SECTION 4

MISCELLANEOUS REPAIRS

Chapter 4.1

GLASS FIBRE REPAIRS

Glass fibre is a material that has recently become fairly popular for many purposes, and it is being increasingly used in gliders. It consists of glass in finely spun form, either woven into a cloth or sometimes in the form of a chopped matting, embedded in a plastic. It can be laid up into almost any shape and any thickness. It has two uses in glider work. The first use is for fairings and other non-stressed components, which on account of their shapes are not easy to make of other materials. The second use is for parts of the glider which, again from their shapes, are difficult to form out of other materials, but which do carry some of the flight loads and which must therefore be considered stressed parts of the glider. Examples of these two uses:

Unstressed: nose cones, parts of canopy frames, fairings of the front ends of skids, wing fairings, etc.

Stressed: cockpit sections and fin roots of Dart gliders, etc.

We must differentiate between these two uses of this material. The strength of glass fibre depends to a very large extent on the mix of the plastic, the proportion of glass in the panel, and what, if any, filler is used in the laying up. The snag with all this is that once the job is done, inspection does not reveal much of these important points. About the only thing that can be seen by inspection is that the dimensions, thicknesses, etc., are correct or otherwise. Therefore, in the case of stressed glass fibre, no repairs should be undertaken without reference to the manufacturer. Only he has the information about the stress in the component, and the details of the mix, type of glass, and proportion of glass, etc.

In the case of unstressed components, the picture is rather different. Here there is no question of strength, but rather the problem of restoring the shape of the component. There would seem to be no objection in these cases to using one of the many proprietary glass fibre repair kits that are on the market these days.

One of the most usual jobs on glass fibre components is the repair of cracks. Using a file, scarf out the edges of the crack to an angle of about 20 : 1 and, if necessary, support the back of the crack. Mix up the plastic resin and apply it to the crack using glass to reproduce, as nearly as you can, the original mix. Build up the scarf, using several layers if needed, and finish by leaving the repair proud of the surrounding glass fibre. Let this harden off, and then pare it down with a file to the level of the surrounding material. Properly done,a repair of this description can be made quite invisible when painted.

Slightly more complicated is the case where a piece of the component has been knocked out and is lost. Prepare the edges as before with scarfs of 20 : 1 and then make up some sort of backer to cover the gap. This can be made of plywood covered with greaseproof paper to stop the resin from sticking to it. Hold this backer in place by any means you like; an easy way is to use a stick of wood to wedge it in place, the other end of the stick resting against any convenient part of the glider. Now start building up, with resin and glass, right up to the outer edge of the scarf, and try to reproduce as nearly as you can the original structure of the component. Build up, using several layers of resin and glass if you need to, until you have a surface which is well proud of the surrounding surface. Let this harden off, and then, with a file, pare down carefully level with the surrounding surface.

No illustrations are given for these repairs because they are very simple and anyone capable of doing wood repairs should find no trouble in tackling glass fibre repairs. A few words of warning may not be out of place. First, be careful of the spun glass, whether it is in the form of chopped matting or woven cloth. It can be very nasty stuff, as it has a habit of getting into your fingers and then snapping off, and this produces a most unpleasant sort of rash. You can get the same sort of trouble when you are cutting down the finished job, if you are tempted to use a sanding disc in an electric drill. This creates a horrible dust of glass which gets in your skin and irritates like mad. It is better for these operations to use a file and go at the job slowly. Do not mix up too much of the resin at once, as it sets very quickly, and do not mix the stuff up in any container that you may want to use again, because you will not be able to. The plastic cups that are supplied in those automatic coffee machines are very useful for this job.

Chapter 4.2

PERSPEX AND PERSPEX REPAIRS

The canopy bubbles of most gliders are made of perspex, and a few words on this material may not be out of place here. Perspex is a plastic, and is readily formed into various shapes when it is heated. It is very soft, and easily scratched, so it should be handled with great care. Never handle the canopies of gliders if you can avoid doing so, and do not wipe them with anything but the softest of cloths. Clean them when necessary with soapy water and soft cloths and when polishing is needed, use the proper perspex polish. Attention to these details will preserve the optical qualities of the bubbles.

Dope fumes will craze perspex, so whenever doping is being carried out, take the perspex parts of the glider well away from the scene of operations. Dust and grit on the canopies should be washed off rather than wiped off, and much damage is done by well meaning people wiping gritty canopies with dry cloths.

Perspex can be cut to shape quite easily, but a few precautions should be taken. Although it is a fairly soft material, it cracks very readily, and the best tool to cut the stuff with is a fine-tooth hack saw. Cut it carefully, and do not rush the job, because, if it becomes heated from the saw, it tends to stick the saw in the cut and jam it, and this is the most usual cause of cracks when cutting the stuff. It may even try to weld up again behind the saw cut, and then it is difficult to separate again without damage. It can be filed as well as cut, but again the motto is slow but sure. Raw edges of perspex can be smoothed off with fine abrasive paper, finishing off with wet-and-dry paper. In all operations on perspex, avoid haste, as this always ruins the job. You must be prepared for a lot of work to get a good result.

For joining perspex you have a choice of several cements. First there is the Tensol Cement sold for the purpose. Second, a good solvent is Glacial Acetic Acid. Third, and perhaps the easiest to use as a solvent is Chloroform. Chloroform is a very volatile liquid, and care should be taken with it, as it is also very inflammable. A very good cement can be made by dissolving perspex chips in chloroform until you have a thick treacly liquid. It takes a while for the perspex to dissolve, so it is a good plan to prepare the cement and keep a stock of it on hand for when you need it. Keep it stoppered, or it will be solid when you want it.

The most usual repair that you will come across in perspex is a crack in a canopy bubble. First of all, as soon as you spot a crack, stop the end of it by drilling a small hole at the end of the crack. Perspex drills easily, but be careful of the drill breaking out on the far side of the hole, so feed it gently. Now, vee the crack out, right to the bottom of the crack, to an angle of about 60 deg. You can now paint in the cement with a fine paint brush, softening both sides of the crack and ensuring that the cement gets right through to the bottom of the crack. You will have to do this a number of times to build up the crack to the original surface, and it takes time to dry. Go on doing this building up process until the crack is filled proud of the surface of the surrounding perspex. The stuff seems to shrink as it sets, so make sure that the crack really is proud. Now let the stuff harden off, and this may take several days. When it is hard, file it down flush, and work up the surface again, going from fine files to wet-and-dry paper, and then to Brasso, and then on to the Perspex Polishes. This does take a lot of effort and time, so do not expect to be able to do the job in a few minutes. The main difficulty in these repairs is to avoid the inclusion of small air bubbles in the joint line. These always seem to appear, but they can be minimised by using the cement as thick and viscous as you can manage. If you soften the edges of the vee with neat chloroform and then paint in the cement in an almost putty-like consistency you will get the best results. Even the best results, however, are somewhat disappointing at times.

Perspex can be quite simply patched, and this has the advantage that it does actually strengthen the place where the crack is. The previously described technique has not got this advantage, and the repair is never as good as the undamaged sheet. To patch perspex, where the sheet is cracked, first stop the crack with a hole at the end. Now, if the crack is on a curved surface, it is important that you do try to get the same curvature on the patch before you stick it on. If you do not do this, you will find that the patch will start to develop small stress cracks in it and this spoils its appearance, apart from reducing its strength.

Go ahead as follows:

1. Having stopped the crack with a hole at the end, prepare a patch which will overlap the crack all round, by at least ¾ in. and chamfer the outer edges down to 5 : 1. Where the patch meets the edge of the sheet, the place where the crack usually starts from, omit the chamfer.
2. Now heat the patch and bend it until it fits the sheet accurately. Don't skip this part of the operation, because, for good results, the patch must be cramped very lightly, and not pulled into shape by the cramping. If you do try to pull the thing into shape, you will have stress cracks developing in the patch.
3. Paint the cement on to both surfaces and cramp the patch into place, using as little pressure as possible, but excluding all the air bubbles in the cemented surface.
4. Allow the cement to set, and this will take a good deal longer than you expect. Two or three days is not too long.
5. Remove the cramping and work up the surface again, using wet-and-dry paper to remove all marks of the cramping, and then going on to Brasso or some similar polish and finishing with the various grades of perspex polishes.

The other most usual job that you will come across is the fitting of a new bubble to a canopy frame. If the bubble comes to you with a protective covering of paper stuck on to the polished surface, do not remove this until the last possible moment. It will help to prevent scratches.

First, prepare the canopy frame, by removing all the old perspex and cleaning the thing up. It is best to do as much trimming of the perspex as possible after the bubble itself is screwed or bolted in place as the bubble is then rigid and there is less chance of damaging the bubble. Until the bubble is fixed into the canopy frame, it is an extremely awkward and floppy thing to handle. However, on many frames, there is at least one edge that has to be fitted before you can screw, or bolt, the bubble to the frame, and if this is the case, then this edge must be very carefully filed, cut, and smoothed until you are satisfied with the fit. Now start bolting or screwing this edge into place, starting at the centre, and working outwards in big steps. Countersink each hole if required as you drill it, and do use a countersink of the *correct* angle. Failure to observe this is to ask for splitting. Do not overtighten the screws or bolts and ensure that there is an ample clearance in the perspex around each bolt or screw. Now turn your attention to the other edges, "Working Opposite" as far as you can. If you are tempted to work along a seam from one end to the other, you will find that you distort the sheet and that you cannot get the last bit to fit. If a sealing compound is used on the original job, use it on the replacement. When the bubble is completely screwed or bolted into place, you can then start to trim the edges to shape, but once again do this slowly and carefully.

Perspex work is intrinsically fairly simple, but you cannot take liberties with the stuff. A false move, the use of force on it, and an expensive bubble can be spoilt; but treat the stuff gently, cut it and file it slowly, using very light pressures, and you will find that you can manipulate it quite easily. Avoid scratching it while working on it and to this end it is a good plan to place a clean thick blanket on the bench to work on. You can then move the canopy about on this without fear of scratching it, but do keep it clean, and shake it out as soon as it needs it.

Chapter 4.3

METAL REPAIRS

There are a number of metal parts on all wooden gliders, and it may seem a little odd to begin this Chapter by saying that, in general, it is far better to replace metal fittings with new items than to try to repair them. There are exceptions to this rule, of course, such as main skid armour plates, tailskid shoes, etc., which can well be reconditioned for further service when they become worn. The real problem occurs when you have a "one off" aircraft, or a foreign built machine for which spares are not readily available. In this case, the Inspector is faced with the necessity of reconditioning metal fittings or even, in the ultimate, of making new parts. In the latter case the first essential is that the Inspector is quite certain that he has the necessary information to enable him to make up the new part. This, as a minimum, must be, the Specification of the material used, heat treatment, if any, and a drawing of the part, unless the fitting is of such a simple nature that it can be made from the original part. If an Inspector can be sure that he has the above information, and is confident of his ability to make the fitting, then he may do so, but he must sign the log book of the aircraft and make it quite clear that he has made the fitting and approved it. For his own protection, he must quote the Release Note number of the material that he used, of course.

One metal item that is found in every glider is the Release Hook, and this is a very important piece of equipment. A failure of the hook to release can have very serious consequences. At present all British Gliders are fitted with the Ottfur type of back-releasing hook. Its mechanism is shown in illustration Fig. A. The back releasing element is obvious on examination. Now these hooks are extremely reliable pieces of equipment, but like any other mechanical device they must be kept in proper order. The releasing action consists of an over-centre device, and the position at which the links come to rest when the hook is in the closed position is clearly critical. Any wear in the links will alter this closed position and will affect the pull required to open the hook, under a given load in the launching cable. The difficulty here is that to determine the load required to open the hook, under a given test load, necessitates a test rig, and this is normally not available at the average gliding repair workshop.

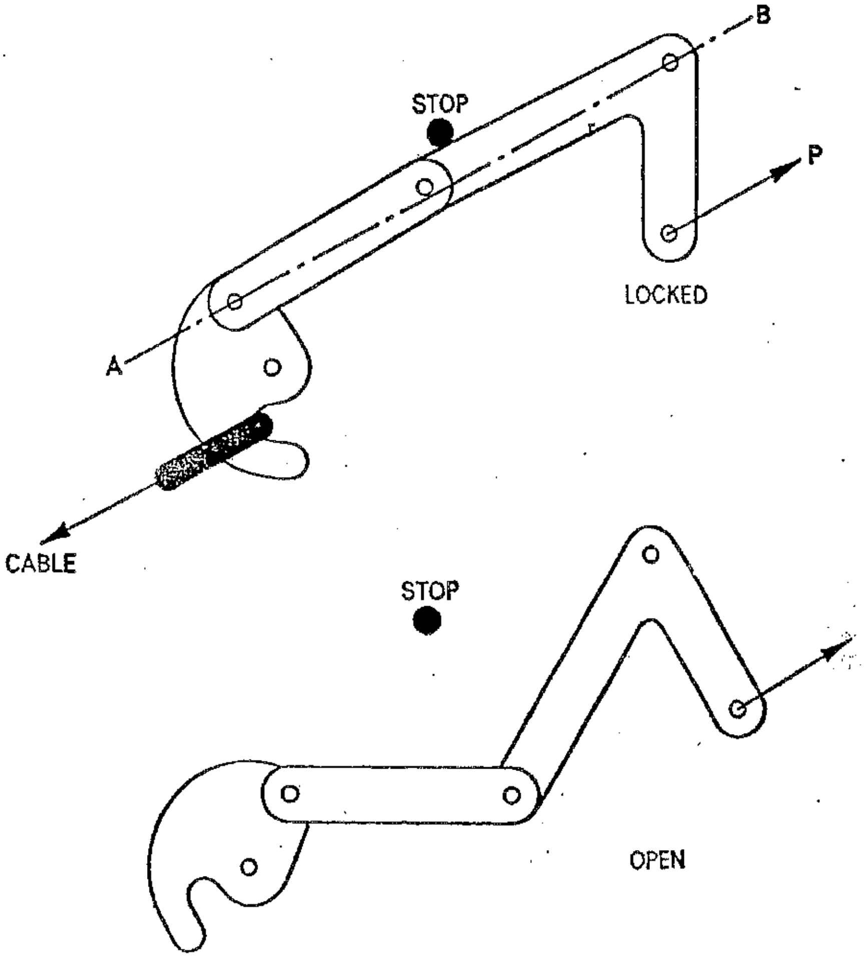


Figure A

Fortunately, the makers run an overhaul and test service for these hooks, and the reconditioning service is so quick, and cheap, that it is hardly worthwhile attempting to do any sort of work on these hooks, apart from such things as replacing broken springs. There are three basic troubles to watch for in these devices. First: breakage of the springs, either the internal, or the external one. The replacement of either of these presents no problem. Second: wear in the links leading to alteration in the over-centre position. This requires overhaul by the makers, and testing on the test rig. The unit is serviced, and re-issued with a Release Note. Third: the launching rings may, after considerable use, wear a groove across the "beak" of the actual hook. This is potentially dangerous, as it delays, and in extreme cases may prevent, the back releasing action. If the whole unit is otherwise in good condition, it may be possible to replace the defective component, but, again, the best plan is to return the unit for re-conditioning.

Flexible cables in control circuits cannot be repaired. In Section 1, Chapter 1.3, when discussing protective treatments, we discussed corrosion and its prevention, but cables also suffer from abrasion and fatigue. They are obviously vital components and no damage to them can be tolerated. Any whiskers on a cable mean that the strands are fatigued or that they are wearing through, and in either case the cable must be thrown away and a new one fitted. An Inspector is perfectly entitled to make up and fit a new cable, provided that he uses approved cable, quotes the Release Note number in the log book of the glider, and that he proof loads the cable to 50% of its nominal breaking load before fitting it. Most glider control cables are 10 cwt. cable of BSS W.9, and this means proof loading the finished cable to 560 lb. It is not a difficult matter to construct a suitable rig, with levers and a spring balance, to apply this load. Hand splicing of cables is rapidly becoming a thing of the past, and there is no question that the swaged eye splice is a far better job, but this must be done by an approved process, and with the correct dies, and ferrules. Remember that the proof loading will settle the strands of the cable and stretch it slightly, so do not make your cables up too long in the first place. Hand splicing, on the other hand, tends to shorten the cable slightly. A little practice will soon show the allowances for this. Hand splicing is an art that must be learned in the workshop, under the tuition of an instructor, but, as things are going at present, hand splicing will have disappeared from the gliding scene in a few years' time. Hinges, and bearings generally, require attention periodically. In many cases, this is a straightforward job, if there is a replaceable element, ball race, bush, etc The difficulty arises when there is no such replaceable element. In some cases it may be possible to ream oversize and fit new suitable pins, but this can only be done with the approval of the manufacturer. The Inspector has not got the stressing figures of the aircraft at his disposal, but the manufacturer has, and reference must always be made to him before any reaming, that could possibly affect the strength of the glider, is undertaken. Also, of course, the Inspector must quote in the log book, the authority from the manufacturer, to ream and fit oversize pins. This is for his own protection.

More and more, these days, manufacturers are fitting bushes into such things as main wing pin fittings, and this makes the problem much simpler. When worn, the old bushes can be drilled out and new bushes fitted, either by screwing them in or peening, whichever method was originally used. If peening was used, the bushes will probably need to be reamed to the exact size since the peening tends to close them up slightly.

Great care must be taken when removing bushes, not to open up the holes in the fittings, as this would leave the new bushes a slack fit in the fittings, and would weaken the fittings themselves. In cases of difficulty, it is a good plan to drill out the old bush slightly undersize, and then collapse the remaining shell of the old bush and pick it out. This can be done quite easily if the old shell is sawn through carefully.

Welding of any glider structure must only be done by an ARB (Air Registration Board) approved welder, and his approval must be quoted in the log book of the glider. However, there are a number of parts on a glider which do not affect strength, or control, such as the armour plates of main and tail skids, and these it is perfectly permissible for an inspector to weld, even if he does not hold ARB approval for his welding. The entry in the log book must make quite clear that the work was done by a non-approved welder. It must be appreciated that many of the parts of a glider that are made of metal have been subjected to some sort of heat treatment, and no heat is permitted on these parts. Should they be heated, there is danger that the heat treatment will be destroyed, and there may well be no indication that this has happened.

A point that must always be borne in mind, when two dissimilar metals are in contact, is that there is a severe danger of electrolytic action between them which will lead to very rapid corrosion. This can be prevented by making quite sure that there is a good film of jointing compound such as Duralac between the two metals. The important point is to ensure that there is no actual contact between the two metals, but that there is always a layer of jointing compound, paint, or other medium separating them. Electrolytic corrosion can only take place where there is moisture, so take extra care to see that the potential trouble spots do not get damp. Light alloys usually show a white powdery deposit when corrosion starts, but this cannot be relied on. In many places you will find steel bolts passing through Dural plates, and in this situation the bolts must be plated either with Cadmium or Chromium. In spite of this plating, jointing compound must still be used on assembly.

In the case of parts which are assembled with a push fit, or drive fit, it may be difficult to ensure that jointing compound is really preventing metal to metal contact, as, of course, it should do. A good plan in these cases is to provide a small chamfer on the outer element and then, when the inner element is pressed into place duly coated in jointing compound, the chamfer will allow a small fillet of jointing compound to be left, and this fillet will effectively seal the assembly against the entry of moisture.

Light Alloys as used on gliders fall into two classes. First, the low strength alloys, which may, to all intents and purposes, be considered to be pure aluminium. These are used for fairings, and other non-structural parts. They are soft and easily worked. They do tend to harden, and, in extreme cases, may crack. Repairs can be made to them by patch rivetting, or a competent welder can weld them, but, of course, this may only be done on truly non-structural parts. Second, there are the high strength alloys, and there are many of these. Even the appellation Duralumin, or Dural for short, now covers quite a number of Specifications. Dural has some peculiar properties and it may not be out of place to say a few words about this alloy. It can be annealed, by heating to about 400°C. and allowing the alloy to cool slowly. In this state it is nearly as soft as aluminium, and can be worked and formed quite easily. It rapidly work hardens, however, as soon as any forming is done on it. However, unless work is done on it, the alloy will stay soft and weak almost indefinitely. It can also be "Solution Treated" and this changes the character of the alloy in a most dramatic manner. Solution Treatment involves heating to about 500°C. and then quenching. After this treatment it is almost as soft as if it had been annealed, but it rapidly age-hardens, and any work that has got to be done on it, must be done within a matter of hours after the quenching. After about five days the alloy is hard, not very ductile, and has a strength approximately equal to mild steel. This means that, in the fully hardened condition, the alloy cannot be formed, and can only be bent round comparatively large radii, without damaging the material.

Some Durals, L.72 for example, can be made even stronger and less ductile by Precipitation Treatment. This involves soaking the material, after Solution Treatment, at about 120° C. for some 24 hours. The material then becomes L.73, the proof stress and the ultimate tensile stress are both increased and the ductility is reduced.

Dural corrodes fairly rapidly, and the more usual way of using this material is in the form of Alclad, which is Dural with a thin layer of pure aluminium rolled on to each surface. Aluminium corrodes, but its oxide acts as its own protective skin, preventing any further corrosion. Take care not to damage the aluminium skin. Do not use scribers to mark out, but use a soft pencil.

When assemblies are made up of Dural, the finished parts are sometimes protected from corrosion by anodic treatment. This forms a hard, impervious coating on the component, but again, care must be taken not to damage this coating. The process requires acid baths, and a means of supplying a controlled current of electricity to the component in the acid bath, and is probably outside the capabilities of the average glider repair shop.

A further process is the Alocrom process developed by I.C.I., who will supply all details. Take care with the solutions of this process as some of them are harmful.

From what has already been said it is obvious that welding is not a possibility as a method of repair for these high strength alloys. The only way to repair them, if indeed repair is possible, is by rivetting. Now here we run into a problem straight away. No rivetted joint can ever be as strong as the plate. Therefore the structure has to be designed to the strength of the rivetted joints and not to the strength of the plates. A little thought will show that this is so, because to join the plates by rivetting, we have to drill holes in them, and this weakens them. Note, by the way, that this does not apply to wooden construction, where the joint can easily be made as strong as the ply or spruce, since a properly made scarf joint does not fail at the glue joint. However, if we accept that the structure of a metal glider is designed to the strength of the joints, we can usually work out an acceptable repair on the principle that the joints of the repair must be as strong as the nearest adjacent joint. This usually means using the same rivets and the same rivet pitch as the nearest adjacent joint.

In the case of members, as against skins, it may well not be possible to restore the strength in a repair. In this case the question boils down to whether we can accept the reduction in strength, or whether we must replace the member *in toto*.

Light alloy structures are repaired by rivetting, though the time may not be far off when the new techniques of resin bonding these materials will be feasible as a repair. Therefore we had better begin by a discussion on the principles of rivetting.

Rivetting

First of all, the hole in which a rivet is set must be slightly oversize to allow the shank of the rivet to expand. The sizes most commonly used and the correct size of drill for them are given in the table below:

Rivet size	*Size of hole*	*Drill*
$\frac{3}{32}$ in.	·098 in.	No. 40
$\frac{1}{8}$ in.	·1285 in.	30
$\frac{5}{32}$ in.	·161 in.	20
$\frac{3}{16}$ in.	·191 in.	11
$\frac{1}{4}$ in.	·257 in.	Letter F

The $\frac{1}{4}$ in. size of rivet is not very frequently found on gliders.

Rivets should always be set with the proper tools. These consist of a "dolly" to hold up the head while the rivet is being set, and a "snap" to form the head. These two tools resemble punches, except that they have a recess in the end, that of the dolly to fit the head already on the rivet, and that of the snap of the shape of the head to be formed. Attempts to set rivets without these tools are doomed to failure.

Rivets in the wing surface, and sometimes in the fuselage skin, are often countersunk or flush with the plate surface. This is achieved by two methods, either by cut-countersinking the hole with a rose bit, or, where the metal thickness is insufficient to permit this, by dimpling the metal at the hole. Dimpling is effected by the use of hand tools. Again, the proper tools must be used, or the results will be erratic. As a guide, the table below indicates which method should be used for the various gauges of plate and rivet.

Gauge of plate	*Rivet diameter*			
	$\frac{3}{32}$ in.	$\frac{1}{8}$ in.	$\frac{5}{32}$ in.	$\frac{3}{16}$ in.
24g and thinner	D	D	D	D
22g	D	D	D	D
20g	D	D	D	D
18g	C	C	D	D
16g and thicker	C	C	C	C

C means countersunk. D means dimpled.

Rivets are available with several different types of head. The three most used are, in order of strength, the snap head, the mushroom head, and the countersunk head.

The snap head is a formed dome on the end of the rivet. The mushroom head is a much flatter dome, which does not project so far into the airflow. The countersunk head rivet is flat on the head and is designed to be fitted so that it is absolutely flush with the skin of the aircraft. Note particularly that there used to be 90° and 120° angles for countersinking. These days a further complication has appeared and that is that the angle of 100° is becoming the standard for countersinking. It is vital that the correct angle is used in all countersinking and dimpling operations. The above table of counter sunk and dimpled rivets applies to the 100° angle.

Dimpling is not as simple an operation as it sounds. It must be done accurately, and without cracking the plates. In some cases, spin dimpling may have to be used, rather than punching the dimples.

To form a snap head satisfactorily, the rivet shank must project about 1½ diameters above the surface of the plate; a trifle more in thick plates as the shank will shorten more as it is expanded. To form a countersunk head in a countersunk hole, the projection should be about ¾ of a rivet diameter, again rather more if the plates are thick. Usually, the countersunk rivet is used, so that the head already on the rivet is set into the countersink on the outside of the skin of the aircraft, and the other head is formed as a snap head, or even simply driven up as a plain flat "cheese". Light alloy rivets are made in various Specifications, but the most usual ones are:

Type of rivet	*Coloured*
Aluminium, L36	Black
Dural, L37	Uncoloured
Magnesium Aluminium alloy, L58	Green
Aluminium alloy DTD, L86	Violet

The Dural rivets L37 *must* be heat treated as mentioned above when talking about Dural. This means that they must be Solution Treated and set within an hour of being quenched. This will probably be beyond the scope of the average glider repair organisation as it required the use of a salt bath to Solution Treat the rivets. The other rivets mentioned in the table do not need Solution Treatment, but they are not as strong as L37 rivets.

One other type of rivet must be considered and that is the tubular rivet. This is frequently, in fact usually, of steel and is found in much larger sizes than the foregoing It is often used in wing root fittings, instead of bolts. The rivet itself consists of a tube, one end of which is belled out and actually turned over. When setting this type of rivet the formed end is held up by a shaped dolly, and the other end is formed with a similar tool, rather like a snap with a "pip" in the centre. This, when driven by a hammer, bells out the end and turns it over. Once again, it is vital to use the proper tools, or the end cannot be formed satisfactorily. The amount of projection above the plate surface is also important, but this cannot be laid down, as it depends on the length of the rivet, and these are often very long. Light blows must be used, or there is a danger of collapsing the rivet instead of forming a proper head. The best tool for this job, if it is available, is one of the pneumatic, or electric, rivetting hammers designed for the job.

Rivetting is a process that requires a little skill to get good results. When rivetting a long line in a plate, do not start at one end and work straight along. If you do this, you will find that the action of driving the rivets will distort the plate slightly and the holes at the end of the line will not line up. Drive a rivet at each end, then one in the middle, and then halve the gaps by driving a rivet in the middle of each. By this means you will ensure that any distortion is spread evenly over the whole plate in every direction.

The plates to be rivetted must be pulled up in close contact, and the best way to do this is to use a number of the small rivetting clamps made for the job. These are inserted in a number of the rivet holes and the plates pulled up. Some of the rivets are now driven and the clamps removed progressively as rivetting proceeds. Perhaps the most usual fault of rivetting is failing to ensure that the rivet is properly held up, while the rivet is being driven to form the head. The dolly must have as big a mass as possible behind it, to guarantee that the rivet is held immovable, while the head is being formed with a hammer on the snap. This is where the power rivetting tools are so valuable, as they deliver an enormous number of very light blows per second, which form the head easily without tending to knock the rivet back in its hole. Another method of driving rivets is the hydraulic squeeze method. This does need the proper equipment, which is rather expensive, but it has the great merit that exact loads can be applied, and extremely regular results can be obtained.

Another technique of rivetting which is most useful, in certain applications, is the use of "blind rivets" of the Chobert, Tucker Pop and Avdel type. These have one great advantage, that they can be used where it is impossible to get at the other side of the plates to hold the rivets up for setting. They all consist of hollow rivets, fitted on to a mandrel, and when the mandrel is fitted into the rivetting tool and the rivet inserted into its hole, the tool draws the mandrel out through the rivet, expanding it. Some of them pull the mandrel right through the rivet, and some types are designed so that the mandrel breaks at a given load, leaving the stem in the rivet, or allowing the end of the mandrel to drop out on the other side of the job, Blind rivets must be used with caution. First, they are not as strong in shear as solid rivets, though even this statement requires qualification. Tucker Pop rivets in Monel metal are as strong as solid rivets, and Chobert rivets plugged with shear pins are also as strong. However, in the thinner gauges of plate which are used on gliders, say 20 g and thinner, the shear strength of the rivets is not normally the design criterion of the joint. It is more likely that it will be the bearing area of the plates that will govern the size and pitch of the rivets. In this case, it may well be that, provided the shear strength of the blind rivets is greater than the bearing strength, of the plates, blind rivets could be used to replace solid ones.

Dural rivets L37 are probably not justified in glider work for the above reason except in the heavier gauges of plate, where the superior shear strength can be used. The sort of place that you might find these rivets used is in the construction of a built up metal spar. If L37 rivets have been used, it is probable that L37 rivets will have to be used in any repair, and this may well be beyond the scope of the average glider repair shop, since these rivets require Solution Treatment before being driven.

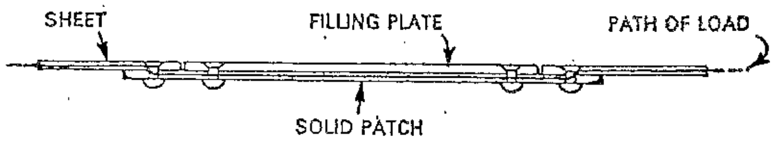
From what has been said, it should now be clear that it is virtually impossible to lay down standard repair schemes that can be used in all cases. Since we cannot replace all the strength in a repair, except in the case of welded structures, we must only adopt repair techniques where some loss of strength can be tolerated. In many cases, of course, strength may not be the major consideration, and there are plenty of places on a metal structure where stiffness or rigidity is the criterion rather than actual strength. For example, it might be quite permissible to put a flush insertion into a fairly large plate to repair a small hole, but it would be most unwise to do the same thing in a spar web. In the latter case, all the spar web loads would have to be carried across the rivets, and it might not be possible to work out a rivetting scheme which would provide the necessary strength reserve. The only alternative here would be to remove the damaged plate altogether and fit a new one, rivetting up into the original holes.

If in any doubt, the scheme proposed should be submitted to the manufacturer of the glider for his approval before the job is started. This approval should always be quoted in the log book when the repair is signed up.

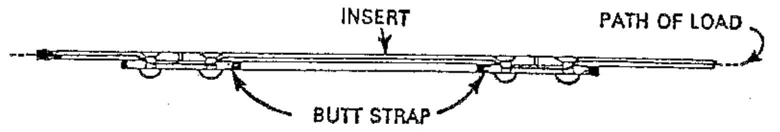
Patch Repairs

These fall into two distinct types: 1. The patch plate and filling plate repair, and 2. The butt strap and insert type. These are shown in illustration 4.3.1. You will see that in the filling plate repair, the actual filling plate carries no load at all; its only purpose is to preserve the outer surface of the skin, and therefore it may be attached to the patch plate by blind rivets if desired. This repair then is only used on the outer surface of the glider where the finish is important, and on parts of the aircraft where finish is of no importance, the filling plate can be omitted entirely.

When using the Butt Strap and Insert type of repair, the load is carried across the insert plate.



PATCH & FILLING PLATE REPAIR



BUTT STRAP & INSERT REPAIR

Illustration 4.3.1
Patch Repairs

General Rules

Repair materials must be of the same Specification as the original structure. Filling plates, patches, and inserts must be of the same gauge as the damaged sheet, and butt straps must be two gauges thicker than the damaged sheet, i.e. 16 swg butt strap for an 18 swg sheet. If the sheet has any appreciable curvature, pre-form the parts before assembly. The rivets should be of the same specification and diameter as the adjacent structure. Jointing compound must always be used when assembling the parts. Protective treatment must always be made good after the repair is finished. Rivet landings, the distance between rivet centres and the edges of material must not be less than 2 D, where D is the rivet diameter. Rivet pitch, the distance between rivet centres, should copy the pitch of the nearest edge of the damaged plate, but must not be less than 4 D.

Before commencing a repair, clean up the damaged area. Stop all cracks by drilling ⅛ in. holes at the ends of them. Cracks in skin over internal members may mean that the member underneath is damaged. Dress all distortion back with a mallet, or hammer and blocks of wood, and then inspect carefully for any cracks that may have been started. Cut out and file all holes to smooth shapes, preferably rectangular for ease of fitting. If you have to drill rivet holes oversize because they have pulled out of shape, make sure that you drill on the original centre. This can best be arranged by filing out the hole opposite to the distortion to an equal amount. The drill will then run through on the original centre. Note that approval may well have to be obtained for using oversize rivets.

Flush Repairs to small damage in clear areas

Scheme 4.3.2.

Use this scheme where: Damage is less than 3 in. max. dimension.
Damage is less than ¼ width of the panel.
You can get at both sides of the panel.

See illustration 4.3.2 and go ahead as follows:

1. Clean up the damage and stop cracks with ⅛ in. holes.
2. Make up the patch plate, using material of the same specification and thickness as the panel.
3. If using a filling plate, cut out damage, and make the filling plate to fit the hole.
4. Using jointing compound, rivet the patch plate into place, and then fit the filling plate with tack rivets. These latter may be blind rivets if desired.

Illustration 4.3.2 shows several types of this repair.

In material of 24 g .. .. use $\frac{3}{32}$ in. rivets
22 and 20 g .. .. .. „ ⅛ in. „
18 and 16 g .. .. .. „ $\frac{5}{32}$ in. „

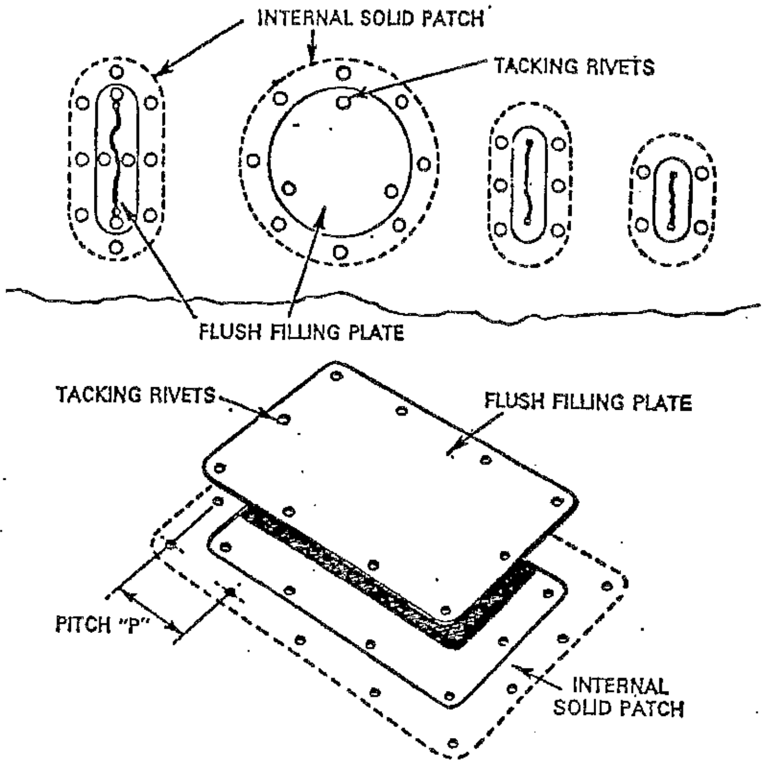


Illustration 4.3.2

Damage up to 2 in. — 8 rivets
„ „ „ 1. in.— 6 „
„ „ „ 1 in. — 4 „
Patch and Filling Plate may be circular if desired. Max. diameter of Filling Plate 3 in.

Scheme 4.3.3. *See Illustration* 4.3.3.

Use this Scheme to replace part of a large damaged panel. Note that the strength of the repair may not be up to that of the original structure, so, in case of doubt, obtain the makers' approval.

Make the butt strap in as few pieces as possible to accommodate the internal members. A gap of $\frac{1}{16}$ in. must be maintained between the internal members and the ends of the butt strap. The gap between the sheet and the insert must not exceed $\frac{1}{16}$ in. Use plenty of jointing compound when rivetting up. A typical example of rivetting at a corner is shown in the sketch. Rivet pitch at a corner may be less than normal, but must not be less than 4D. D being the rivet diameter.

Use existing rivet holes where possible. If the damage is near the edge of a panel, cut it out to the edge of the panel. The repair then becomes the partial replacement of a panel.

Use the same rivet pitch as the nearest adjacent parallel joint. Where the joint crosses an internal member, and the rivet pitch is more than 8D, make the cut midway between two rivets. If the rivet pitch is more than 8D, make the cut 2D from one rivet and insert an additional rivet 2D from the other side of the cut. This point is shown in the illustration.

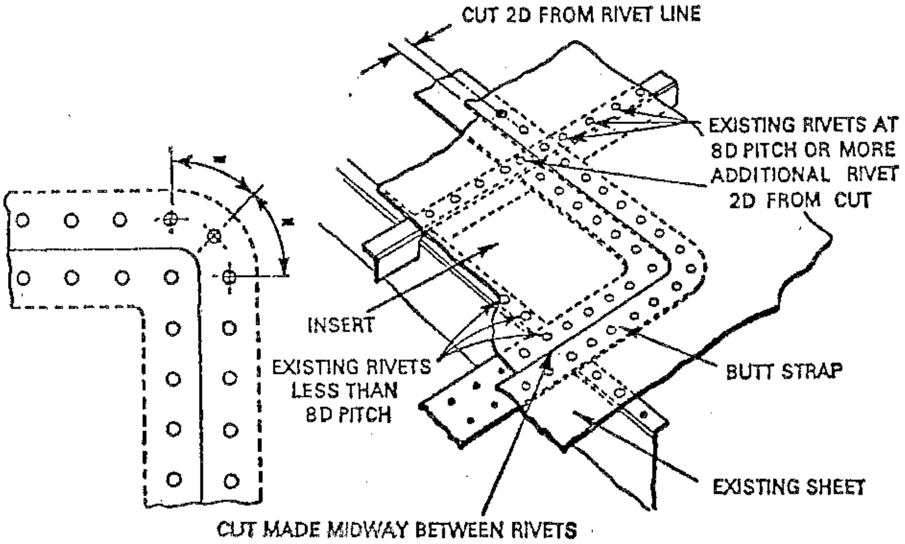


Illustration 4.3.3
Repair to replace part of large panel