SECTION 1

GENERAL CONSIDERATIONS APPLYING TO REPAIRS

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Chapter 1.1
SAFETY IN FLIGHT

The safe operation of a glider depends on three things. The manner in which it is flown, how it is maintained, and how it is repaired after damage or deterioration. The first is outside the scope of this book, the second has already been covered in the Glider Maintenance Manual obtainable from the B.G.A. and, while some aspects of repairs are included in that publication, it is the purpose of this book to go into this matter in rather more detail.

It is quite impossible to draw up a repair scheme for every conceivable repair that will ever have to be made. However, it is quite feasible to consider the more usual types of damage, and to lay down standard methods of dealing with these. It will then be found that nearly all types of repair can be carried out by employing combinations of these basic methods. In cases of great complexity a scheme can be worked out, and if there is any doubt in the mind of the Inspector, reference should be made to the manufacturer who will always advise on the suitability of the scheme.

The structure of a glider can be divided up into three categories—Primary, Secondary and Tertiary. These may be defined as follows:

Primary: those portions of the airframe in which a single failure would cause collapse of the structure or complete loss of control.

Secondary: those portions of the airframe which would normally be considered as primary, but which unavoidably have such a reserve of strength that appreciable weakening can be permitted without risk of failure, and structure which, if damaged, would not impair the safety of the aircraft.

Tertiary: those portions of the airframe in which stresses are low, but which for various reasons cannot be omitted from the aircraft.

It is here that the Inspector requires some knowledge of the theory of structures when deciding into which category any component of a glider falls. As a very rough guide some examples follow:

Primary structure: all spars, longerons, ply skinning of torsion boxes, diagonal members of girder type fuselages, ply skinning of monocoque fuselages, attachments of wings, tailplanes, etc.

Secondary structure: minor parts of the airframe whose main duty is to provide correct profiles, skids, etc.

Tertiary structure: fairings and suchlike parts of the airframe which contribute little or nothing to the strength of the glider.

Bear in mind that these examples must be considered with some intelligence, and not applied too rigidly. A fairing may be Tertiary structure in itself, but if its failure were to involve the possibility of its fouling a control surface, then clearly we must think again.

Circumstances alter cases too, and we could well consider the tyre of a glider with a normal main skid to be Tertiary structure since bursting of the tyre would have no effect at all on the safety of the machine. This would not be true in the case of a glider with a main landing wheel but no proper main skid where bursting of the tyre might well result in considerable fuselage damage.

From the definitions of structure, it is clear that a repair to Primary structure must replace all of the strength lost by damage. In the case of Secondary and Tertiary structure some loss of strength can be tolerated. However, the Schemes that follow in this book are based on Primary structure requirements, i.e. the replacement of all the strength of the members damaged. They can therefore be used for all categories of repair.

It can be accepted that if a repair is made to a wooden aircraft, using approved materials and glue, and using ply splices of not less than 12 : 1 angle, and not less than 15 : 1 splice angle in solid members, the resulting repair will be as strong as the original structure. A reasonable standard of workmanship is required, but rather more important,

complete honesty on the part of the workman and the Inspector as regards dimensions, cleanliness of joints, accuracy of profiles, and the gluing techniques. On these may depend the lives of pilots flying the repaired aircraft.

Apart from restoring the strength of a damaged component, three other considerations must be satisfied. The stiffness of the member must not be materially altered or it will throw some of its duty on to the adjacent structure. The weight of the repaired structure must not be significantly more than that of the original, and lastly, the protective treatment of the structure must be made good. If all these four aspects of a repair are satisfactorily covered, then the repair is a good one.

Before starting a repair, make a full inspection of the damage, cleaning away all protective treatment as necessary to be sure that no damage escapes detection. In this connection remember that it is quite possible for damage to show up a long way from the source of the trouble. For example a fuselage damaged at the tail end may well show compression shakes in the longerons up at the front end near the main frames where the wings attach. Classify the damage into three categories, negligible, repairable, and replacement. Make a clear plan of action, so that you do not cause yourself unnecessary difficulties through rebuilding parts of the structure in the wrong order. A little thought here can often save a lot of time. If the structure is badly damaged, make sure that it is correctly supported so that you do not build distortions into it. Frequent use of levels, clinometers, and measuring tapes will ensure that the final result is true to drawings. If drawings are needed for the rebuild, the manufacturers will be found only too willing to supply these, and any other advice and assistance that the Inspector may require.

At each stage of the repair the Inspector must satisfy himself that the work has been satisfactorily carried out before he gives the o.k. for the next stage to go ahead. In all aircraft work it is the Inspector who is the man who carries the responsibility and it is his signature which guarantees the work. Anybody may *do* the work: all that is required is that an Inspector approved by the B.G.A. signs that he has inspected it and is satisfied that it has been properly done.

Electrical Bonding leads are now (October, 1966) a mandatory requirement in all gliders which hold a B.G.A. cloud-flying category. If bonding leads are fitted, a check must be made to ensure that any damaged, or removed for access to the repair, have been replaced and that the continuity of the leads is correct.

A check must be made to ensure that all drainage holes are clear, and that the ones in the repaired structure have been drilled in the correct places.

When a repair has been made to a control surface which carries a mass balance, a check must be made to verify that the mass balance has not been upset. Most glider control surfaces are not fully mass-balanced, that is, the c.g. of the surface is not brought to the hinge line, or slightly in front of it, as is usual on powered aircraft. This is because the criteria for the mass balancing are considerations of stability, or the handling of the glider, rather than purely prevention of flutter. It is unusual to find the limits of the c.g. of control surfaces in the glider's handbook, and in case of difficulty reference should be made to the manufacturer. It is assumed that the Inspector is familiar with the Principle of Moments in which case he should have no difficulty in determining the c.g. of the control surface by weighing it, and then supporting it at its hinge line and measuring the out of balance moment with a small spring balance, or by moving a small test weight about on the surface until balance is achieved.

Chapter 1.2

WORKSHOP—EQUIPMENT AND TOOLS

It cannot be overemphasised that satisfactory work demands a certain minimum of equipment and tools. If that minimum is not available then the Inspector should refuse to sanction the work. A workshop in which glider work is going to be done must have a heating system capable of maintaining the temperature at 50F under all weather

conditions as a minimum, a good lighting system, and sufficient ventilation to enable doping to be carried out without unpleasant consequences, and it must be equipped with trestles, benches, etc. to permit work to be done in comfort. It is an advantage if the floor is of wood, as this permits the erection of jigs and other fixtures of a temporary nature very simply and rigidly. Also there must be an adequate supply of efficient fire extinguishers, as the fire risk in the average glider workshop is potentially great.

Fixed Equipment

Proper woodworking benches must be provided, and each should have a woodworking vice fitted to it, and a fitters vice at one end. How many benches will be needed depends, of course, on the number of men expected to be using the shop at one time. Some sort of grinding wheel is a necessity, though this can quite well be one of the hand or foot operated type, for a small shop. A pillar drill is a useful tool as it assists accurate drilling, but good attachments can be bought these days to enable the small electric drills to be used as pillar drills.

From the safety angle, ensure that the lighting is good in the working areas of any power tool and benches. Many accidents can be traced to poor lighting.

Tools

Nothing very exotic is required in the way of woodworking tools. An assortment of chisels ranging from about ½ ins. to 1 in. or a little bigger will be needed, and they must be kept really sharp, so something good in the way of an oilstone is also needed. Use the oilstone properly so that the surface of it remains flat, otherwise it will be impossible to maintain straight cutting edges on the tools. A few planes will be required ranging from jack planes down to the small bull-nose planes, and a spokeshave. These also need to be kept really sharp if good work is to be done. A few screwdrivers of various sizes, and an assortment of spanners to cover the range from 0 B.A. to 6 B.A. and from $\frac{3}{16}$ ins. to about ½ in. B.S.F. will cover most of the requirements of fittings on British gliders, but if you anticipate much work on foreign machines, then these should be supplemented by a set of metric spanners. A number of files should be available of various sizes and these will be found of great help in preparing scarfs. In particular, 'Millenicut' files do very good work on ply scarfs, and one of the adjustable body files, as used by coachbuilders, will be found very useful for the same purpose. These latter have a Dreadnought cut on the teeth, and these do not leave tooth marks on the wood. A further advantage of files in general is that they do not suffer from damage if they strike the odd tack which has been overlooked.

Several saws are required, from the common hacksaw for metal, to a range of saws for wood. A small dovetail saw cuts ply and small sections of spruce, but you will need a larger tenon saw for some of the heavier work. A powered circular saw is a great time-saver, as also is a bandsaw, but if these are out of the financial budget, an ordinary treadle fretsaw, with a tilting table, will do some very good work. The great merit of the latter is that it leaves the cut surface almost perfectly smooth, so that corner blocks, etc. leave the saw virtually ready to glue in with the minimum of sanding to fit.

Hammers you will need in plenty. You cannot have too many tack hammers, as frequently you will find that you need several assistants to tack up a large panel of ply when you are working against time to get the panel fixed before the permitted shuffling time of the glue. A few larger hammers will be needed for the odd workshop jobs, and you must have a mallet for use on the chisels. Normally you will not need to strike the chisels, but there are a few jobs where a mallet is very handy. Do not hit the chisels with a hammer, as this will wreck the chisel handles. Use the proper tool, the mallet.

Hammers, of the tack variety, are primarily used for driving the small brads or tacks which are used to close up the scarfs. The tacks should be bent over preferably, and not driven home on to the tacking strip, as this spreads the load over the tacking strip. However, one further tool will be found very useful for this job and that is one of the hand tackers used by shopkeepers and others for labelling. These tools drive a U-shaped staple, and since they can be loaded with a number of staples and drive them in

automatically, they save a lot of time in making up tack strips. They can be used with one hand and can drive staples much faster than one can drive tacks. They cannot be used on all jobs, as the holding power of the staples is not quite as good as tacks for the larger scarfs in solid timber, but they are a worthwhile investment.

Special Equipment

You cannot have too many 'G' cramps in the workshop. These must be of various sizes, and for the smallest jobs the spring clothes pegs, obtainable from any ironmonger, are excellent. Bulldog clips are also very good for these small jobs.

There are also available some special cramps designed to pull leading edge ply round the ribs and down on to the spar. Three of these are a worthwhile investment, as they save no end of time when replacing heavily curved ply.

There must also be means of applying heat to setting glue joints. Nothing fearfully elaborate is needed: in fact many joints can be cured quite satisfactorily by the use of the humble hot water bottle. However, the scope of the workshop is greatly increased if a few old electric fires are available which can be placed in strategic positions round a setting glue joint. Also useful is an old electric blanket, or heating pad. This can often be arranged over the setting joint and then covered with a blanket to conserve the heat. Infra-red heaters, of the p.g-lamp variety will do the same job and these lamps do seem to drive the heat right into the job, which of course is what is wanted. Never, under any circumstances, attempt to glue a repair unless you are certain that the necessary temperature can be attained to cure the job.

Some sort of weighing equipment must be available to weigh gliders and to determine c.g. positions. Two spring balances reading to 400 lbs. will do this job, or platform scales can be used. The latter are the more convenient, but the main difficulty is that most of them have the platform so close to the pillar that it is difficult or impossible to get the wheel of the glider on to the scales. A small platform scale will do the job of the tailskid balance. More information about weighing is contained in Section 6.

If you intend to make up control cables, either by hand splicing or by means of the Talurit swaging process, then you will need to make up some rig by which the cables, after manufacture, can be proof loaded to 50% of their nominal load. Most cables are 10 cwt. so you will need a rig to put 5 cwt. load on to the cables. This can quite easily be done by a system of levers and a spring balance. A spray plant for applying finish dope is almost a necessity. Quite cheap plants are available these days and while it cannot be said that one is absolutely necessary it will save a lot of time in the long run.

The above list of equipment is a reasonable minimum, but the enterprising repair man will add quite a lot of extra tools to this list. Electric power tools, from drills, to disc and orbital sanders, speed up the work and make for efficiency. A compressed air line running round the shop, with plug in points at convenient places, is probably beyond the budget of all but the largest establishments, but it enormously increases the scope of the shop. Apart from spraying, there are many small pneumatic tools which have a lot of advantages over electric tools. They are safe, very small for their power, and can be stalled and generally maltreated with no damage to windings or danger of burn-out.

Chapter 1.3

PROTECTIVE TREATMENTS

Virtually all the parts of an aircraft will be found to have been treated in some way to protect them against deterioration. It should be the aim of the repairer to ensure that the repaired structure is protected to the same standard as the original structure. The main things to guard against are water, ultra violet light in the case of fabric, acid attack, and bacteriological attack.

In the case of fabric, the doping scheme itself is a protective treatment and this is considered more fully in Section 2.

As regards the timber in a glider, it is usual to spray the interior of fuselages, and the structure of wings before covering, with a light coat of a cellulose dope. This has the effect of minimising the transference of moisture from the atmosphere to the wood and *vice versa*, and also discourages bacteriological and insect attack. To assist in ensuring a sound coat of the dope some colouring is usually added to it. In repair work, clear cellulose dope is quite satisfactory, but a little pigment added makes the spraying simpler, as it is easy to see where the spray gun has missed.

All the metal components of a glider are liable to corrosion and are protected by some sort of protective film. The only exceptions to this are such things as ballraces, plain bearings, and wing and fuselage pins where painting is clearly impossible. In these special cases the grease or oil is relied on to keep the corrosion at bay. For everything else the aim must be to keep the protective film intact. In repair work the metalwork must be carefully inspected and any corrosion removed before the protective film is made good. There are a number of commercial enamels and paints which will be found very useful for this particular job.

In the case of steels the protective film may take the form of a plating of a non-corrosive metal, or a coating of some sort of paint. In the former case the plating, usually of cadmium or chromium, will have been done on construction, and few workshops are equipped to replate parts, so the object must be to prevent damage to the plating. Where it does occur, then any corrosion must be cleaned off and the part protected by means of some sort of paint. As regards the painting of steels, the stove enamelling process to specification DTD56A (Directorate of Technical Development) is good, but this involves ovens to stove the parts after painting. The makers of aircraft finishes make many products for the protection of metals, and new methods are continually being developed in their research departments, and they will be found very helpful in any special cases of difficulty.

Light alloys are usually protected by a chemical process known as anodic treatment. The components are cleaned and then immersed in a diluted solution of pure chromic acid and a current is passed through the solution, the component being the anode. This produces a very corrosion resistant film on the metal, but it is important to avoid damaging this film.

Aluminium itself oxidises rapidly, but once this has started, the oxide layer forms a good protective film to prevent any further oxidation. For this reason Dural sheets are sometimes coated with a thin layer of pure aluminium, and in this form the metal is known as Alclad. It requires no further protection.

Vitally important is the case where metal parts such as bolts pass through wooden members, and where dissimilar metals are held in contact. In the latter situation we have electrolytic action attacking the metals should there be any moisture in the area. In these two cases it is absolutely essential that the parts are assembled by the 'Wet Assembly' process where the metal is thoroughly coated with an approved jointing compound such as Duralac and assembled while this coating is still wet. This still applies whatever the protective coating on the bolts, or other parts, and it will be realised that aircraft bolts are normally plated with cadmium or chromium. The only metal parts that may be considered proof against corrosion are those made from stainless steel, but even in this case the metal is not safe from electrolytic attack.

From the above remarks it should be obvious that drainage holes in the structure of a glider are very important. They must be kept clear, otherwise there is a chance of an accumulation of moisture in hidden places. Any drain holes 'lost' during repair must be replaced and they should be made the same size and in the same places as the original ones. Care must be taken to avoid raising internal burrs and the cut edges of the holes, when drilled in ply, should be treated with bituminous paint.

Control cables are a special case. They should be treated with a resin compound such as 'Red Sozzle', lanolin resin compound DTD 279 or 663, or one of the Chromate Cable Preservatives (DTD 297b). These may be applied by means of a cloth soaked in the stuff and rubbed along the cable. They do not dry out hard but remain slightly flexible. No grease or oil should be allowed to get on to cables, as these tend to collect

grit and the cables then grind themselves away. This particularly applies where the cables pass around pulleys, or run over fairleads.

Acid mainly comes from accumulators used for driving blind flying instruments. The greatest care must be taken to ensure that no acid can escape from these accumulators, and any spillage, however small, must be carefully washed out and dried.

Chapter 1.4

LOG BOOKS AND OTHER PAPERWORK

All work done on a glider must be recorded in the log book, and signed by an approved person. This means an Inspector approved by the B.G.A. Only by strict adherence to this rule can it be ensured that the log book does give a true history of the glider. It is quite in order, of course, for a private owner to carry out repairs or adjustments to his own machine, but he must have the work inspected by an Approved Inspector who must also sign the log book entry. This means that the log book must, at all times, be kept with the glider, or in such a place that entries can be made as soon as the work has been done and inspected.

The B.G.A. has recently introduced some new forms with the idea of simplifying and streamlining the keeping of records. The form Insp/6, put up in pads of triplicate, 'no carbon required', paper is used for recording the work done on Certificate of Airworthiness overhauls and major repairs. The three copies are used as follows:

top copy inserted permanently into the log book;
the second copy is sent to the B.G.A.;
the third copy is retained by the Inspector for his own records.

A further form, Insp/7, put up in similar pads, is used for the reweighing of gliders, and the distribution of the copies is the same. In addition the details of the re-weigh must be entered in the front pages of the log book in the panel marked 'Weighings'. By this means a history of the glider will be available not only in the log book, but also in the records of the B.G.A.

Release Notes

Release Notes are always issued with approved materials and components. The purpose of these release notes is to prove to the user that the parts in question have been inspected and approved, and are released from store to be incorporated in aircraft. The Inspector will have his own system for filing such documents, but it is essential that the numbers of the release notes for the parts or materials used in a repair are quoted in the log book. Should there ever be any subsequent query as to the quality of a repair, the Inspector has only himself to blame if he cannot prove that the material used was approved. The only proof that he can produce is the Release Note, and even if that is lost, provided that the number has been quoted, the material can be traced back to the original supplier and the original approval.

It is, of course, true that no amount of paperwork can keep a glider serviceable. But, equally, it is a waste of time and effort not to keep records of what has been done, because this merely means that on subsequent inspections much work will have to be done again, simply because there is no proof that the work has been properly carried out. It is also important that the work is recorded in the log book, and in the proper form, since when the machine changes hands, the responsibility of the maintenance will probably also change to another Inspector.

Chapter 1.5

MODIFICATIONS

Anything which alters the state of an aircraft from that in which it was delivered from the manufacturers is, strictly speaking, a Modification. Modifications fall broadly into

two categories: Official, and Unofficial. All Modifications must be recorded in the log book of the aircraft and signed by an Approved person.

Official Modifications are fairly straightforward. They may be Mandatory, or Optional, but in either case the method of incorporation is supplied to the Inspector, frequently with manufacturers' drawings, and there should be little difficulty in carrying them out. They are normally circulated through the B.G.A., direct to owners and Inspectors, and included in this is the degree of urgency attaching to the Modification, e.g. Immediate (before further flight), at next C. of A. overhaul, etc.

Unofficial Modifications present a little more difficulty. Firstly there is the trivial modification which cannot in any way affect the safety or strength of the aircraft. Examples of this type of thing: the installation of instruments, unless this affects the weight and c.g. significantly, the fitting of map pockets in the cockpit. While on this subject it is worth noting that the ideas of owners and Inspectors on what is a trivial modification frequently do not quite coincide. The Inspector must satisfy himself that the modification is satisfactory in every way. Can it come loose? What would happen if it did? Can it in any way contact the control system? These are the questions that the Inspector must ask himself among others. If he really is satisfied on all these matters then he may approve the modification, record it in the log book, and sign it. By doing this the Inspector accepts responsibility for the modification.

More thought is required in the case of a modification which clearly cannot be considered trivial, but which seems a good idea. In these cases there is a question of strength of the glider, or alteration of its flying characteristics, or its controllability. Examples of this sort of thing: making canopies for open gliders, the installation of heavy items, accumulators, oxygen equipment, etc., and the fitting of permanent ballast. In all cases of this sort the scheme should be submitted to the B.G.A. with sufficient information and sketches to show what is proposed. The usual result is that the B.G.A. will issue approval for it as an optional modification. It is worth pointing out that this system can often save time, since if the Inspector applies to the B.G.A. in the first place, he may well find that there is an official modification (optional) for the very job that he wants to do. In working out the scheme to be followed the Inspector must bear in mind the British Civil Airworthiness Requirements, Section E—Gliders. For instance, in the case of a cloud flying glider, the ultimate load factor is, at present, 7·5 so that if he is fitting a bracket to carry a 10 lb. battery that bracket must be at least strong enough to carry a 75 lb. normal load and the structure to which it is attached must be capable of accepting this load. Also, of course, the structure must be capable of taking negative loads, i.e. upward loads, and as the ultimate factor in this direction is 3·75, the bracket will have to be strong enough to take 37.5 lb. in the upward direction. This is often where help is needed because the stressing figures for a given glider are not normally available to the Inspector, but in all cases the manufacturer will give all the information and assistance needed.

A further point that must be kept in mind is that modifications of this nature usually affect the All Up Weight and the c.g. position of the glider. If this is the case, then the alterations must be calculated and recorded in the log book, or the machine must be re-weighed.

In all cases where the Inspector feels any doubt, he should refer to the B.G.A. in the first instance. Inspectors should feel that they have the resources of the B.G.A. at their elbow to call upon whenever required. If the answer to a problem is not immediately available, it will be found as soon as possible.

The Inspector must never forget that he carries a very heavy responsibility in life and limb, and a wrong decision by him can have disastrous results.