takes longer than the one described, as it involves three separate gluing operations.

A good craftsman will prepare some few feet of trailing edge member for the various machines in his charge so that, as soon as one machine suffers damage, he has a piece ready to be cut and scarfed in. The ply scarfs, of course, are unbacked in this case, but this does not matter, because the scarfs can be cramped up with blocks each side, and a perfect glue joint can be guaranteed. After setting has taken place, the cramps and blocks can be removed. Most people will find that it is a great help to cramp a block behind the free edge of the ply while cutting the scarf, otherwise it is only too easy to break the edge of the ply.

Many aircraft do tend to bend their trailing edges over the years, due to the tension of the fabric. In these cases, it is a good plan to renew the trailing edge member when re-covering the wing with new fabric. If this is not done, the trailing edge will bend even more when the new fabric is doped up and you will end up with a sort of scalloped effect.

Chapter 3.5

BOX MEMBER REPAIRS

General Considerations

Many spars of gliders, and a few other members, are made by gluing together spruce booms and ply webs to form a box member. These are some of the most important components of a glider, so the most scrupulous attention to accuracy and quality of workmanship is needed. The work involved in repairing these items really falls into two categories, the Spruce repairs and the Ply repairs, All the spruce repairs must be made with scarfs of 15 : 1 minimum angle, but the ply repairs may be made with 12 : 1 scarfs. In some aircraft the webs of the spar (the plywood facings) do not run right up to the top and bottom edges of the booms, but are cut back some 1/16 in. This is done to ensure that if there should ever be any shrinkage of the timber of the boom, the leading edge ply will not be forced off the boom. This is not very much used these days, but if you come across this form of construction, it is vital that you follow the original plan in any repairs and do allow this small clearance.
See illustration 3.5.1.

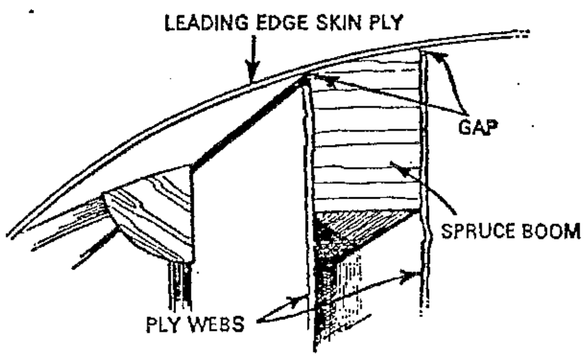

Illustration 3.5.1. Spar Web Gaps

Patch repairs should be avoided wherever possible. This is because, in the case of glider spars, no alterations to the stiffness of a section of spar must be made. Attempts to make a spar stronger than it ought to be, only result in the load being transmitted (owing to the greater stiffness) on to the nearby portions of the spar and these, in consequence, bear a larger load than they are designed to bear. The net result is a spar which, as a whole, is weaker than it ought to be. Sudden changes in section also breed compression shakes. The section of timber in this sort of repair is somewhat larger than the usual glider repair job, and cramping becomes a little more important. Joints must fit before they are glued up, but sufficient pressure must be exerted to close the glue line properly. Cramps must *never* be applied direct to the timber. To do so is to crush the fibres of the timber for a certainty. Scrap timber load spreaders must always be used between the cramps and the job.

Repairs to spars of gliders nearly always mean that there is some risk of the shape of the wing altering, unless means are taken to prevent this happening. As soon as a piece of leading edge ply is removed, the wing is no longer stiff in torsion and will twist if allowed to do so. Therefore, before you wade in on this sort of job, make sure that the wing is properly held in some sort of fixture or jig that will preserve its shape while you work on it. In spite of this precaution, the good craftsman will make fairly frequent use of the Clinometer as the work progresses to satisfy himself that he is not 'building in' an error of some sort.

It cannot be over-emphasised that in spar work, dimensional accuracy is vital. When fitting in insertion pieces to spar booms, they can with advantage be left a little oversize, so that when the glue has set they can be pared down to exactly the correct size. Attempts to get them to size before gluing in, often result in the job finishing up undersize, and that, of course, means that the work must be cut out and done again.

All the internal spaces of the spars must be ventilated to atmosphere. This is a very important point for two reasons, first so that fresh air circulates through these spaces, keeping the moisture content of the wood constant, and preventing the growth of moulds, and second, and much the most important, so that there is no chance of a differential pressure building up in the spar. If a sailplane is flown to 20,000 feet the air pressure is approximately half that at ground level, so if there should be a sealed compartment in a spar, the pressure inside it is the equivalent of 7·5 lb. per square inch. It does not take much imagination to see that, if the area of the sealed compartment is large, it is quite possible for the spar to burst its web off the booms. In consequence, it is necessary to make quite sure that all the compartments are properly ventilated, and that no ventilation holes are 'lost' in repairs. These holes must be re-drilled if they occur in new ply, in the same place and of the same diameter. The drilled edges of the holes must be treated with bituminous paint to prevent moisture content loss or gain.

The grain direction in all spars is of primary importance. Frequently you will find that the webs are applied to the booms with the grain running at 45 degrees to the length of the spar. Should any repairs be made to these webs, the grain direction must be accurately followed in the repair, otherwise the web will be below strength. Similarly, when splicing in insertion pieces into the booms, you must ensure that the insertion piece has a grain direction that is within the 15 : 1 limit, but it is preferable to select a piece of timber with grain as nearly parallel to the length as possible.

You will find in the case of most box members that there are a number of stiffeners or 'soldiers' fitted between the booms and webs. In the planning of a repair, it is vital that none of these soldiers is omitted. Normally, you will plan the job so that you can do the ply scarfs on one of these soldiers, suitably thickened up, if necessary, to provide ¾ the width of the scarf, but sometimes you will have to fit an extra soldier to support your ply scarf. This is quite acceptable: an extra soldier does nobody any harm, but you must never omit a soldier. To do so is to leave a section of the web insufficiently supported, and this means that the ply of the web will buckle at a lower load than it should.

In general, the more you can use cramps in place of tacks on box members, the better. This is not to suggest that driving tacks into spar booms seriously weakens them, but nobody could suggest that it improves timber to perforate it. The booms get quite a lot of tacking, since not only the webs, but also the ribs, have to be glued to the spar, so that when repairs have to be done, the less you need to perforate the timber the better. Do not take this as an excuse for not closing a scarf joint properly. All it means is, if you *can* use cramps instead of tacks, do so.

In all box member spars and, to some extent, in other box members, you will find that the booms taper. In certain places you may find that the booms completely fill up the space inside the spar. The spar has become solid in fact, at this spot. A typical example of this is at the strut joint of the spar of a strutted glider. Now, where the spar changes from solid to hollow, there is a very gentle transition. The solid portion divides in the form of a 'bird's mouth' block and the two booms taper off from here. Now clearly it is easiest to make your ply scarf on a solid portion of the spar, if you can do so, as the scarf is fully supported all the way, so if you can find out the position of the solid portions of the spar, you may be able to save yourself trouble. This really boils down to saying that a drawing of the spar can often save you hours of work on a repair.

Scheme 3.5.2. Patch Repair to Spar Web.
Use this method for minor damage, where the booms of the spar are undamaged, where the damaged or abraded area of the web does not exceed 1 in. in the spanwise direction, and the web is perfectly flat. Failure to satisfy the latter point will result in difficulty in getting the patch to glue down properly.
See illustration 3.5.2. and go ahead as follows:

1. Remove fabric and ply to obtain access to the damage.
2. Cut the patch: (a) To the dimensions shown.
   (b) Of the same grade and thickness of material as the original.
   (c) Of the same grain direction as the damaged web.
   (d) With the vertical ends chamfered to 5 : 1.
3. Glue and cramp or tack the patch centrally over the damaged area.
4. Make good any ply or fabric removed in operation 1.

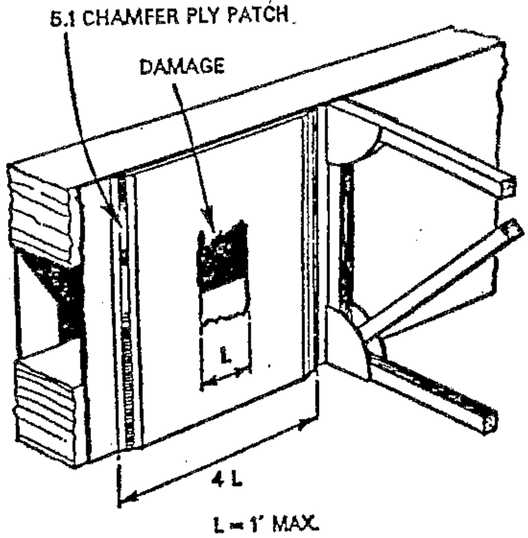

Illustration 3.5.2. Patch Repair to Spar Web

NOTES ON SCHEME 3.5.2: This is about the only lap joint that we can permit on spars. The main difficulty is in getting the patch to glue down properly on those portions of the web where there is no support behind the ply. If the web is at all bowed, do not try this scheme, but replace a portion of the web as in Scheme 3.5.3. Any tacks should be drawn after the glue has set, but, if this is impossible for any reason, then the tack *must* be of brass and *not* of steel. Note that if this repair should cross a rib, Scheme 3.5.3 will save you time, otherwise you will have to mess about altering the length of the rib to suit.

Scheme 3.5.3. Insertion Repair to Spar Web

Use this method for damage where the booms are undamaged. Any length may be replaced and both webs may be repaired. It is good practice, however, to stagger the web splices by one 'soldier pitch' so that the splices do not come opposite each other. See illustration 3.5.3 and go ahead as follows:

1. Remove ply and fabric as necessary to get at the repair.
2. Cut away the damaged web to the full depth of the spar.
3. Check the width of the soldiers and if they are inadequate to support a 12 : 1 splice, cut reinforcing members and glue these into position against the soldiers, to give the necessary ¾'W' backing, where 'W' is the width of the scarf.
4. If necessary, you may make up extra soldiers to avoid cutting back the web unnecessarily far. If you have to do this, the extra soldiers must be of thickness ¾'W', but otherwise they must be exact copies of the existing soldiers.
5. Scarf the cut ends of the web to 15 : 1.
6. Cut the ply insertion panel from ply of the same grade and thickness as the original and scarf the ends to 15 : 1. Ensure that the grain direction is the same as the original, but do not trim down to the exact depth of the spar at this stage.
7. When satisfied with the fit, glue and cramp or tack the insertion piece into place.
8. When the glue has set, remove all tacks, cramps and pare the insertion piece down to exactly the depth of the spar.
9. Make good any ply, fabric removed in operation 1.

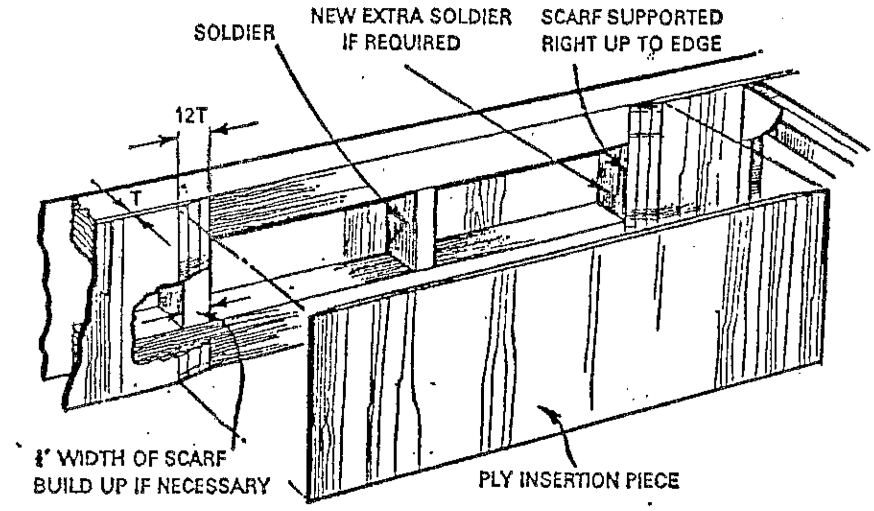

Illustration 3.5.3. Insertion Repair to Spar Web

NOTES ON SCHEME 3.5.3: If you have to take both webs off a spar, watch out for twisting of the spar. This applies, in fact, as soon as you remove one web, but the effect is increased with two webs off and is, of course, worse, the more web you take off. If you cross several bays of the spar, it is vital that the web is properly glued to *all* the soldiers. Mark the positions of these on the outside of the ply so that you can ensure proper gluing. Often you will have to take out ribs to get at the spar. Think before you cut the ribs, as frequently there is one place where the subsequent repairing of them is a minimum.

Do not forget to check for any ventilation or drain holes in the web. Any that have got 'lost' in the repair *must* be replaced in the same place and of the same diameter as the original. Paint the cut edges of the holes with bituminous paint.

Scheme 3.5.4. Insertion Repair to Spar Boom.

Use this method where the boom is damaged more than can be dealt with by Scheme 3.4.2. See illustration 3.5.4 and go ahead as follows:

1. Remove sufficient of the ply webs to enable the damage to be cut away, and the ends of the boom to be scarfed off at 15 : 1.

2. Prepare an insertion piece of Spruce of the same grade and scarf the ends off at 15 : 1. Do not worry too much about getting the insertion piece down to the exact size at this stage.
3. When you are satisfied with the fit, glue and cramp the insertion piece into place.
4. When the glue has set, remove cramps and carefully pare the insertion piece down to the exact size.
5. Replace the portions of the ply web removed, using Scheme 3.5.3.
6. Re-cut any ventilation holes lost in the repair.

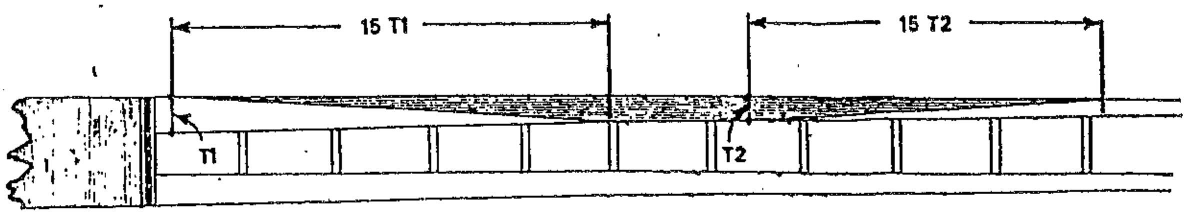

Illustration 3.4.5. Insertion Repair to Spar Boom

NOTES ON SCHEME 3.5.4: You may scarf the booms in either direction, that is, with the scarfs running vertically or horizontally. Which way you adopt depends on the circumstances of the repair. By arranging the glue line to be in the vertical plane, you can often repair a boom and only have to take off one of the webs. Remember that in this repair you are certain to get distortion of the wing, unless you take precautions to prevent it. This means a jig, or some sort of fixing arrangement, for the wing while you carry out the repair. As an added insurance, make frequent use of the clinometer, while the job is in the various stages of repair. The centre line of the boom splice should be marked. One way is to stencil a line and the words 'C/L Boom Splice' on the centre line. Another method is to glue on a small diamond-shaped piece of ply, about ½ in. by ⅜ in. on the outside of the web, exactly on the centre line of the boom splice. The object of this is to make things easier for the next man who has to repair the boom. If he can see where the splices have been done, then he can plan his repair, so that it avoids the splices already in the boom.

Frequently, when you are splicing a broken wing, some of the soldiers will have got lost. You must make sure that all the soldiers are fitted in the right places, as these are part of the structure of the spar. When you have to splice both booms, it is considered good practice to make the two splices so that they do not overlap.

Big Repair Jobs

The sort of thing that the repair man is frequently faced with is a wing completely broken in two pieces, and perhaps a badly damaged fuselage as well. The first thing he will need to work out is what drawings he is going to need. Has he sufficient of the structure intact to enable him to rebuild the rest, and to be sure that the original dimensions of the job will be maintained? If not, then he must obtain such drawings as he is going to need. Having studied the preceding schemes in this Chapter, it will be apparent that the biggest job can be broken down into small units, and each unit can have a separate scheme applied to it. It is felt that, while it is impossible to produce a scheme to cover every conceivable type of damage, the foregoing schemes do provide a fairly wide field from which to choose. Using them intelligently, and using part of one and part of another, where necessary, it is not difficult to work out a scheme to fit any particular type of damage. The really important thing is to observe the principles that have been demonstrated in these schemes. These principles can be briefly summarised as being to replace all damaged material with new, using material of the same specification, and ensuring that all splices are of not less than 15 : 1 in spruce, and not less than 12 : 1 in ply. All glue joints must be properly made, and the structure must be so supported during the repair operations, that the original dimensions, angles, etc., are faithfully reproduced in the repaired job. A little thought beforehand, on exactly the order in which to repair the damage, will often save a lot of time, by avoiding building material which gets in the way of later repairs. Think out carefully the order which will make the job easy.

Another small point, which causes trouble very often, is that it is quite difficult to cut a smooth scarf in a laminated member, if the scarf is cut in the direction so that the glue lines run across the scarf, rather than along it. The glue is so much harder than the timber that wood-cutting tools tend to leave the glue lines rather proud, and you get a wavy surface instead of a flat one. You can avoid this by finishing the scarf with a file or similar tool which is unaffected by the difference in the hardness, or, of course, you can cut the scarf so that the glue lines run along the scarf, that is, cut the scarf the other way.

The big jobs also make you think about the timing of the gluing. When you have a large piece of web to glue on to a spar, you must take into account the ambient temperature when deciding which hardener you are going to use with the glue. Too rapid a hardener when the day is hot, and you will find that you run out of time before you have got the joint closed. On the other hand you must ensure that the temperature is high enough for gluing. In general, it is probably best to settle for the slowest hardener that you can use unless there is some pressing need for speed, such as a competition glider which is needed for flying next day. In extreme cases of large panels that have to be glued in, you may have no alternative but to get an assistant, or even two, and arm them with tack hammers, so that at the word "go" you can all set to, and tack up simultaneously.

While not really a repair scheme, it may be instructive to go through an imaginary repair of a broken fuselage. Let us say that the fuselage is broken in two pieces behind the wings, and that there is a fair amount of damage to the frames up at the front of the fuselage. The first thing to do is to make a thorough examination of the damage, list it all, and decide whether you are going to repair the damaged frames or whether you are going to put in new frames from the manufacturers. Next you will have to get sufficient timber to make up some sort of a jig to hold the pieces of the fuselage in their correct positions relative to each other while the repair proceeds. Set up the main frame in its correct rigging position and make sure that it is laterally level. Set up the rear fuselage at its correct rigging angle and again make sure that it is laterally level and that the fin is truly vertical. Splice the longerons using a suitable scheme from Chapter 3.4. Assuming that the fuselage is a plywood component, you can now splice in new ply, thickening up any frames, where necessary, to give you the required backing for the scarfs. Frequent use of levels and clinometers will ensure that you do not built in any twists or other errors. Now the front of the fuselage can be dealt with. Remove all damaged ply, and take off enough, to let you get any new frames that you are fitting, into place. When you have replaced all the damaged frames, or repaired those that you are not replacing, you can glue on new ply to complete the skinning again. All scarfs will, of course, have to have proper backing up to ¾ of the width of the scarf. While you are making your examination of the damage, you will have listed any damaged fittings that must be replaced, and make a note of the stage in the operations when the replacement of fittings will be easiest. Clearly you will want to do this when the particular section of the fuselage is at its most open stage. Remember to use plenty of jointing compound when bolting on new fittings, and pay attention to the locking of bolts, etc., particularly the ones that are going to be inaccessible when the repair is finished.

Instruments, of course, must be sent for checking, as any that have been in an accident are unserviceable, until an Instrument Laboratory has given them a clean bill of health.

Taking a similar sort of repair on a wing; let us assume that the wing is a cantilever job and that it is broken in two pieces, somewhere about the root of the aileron. The leading edge will be damaged for quite some way each side of the actual break. First, make an examination of the extent of the damage, and decide what ribs you are going to repair, and what ones you are going to buy from the manufacturer. In some cases, of course, you will have to make the ribs, but this is fiddling work and very time consuming, so, if you can get them ready-made, it is a good bet. You will almost certainly need a drawing of the wing, to get the angles of incidence correct at the various stations along the wing, and to get all the other dimensions of the wing correct. Now make up a jig to hold the wing pieces in their correct relative positions. In most cases, it is easiest to set the wing vertical with the spar level and with the leading edge up. In many cases, you will find that one of the faces of the spar is taken as the Datum line of the wing, from which all the measurements are made. If this is so, set this line level. Now splice the spar booms, and then splice the webs. You can now cut away all the damaged leading edge ply, clean up the spar, and glue on the new, or repaired, leading edge ribs. These must now be accurately lined up. Some of them may have to be built up slightly, and if this is so, glue on spruce strips as required. The use of a long straight edge will show whether the ribs are truly lined up, and one of the easiest ways of getting them true is to glue a piece of glass paper on to a long straight piece of wood, long enough to span several ribs, and to rub this chordwise over the ribs until it is cutting every rib. You can then glue on the leading edge ply, thickening up such ribs as necessary to give the $\frac{1}{4}$ of the width of the scarf backing. Make quite sure that the twist of the spar, if any, is dead correct before you glue on the leading edge ply as, once this is on, the spar will be absolutely rigid and no further adjustments can be made. Now the damage aft of the spar can be attended to. This will mostly be rebuilding ribs, or fitting new ones, and truing and splicing in new pieces of trailing edge. If the construction is such that there is a rear spar, this will have to be spliced, but this does not present any particular problem. When all the structure of the wing has been repaired and any damaged fittings have been replaced with new, the damaged area of the wing will have to be recovered, and this is fully described in Section 2, Chapters 2.2 and 2.3.

From the foregoing, it will be seen that even very big repair jobs can be broken down into a number of small ones, and if the Schemes that have been outlined in the earlier Chapters of this Section are studied, it will be found that almost any sort of repair can be undertaken. Do not be disheartened by the appearance of a crashed glider. Frequently it is the most fearful looking wreck that proves to be the simplest to repair. For instance, a fuselage broken in two, looks to the uninitiated to be almost a write-off, and yet it is actually quite a simple job to splice the two pieces together again. Conversely, a fuselage that has had a heavy landing may look all right and yet you may find that nearly every frame has been crushed, and this can take an enormous amount of work to repair.