Chapter 5.1 GENERAL INFORMATION

LIST OF CONTENTS

5.1.1

INTRODUCTION

General

1. The information given in this chapter covers the general aspect of repairs to wooden components of aircraft structures. Examples of such construction are wooden fuselage frames and shells, fabric covered control surfaces, decking, some types of rotorplane blades and the structure of gliders and sailplanes.

2. While metal has generally superseded wood in airframe construction in recent years, it is considered desirable to perpetuate acquired knowledge and experience of wooden repairs technique in this publication. Complementary repairs to those given in this chapter are repairs to fabric-covered surfaces which are dealt with in Sect. 8.

3. Repair methods employed on wooden airframe components are dependent on the type of construction and must form an integral part of the type design; therefore no structural repairs may be effected without the design authority approval referred to in Scheme 1.1.2 of this publication.

Damage arisings

4. The basic causes of damage to wooden components are summarised in the following list, the type of repair to be effected being largely influenced by the manner in which the damage was sustained.

(1) Fracture of components
(2) Crushed members due to causes such as over-tightening of bolts
(3) Elongation of holes
(4) Deterioration of glued joints
(5) Oil or water soakage
(6) Shrinkage or distortion
(7) Dry rot, woodworm, etc.
(8) Normal wear and tear

Basis of repair

5. Consideration must always be given to the function of components which are to be repaired and for this purpose the structure of an airframe is divided into three categories, namely primary, secondary and tertiary. The application of these categories is given in Scheme 1.2.2 of this publication and any repair scheme must be developed from them.

6. The weight factor must always play a vital part in the consideration and development of any repair scheme. To keep the weight/strength ratio down to a bare minimum, therefore, the reserve factor in any structure should not normally be restored to a figure greater than 1.2. In some cases, however, this figure may be the minimum permissible for the type of repair.

Note . . .

Scheme 1.2.1 of this publication gives information on the basic requirements for strength and quotes the circumstances in which reserve factors in excess of 1.2 are necessary.

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DETECTION OF DAMAGE

Initial damage

1. Where extensive damage has been sustained, the centre of the damage may be easily detected and, from a general survey of the aircraft, the amount of repair work necessary can be assessed. However, after an initial survey of the damage, a careful examination of the complete structure must be effected before deciding upon the type of repair scheme to be adopted.

Secondary damage

2. Secondary damage may have occurred, due to abnormal loads being transmitted along the structure, which are not immediately noticeable; damage to one end of a member, for instance, may result in the other end being strained or equally unserviceable. A typical case would be that of a wooden strut fractured under compression, when the attachment bolt holes in the wooden structure would probably be elongated and cracks may have developed in other components.

3. With regard to the latter, the detection of cracks in wooden members may be very involved and is not dealt with in detail in this chapter. However, where cracks are suspected in a member of small cross-sectional area, light bending or twisting of the member by hand will usually help to reveal any cracks.

Visible damage

4. Damage of a minor nature consisting of cracked plywood fairings, holed skinning or fractured wooden brackets, etc., is usually visible and will be detected during the servicing of the aircraft. This damage may be repaired in the field, the methods of effecting the repairs being given in Chap. 5.2 to 5.6 of this publication.

Covered components

5. Where wooden components are covered by fabric binding or heavy protection treatment, the indications of damage to the components may not be obvious; therefore a close examination of all damage which may have extended beneath the covering must be effected. The damage may be indicated by the lifting of the fabric or the formation of a sharp, raised line on the fabric, denoting a fracture. These signs of altered contour must never be ignored and the covering must be removed and the wood examined. Where necessary, the damaged portion of the components must be removed and an approved repair made.

Detection of deterioration

6. When it is necessary for a wooden or composite wood and metal aircraft to be picketed out for a period in all weather conditions, the detection of deterioration of the timber and glued joints is essential. A thorough examination of the airframe structures must be made periodically to ensure that no damage has occurred through water-soaking, wet rot or dry rot, and that there are no signs of the structure being attacked by woodworm or bacteria peculiar to the tropics which may be the result of unsatisfactory protective treatment. Where such damage has occurred, all affected components or sections of components must be renewed immediately, especially where joints in an old airframe may have been glued with Casein cement, which is not impervious to moisture.

Note . . .

Casein cement is no longer used for glueing wooden components of Service aircraft, having been superseded in its use by the various synthetic glues mentioned in Chap. 5.2.

7. To a greater extent, oil-soaking of wooden components can be disregarded as a source of real damage. It does not appreciably affect the strength of the component and does not penetrate the grain as badly as water-soaking. Where it is detected, and, for instance, layers of plywood are soggy and tend to lift, the component should be renewed when convenient.

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8. Wooden components affected by wet or dry rot, other fungi defects, or damage caused by insects, must be examined thoroughly before the extent of any damage can be finally assessed and the causes eliminated. The visual examination will necessitate the removal of any fabric covering on components in the affected area where deterioration is evident. This may be recognised by the fabric lifting or bubbling, with an accretion of a white, powdery substance in the vicinity.

9. To enable the various defects to be recognised, comprehensive information is given in A.P.1464B, Vol. 1, Part 2, Sect. 4, Chap. 2 and reference to this publication should be made before repair assessments are commenced.

Mechanical damage

10. Damage caused by the crushing of components by the over-tightening of bolts may be detected during the close examination of members renewed during servicing or repair. If the wood fibres have not been damaged and the depth of the indentation does not exceed the approved limit, no immediate repair action is necessary. Where the indentation of the member exceeds the limit, a patch repair must be effected.

11. During the routine servicing of an aircraft, bolt holes in wooden components may be found to be elongated due to wear or crushing. The components affected should be repaired by metal bushing of the holes where permissible; alternatively, the components should be renewed.

Distortion

12. Damage which may be caused by the shrinkage or distortion of wooden components can only be determined by a detailed examination of the stripped structure. Where visible examination cannot be made in cases such as the detection of loose plywood panels a rubber suction device may be used.

REPAIR TECHNIQUE

General

1. The various methods of effecting approved standard repairs to wooden aircraft components are described and illustrated in the ensuing chapters of this Section, the type of repair to be employed being indicated according to the damage sustained on different types of structure. In the following paragraphs, items of standard procedure are given as a guide to the operator prior to commencing any sequence of repair operations, but the type of repair to be effected must be, wherever possible, in accordance with the instructions contained in the relevant aircraft Vol. 6, which is the basic design authority (*Chap.* 1.1 *refers*).

Support of structure

2. Before any structural repair of a wooden aircraft component is attempted, consideration must be given to the effect on the structure of the removal of members to carry out the repair; any extensive repair will necessitate adequate support being suitably positioned to prevent distortion.

Interchangeability

3. Component interchangeability must not be destroyed in the process of carrying out any repairs. If the interchangeability points are disturbed during repairs, the affected component must be checked by a reference jig or gauge after the completion of repairs.

Cracks

4. In very lightly stressed or non-stressed components, if an immediate repair is not considered essential, it is permissible for a $\frac{1}{8}$ in. dia. hole to be drilled at the extremities of any cracks to prevent them spreading.

Ventilation

5. When a boxed wooden component is being repaired, care must be taken to ensure that no permanently air-tight compartments are introduced. To avoid this possibility, a $\frac{3}{8}$ in. dia. hole should be bored at the lowest corner of the panel bearing the least load in any such compartment.

Construction details

6. During the process of cleaning out damage to components, compartments, bays, etc., it is advisable to make notes and sketches of the grain direction, screw lengths and pitches and any other relevant points considered necessary, as these items may not be obvious after removal, especially if an aircraft repair publication is not available.

Removal of undamaged components

7. Before cutting out any damage, a visual check must always be made to ensure that other structure, pipe runs, cables, control runs, etc., are not hidden behind the damaged area. If any components are likely to interfere with the cutting operation, they must be removed; if necessary, access holes should be cut where convenient to effect the removal. Where access holes are to be made in skin panels, the skin must be suitably supported during cutting, to prevent splitting.

Mass-balanced control surfaces

8. Repairs to mass-balanced control surfaces of wooden construction, which introduce additional weight, will usually disturb the balance of the control surface and adjustment will be required, mass-balance weights being added or removed when the repair is respectively aft or forward of the control hinge line. For detailed information on checking the mass balance, refer to Scheme 1.1.4 of this publication.

Materials used for repairs

9. The advantages of wooden aircraft construction are the simplicity with which repairs can be made and the small number of tools required. Apart from the standard tools used by the aero-carpenter, G-cramps, tacking strips and special cramping devices are sufficient for most repairs. Some special moulds, together with tensioning bands, may be required to effect repairs to preformed skins.

Timber

10. The types of timber required for repair are Sitka and Hemlock spruce, or the nearest substitute (Douglas Fir), Mahogany, Walnut, Ash, plywood and some types of compressed wood. Before any timber is used, it must be carefully examined for defects (*A.P.*1464*B*, *Vol.* 1, *Part* 2, *Sect.* 4, *Chap.* 2 *refers*).

Adhesive

11. Aerolite 306 to B.S. Spec. 1204 is the approved synthetic resin adhesive used, together with wood screws or tacks, to secure an efficient wood-to-wood joint. For detailed information on the use of this glue, refer to Chap. 5.2 of this publication and also to A.P.1464B, Vol. 1, Part 2, Sect. 4, Chap. 9.

Note . . .

Where joints have previously been made with Casein cement, these should be cleaned up so that the two different adhesives are not in contact, except across a line. Where a joint in which Casein cement is used does not form part of a repair and the repaired members pass over it, the original adhesive may remain.

Screws and brads

12. In glued joints liable to fail through the warping or buckling of plywood, reinforcement with wood screws should be effected. These should not be used in members whose smallest width of cross section is less than $\frac{1}{2}$ in. For members where the smallest width of cross section is approximately $\frac{1}{2}$ in., wood screws no larger than No. 2 should be used. Where brads are used to maintain glued surfaces in close contact, they should be dipped in resin before use.

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REPAIRS TO WOODEN STRUCTURES

General

1. There are five basic classes of repair, namely, the treatment of negligible damage, the patch repair, the insertion repair, the replacement repair and the special repair involving both replacement and the building up of existing structure. In practically every case the spliced, or scarfed, joint plays a decisive part and the effective completion of repairs, as a whole, depends on the strength and soundness of these joints.

2. The basic repair classes referred to in para. 1 are covered in Chap. 5.3 to 5.6 and in all cases, the schemes may be adapted to suit specific conditions. The basic design authority for any repair is always the relevant aircraft repair publication, in which, also, the amount of negligible damage which will not require extensive repair work is given.

Spliced joints

3. When splicing two solid wooden members together, the splices should be as long as possible. The minimum length of the scarf joint should be from 9 to 15 times the thickness of a member, according to the function of the structure involved. Laminated members may be repaired by a single splice as used for solid members, or by separate splices in the individual laminations (*Chap. 5.4 refers*). Some variations of the splicing angle are shown in the following table:—

Member	*Length of splice* — *solid wood or plywood*
Members in tension and all structural members	1 in 15
Secondary and non-structural members	1 in 10
Members in compression and all other members	1 in 9

4. All spliced joints must be made so that they are of equal strength to the original strength of the member. Where accessibility is difficult and conditions are unfavourable, joints may be made *in situ* providing they are so designed to be as strong as the original structure. In all cases the direction of the grain on the repair must follow that of the structure. This may be indicated on the appropriate structure illustrations in the Vol. 6, if it is not obvious on the airframe because of heavy protective treatment or fabric covering.

Cramping

5. When making a glued joint, an even pressure must be applied and retained for from 1¼ to 12 hours, the actual cramping time being determined by the temperature and the method of the gluing employed. The repair and the equipment necessary for the job must be planned to ensure that the joints can be made and cramped within the appropriate "shuffling" time. G-cramps should be used to provide the required pressure and should be spaced at a 4 in. pitch, the pressure being evenly distributed along the joint by using lengths of wood well overlapping the length of the splice. If G-cramps cannot be used, plywood bradding strips may be used as an alternative for ply repairs.

Note . . .

When removing brads from the bradding strips, wooden blocks must be placed under the pliers to provide the necessary base for levering the brads free with the pliers and also to protect other components from damage.

6. When cramps cannot be used for repairs to solid members, wood battens, of sufficient length to overlap each end of the spliced joint, may be drilled to pick up with any existing attachment holes on the spliced length and placed on top and underneath the splice, over-length bolts being fitted and tightened to draw the battens together to distribute the necessary pressure. If this method is impracticable, a local rig should be made up to provide the pressure on both sides of the spliced joint.

Plywood splices

7. When making a spliced joint in plywood, the length of the splice must be at least nine times the thickness of the ply. Each surface to be mated must be tapered off to a knife edge and must be supported on a suitable, rigid surface during cutting. In all cases, the edge of the tapered portion must lie along the edge of a supporting member to prevent damage to the supporting member during scarfing and to ensure that the scarf edges are parallel and the splice correctly angled. If the width of the splice is greater than that of the supporting member, the latter must be increased in width by the addition of a spruce packing strip. As a generally accepted rule, no two splices may be made within one splice length of each other and splices in plywood must not overlap splices in any other members.

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5.1.5

PRECAUTIONS AGAINST DETERIORATION OF WOODEN COMPONENTS

General

1. Where wooden components form part of an airframe structure, e.g. wooden fuselage, tail unit, main planes, control surfaces or internal components, suitable precautions against the deterioration of these components must be taken at all times, particular attention being necessary when the aircraft to which they are fitted is picketed for long periods in all weather conditions.

Weatherproof covers

2. The main consideration must always be to prevent the ingress of rainwater or other moisture into the interior of the aircraft. This may be achieved by correctly and securely fitting all weatherproof covers provided for the aircraft but, as these do not normally cover the whole aircraft, unprotected parts, such as the control surface hinge gaps, must be considered as potential sources of ingress, and, where necessary, suitable covers should be made up from local resources.

Procedure after heavy rain

3. If an uncovered aircraft of wooden or composite wood and metal construction has been subjected to rain soakage through inclement weather, it must be thoroughly cleaned internally and externally and dried out by opening all access holes and panels and using a hot-air drier. After this, all components must be examined to ensure that they are completely dry and free from all signs of incipient deterioration through wet rot. If any components are affected, they must be repaired or renewed as necessary.

Ventilation and drainage

4. The ventilation and drainage of aircraft constructed of wooden components is of great importance and will function satisfactorily only if adequate drain holes are provided at the approved points shown on the appropriate illustration in the relevant aircraft Volume 1.

5. Drain holes are provided on the underside of the fuselage, the lifting surfaces, the control surfaces and on the lower portion of the rudder to allow moisture drainage from the structure within the contours of the fuselage or aerofoils, thus assisting in the prevention of deterioration in the wooden components.

6. In addition to being an outlet for moisture, the drain holes act as ventilators and must be kept clear of obstruction at all times.

7. Where repairs to a fabric-covered aircraft involve the removal of the plastic drainage eyelets, the position of the eyelets must be noted to enable new ones to be fitted correctly on the completion of the repair.

Deterioration due to acid

8. If corrosive acid is spilt on a wooden component, the acid must be removed immediately, the component thoroughly scrubbed with clean water and dried with a hot-air blower. If the acid has been allowed to remain on the component, deterioration will have commenced immediately and the affected area must be removed and a suitable repair effected to restore the component to its original strength and serviceability.

Protective treatment

9. The prescribed protective treatment for all wooden aircraft components mainly consists of applying approved varnishes, primers, pigmented cellulose enamels, waterproof and acid-resisting paints, linen tape, fabric and/or madapollam in accordance with current procedure.

10. The type of protective coating to be used during or after any repairs to wooden components must always be similar to, or of a higher grade than, the original protective medium.

11. In some aircraft repair publications (*Vol.* 6 *or Vol.* 2, *Part* 3), tables are included in Chap. 1 to show the type of treatment to be used, together with the application. Where these are not available, refer to A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1 for detailed information on aircraft protective treatments and, if necessary, to A.P.2656A, Vol. 1 for information on the external and internal finish of aircraft.

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Chapter 5.2 GLUING

LIST OF CONTENTS

5.2.1

GLUING METHODS AND PRECAUTIONS

General information

1. The prescribed method of securing permanent joints in the construction and repair of wooden aircraft structure is that of gluing and screwing, or tacking, under pressure. The glues in current use are the synthetic resin (S.R.) adhesives used very widely in the manufacture of plywood and the assembly of wooden aircraft components.

2. The approved glue for use on all wooden airframe repair work in the Services is Aerolite 306, which is the commercial name for adhesive, synthetic resin, Type B.70 to Spec. B.S.1204. For detailed information on this adhesive, its characteristics and use, refer to A.P.1464B, Vol. 1, Part 2, Sect. 4, Chap. 9, which, in addition to describing Aerolite 306 and the approved G.B.M. hardener, deals with the method of using this adhesive on old Casein glue joints and gives information which includes the identification of glue, accelerated gluing methods, the Redux process of metal-to-wood and metal-to-metal bonding, precautions against dermatitis and other skin injuries likely to arise when working with the S.R. adhesive and a glossary of terms appropriate to gluing operations.

3. Since the Casein glue (an alkaline) is adversely affected by moisture and humid air conditions, it is no longer used in the construction or repair of wooden airframe components. Where, however, a repair has to be effected on such components which have existing joints employing Casein glue as an adhesive, these can be re-made with the S.R. adhesive and G.B.M. hardener (an acid), provided the precautions given in para. 9 are observed to ensure full-strength joints. In no circumstances may S.R. adhesives be applied direct to joints which have existing Casein glue in them, as the re-made joints would be below strength and would fail, but it is permissible to use the adhesive across an existing Casein glue line, without taking the precautions given in para. 9, provided all signs of surplus Casein are removed from the glue line before the hardener is applied.

Temperatures

4. The maximum shade temperature at which repairs, requiring the use of S.R. adhesives, may be effected is 32 deg. C. (90 deg. F.). This limit applies also to the temperature of the aircraft structure, and wooden airframe components exposed to the direct rays of the sun will reach temperatures considerably in excess of the shade temperature, the highest temperature being on the outer surface of the top skin and the lowest on the inner surface of the bottom skin of the aircraft. Even the latter temperature condition, however, may be much higher than that of the standard shade temperature, therefore, before a repair is attempted, a strict temperature check must be made to ensure that the temperature is low enough for all glued joints to be made to the high strength standard required. No gluing operations, however, should be carried out at temperatures below 10 deg. C. (50 deg. F).

5. In all overseas commands, and in very hot weather conditions in home commands, repairs must not be effected in the direct rays of the sun. An aircraft requiring wooden airframe component repairs must be moved under suitable cover and kept there for sufficient time to ensure that the temperature of the structure has fallen to the shade temperature, or is below 32 deg. C.

Accelerated gluing methods

6. These methods cater for electrically heating glued joints to lower the cramping time and thus enable a quicker repair to be effected. In normal circumstances, all joints made with S.R. adhesive will be set by using one of the accelerated gluing methods given in Scheme 5.2.3., the cramping and setting times being obtained from the accelerated method shown in the appropriate Scheme. In emergency, however, when no heating appliances are available and the atmospheric temperature is above 10 deg. C. joints may be made in the "cold" condition as detailed in Scheme 5.2.2., the appropriate cramping and setting times being indicated at para. 19 and 20 of this Scheme.

Preparations for gluing

7. Before applying any type of glue, it is essential to ensure that all the faying surfaces to be joined are smooth and free from any kind of protective coating, lubricant, dirt or old adhesive. The surfaces must be thoroughly sanded with medium sandpaper before the adhesive is applied. This operation is necessary to remove burred fibres or surface glaze (which is particularly noticeable when plywood joints are being made) and is not primarily used to score the surfaces to induce adhesion.

Note . . .

The fact that the sanding operation is essential must always be remembered, otherwise the glued joints will be under strength due to lack of adhesion where air is trapped as shown in fig. 1. Only light sanding of the faying surfaces is necessary as heavy application of the sandpaper will remove too much wood and the joints will not fit.

8. All timber used in repairs to wooden airframe components must be thoroughly examined to ensure its dry condition before the application of the S.R. adhesive and hardener.

(A.L.11, Jan. 58)

9. If any of the surfaces to be joined by the adhesive appear to have been heavily contaminated with Casein cement, the surfaces must be cleaned off and the following precautions taken to ensure full-strength joints when the adhesive and hardener are applied:—

(1) Clean off the affected faying surfaces with a moistened rag, carefully using a suitable, sharp chisel to remove any uneven pieces of wood and Casein which remain on the surfaces, taking care to avoid damaging any surface, until all traces of the Casein have disappeared.

(2) Allow time for all moisture in the wood to dry out.

(3) Apply one coat of G.B.M. hardener and allow this to dry.

(4) Apply a second coat of hardener and allow it to dry, then proceed to make a normal joint of all the surfaces as instructed in Scheme 5.2.2.

Masking free surfaces

10. If an excessive amount of adhesive has been applied to joints, two surfaces which should remain separate may become joined together. Accidental gluing can be prevented by masking with waxed paper, before gluing operations are commenced, all surfaces in the vicinity of the repair which do not have to be joined. An example of the use of this method is where it can be employed between a bradding strip and plywood to be glued.

11. Whenever possible, all excess adhesive must be removed from around the joints before it has time to set hard, since, if the wood concerned is to be planed or otherwise shaped at a later phase of the repair, the cutting edge of the tools will very quickly become blunted by the dried adhesive if it has been allowed to harden outside the joints.

12. If accidental gluing of surfaces has occurred, the repair work in hand must be stopped and all joints adjacent to the wrongly-joined surfaces must be broken, all surfaces cleaned off, allowed to dry and the work restarted with the waxed paper method of protection employed (*para.* 10).

Closed assembly time

13. The closed assembly or "shuffling" time is the period allowed, according to the temperature in which the gluing is being done, for positioning and securing the faying surfaces of wooden joints after the adhesive and hardener have been applied.

14. Immediately the adhesive and hardener-coated surfaces are placed in contact, the setting process will commence. It will gradually change from a viscous liquid to a soft jelly and from the jelly condition to that of a glass-hard solid. It is in the jelly or "gelled" condition that the position of the two members of the joint *must not be moved relative to one another.*

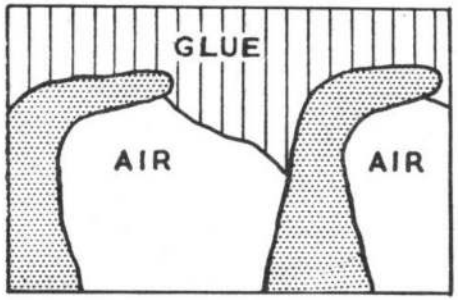
15. The shuffling time at a temperature of 32 deg. C. is limited to eight minutes and all work should be planned accordingly, allowance being made for work being effected at lower temperatures, when the shuffling time will be greater.

Application of pressure (*fig. 2*)

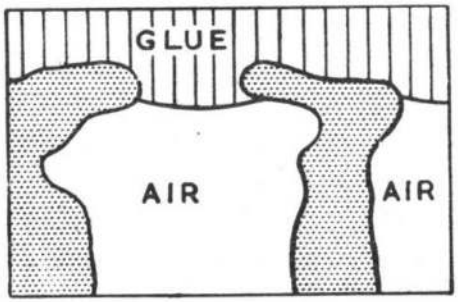
16. Pressure to a glued joint will, in most cases, be applied by the use of G-cramps for solid and thick plywood members or by bradding strips or screws for plywood panels, as shown in the illustration. Where it is possible for suitable battens to be bolted to a glued member through existing holes in the member, this method should be adopted but, whatever method is used, the primary objective must be to secure an even pressure over the whole area concerned.

Cramps

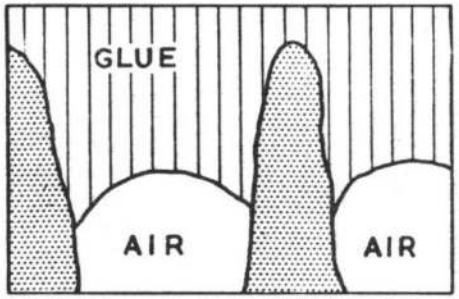
17. Whenever possible, cramps of the type shown in fig. 2 should be used in conjunction with wood packing blocks or battens, about one inch thick and long enough to overlap the area of glued joints in solid members. If the use of cramps is impracticable, wood-



Unsanded glued surface with fibres crushed in one direction by action of plane or similar tool, resulting in trapped air beneath the bent fibres and only one side of fibres in contact with glue.



Unsanded glued surface with ends of fibres burred over. The trapped air, in this case, reduces glue contact area to top surface of fibres only.



Surface which has been sanded prior to application of glue. Trapped air is reduced to a minimum and positive glue contact is made around fibres, resulting in good resistance in shear.

Fig. 1. Effect of surface finish

GLUING METHODS AND PRECAUTIONS (*Continued*)

screws may be used to secure the joints, but this may be done only if there is sufficient width of wood in the joined members to prevent splitting and the screws can remain in position on the members after the glued joints have set. The use of screws in the manufacture of the component or structure being repaired is a good indication that this is the best method of cramping.

Bradding strips

18. These should be used to provide the necessary pressure where neither cramps, woodscrews nor bolts passing through holes in battens and existing bolt holes in members can be used. The strips should normally be of $\frac{3}{16}$ in. plywood and the brads used will depend on the dimensions of the joint to be glued. When using bradding strips on a scarf joint, a sufficient number of them must be applied, side by side, to cover the joint completely, with the brads staggered in adjacent rows. For normal repair work, the brads should be placed at about $\frac{3}{4}$ in. centres, whether in single or staggered rows. Brads for $\frac{1}{16}$ or to $\frac{3}{32}$ in. plywood should be $\frac{7}{8}$ in. long, and each brad should be driven in until about $\frac{1}{4}$ in. is left proud of the top surface of the bradding strip. The exposed part of the brad should then be bent at right angles and finally driven home with a sharp tap of a suitable hammer as shown in fig. 3. On the completion of the cramping time, the brads can very easily be removed by levering up the bent portion with a screwdriver and extracting each brad with a pair of pliers or suitable pincers (*fig.* 4). By using this method, the danger of damaging the structure during the operation is minimized. When applying pressure to a convex surface, it is recommended that old machine belting is used as bradding strips instead of plywood.

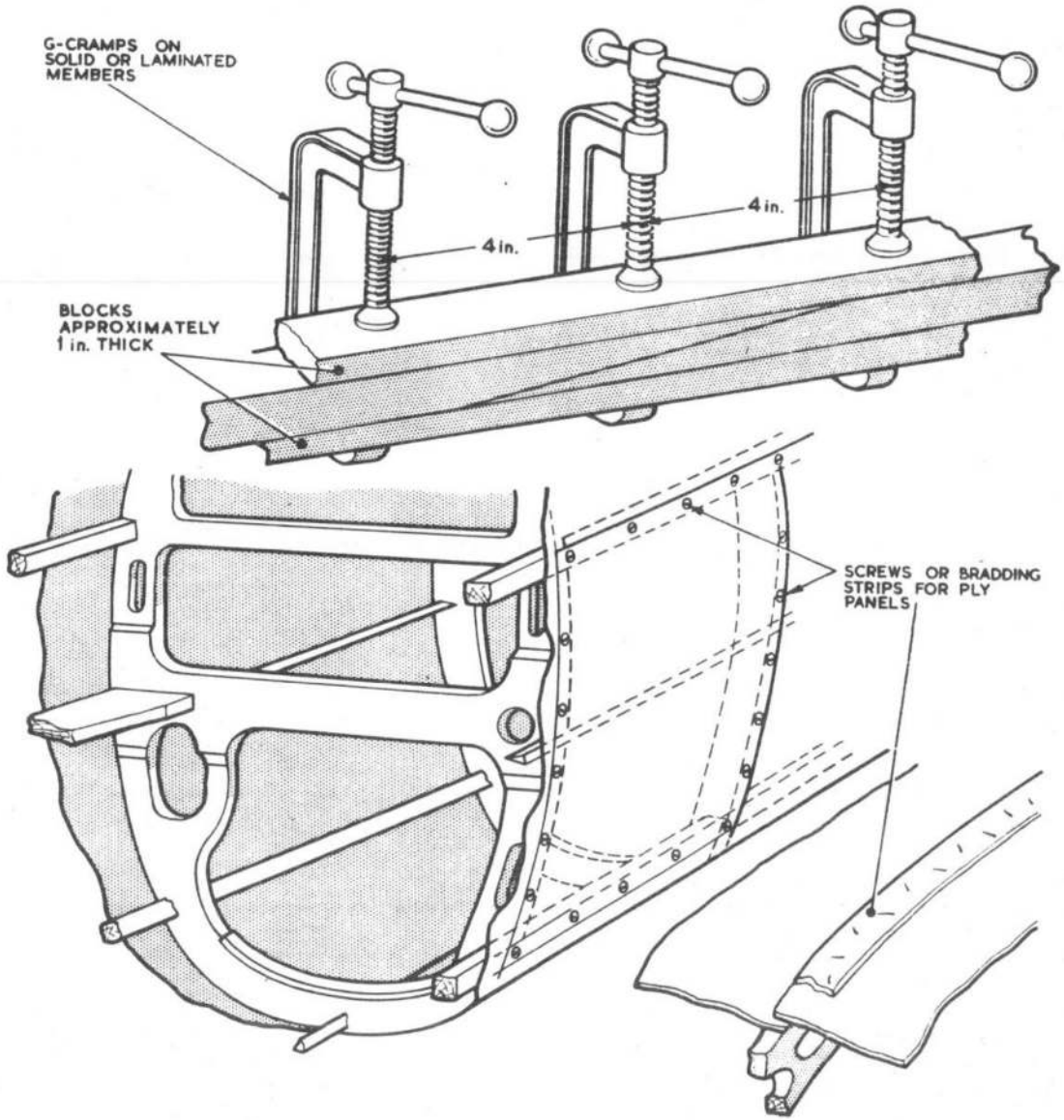


Fig. 2. Application of pressure to glued joints

Cramping time

19. This is the period during which pressure is applied to glued joints by any of the cramping methods given in para. 17 and 18. Joints must remain under pressure for the minimum times shown in Table 1 (*which is applicable to the "cold" gluing method only*) but the length of the period will be governed by the method of gluing employed, the temperature in which the work is carried out and the rate at which water can escape from the joint; the latter factor is dependent on the moisture content of the wood and the humidity of the surrounding air.

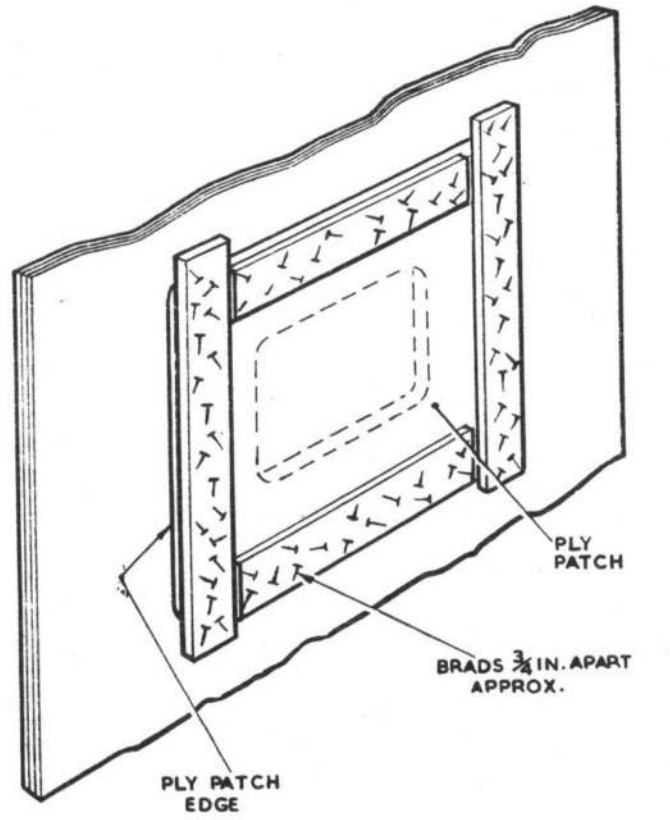
TABLE 1

Cramping times

Temperature (deg. C.)	10	16	21	27	32
Cramping time (hours)	12	5	3½	2½	2

Setting times

20. When the minimum cramping time has elapsed, a further period of setting (or curing) time must be allowed before an aircraft may be considered serviceable for flying. In Table 2, the setting times are given according to the cramping times shown in Table 1. When accelerated gluing methods are used (*para.* 6), both cramping and setting times are lowered and a quicker repair job effected.



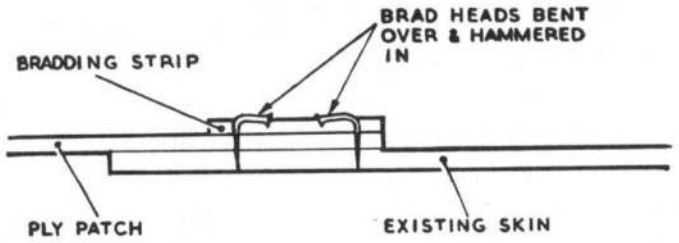


Fig. 3. Securing bradding strips

GLUING METHODS AND PRECAUTIONS (Continued)

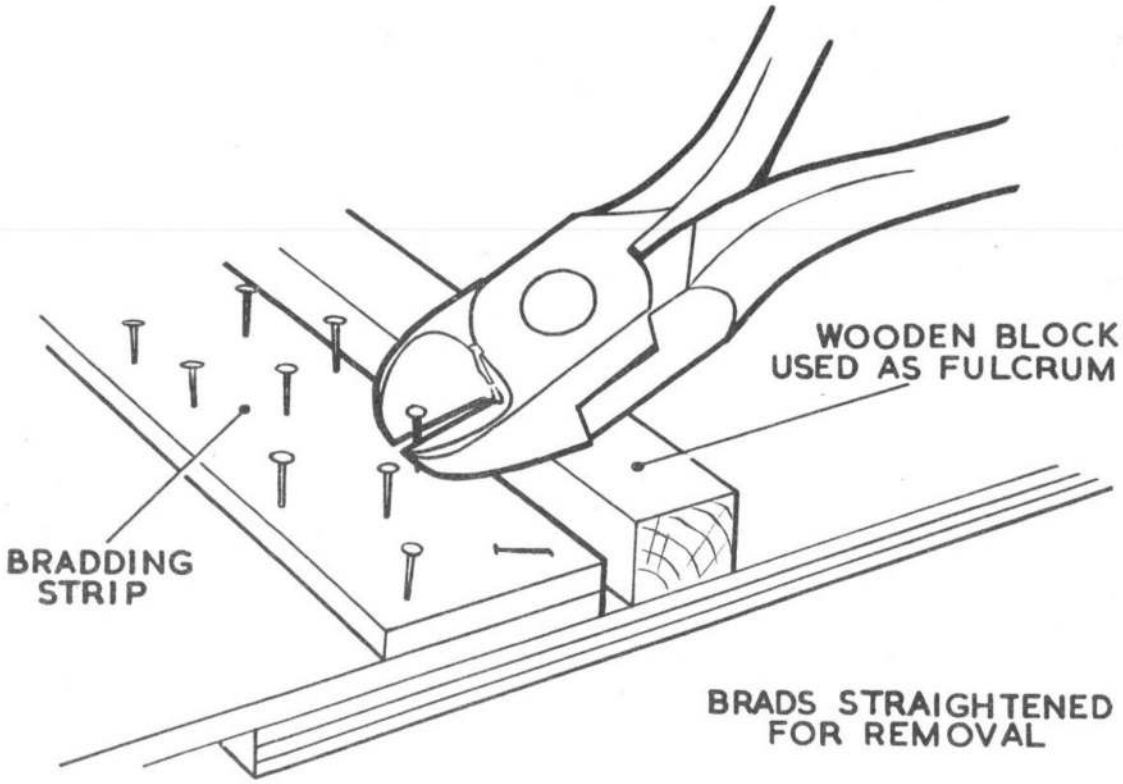


Fig. 4. Method of extracting brads

Screwed and glued joints

21. If woodscrews are required in a glued joint, they must be inserted while the adhesive is wet or tacky. Where bradding strips are to be secured by screws instead of brads, holes must be made in the strips, before they are placed in position, to enable the screws to be easily inserted into the wood.

22. Where wooden strengthening blocks are to be glued and screwed into the corners of any structure, with screws set at different angles, those with the greatest wedging effect must be screwed in first, as shown in fig. 5.

TABLE 2

Setting times ◄(hours)►

Cramping times	Setting times	
	Structural members	Non-structural members
12	24	12
5	10	5
$3\frac{1}{2}$	7	$3\frac{1}{2}$
$2\frac{1}{2}$	5	$2\frac{1}{2}$
2	4	2

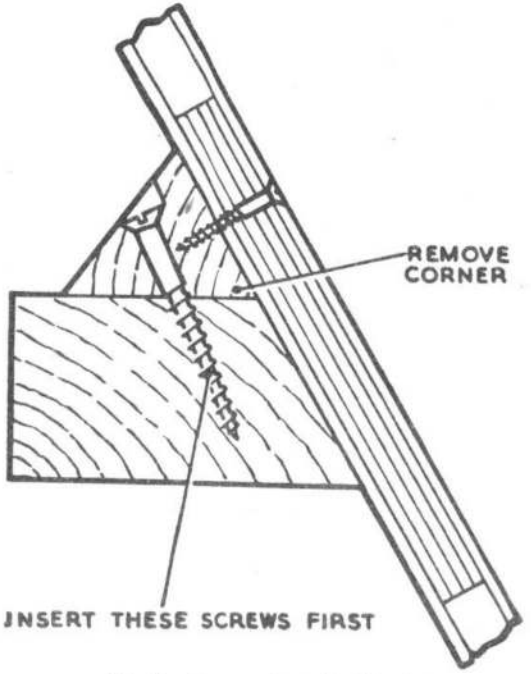


Fig. 5. Screwed angle blocks

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AEROLITE 306, S.R. ADHESIVE, TYPE B.70

General information

1. This gap-filling adhesive is the approved medium to be applied to all joints made in the repair of wooden aircraft structures in the Services at home and overseas. It is supplied in powder form and, from the date of manufacture, will remain usable for two years at home and N.W. Europe, or for eighteen months in all overseas Commands, provided it is kept in a cool, dry storage.

2. The Aerolite 306 powder must be converted to an adhesive substance by the addition of water and methylated spirit, after which it is ready for use, in conjunction with an acid hardener. The hardener, used as a catalyst, causes a chemical reaction in the adhesive, which generates heat, although the hardener itself remains chemically unchanged; its influence on the adhesive being such that it starts and then controls the setting of the glued joint. The addition of methylated spirit to the Aerolite 306 powder is necessary to assist in freeing the air bubbles from the adhesive mixture before the adhesive is used.

3. The necessary stores-referenced items for mixing and using the S.R. adhesive are listed in the following Table and include references to two protective creams, either of which must be applied to the hands before gluing operations are commenced, as a precaution against dermatitis which may occur if the hands are unprotected.

4. In addition to the listed items, spatulas for stirring and applying the adhesive, and a container for mixing it, will be required.

Glue room

5. Where facilities permit, it is advisable to allocate a small room or partitioned portion of a hanger for the mixing and issuing of adhesive and its hardener. The essential strict control can then be exercised over the mixing, storage and issue of the adhesive, and the permissible life (7 *days*) of any one mix in the workshops. A suggested layout for a glue room is shown in fig. 1 and, in designing the layout, the primary object has been to keep the adhesive and hardener strictly separate, this being the essential factor throughout the mixing and spreading operations.

Mixing the adhesive

6. To mix the Aerolite 306, commence by obtaining a clean, serviceable container of glass, earthenware, tin or wood which is free from hardener and alkaline substances such as soap or Casein glue. An ideal container for mixing large quantities of adhesive is a dope-thinners can with the tapered top removed and the edges turned over. To mix small quantities for immediate use, small clear-glass jars or similar vessels should be used.

7. The standard quantity of Aerolite 306 powder contained in the ◄ 5½ oz. ► tin ► ◄ is sufficient to ► ◄ make up ½ pint of mixed adhesive. Where smaller or larger amounts of adhesive are required, the dry powder should be mixed with water and methylated spirit in the following proportions, by volume:—

	Parts
Aerolite	10
Water	4
Methylated spirit	0·5

8. With the proportions of the mixture given in para. ◄ 7 ► in mind, any quantity of adhesive may be prepared to suit any requirement and, assuming that only the smallest quantity is required for a particular job, mixing should proceed as follows:—

TABLE I

Expendable equipment

Ref. No.	Nomenclature	Remarks
33C/1188	Synthetic resin adhesive, Type B.70 (Aerolite 306)	Issued in 5½ oz. tins as a powder. Will make approx. ½ pint of prepared adhesive when ⅛ pint of mixed fluid is added.
33C/973	Hardener G.B.M.	Issued in 2 gall. stone jars.
33D/363 33D/373	Ointment, prophylactic Rozalex No. 2	Issued in 7 lb. tins. For the protection of the hands and skin during gluing operations.
34D/312	Methylated spirit	Industrial
40D/654 40D/655	Container, glue Container, hardener	Waxed paper cartons for use as the working and storage containers for both the mixed adhesive and hardener. The cartons are marked "GLUE" or "HARDENER", as appropriate, on both the lid and body of each carton.

AEROLITE 306, S.R. ADHESIVE, TYPE B.70 (*Continued*)

(1) Into a clean glue container, pour two teaspoons of methylated spirit.

(2) Add water until the mixture reaches the lower black line in the carton, i.e. $\frac{1}{8}$ th pint of fluid.

(3) Stir the mixture of methylated spirit and water thoroughly then, slowly, add the complete contents of the $5\frac{1}{2}$ oz. tin of Aerolite 306 powder, stirring constantly.

Note . . .

Do not add the powder all at once, or too rapidly, as this will cause the mixture to become lumpy.

(4) Continue to stir the mixture until an even consistency is achieved.

Procedure after mixing the adhesive

9. The mixed adhesive must be free from all air bubbles, as their presence in the liquid would prevent complete adhesion and result in under-strength joints. Before use, therefore, the adhesive must be allowed to stand for a minimum period of 24 hours in the GLUE carton, with the lid tightly secured, to ensure complete dissipation of the trapped air. The carton must be clearly marked with the time and date of completing the mixing.

Note . . .

The standing period is very important and must NEVER *be omitted.*

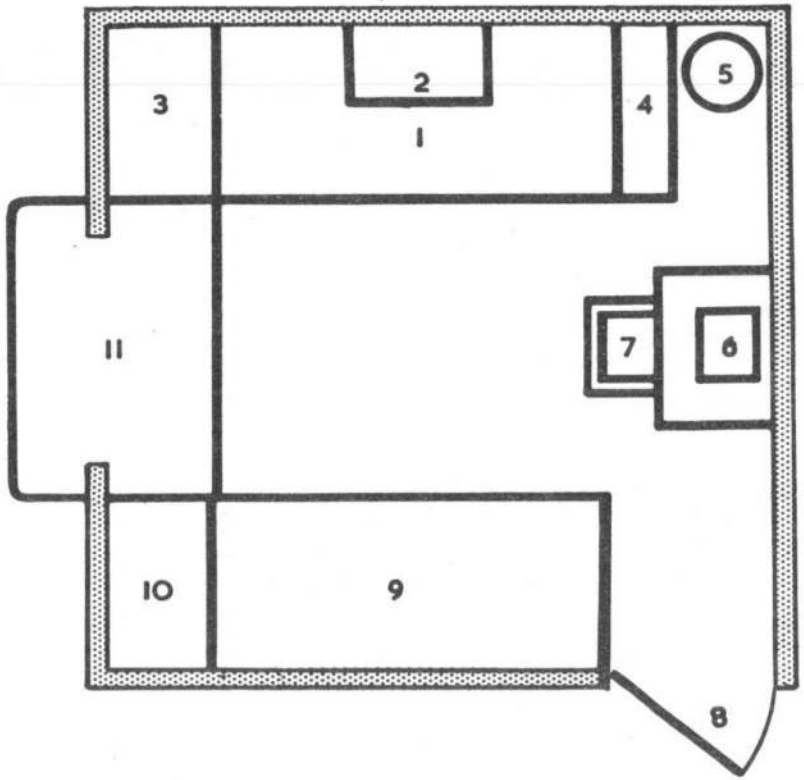
10. When a large quantity of adhesive has to be prepared for a given requirement, or to build up a stock of ready-for-use adhesive to cover a period of 7 days, it must be mixed in a large container (*para.* 6) and poured into new, clean, waxed-paper GLUE cartons which must be sealed, marked (*para.* 9) and suitably stored.

11. The mixed adhesive will remain in sound condition if it is stored in a cool place in its waxed-paper GLUE carton with the lid tightly secured, always provided the lid is refitted tightly on the container immediately after any period of use. If, on re-opening the container it is noted that a skin has formed on the surface of the liquid, the adhesive is still usable, provided the skin is removed.

Note . . .

(1) *No attempt should be made to stir the skin into the liquid as it will not dissolve.*

(2) *When waxed-paper cartons have been emptied of their contents, they must not be used again.*



KEY

1 GLUE MIXING BENCH (AEROLITE 306 POWDER AND CLEAN CONTAINERS STORE)
2 WATER SUPPLY AND SINK
3 RACK FOR GLUE SPATULAS
4 RACK FOR MEASURING VESSELS
5 METHYLATED SPIRIT
6 DESK FOR MIXING AND ISSUE RECORDS
7 CHAIR
8 DOOR
9 HARDENER BENCH (HARDENER AND CLEAN CONTAINERS STORE)
10 RACK FOR HARDENER SPREADERS
11 ISSUE COUNTER AND HATCH

Fig. 1. Glue room layout

G.B.M. hardener

12. This hardener, which is a purple fluid, is supplied in 2-gall. stone jars. It is classified as a slow-setting hardener and has a weak-acid base; it must be kept well-corked when not in use to prevent spillage and possible injury to personnel or damage to clothing and, when required for use, it should be poured into a new, clean wax-paper carton marked HARDENER; ensure that a lid, bearing a similar marking, is securely fitted to the carton while the hardener is not being used.

Note . . .

When pouring out the hardener into a carton, care must be taken to avoid splashing the skin or clothes.

Instructions for using the adhesive and hardener

WARNING

Before mixing or using S.R. adhesive and hardener, the hands and wrists must be protected by the application of either prophylactic ointment or Rosalex No. 2 cream. The hands must be thoroughly washed after the gluing work has been completed.

13. With the necessary implements such as clean spatulas, spreaders and an adhesive stirrer to hand, obtain from the glue room or store sufficient hardener and mixed adhesive to do the required work. The adhesive must be checked to ensure that the adhesive has not been mixed for more than 7 days.

Note . . .

It is essential to prevent even a small trace of hardener from entering the GLUE *container as it would contaminate the adhesive, harden it in patches and make it unusable. To avoid this, spatulas, spreaders or brushes used for applying the hardener must never be brought into contact with those used for the adhesive, or vice versa. To facilitate the separation of the adhesive and hardener cartons and spatulas, etc., the* ◀ *container and* ▶ *carrier shown in figs.* 2 ◀ *and* 3▶ *may be manufactured from local sources.*

14. Before applying the adhesive, ensure that the faying surfaces are perfectly clean and dry and, where necessary, have been lightly sanded, as in the case of plywood surfaces. Assemble in a dry condition the joints to be glued; note and remove any gaps or steps on the surface before gluing.

Applying the adhesive

15. Give the adhesive a final stir (*this must be done gently to avoid the formation of air bubbles*) and then apply the adhesive in a thin, even film to one of the surfaces to be joined, using a spatula or one of the implements for gluing shown in fig. ◀ 3. ▶ As a general guide, the rate of application should be between four and five fluid ounces of adhesive to cover ten square feet of surface. This rate of application may have to be exceeded in cases where uniform cramping pressure cannot be applied or where accurate mating of the surfaces is not possible.

16. Allow the adhesive on the treated surface to become tacky and, during this time, apply the hardener to the other surface of the joint, the hardener being applied evenly with one of the implements shown in fig. ◀ 3 ▶ or by a soft brush.

17. Immediately the adhesive has become tacky and the hardener applied, make the joint, "shuffle" the surfaces into their correct positions, and cramp up as quickly as possible. Once the joint has been made, no shuffling should be attempted, otherwise the ultimate strength of the joint will be reduced. If the adhesive appears to have become nearly dry before the cramping operations have been completed, the joint must be broken, all adhesive cleaned off and the joint re-made with new adhesive and hardener.

18. When making a joint with S.R. adhesive and hardener, it is essential for the operator to remember that as the temperature of the surrounding air increases, the time taken for the adhesive to become dry is shortened. For instance, at a temperature of 21 deg. C. (70 deg. F.), the adhesive and hardener must be applied, the joint shuffled into position and the cramping operations completed in 20 minutes. At 32 deg. C., however, all this work must be completed in eight minutes. Therefore, with these facts in mind, if the work is to be done when the atmospheric temperature is high, the cramping sequence must be planned to avoid over-shooting the time available for the operations. The use of any of the accelerated gluing methods (*Scheme* 5.2.3) will not, however, affect the time for making and cramping-up a joint.

Note . . .

As the rate of absorption of the hardener into the wood is high, the hardener will dry very quickly. Therefore, a joint must never be closed if the hardener-treated surface has been allowed to dry. Should this happen, a fresh application of hardener must be made and the joint closed immediately, provided the adhesive is tacky (*para.* 17).

AEROLITE 306, S.R. ADHESIVE, TYPE B.70 (*Continued*)

Alternative methods of application

19. Where one of the two faying surfaces to be joined is inaccessible, either of two methods of application of the adhesive and hardener may be employed as follows:—

Method A

(1) Apply the adhesive to the accessible surface of the joint to be made as described in para. 15.

(2) When the adhesive is tacky, spread the hardener lightly over the *same* surface.

(3) Bring the treated surface into close contact with the untreated surface of the joint as quickly as possible, shuffle the surfaces into their correct positions and apply the cramping pressure.

Method B

(1) Apply the hardener to the accessible surface of the joint to be made (*para.* 15) and immediately spread the glue on the *same* surface.

(2) Bring the treated surface into close contact with the untreated surface of the joint as quickly as possible, shuffle the surfaces into their correct positions and apply cramping pressure.

Setting time

20. After the adhesive has been applied and the minimum cramping time of the joints has elapsed, the appropriate setting time must be allowed, according to the gluing method employed (*Scheme* 5.2.1, *para.* 6, *refers*).

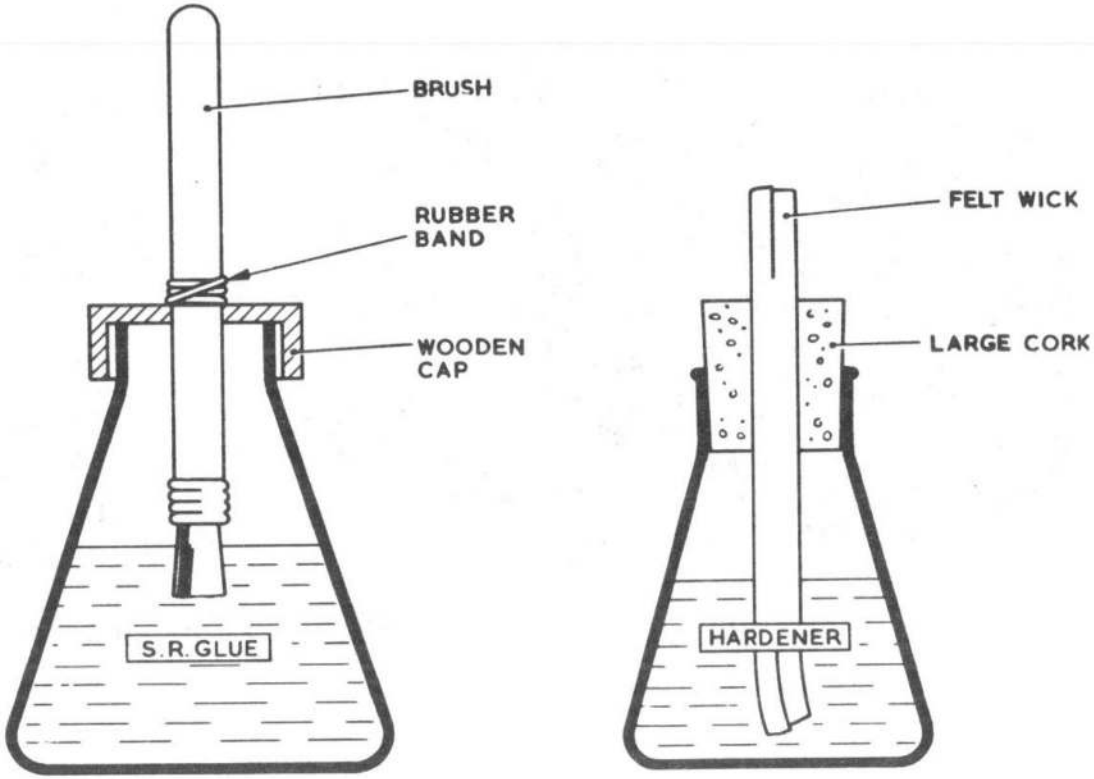


Fig. 2. Empty glass paste pots used as containers

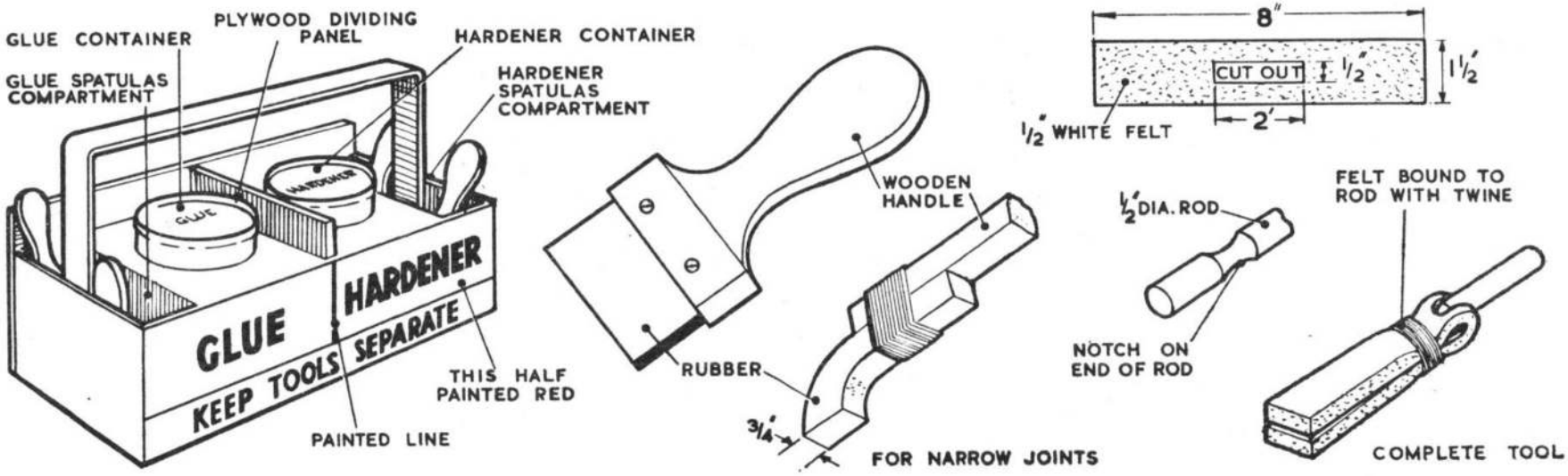


Fig. 3. Typical gluing implements

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ACCELERATED GLUING METHODS

General information

1. The application of heat to glued joints in the repair of wooden aircraft components is known as accelerated gluing. It is employed either to reduce the cramping and setting times of the S.R. adhesive at normal temperatures or to offset the effect of making glued joints with the adhesive at a low atmospheric temperature, thus expediting the completion of a repair.

2. In the Services there are four approved methods of getting the heat to the glue film and, as each tends to have a specialized application, the main characteristics of each method are shown in the following Table.

3. The data given in Table 1 will enable the method which is most suited to any particular type of repair work to be adopted. Full working instructions for the application of any of the methods are given in Schemes 5.2.4, 5.2.5, 5.2.6 and 5.2.7, in conjunction with illustrations, showing the required special equipment to be locally manufactured, included in Sect. 3, Chap. 5 of this publication or in the Appendix (Schemes A.1 to A.5) of A.P.2662A.

Tacking

4. This is a specialized application of the hot wire method of accelerated gluing, the joint being subjected to heat for a period which, although very short, is sufficient to set the adhesive in the immediate vicinity of the heating elements. The partially-set joint is sufficiently strong to permit the removal of the cramping pressure without jeopardising its ultimate strength. This procedure is very useful when dealing with complicated repairs where the last phase of the repair would have to be held up until the cramps have been removed from joints made earlier in the repair sequence. Detailed instructions for the tacking operations are given in Scheme 5.2.6.

Table 1

Methods of applying electrical heat in workshop, dispersal point or field

Method	Basic principle	Type of repair	Equipment required (excluding that for making a glued joint)
(1) Steel foil	Heating steel foil strip clamped directly over the joint	Straightforward repairs to plywood less than $\frac{3}{16}$ in. thick or to solid members less than $\frac{3}{8}$ in. thick	(1) 12- or 24-volt trolley battery (2) Steel foil (as required) (3) Felt lagging (4) Resistance board (*Sect.* 3, *Chap.* 3.5) (5) Adapter box (*Sect.* 3, *Chap.* 3.5)
(2) Electric blanket	Heating a wire element built into a blanket lashed over the repair area	Repairs to plywood less than $\frac{3}{16}$ in. thick, of any degree of complication, provided the repair area is less than 3 ft. 0 in. square	(1) 24-volt trolley battery (2) Electric blanket (3) Felt and tarpaulin lagging (4) Sheet of brown paper (5) Adapter box (*Sect.* 3, *Chap.* 3.5)
(3) Hot wire *Note . . . *In emergen*	Heating fine copper wire buried in the glued joint *cy, the aircraft batter*	Repairs to plywood greater than $\frac{3}{16}$ in. thick or to solid members of any size *y may be used, at the discr*	(1) Reel of 38 s.w.g. bare copper wire (2) 12-volt battery* (3) Felt lagging (4) Ammeter or adapter box (*Sect.* 3, *Chap.* 3.5) *etion of the Chief Technical Officer*
(4) Radiant heat *Note . . . *Electrical*	Heating the repair area with infra-red rays emitted from a standard electric light bulb * *mains supply must be*	Repairs to plywood less than $\frac{3}{16}$ in. thick or to solid members less than $\frac{3}{8}$ in. thick, particularly in inaccessible parts of a structure *available*	A 40-watt electric light bulb mounted in a special reflector (*Sect.* 3, *Chap.* 3.5)

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5.2.4

STEEL FOIL ACCELERATED GLUING

General information

1. From the data given in Table 1 of Scheme 5.2.3., steel foil is considered particularly suitable for electrically inducing the required heat for the accelerated gluing of straightforward repairs to plywood less than $\frac{3}{16}$ in. thick or solid members up to $\frac{3}{8}$ in. thick (*para.* 8), provided the joint length is less than 17 ft. 6 in. for an electric circuit with a 12-volt battery, or 35 ft. with a 24-volt battery, the joint lengths being dependent on the voltage of the type of battery available.

2. The basic principle of the method is that of attaching a strip of steel foil 1 in. wide and 0·002 in. thick (Ref. No. 30A/2784) over a newly-made glued joint, securing it in place with bradding strips and, after applying pressure to the joint, using either the bradding strip or separate cramps, passing an electric current, supplied by a 12 or 24-volt battery, though the steel foil to generate the necessary heat (*para.* 5).

3. The generated heat is conducted through the structure to the film of adhesive in the joint, where the setting process is accelerated. With a fixed supply voltage, the heating effect will depend on the length of steel foil in the joint. To keep the heating effect constant for repairs of different sizes, the foil must be connected to the battery through an adjustable resistance board. In addition, an adapter board must be installed in the circuit to enable the resistance and heating circuit to be connected to a trolley battery.

Resistance board

4. This must be manufactured from local resources to the instructions and dimensions given in Sect. 3, Chap. 3.5 of this publication or in the applicable illustration in the Appendix (Scheme A.3) of A.P. 2662A.

5. The fact that the steel foil used in the resistance board is tapped at intervals of 6 in. should be noted. To obtain the required heat temperature, there must be a current through the foil of 18 to 20 amp., regardless of the size of the repair. To maintain this current, the length of the steel foil in the joint, plus that tapped off the resistance board, must always total 18 ft. for a 12-volt battery, or 36 ft. for a 24-volt battery. Typical examples are given in the following table:—

Table 1
Typical lengths of foil

Length of steel foil in repair (in feet)	Length of steel foil tapped off resistance board (in feet)	Total length of steel foil (in feet)	Battery voltage (volts)
8	10	18	12
19	17	36	24
*25	11	36	24

***Note . . .**
This length may consist of two lengths of foil, e.g. 17ft. and 8ft., connected in series, and used for heating different parts of a repair, or for two repairs being effected at the same time.

Adapter board

6. The adapter board (*para.* 3) which must be constructed by Units from local resources to the instructions given in Sect. 3, Chap. 3.5 of this publication or in the Appendix (Scheme A.4) of A.P.2662A, places an ammeter and switch in circuit, the former enabling the current to be checked periodically. The electrical connections for making the circuit are shown in fig. 1 and, since the current taken by the steel foil and resistance is heavy, a fully-charged trolley battery should be used to supply the necessary electrical power; the charging motor on the trolley must be continually running during the heating period to ensure that the current supplied by the battery will be maintained within reasonable limits.

Note . . .
(1) *At no time should a battery of less capacity than that of a fully-charged trolley battery be used for the heating operation.*
(2) *Where separate lengths of steel foil are connected in series, Unipren 24 cable should be used.*

Heating the joint in skin repairs (*fig.* 2)

7. Skin repairs involving the lap or scarf joints will necessitate the steel foil being positioned centrally over the joint width under the bradding strips or cramping blocks and cramps. Joints up to 2 in. wide will require only one run of coil, but joints between 2 and 4 in. will require two parallel strips to be fitted equidistantly over the width of the joint. The foil must be looped at the corner of a repair and never folded under the bradding strips, as this would result in uneven heating of the corners. To prevent short-circuiting at the corners of a repair, between the runs of foil at right-angles, the bradding strips must be at least $1\frac{1}{4}$ in. wide. When parallel strips of foil are being used, ensure, when laying the runs, that they do not come in contact with each other and so short-circuit at any point of the runs.

Heating the joints in solid members (*fig.* 2)

8. Solid members may be repaired by this method of accelerated gluing, providing they are not more than $\frac{3}{8}$ in. thick. The steel foil should be placed on opposite sides of the joint in the member, the foil being held in position by brads pitched at about $1\frac{1}{4}$ in. through the bradding strips, pressure being applied to the joint in the normal manner with the cramps and battens.

Note . . .
(1) *The application of heat by this method, to joints incorporating members over $\frac{3}{8}$ in. thick will effectively accelerate the setting process of the adhesive, but longer setting times than those given in Table 2 must be allowed.*
(2) *The steel foil strips must not be fitted on the sides on which the feather edges of the scarf joint are located.*

STEEL FOIL ACCELERATED GLUING (Continued)

Applying the method

9. The steel foil method of accelerated gluing is applied in the following sequence of operations:—

(1) Prepare the wood joint, apply the adhesive and hardener and shuffle as in a normal joint.

(2) Apply a measured length of foil in single or double runs, as appropriate for the width of the joint, placing bradding strips over the foil as it is being fitted on the sides of the joint (*fig.* 2). Leave about 3 in. of foil projecting from the bradding strips for the electrical connections to be made.

Note . . .

If the foil has been used on previous work, ensure by visual examination before fitting it to the member, that it is not cracked, that there is not more than one brad hole in a cross section and that the edges are free from notches deeper than $\frac{1}{16}$ *in. If this precautionary examination is neglected, excessive heating at such points of damage may occur, with the attendant fire risk. All foil damaged beyond the limits given must be scrapped.*

(3) Make the electrical connections to the foil through the resistance board to the adapter board as shown in the circuit diagram (*fig.* 1), ensuring that the correct terminals on the resistance board are used (*para.* 4).

(4) Place felt or sack lagging over the whole of the repair area to prevent heavy heat losses during the heating period.

(5) Connect the plug of a fully-charged trolley battery to the appropriate socket on the adapter board and switch on the circuit.

(6) Leave the repair joint for the required heating period, as shown on Table 2, keeping the charging motor on the trolley running throughout this period and checking the reading of the ammeter on the adapter board periodically; it should be between 18 and 20 amps. (*para.* 5).

(7) Switch off the circuit at the end of the heating period and disconnect the leads from the steel foil to the resistance board. Leave the lagging in position over the area of the repair for a further 15 minutes.

TABLE 2

Heating and cooling times (hours)

Temperature	Heating period	Cooling period (joint still cramped)	Total time for heating and cooling
Above 0 deg. C.	$\frac{3}{4}$	$\frac{1}{4}$	1
Below 0 deg. C.	1	$\frac{1}{4}$	$1\frac{1}{4}$

(8) After the cooling period, remove the lagging, cramps or bradding strips and the steel foil.

Note . . .

If the steel foil is in good condition and quite free from defects (sub-para. (2)*, note refers), it should be carefully wound on a suitable reel and stowed for future use.*

(9) Complete the repair as instructed in the appropriate repair scheme, allowing the appropriate setting time for the glued joints (Table 2 and Scheme 5.2.1.).

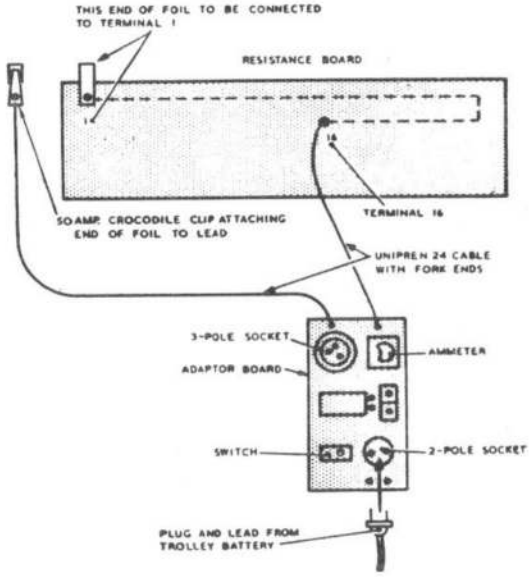

Fig. 1. Electrical connections

STEEL FOIL ACCELERATED GLUING *(Continued)*

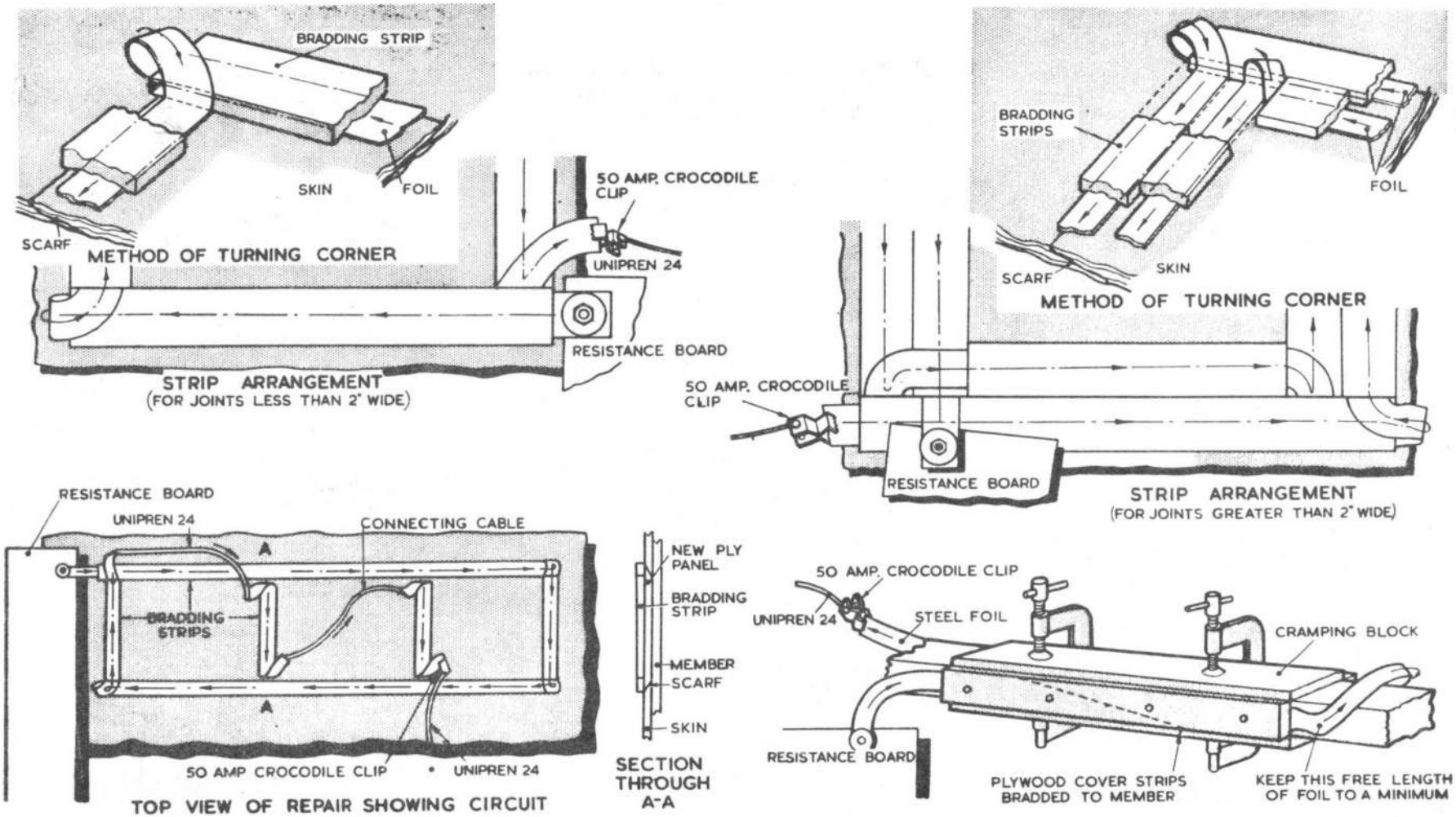

Fig. 2. Arrangement of foils

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ELECTRIC BLANKET ACCELERATED GLUING

General information

1. This method of accelerated gluing is particularly useful for dealing with complicated repairs to plywood structures or panels up to $\frac{3}{16}$ in. thick and where the repair area does not exceed 3 sq. ft. If the repair area is greater than this limit, one or more additional blankets must be used, each blanket being connected to a separate battery and circuit. Alternatively, if only one blanket is available, this must be used successively in different positions until the whole area under repair has been in close contact with the heating pad for the specified time (*Table* 1).

2. The basic principle of this method of accelerated gluing is the covering of the adhesive-treated repair joints, for a specific period, with an electric blanket (Stores Ref. 5A/3532) containing thermostatically-controlled elements which are heated by connection, through an adapter board, to a 24-volt trolley battery. The heat produced by the elements is conducted through the blanket and wooden structure to the adhesive film in the joint, thereby accelerating the setting process. To maintain a predetermined, constant temperature, the current passing through the elements is controlled by the thermostat built into the blanket.

3. A full description of the blanket, its construction, method of use and servicing, together with precautions to be taken to ensure serviceability and long life are contained in A.P.4343G, Vol. 1, Sect. 15, Chap. 3. When not in use, the blanket should be carefully rolled and kept in a canvas container of local manufacture.

4. The blanket consists of a pad approximately 3 ft. square containing the elements. It is backed with a layer of kapok for heat insulation and enclosed in fabric stitched centrally to a 4 ft. square of canvas which has brass eyelets fitted to the edges to take the cordage used for lashing the blanket in position.

Electrical connections

5. On receipt of the blanket at a Unit, it must be correctly connected to a 3-pole plug (Stores Ref. 5A/2085) by the two Dusheathground 4 and 19 cables, (Stores Ref. 5E/2973 and 5E/2975), leading from the thermostat and elements respectively, which are attached to the blanket. The 2-core cables are of different diameters, the larger of the two being the Dusheathground 19 serving the elements. The electrical connection to the plug (*fig.* 1) should be effected as follows:—

(1) Connect the positive cores of the two cables to the positive terminal on the plug.

(2) Connect the negative core of the larger cable (*Dusheathground* 19) to the negative terminal of the plug.

(3) Connect the negative core of the Dusheathground 4 cable to the larger terminal of the plug, secure all leads and close the plug.

Electric current

6. The amount of current taken by the blanket is high, therefore the electrical supply should always be taken from a trolley battery, where available. In no circumstances may a battery of lower capacity than that of a fully-charged, 24-volt trolley battery be used for the source of electrical supply. To connect the blanket to the battery, an adapter board must be fitted in the circuit; the adapter must be constructed locally by Units to the instructions and dimensions given in Sect. 3, Chap. 5.3 of this publication or in the Appendix (Scheme A.4) of A.P.2662A.

7. When the blanket circuit is switched on, the current passing through the elements will increase to a maximum value and then fall to a steady value of about 13·5 amp. as the elements heat up and the thermostatic control becomes effective. The trolley battery charging motor must be running while the blanket is being heated to reduce the discharge from the battery to about 5 amp. of the required current.

8. During the heating period (*Table* 1), the current flowing through the circuit must be checked periodically with the ammeter on the adapter board to ensure that no current failure has occurred. If a zero reading is evident on the ammeter for short periods, this may be ignored as it will indicate that the thermostat and relay are cutting out the current as the heat in the elements is greater than that required. If, however, the normal

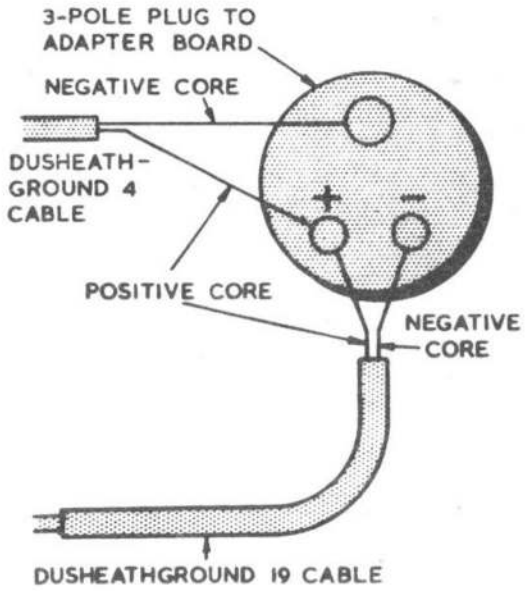

Fig. 1. Electrical connections

reading on the ammeter is not regained after a reasonable time, a failure in the circuit must be suspected and the circuit examined. Should a failure of one of the blanket elements occur, the current will fall to about 10 amp.

9. The circuit diagram and the electrical connections between the blanket, the adapter and the trolley battery are shown in fig. 2.

Applying the method

10. Instructions for the application of the electric blanket method of accelerated gluing are given in the following sequence of operations:—

(1) Unroll the blanket and place it, canvas side downwards, on a tarpaulin sheet alongside the repair and cover the heating pad, now uppermost, with a suitable piece of felt or sacking.

Note . . .

Do not connect a rolled-up blanket to a battery, or tread or place heavy weights on the heating pad as the electric elements are very fragile and will fracture or become distorted easily.

(2) Insert the 3-pole plug on the blanket leads (*para.* 5) and the 2-pole plug on the trolley battery leads into their respective sockets on the adapter board, start the trolley charging motor and switch on the heater circuit.

WARNING

A wet blanket must never be connected to a battery.

(3) While the blanket is heating up and reaching a steady temperature, apply the adhesive and hardener to the faying surfaces of the joints, make the joints by shuffling them into their correct position and apply pressure by using tacking strips or cramps.

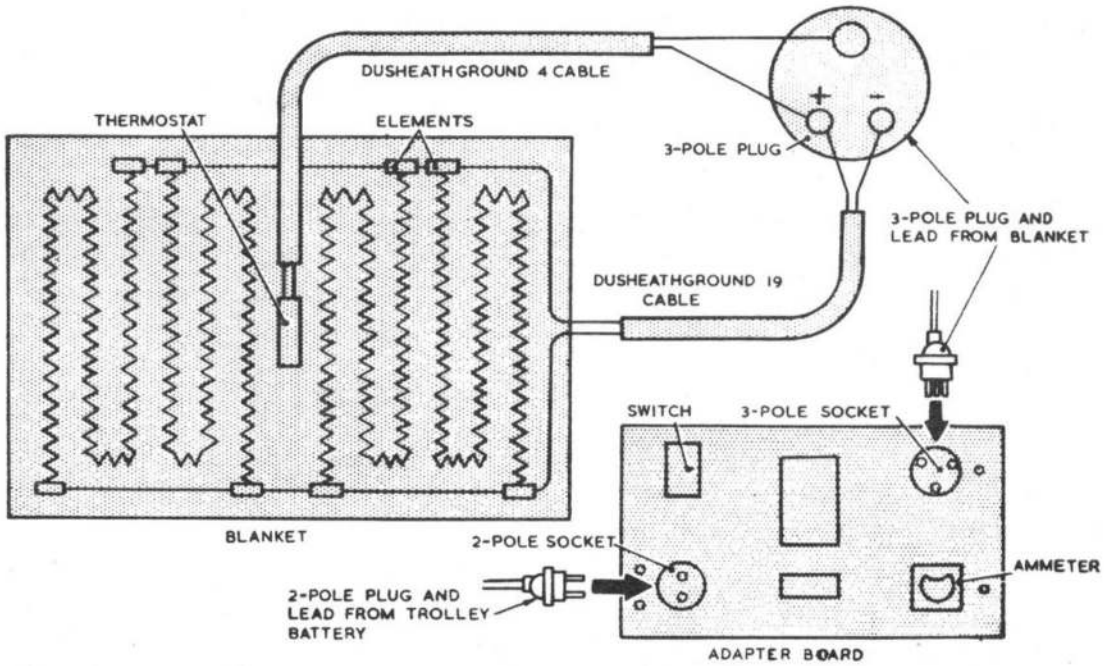

Fig. 2. Circuit diagram and connections

ELECTRIC BLANKET ACCELERATED GLUING (*Continued*)

(4) Wipe off as much surplus adhesive as possible from the repair area.

(5) Wrap paper or rag around all joints to prevent any glue remaining on the outer surfaces of members from sticking to the heating pad.

(6) Switch off the heating circuit and lash the blanket centrally over the repair, ensuring that the heating pad is in close contact with the whole repair area.

Note . . .
Where cramps are used, they must be arranged to meet this requirement.

(7) Switch on the heating circuit current again.

(8) Lag the blanket with a piece of felt or sacking to minimize the heat losses over the repair area if the blanket has to be fitted over the outer surface of a structure and the temperature of the surrounding air is less than 10 deg. C. and, if necessary, lash a tarpaulin cover over the area to protect the blanket and lagging from rain.

Note . . .
Ensure that moisture does not reach the blanket due to seepage between the tarpaulin and lagging or the surface of the repair area.

(9) If the blanket is fitted on the inner surface of a structure and lagging is unnecessary, fit a sheet of thin plywood over the blanket and secure in position with suitable wooden battens to ensure that the heating pad is in close contact with the repair area.

Note . . .
When this method of accelerated gluing is used on a built-up structure, an electric blanket is needed on both sides of the structure, and the outer one should be lagged. Alternatively, it may be necessary to repair the inner surface first, using one of the other methods of accelerated gluing as appropriate, followed by the use of the electric blanket method on the outer surface.

(10) When the heating time (*Table* 1) has elapsed, switch off the heating circuit and disconnect the blanket plug from the adapter board, leaving the blanket (and lagging, if used) in position on the repair for another 30 minutes.

(11) At the end of this cooling period, remove all lagging, the blanket and paper or rag wrapping from the repair area.

(12) Remove the bradding strips or cramps and battens from the joints and complete the repair as instructed in the appropriate repair scheme.

TABLE 1

Heating and cooling times (hours)

Temperature	Heating period	Cooling period (cramps and blanket still in position)	Total time for heating and cooling
Above 0 deg. C.	1	½	1½
Below 0 deg. C.	2½	½	3

Setting times

11. On the completion of accelerated gluing operations, the appropriate setting time must be allowed as shown in the following Table:—

TABLE 2

Setting times (hours)

Temperature	Total heating and cooling times	Setting times	
		Structural members	Non-structural members
Above 0 deg. C.	1½	3	1½
Below 0 deg. C.	3	6	3

Precautions

12. To ensure the maximum serviceability of the electric blanket, the following precautions should be observed:—

(1) Handle the blanket with care to avoid damaging the elements and thermostat.

(2) Do not permit the blanket to get wet. If this should inadvertently happen whilst it is in circuit, the current must be switched off immediately and the blanket spread out and dried before further use.

(3) Do not fold the blanket. It must be checked for complete dryness, rolled, with the canvas face outside, and then placed in a canvas container of local manufacture for storage in a dry place.

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HOT WIRE ACCELERATED GLUING

General information

1. The hot wire method of accelerated gluing is considered to be the only satisfactory scheme which can be employed to achieve quick setting of the adhesive by imparting heat to glued joints in the repair of plywood thicker than $\frac{3}{16}$ in. or solid members of dimensions greater than $\frac{3}{8}$ in. thick.

2. The basic principle of the method is the application of heat direct to the adhesive and hardener by burying a length, or lengths of fine-gauge, bare copper wire in the glued joints of a repaired member and electrically heating the wire by connecting it, through an adapter board, to a 12-volt battery, the heat produced being conducted through the adhesive film, thus accelerating the setting process.

3. Hot wire tacking (*para.* 9 *and* 10) is a derivation of the basic method, and may be used to obtain quicker acceleration of the adhesive setting process when complicated repairs are in hand. In both cases, the wire is permanently set in the joint after being severed at the ends when the heating operations have been completed.

Heating elements

4. The heating elements consist of 9 ft. lengths of 38 S.W.G. (0·006 in. dia.) bare copper wire (Stores Ref. 5E/2862), each of which will carry a current of approximately 4 amp. when connected to a 12-volt battery. Single elements may be installed but, where one element is inadequate to cater for the area of the joint being glued, as many as four may be connected *in parallel* to one battery as shown in fig. 1 and 2. If a greater number of elements is necessary to cover the surface area of several joints required in a repair, the elements should be connecetd in groups of four, *in parallel*, to separate 12-volt batteries.

5. If the position of the joint prevents the ends of the heating elements from reaching the adapter board (or battery, if an adapter board is not available) terminals, the connections should be made with suitable single-core cable (e.g., 3/036).

Adapter board

6. This component, while not essential to the heating circuit, will, if fitted, provide a switch for emergency use and an ammeter to check the correct functioning of the circuit, thus eliminating the need for periodic examination of the wires. It should be locally manufactured by Units to the instructions and dimensions given in Sect. 3, Chap. 3.5 of this publication or in the Appendix (Scheme A.4) of A.P.2662A. When installing the adapter board, the battery leads should be connected to terminals G and H and the ends of the heating elements to terminals E and F (*fig.* 3).

Note . . .

When installing separate heating elements it is essential that they are always connected to the battery IN PARALLEL.

Spacing the elements

7. The spacing of the heating elements is not considered critical but it must, however, conform with the general layout shown in the illustration. The main objective of the operator must always be to use as much of the element wire as possible in the joint, within the limiting dimensions shown.

Applying the method

8. With the required number of 9 ft. lengths of 38 s.w.g. bare copper wire available, proceed with the following sequence of operations:—

(1) Lay the element wire on one face of the joint, using one of the runs shown in the illustration, and anchor the elements in position by passing them around brads temporarily set just outside the joint.

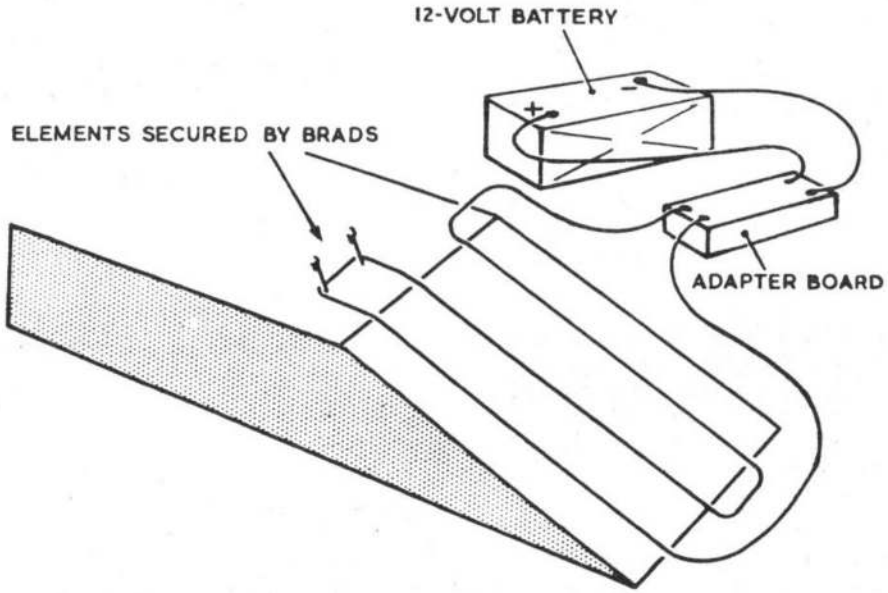


Fig. 1. Heating element arrangement

HOT WIRE ACCELERATED GLUING (*Continued*)

Note . . .
To avoid any short-circuiting occurring when the joint has been made, ensure that all runs of wire are quite clear of each other, either between different parts of any one element or between different elements.

(2) Plan the cramping scheme to avoid over-shooting the shuffling time.

(3) Apply the adhesive ◄ (*Scheme* 5.2.2) ► to the surface on which the elements have been secured, taking care to avoid moving the wires when so doing.

(4) Wait for the adhesive to become tacky and then apply the hardener ◄ (*Scheme* 5.2.2) ► to the opposite surface of the joint.

(5) Make the joint, again taking care not to disturb the position of the elements and cramp up as for a normal repair joint.

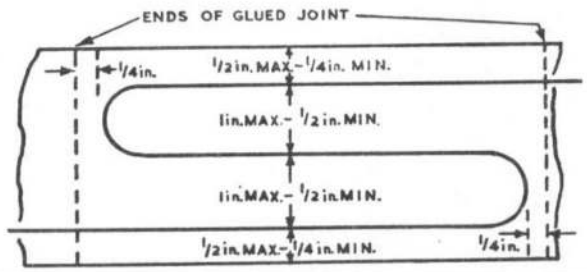
(6) Cover the joint (or joints in the repair area) with felt or sack lagging to minimize heat losses.

(7) After operations (5) and (6) have been completed, connect the heating elements to the adapter board or battery (*para.* 4 *to* 6 *refer*) and switch on the current.

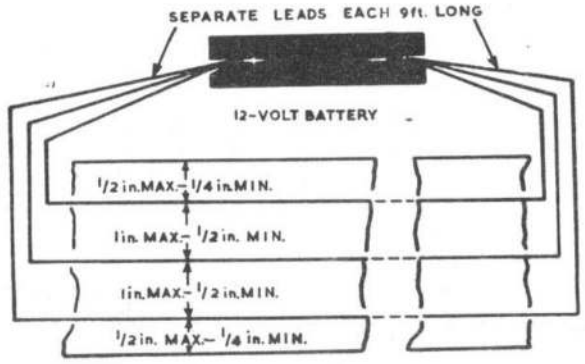
(8) After a period of approximately 10 minutes, check that all the joints are heating up by feeling the joint area and taking the ammeter reading of the current in ◄ all circuits, ► which should be about 4 amp. for each element.

(9) On the completion of the heating period shown in Table 1, switch off the current and disconnect the battery, leaving the element leads and the lagging in position for another 15 minutes. At the end of this cooling period, remove the lagging and cut off the ends of the elements as near to the joint as possible.

(10) Complete the repair as instructed in the relevant repair scheme, allowing the appropriate setting time for the glued joints (*Table* 1 *and Scheme* 5.2.1).



SINGLE ELEMENT



MULTIPLE ELEMENTS

Fig. 2. Heating element spacing

TABLE 1
Heating and cooling times (hours)

Temperature	Heating period	Cooling period (joint still cramped)	Total time for heating and cooling
Above 0 deg. C.	¾	¼	1
Below 0 deg. C.	1	¼	1¼

(*A.L.*20, *Aug.* 58)

Hot wire tacking

9. This method of accelerating the setting process of adhesive in a joint may only be used when the atmospheric or hanger temperature, as applicable, is above 10 deg. ◄ C. ►. The method may be found useful for dealing with complicated repairs, which include scarf joints in heavy members, as it will set the adhesive in the immediate vicinity of the heating elements during a very short heating period, leaving the joint sufficiently strong to permit the removal of the cramping pressure, thus allowing other phases of the repair to proceed. It is stressed, however, that as the strength of the joint is probably less than 50 per cent of its ultimate strength after the short heating period, it is essential that the appropriate setting time given in Scheme 5.2.1 is allowed to elapse between tacking the joints and certifying the aircraft serviceable.

Procedure

10. Certain operations for the ordinary hot wire method being applicable, proceed as follows:—

(1) Carry out operations (1) to (7) of para. 8.

(2) Heat the joint(s) for 10 minutes.

(3) Disconnect the battery at the end of this heating period and cut the ends of the element as near to the joints as possible.

(4) Proceed with other phases of the repair work but, in all cases, allow the prescribed setting time to elapse (*Scheme* 5.2.1) before considering the repair completed.

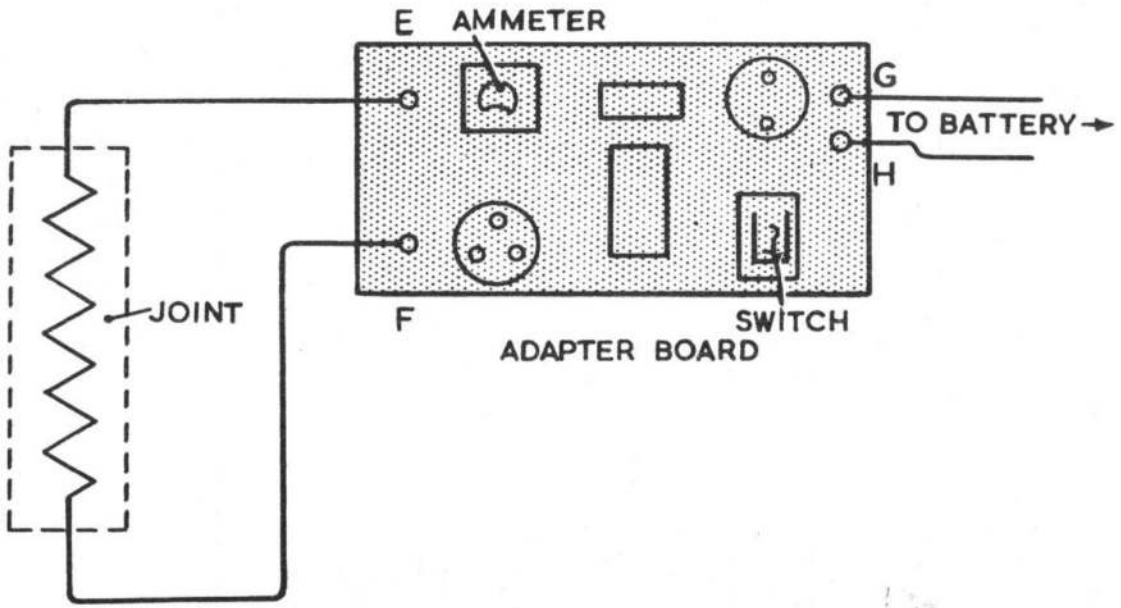


Fig. 3. Heating circuit and electrical connections

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RADIANT HEAT ACCELERATED GLUING

General information

1. The radiant heat method of accelerating the setting process of S.R. adhesive and hardness in a glued joint is particularly suitable for dealing with the repair of plywood less than $\frac{3}{16}$ in. thick or solid members less than $\frac{3}{8}$ in. thick in inaccessible parts of a wooden structure where the application of any of the other methods of accelerated gluing would be impracticable.

Note . . .

The application of radiant heat to joints incorporating solid members which are over $\frac{3}{8}$ in. thick will accelerate the setting process of the adhesive, but setting times longer than those given in Table 1 must be allowed.

2. One of the advantages of this method is that the heating arrangements do not interfere with the jointing and cramping operations, but repairs will be confined to hangers or workshops unless an electrical mains supply is available at dispersal points.

3. The basic principle of radiant heat accelerated gluing is the placing of a highly-polished aluminium reflector, fitted with a standard 40-watt electric lamp of correct voltage, directly over the repair area. The heat radiating from the lamp and reflector will considerably raise the temperature of the structure surrounding the joint(s) and the adhesive film, thus accelerating the setting process.

The heat reflector

4. This component should be constructed at Units from local resources to the instructions and dimensions given either in Sect. 3, Chap. 3.5 of this publication or in the Appendix (Scheme A.5) of A.P.2662A. When completed, the reflector base will be 10 in. square, which will allow several reflectors to be placed in line, or in the form of a square, to enable a concentration of radiant heat to be focused on large repair areas where this is necessary.

The lamp

5. The source of radiant heat for this scheme is a standard 40-watt tungsten filament electric light bulb, fitted into the bayonet socket secured to the truncated-pyramid top of the reflector, and connected by suitable flex to the electrical mains supply.

Note . . .

On no account should a light bulb of higher wattage be used in the scheme, since to do so may cause the adhesive to bubble and produce an under-strength joint.

Applying the method

6. To use this method of accelerated gluing, proceed as follows:—

(1) Apply the adhesive and hardener, make the joint and cramp up in the normal manner with cramps or bradding strips.

(2) Place the radiant heat reflector assembly over the repair area, using as many assemblies as required, according to the size of the repair area (*para.* 4), and cover with felt or sack lagging to minimize heat losses.

(3) Connect the heating lamp(s) to the electrical mains supply and heat the joint(s) for the appropriate heating period shown in Table 1.

Note . . .

As the heating period is not critical, no harm will be done to the joint if this period is exceeded.

(4) At the completion of the heating period, switch off the lamp, but leave the lagging and cramps or bradding strips in position on the repair for a further 15 minutes.

(5) When the cooling period has elapsed remove the lagging and reflector assembly(s) from the repair area.

(6) Remove the cramps or bradding strips from the joint(s) and complete the repair as instructed in the appropriate repair scheme.

TABLE 1

Heating and cooling times (hours)

Temperature	Heating period	Cooling period (joint still cramped)	Total time for heating and cooling
Above 0 deg. C.	$\frac{3}{4}$	$\frac{1}{4}$	1
Below 0 deg. C.	1	$\frac{1}{4}$	$1\frac{1}{4}$

Setting times

7. On the completion of accelerated gluing operations, the appropriate setting time must be allowed as shown in the following Table:—

TABLE 2

Setting times (hours)

Temperature	Total heating and cooling times	Setting times	
		Structural members	Non-structural members
Above 0 deg. C.	1	2	1
Below 0 deg. C.	$1\frac{1}{4}$	$2\frac{1}{2}$	$1\frac{1}{4}$

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Chapter 5.3 PLYWOOD

LIST OF CONTENTS

USE OF PLYWOOD

General information

1. In the construction and repair of wooden airframe components, plywood in various forms and thicknesses is used whenever possible, the most important uses being the covering of fuselages and aerofoils and the manufacture of built-up internal frames and brackets, webs of ribs and spars, cockpit and cabin floors and airframe fairings. Further information on the use of aircraft plywood is given in A.P.1464B, Vol. 1, Part 2, Sect. 4, Chap. 2.

2. The use of plywood in the construction of ply sandwich components, box spars and other box members is given in Chap. 5.5. and Chap. 5.6. in this publication, respectively.

3. The standard plywood approved for Service use in repairs of wooden aircraft components is that which is manufactured to B.S. Spec. 6V.3; this specification defines the limits of permissible natural defects in the wood laminations. Plywood is provisioned in two grades, A and B. Grade A plywood has birch or maple wood laminations, with the grain of the centre lamination set at 45 or 90 deg. to that of the outer laminations. It is basically used for structural members and skinning. Grade B plywood may have mixed birch and maple wood laminations in each sheet, or all laminations may be of the same wood, viz: birch, maple or beech, with the grain of the laminations at 45 or 90 deg. This grade of plywood is only to be used for non-structural repairs.

Thickness of plywood

4. In Spec. 6V.3, the standard thickness of plywood is indicated by a code number appropriate to each thickness, e.g. 6V.3/120 refers to $\frac{1}{16}$ in. plywood (Appendix B). A reference number for each available type and thickness of plywood is given under Section 31A of A.P.1086, Book 13 but this publication does not indicate the relevant code numbers. The following Table is therefore included to show the code numbers and data, together with the reference numbers of some of the thicknesses in general use:—

Note . . .

Where a repair scheme in the relevant aircraft air publication Volume 6 specifies a plywood thickness in fractions of an inch and is not available, the nearest equivalent in millimetres above the specified size should be used.

Sub-standard plywood

5. Where lightly-stressed components, or those of tertiary classification, have been damaged and plywood to Specification 6V.3 is not obtainable, a lower grade of plywood to B.S. Spec. V.35, or a good commercial grade, may be used to effect a full-strength repair, Before using these plywoods, however. reference must be made to the relevant aircraft Vol. 6 to ascertain whether the use of the lower grade plywood is permissible, as the specification is less exacting.

Note . . .

In no circumstances may sub-standard plywood be used for the repair of highly-stressed components.

TABLE I

Standard thicknesses of plywood

Code Number	Reference number	Thickness in inches	Equivalent in millimetre	Tolerance	Top limit in inches	Bottom limit in inches	Grain angle
6V.3/100	31A/78	$\frac{1}{32}$–0·031	0·793	± 10 per cent	0·034	0·028	90 deg.
6V.3/110	31A/81	$\frac{3}{64}$–0·047	1·190	± 10 per cent	0·052	0·042	,, ,,
6V.3/120	31A/27	$\frac{1}{16}$–0·0625	1·587	± 10 per cent	0·069	0·056	,, ,,
6V.3/130	31A/83	$\frac{5}{64}$–0·078	1·984	± 10 per cent	0·086	0·070	,, ,,
6V.3/140	31A/28	$\frac{3}{32}$–0·094	2·381	± 10 per cent	0·103	0·084	,, ,,
6V.3/150	31A/29	$\frac{1}{8}$–0·125	3·175	± 5 per cent	0·131	0·119	,, ,,
6V.3/160	31A/30	$\frac{5}{32}$–0·156	3·968	± 5 per cent	0·164	0·148	,, ,,
6V.3/170	31A/31	$\frac{3}{16}$–0·1875	4·762	± 5 per cent	0·197	0·178	,, ,,
6V.3/180	31A/32	$\frac{1}{4}$–0·25	6·35	± 5 per cent	0·262	0·238	,, ,,

USE OF PLYWOOD (*Continued*)

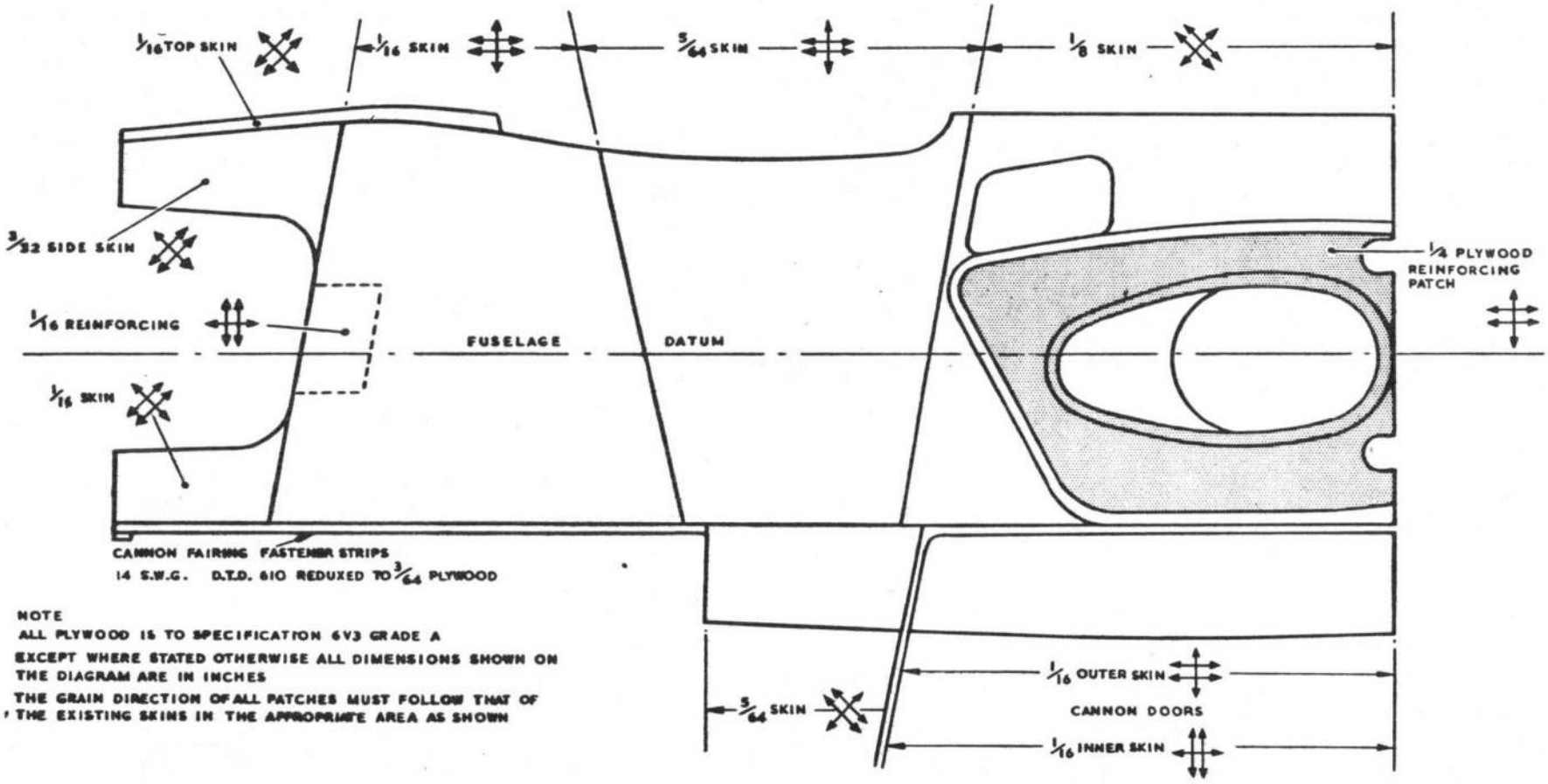

Fig. 1. Typical plywood skinning diagram

Double thickness centre lamination plywood

6. This type of plywood, known in the Services as "D.T.C.L.", is used in some structures which are designed to take torsional loads. The difference between ordinary plywood and the D.T.C.L. type is that the latter has the same strength in any two directions at right-angles and is, therefore, very suitable for taking torsional loads. D.T.C.L. plywood is issued to the Spec. 6V.3 range and is available in the thicknesses shown in the following Table:—

TABLE 2

Data applicable to D.T.C.L. plywood

Reference number	Thickness in inches	Grain angle
31A/89	0·05	All at 90 deg.
31A/90	0·09	
31A/91	0·12	
31A/96	0·15	
31A/97	0·18	

Plywood repairs

7. When repairing plywood, it is essential to remember that every part of the structure under repair has been designed to cater for the loads it has to carry and that it is necessary, therefore, for the completed repair to produce a structure equally as strong as it was before the damage was sustained.

8. Where patch, insertion or renewal repairs are required, the repair material must always be checked to ensure that it is of the same specification, thickness and grain direction as the original plywood. Should the relevant aircraft Vol. 6 specify the use of plywood other than the original in any applicable repair scheme, the specified material must always be used.

Grain direction

9. An essential feature of any plywood repair is the care which must be exercised to match the grain direction of the repair material with that of the original structure, as this may vitally affect the strength of the plywood in its particular structural position on the airframe.

10. When matching, the fact must be noted that due to the directions of the loads, some items, e.g., the webs of box-beams, are constructed of plywood in which the grain direction of the centre lamination is set at 45 deg. to that of the outer laminations.

Skinning diagrams

11. In all repairs to fuselage and aerofoil skinning, the correct thickness, lamination and grain direction of the plywood in the repair area must be ascertained and the repair material must be of similar specification and size. To enable personnel to obtain information on the skinning schemes appropriate to any given aircraft, skinning diagrams are normally contained in the relevant Vol. 6 and these should be used whenever possible. An example of the type of useful information given in a skinning diagram is illustrated in fig. 1.

Bending plywood

12. When bending plywood, personnel will probably experience difficulty in obtaining the required curvature without damaging the wooden structure to be covered. To avoid this, the plywood should be pre-formed by one of the following bending methods:—

(1) Steaming or soaking the plywood in boiling water and clamping around a former, shaped to the required contour, until it is completely dry.

(2) Gluing together laminates of plywood, building up to the required thickness and cramping them around a former, shaped to the required contour, until the adhesive has dried in the approved setting time.

Note . . .

Adjacent laminations in a built-up member or panel must have their grain directions at right-angles to each other.

13. Where possible, Grade A plywood to Spec. 6V.3 should be used for the bending operations. Grade B ply may be used if the superior grade is not available, provided care is taken to select only straight-grained material which is free from short grain on the surface.

Removal of madapollam covering

14. The removal of madapollam or other types of fabric coverings from plywood panels requires great care and patience to be exercised by the operator. Although ordinary doped fabric coverings can normally be removed easily by the application of a dope solvent, there is at present, no known solvent which will remove madapollam from plywood, due to the tenacious character of the adhesive. When the removal of this covering is necessary to effect the repair of a plywood panel beneath it, the area of the material to be removed must be moistened with solvent and the surface carefully rubbed with coarse sandpaper until the surface of the adhesive on the plywood can be seen. The bared surface must then be evenly scraped with a metal scraper until the whole area has been cleaned off. At no time should attempts be made to rip off the madapollam covering from plywood in long strips as this would only result in lifting the top lamination of the plywood, thus causing additional damage to that which exists and necessitating the repair of a larger area of damage.

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SPLICING AND CROSS-SPLICING PLYWOOD PANELS

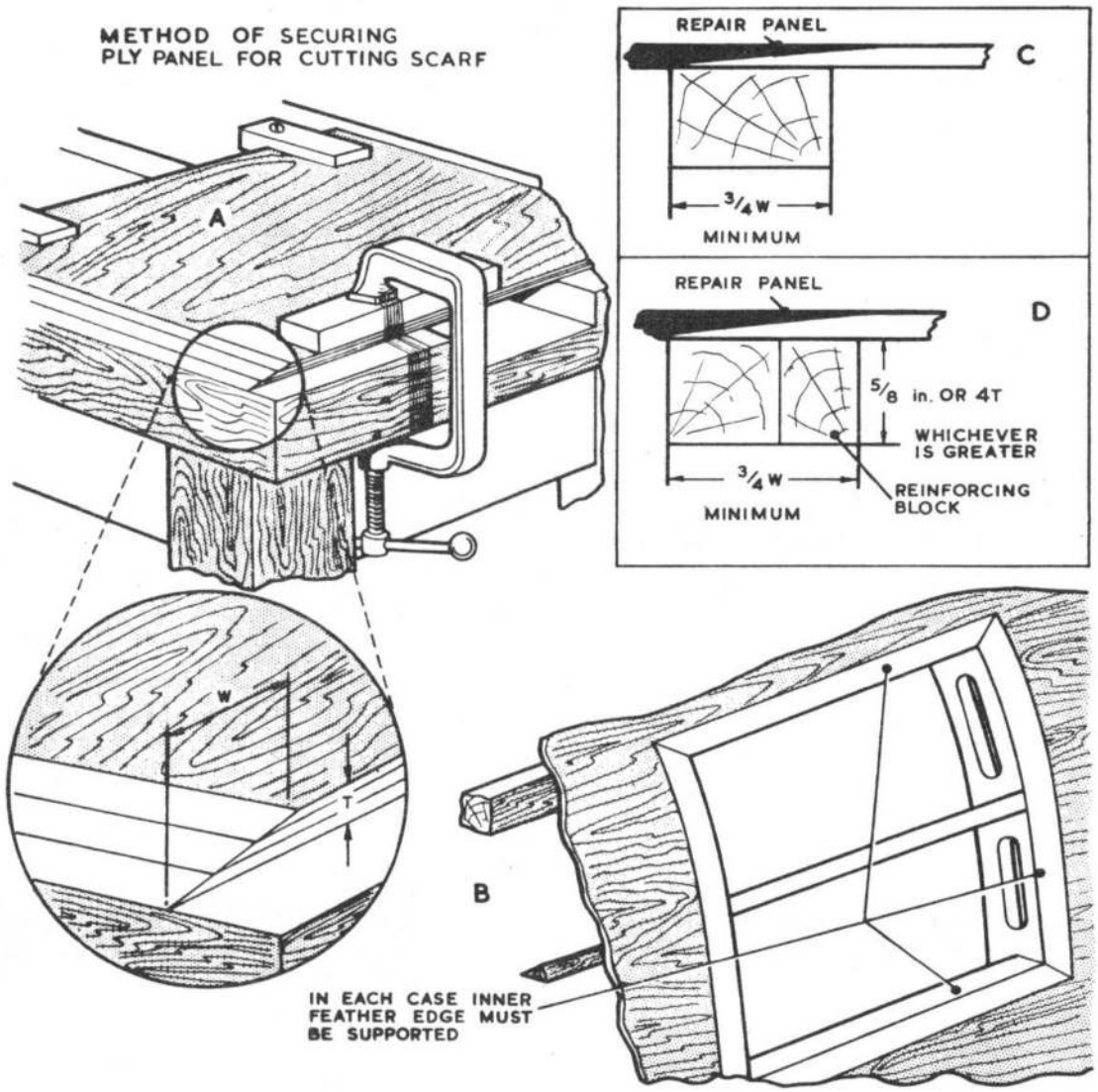

Fig. 1. Methods of supporting spliced joints

General information

1. In the following paragraphs, brief instructions are given on the purpose and preparation of spliced joints in plywood. The detail diagrams in fig. 1 show the methods of supporting a spliced panel with and without a reinforcing block, and fig. 2, the method of cross-splicing a panel which has previously been spliced.

2. Any glued joint must be at least as strong as the corresponding sections of wood which are being joined. This essential requirement basically determines the area, and consequently the length of overlap, of the glued surfaces. A lap joint could be made to provide the necessary strength, but its use would introduce complications due to offset loading, the need for a filler patch for flush repairs, interference with supporting structure and, on large repairs, added weight. The spliced joint is therefore used wherever possible, as the accepted medium of joining two pieces of wood together since, by its use, the load paths are unchanged, a flush finish is obtained on both faces of the repair, a minimum of interference is caused with any supporting structure, and no weight is added unless reinforcing is required on the supporting members.

3. In theory, a splice length of approximately 6 times the thickness of the plywood would provide the required strength, but the theoretical determination of the strength of glued joints is dependent upon uniformity of manufacture. In practice, however, the tensile strength of glue is unreliable and even the shear strength varies due to factors such as the thickness of the adhesive coating, temperature and humidity. Since uniformity of these conditions is seldom achieved, a safety factor is necessary and a standard splice length of 9 times the thickness of the plywood has been adopted.

Cutting ordinary splices

4. When cutting splices of any kind, careful work is essential to ensure an accurate fit of the faying surfaces, and the following initial instructions should be applied:—

(1) Before work is commenced, all required materials and tools must be close to hand. All tools must be checked for sharpness.

(2) Before cutting out the damaged portion of a plywood panel, check the width of the supporting member upon which a splice is to be made. If it is less than $\frac{3}{4}$W, a reinforcing block will be necessary; therefore the plywood must not be cut right back to the member, but only as far back as the thickness of the reinforcing block will allow.

(3) Ensure that the splice length W is 9 times the thickness T (*fig.* 1, *detail* A).

(4) Make clear cutting lines with a scriber on the wood to be spliced and ensure that the saw cuts are made just outside of, and parallel with, the cutting lines.

(5) Where possible, use the smoothing plane to obtain a good, level, joint surface and then rough up with fine sandpaper.

(6) Ensure that the inner feather edge of the splice in a panel is always supported by an internal member or reinforcing block, which must be at least $\frac{3}{4}$W as shown in fig. 1, detail D.

Cutting cross-splices

5. The information given in para. 5 is equally applicable to this method of splicing. The direction of the splice in the original joint may be disregarded when cutting away the damaged portion of a plywood panel and the series of operations necessary to effect a new spliced joint on top of the old one are shown as stages 1 to 3 in fig. 2.

6. On completion of the cross-splice, observe the correct setting time for the S.R. adhesive (*Chap.* 5.2.). This will ensure a full-strength joint.

7. Under circumstances specific to a given aircraft type, the relevant aircraft Vol. 6 may stipulate the use of a 15:1 splice length in a plywood repair scheme. While this length of splice is unusual in plywood, the longer splice must be used if so specified.

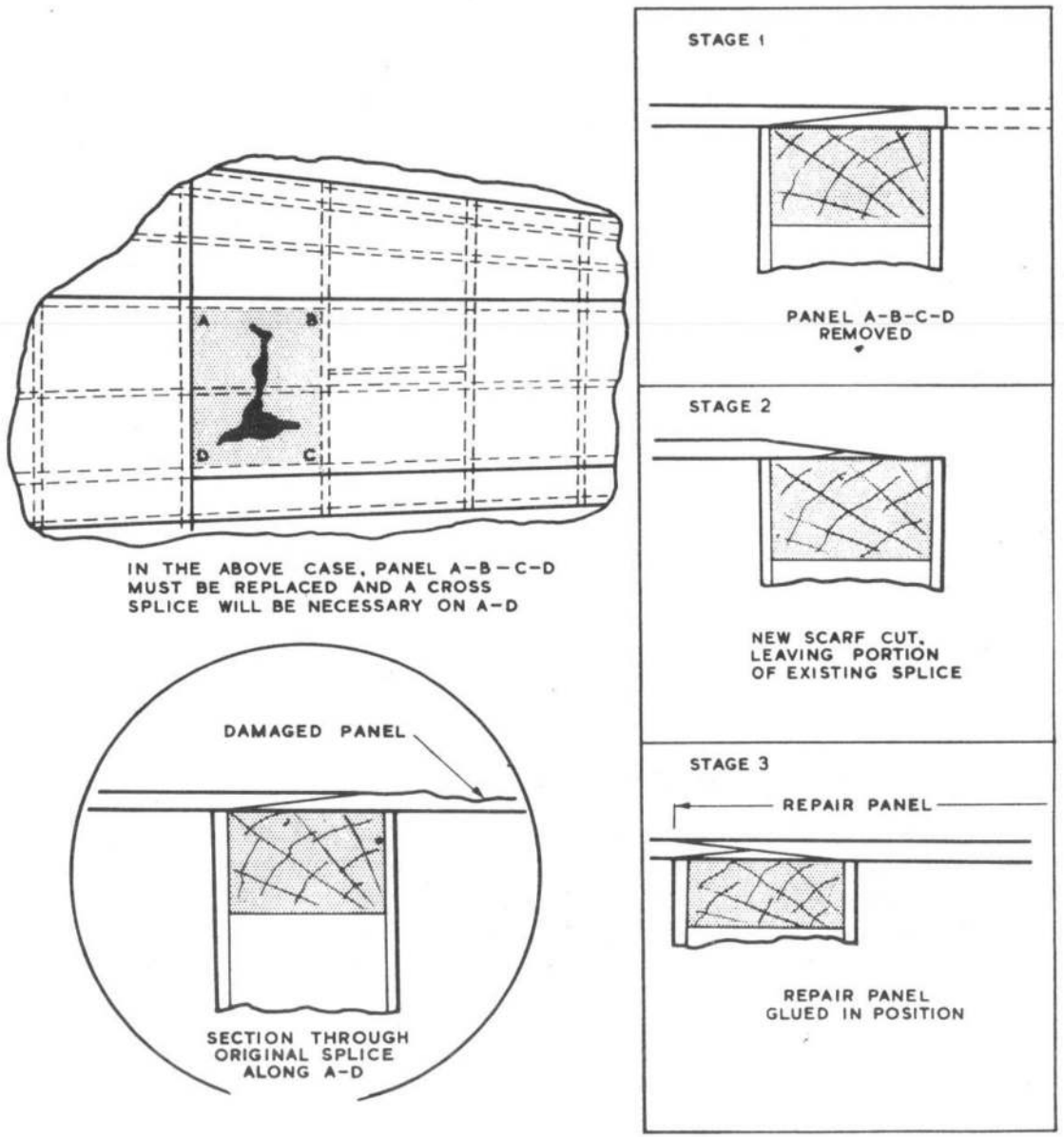

Fig. 2. Method of cross-splicing an existing splice

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PATCH REPAIR OF CRACKED PLYWOOD INTERNAL PANEL

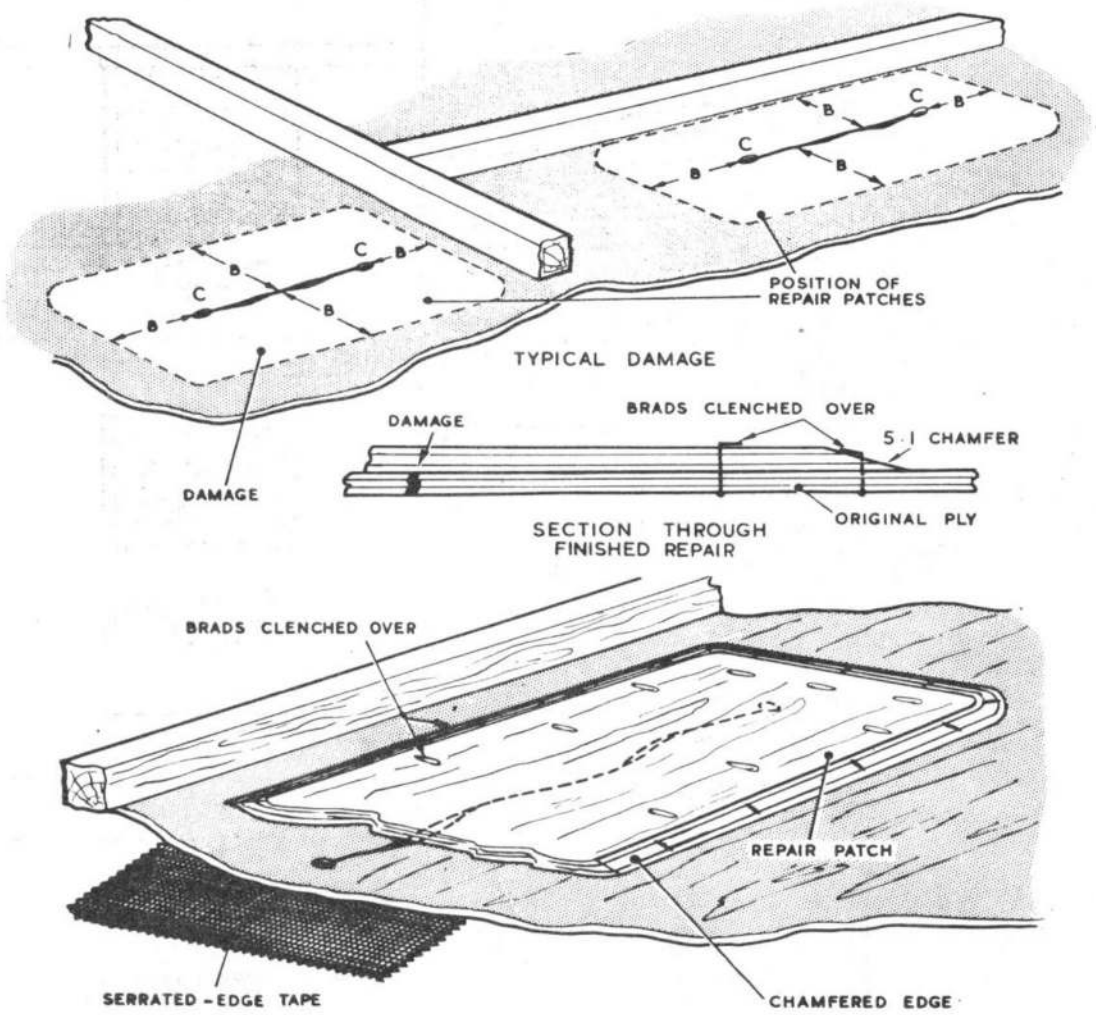

Fig. 1. Patch repair of cracked panel

General application

1. This repair method may be used on plywood up to $\frac{1}{8}$ in. thick where the crack is not more than 12 in. long and is in a position where a patch overlap of at least 2 in. all round the damaged area can be obtained, with free access from both sides of the panel available through access or servicing apertures.

2. In fig. 1, which shows typical damage and the method of repair, item B indicates the overlap of the patch over the crack and item C, the position of the holes to be drilled at the end of a crack to prevent any extension in the length.

Repair procedure

3. With sufficient plywood of the same grade, thickness and grain direction as the damaged panel, and the requisite amount of S.R. adhesive, hardener and glue brushes (*Chap.* 5·2) to hand, proceed with the repair in the following sequence of operations:—

(1) Clean or, if necessary, remove the fabric on the outer face of the panel. If madapollam covering is fitted it should be removed as instructed in Scheme 5.3.1, para. 14.

(2) Drill $\frac{1}{8}$ in. dia. holes C (*fig.* 1) at the extreme ends of the crack to prevent it spreading.

(3) Cut a suitable patch from the repair plywood ensuring that the overlap B is sufficient, i.e., not less than 2 in.

(4) Radius the corners of the patch at least $\frac{1}{2}$ in. and chamfer the edges to a ratio of 5 to 1.

(5) Clean and sandpaper the inner surface of the cracked panel and the patch and apply a coat of S.R. adhesive to the panel. While waiting for the adhesive to become tacky, apply a coat of hardener to the inner face of the patch.

(6) Place the patch centrally over the crack and secure it with brads driven in through the outer face of the panel and clenched on top of the patch with the ends of the brads pointing inwards across the grain.

Note . . .

The panel and patch must be suitably supported during the driving and clenching operations.

(7) Clean off any surplus adhesive and then leave the repair for the prescribed setting time (*Chap.* 5.2.).

(8) If the covering material has been removed, recover the outer face of the panel with fabric or madapollam, as appropriate. If, however, the repair area was not originally covered, a strip of 4 in. serrated fabric should be doped over the plywood to cover the area of the crack and the brads securing the patch.

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PATCH REPAIR OF PLYWOOD INTERNAL PANEL

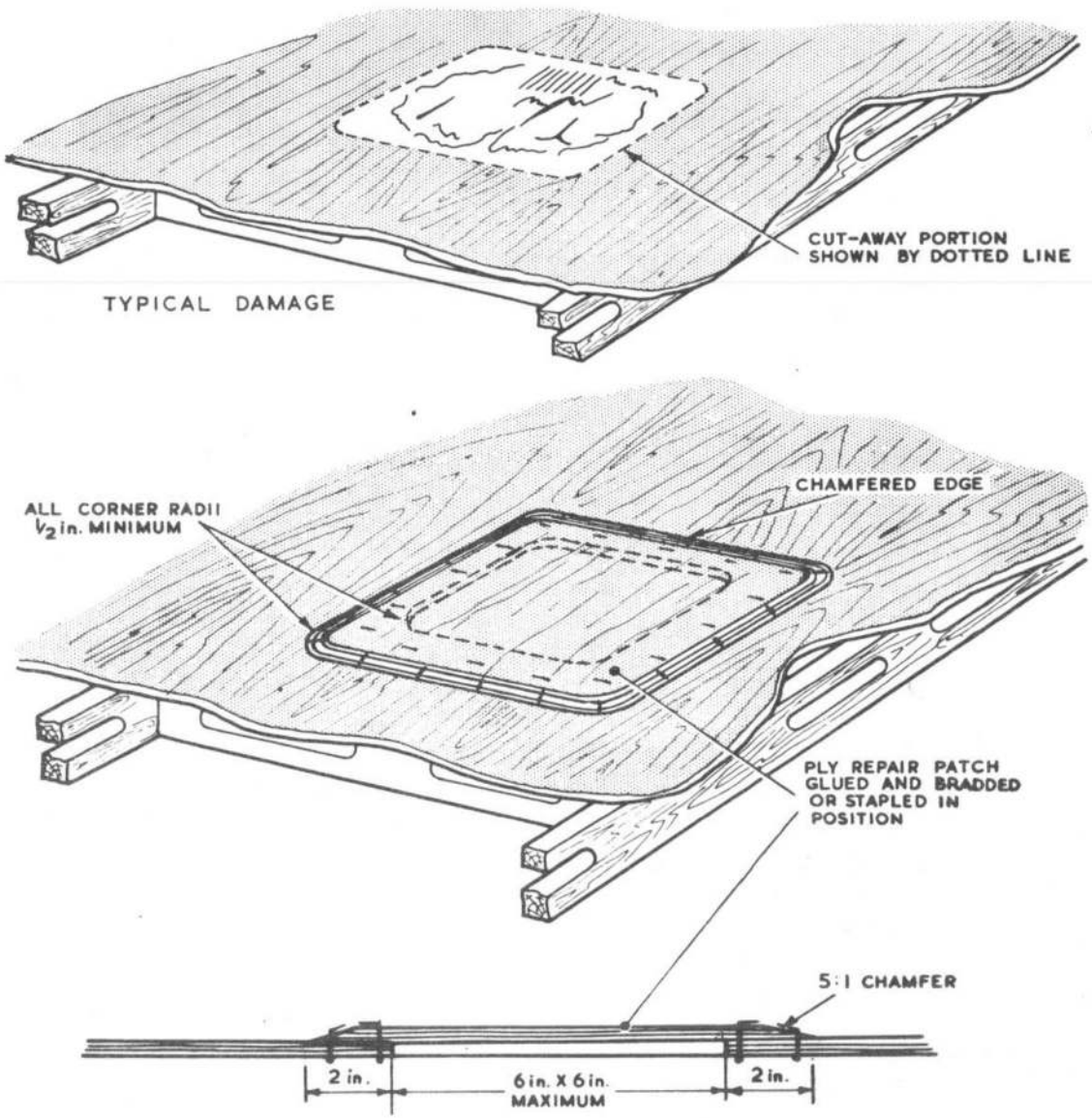

Fig. 1. Patch repair of internal panel

General application

1. This type of repair should be effected where plywood up to $\frac{1}{8}$ in. thick is damaged, provided the area of damage is within a 6 in. square, the panel is not exposed to the airflow and adequate access can be made on both sides of the panel.

Repair procedure

2. With the required amounts of prepared S.R. adhesive and hardener (*Chap.* 5.2) and the necessary equipment available on site, proceed as follows:—

(1) Supporting the plywood as necessary, cut away the damaged area and trim the hole in the panel to a clean square or rectangle with corner radii of at least $\frac{1}{2}$ in. Clean and sand the edges.

(2) From plywood of the same specification grade, thickness and grain direction as the damaged panel, cut a patch with an overlap of 2 in. all round the hole in the panel.

(3) Radius the corners of the patch at $\frac{1}{2}$ in. and then chamfer all edges to a ratio of 5 to 1.

(4) Clean and sandpaper the inner surfaces of the panel and patch prior to applying the adhesive.

(5) Apply the adhesive and hardener to the inner faces of panel and patch as appropriate and position the patch centrally over the hole cut in the panel so that there is a 2 in. overlap all round.

(6) With the plywood suitably supported against hammer blows, drive in the brads through the outer face of the panel and clench the ends over the outer face of the patch so that they lie across the grain, facing inwards as shown in fig. 1.

Note . . .
If staples are used to secure the patch, they must be driven into the upper face of the patch across the grain.

(7) Clean off all surplus adhesive and allow the joint to stand for the specified setting time.

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5.3.5

UNSPLICED INSERTION REPAIR OF PLYWOOD EXTERNAL PANEL

General application

1. This method of repair is applicable to damaged plywood up to $\frac{1}{8}$ in. thickness which is exposed to the airstream and the area of damage does not exceed 5 in. across the grain or $7\frac{1}{2}$ in. along the grain of the outer laminations, with suitable access available for the positioning of internal support of the plywood while bradding or stapling operations are in progress.

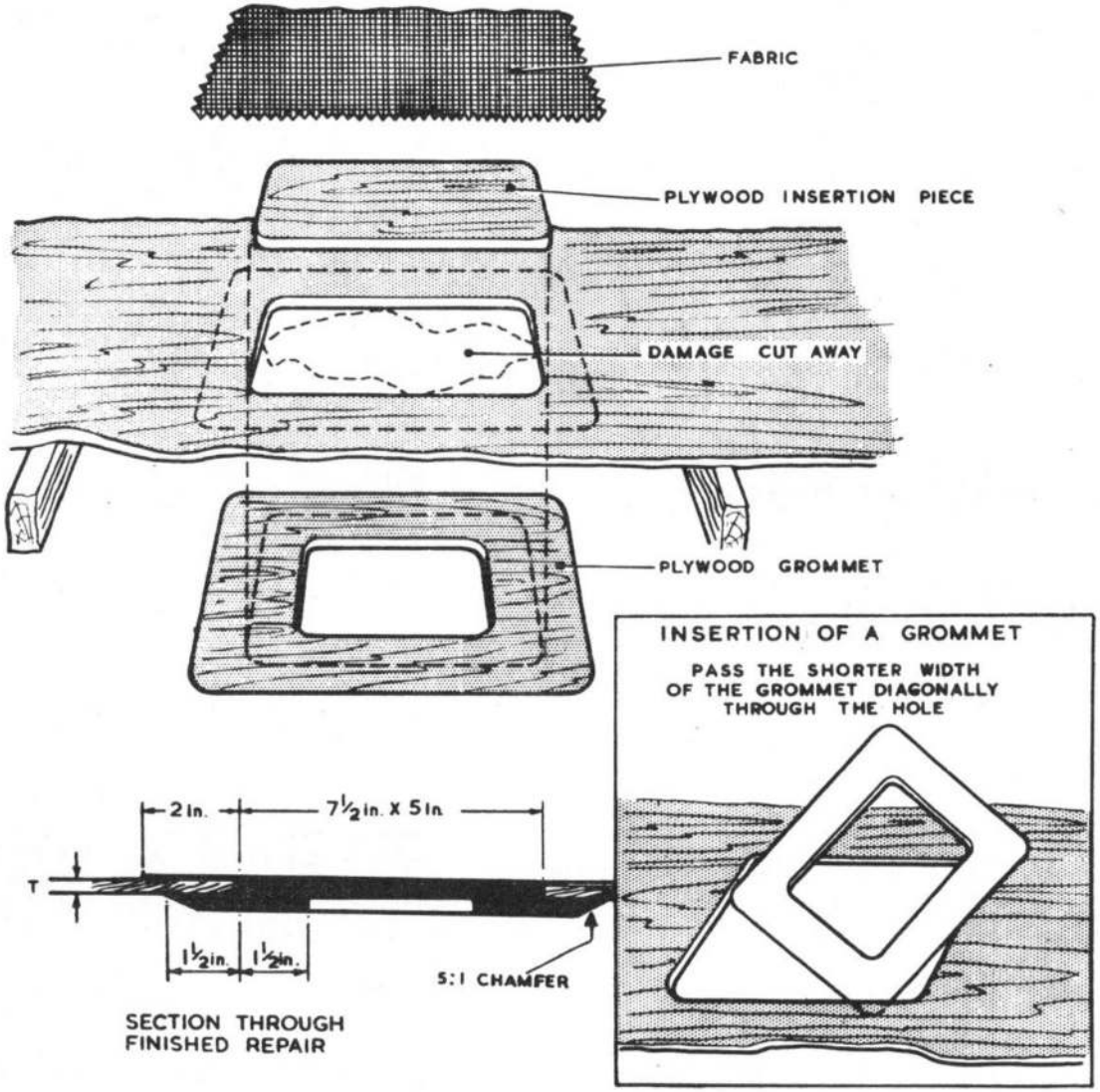

Fig. 1. Insertion repair of external panel

Repair procedure

2. With all the equipment necessary to complete the work assembled adjacent to the job, proceed in the following sequence of operations:—

(1) If the plywood panel is covered with fabric or madapollam, remove this covering in the prescribed manner (*Scheme* 5.3.1, *para.* 14). Support as necessary and clean out the damaged area by cutting a rectangular hole to the maximum dimensions of 5 in. × $7\frac{1}{2}$ in. with corner radii of at least $\frac{1}{2}$ in.

Note . . .

If the damaged area of the plywood is small, the size of the rectangular hole should be proportionally smaller than 5 *in.* × $7\frac{1}{2}$ *in.*

(2) Clean and sandpaper the edges of the hole in the plywood panel.

(3) From plywood of the same specification grade, thickness and grain direction as the damaged panel, cut a grommet to give the overlaps of $1\frac{1}{2}$ in. all round the hole and $1\frac{1}{2}$ in. within the hole in the panel as shown in the sectioned drawing in fig. 1.

(4) Chamfer the edges of the grommet to a ratio of 5 to 1 towards its outer face (*fig.* 1).

(5) From similar plywood used in (3) above, cut an insertion piece to fit accurately into the hole cut in operation (1).

(6) Clean and sandpaper the inner face of the existing plywood around the hole and the complete upper surface of the grommet.

(7) Apply the adhesive and hardener to the faying surfaces of the grommet and panel respectively and, with the inner surface suitably supported to withstand hammer blows, drive in the brads or staples, clenching the brads across the grain on the lower face of the grommet.

(8) Clean off all surplus adhesive from the joint and, while waiting a short period for the adhesive to harden, clean and sandpaper the lower face and edges of the insertion piece.

(9) Apply the adhesive and hardener to the face of the grommet inner overlap and edges of the hole cut in the original plywood and the corresponding face of the insertion piece and the edges respectively and, with suitable support beneath the inner surface, secure the insert to the grommet with brads or staples, the brads being clenched across the grain of the grommet.

(10) Allow the prescribed setting time for the adhesive and then suitably cover the repair area with serrated fabric or madapollam, as appropriate, to current Service requirements.

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UNSPLICED INSERTION REPAIR OF PLYWOOD EXTERNAL PANEL OVER MEMBER

5.3.6

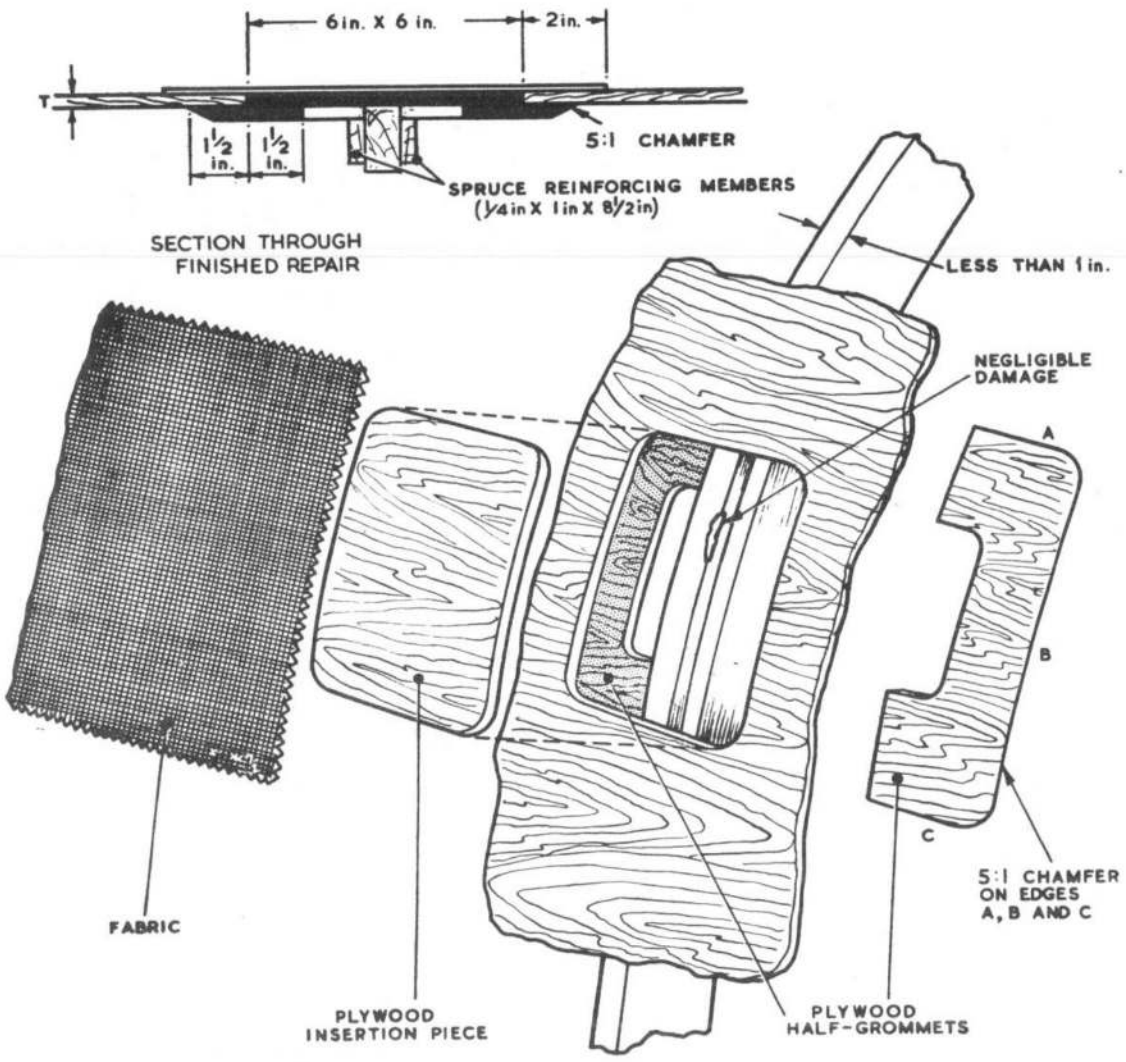

Fig. 1. Insertion repair of panel over member

General application

1. The type of repair depicted in fig. 1 should be effected where damage has occurred to a plywood skin of up to $\frac{1}{8}$ in. thickness, in the vicinity of an internal frame or other member. The method of repair is a variation of that given in Scheme 5.3.5, the application being the same as quoted in para. 1 of that scheme, with an added requirement that the members beneath the panel must be less than 1 in. wide and, if it has sustained more than negligible damage, it must be repaired in accordance with the appropriate scheme given in the relevant aircraft Vol. 6 before the panel repair is commenced.

Repair procedure

2. The general instructions given in Scheme 5.3.5. apply, but the repair arrangement is different. The hole in the panel must not exceed 6 in. square and must have a radius of at least $\frac{1}{2}$ in. at each corner. The grommet must be made in two separate halves, to fit close against each side of the existing member, and spruce reinforcing members are required to support each half of the grommet, as shown in fig. 1.

3. The two spruce reinforcing members must be cut from straight-grained wood and shaped to the contour of the existing member. They should be $\frac{1}{4}$ in. wide, 1 in. deep and $2\frac{1}{2}$ in. longer than the corresponding width of the cut-out.

4. When shaped and sandpapered, they must be glued and screwed to each side of the existing member, symmetrically positioned about the damage area so that they are tight against the underside edge of each half-grommet that they support.

5. Each half-grommet must be cut so that an overlap of $1\frac{1}{2}$ in. extends on either side of the edges of the hole in the plywood panel, thus giving it a maximum length of 9 in. and a maximum width of $4\frac{1}{2}$ in., less half the width of the member, with an approximate width of 1 in. for the hole in the centre of the grommet.

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SPLICED AND BUTT-JOINED INSERTION REPAIR OF PLYWOOD PANEL

General application

1. The application of this repair is similar to that given in Scheme 5.3.6, together with the splicing instructions given in Scheme 5.3.2, therefore all the standard requirements of plywood specification grade, thickness and grain direction are satisfied. The repair method should be used when damage occurs close to a frame or similar member, using a half-grommet to support the plywood insertion piece as shown in fig. 1. The damaged area must be within a 6 in. square.

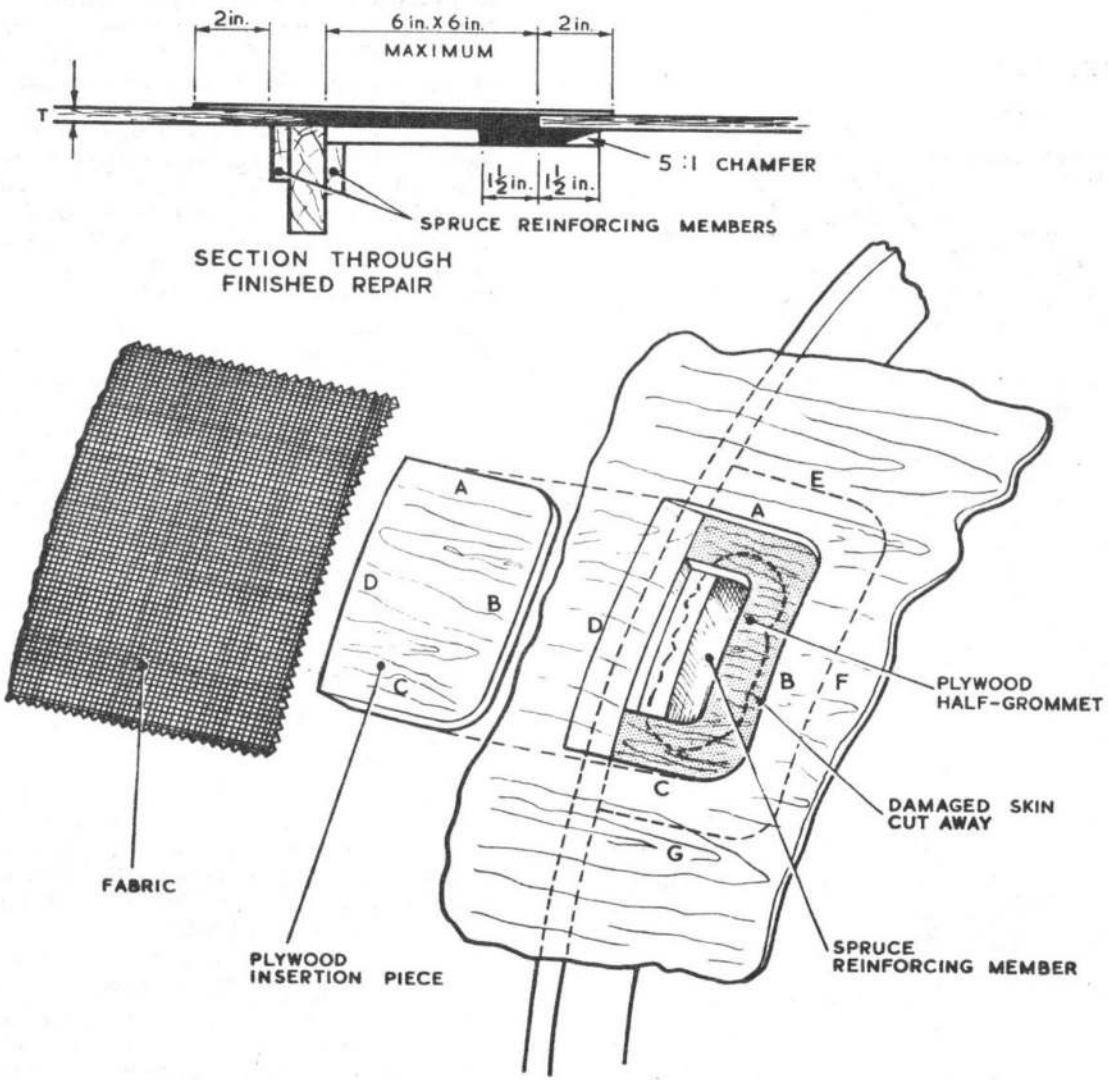

Fig. 1. Spliced and butt-joined insertion repair of panel

Repair procedure

2. Refer to Scheme 5.3.2 and 5.3.6 and, with all necessary tools and material available on site, proceed as follows:—

(1) Remove the fabric or madapollam covering (*Scheme* 5.3.1, *para.* 14) from the area of damage.

(2) Support as necessary and cut the plywood panel to a dimension not exceeding 6 in. square, with two corner radii at ¼ in. so that the edge of the cut nearest to the member is flush with it, thus leaving two right-angle corners.

(3) Cut the splice (*Scheme* 5.3.2) on the plywood remaining on top of the member (*fig.* 1), ensuring that the corners of the spliced edge are sharp, and then trim the edges of the hole to give a clean cut.

(4) Cut the half-grommet (*Scheme* 5.3.6, *para.* 5) and chamfer the edges E, F and G (*fig.* 1) to a ratio of 5 to 1 towards the lower face.

(5) Cut a spruce reinforcing member (*Scheme* 5.3.6, *para.* 3) to the contour of the main member, to support the half-grommet; this member should be ¼ in. wide, 1 in. deep and 2½ in. longer than the dimension of the cut-out portion of the panel.

(6) If required (*Scheme* 5.3.2, *para.* 4) a second reinforcing member must be cut and attached to the opposite face of the main member, to support the area of the splice (*fig.* 1).

(7) Fit the reinforcing members, half-grommet and insertion piece, glue and secure and complete the work as in Schemes 5.3.5 and 5.3.6.

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PART-RENEWAL REPAIR OF A LARGE PLYWOOD PANEL

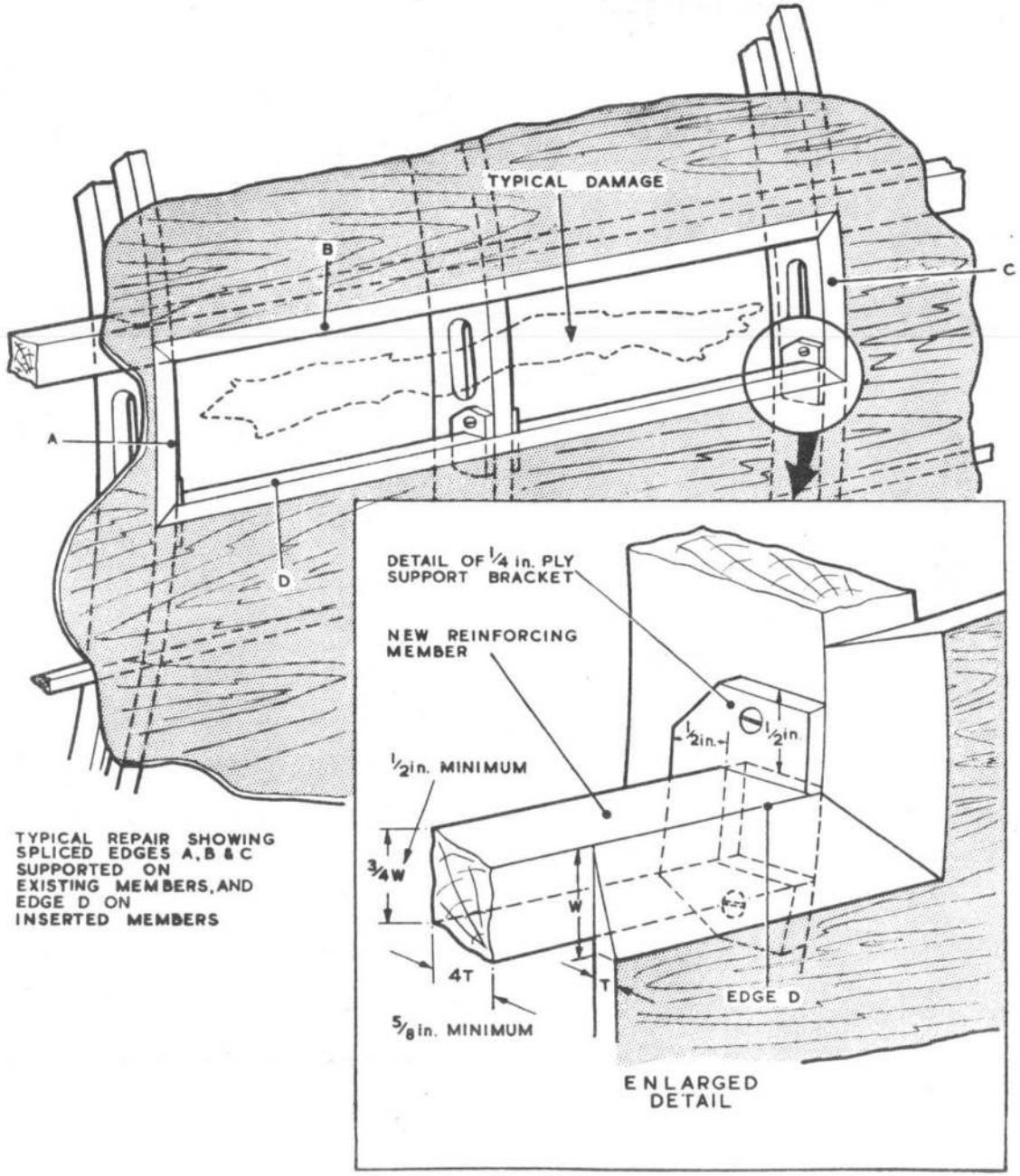

Fig. 1. Spliced part-panel renewal repair

General application

1. This scheme applies, when the renewal of a complete panel is considered unnecessary, to general spliced repairs of plywood panels greater in thickness than $\frac{1}{8}$ in., and to more extensive damage to panels up to $\frac{1}{8}$ in. thick than that covered in preceding schemes. The scheme should also be used to effect a repair when access is available on one side only (*fig.* 1).

Repair procedure

2. With all necessary repair material and tools available on site, refer to Scheme 5.3.2 (splicing methods) and proceed in the following sequence of operations:—

(1) If the plywood is covered with fabric or madapollam, remove the covering as directed in Scheme 5.3.1, para. 14, cutting back to 2 in. all round the damage area.

(2) Support as necessary and cut the plywood back to the existing members, where convenient, on three sides of the panel and to a line such as D in fig. 1, where a reinforcing member can be fitted.

(3) Clean up the edges A, B and C shown in the illustration and cut splice angles on them at a ratio of 9 to 1.

(4) Cut spruce reinforcing members to the dimensions given in fig. 1; these are required to support the edge D. Now cut U-shaped plywood support brackets for the reinforcing members as shown in the detail.

(5) Secure the reinforcing member(s) with S.R. adhesive (*Chap.* 5.2) under the edge D and glue and screw the support brackets into the existing solid members at each end.

(6) Clean up the edge D and cut a splice angle on it at a ratio of 9 to 1.

(7) From plywood of the same specification grade, thickness and grain direction as that of the damaged panel, cut an insertion panel to the required dimensions; then cut a splice angle on each edge of the insert to mate up with the splice angles cut in operations (3) and (6).

(8) Apply adhesive and hardener to the joint faces and fit the insertion panel in position, securing it with brads or staples driven through the splices into the solid members. Allow the appropriate setting time to elapse before further work on the repair is effected.

(9) If the plywood was originally covered with fabric or madapollam, cut a new cover and butt-joint it into position over the repair area, covering the joints with strips of 2 in. serrated fabric. If the original panel was not covered and the repair has been made on the exterior of the aircraft, the splice lines should be covered with strips of 2 in. serrated fabric only.

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RENEWAL OF A LARGE PLYWOOD PANEL

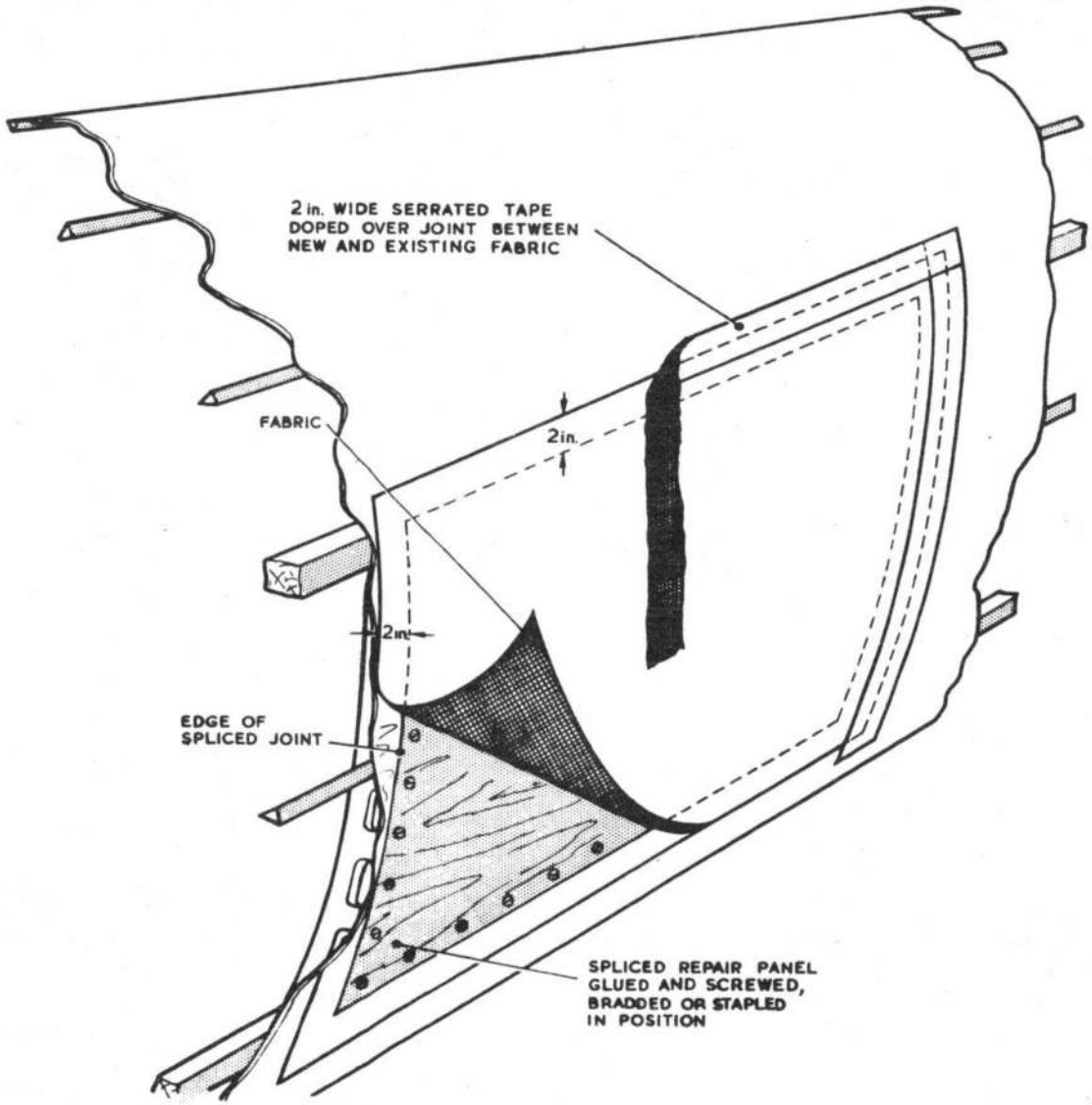

Fig. 1. Spliced renewal repair of complete panel

General application

1. This repair scheme covers the renewal of a large complete plywood panel of any thickness which has been extensively damaged or has been cut out to gain access for repairs to be made to internal damage. Although of general application, the scheme is most likely to be used for the repair of aerofoil of fuselage skinning, as shown in fig. 1.

2. The panel should be renewed by using the splicing technique given in Scheme 5.3.2 and the repair procedure in Scheme 5.3.8, the renewal repair being effected by splicing in a new panel, flush with the existing plywood, over the existing frames and support members which are either damaged to a negligible amount or have been repaired to the full-strength standard.

Repair procedure

3. With the necessary repair materials and tools assembled near the job, proceed in the following sequence of operations:—

(1) If the plywood is covered with fabric or madapollam, cut back the covering to clear the panel boundaries and remove it (*Scheme* 5.3.1, *para.* 14).

(2) Remove the panel by cutting back to the appropriate internal members which will form the supports for splicing and the boundary members of the hole in the plywood.

Note . . .

If necessary, build up the width of the existing members so that they are at least three-quarters of the splice length (*Scheme* 5.3.2, *para.* 4).

(3) Clean up the edges of the plywood and cut a splice face at a ratio of 9 to 1 on each edge.

(4) From plywood of the same specification grade, thickness and grain direction as the existing plywood, cut a panel to the appropriate dimensions and scarf the edges to a ratio of 9 to 1.

(5) Apply S.R. adhesive and hardener respectively, to the splice faces. When the adhesive is tacky, fit the panel into the aperture and line up the edges of the splices, then screw, brad or staple the insertion panel to secure it to the upper face of the existing internal members. Allow the appropriate setting time to elapse before further repair work is effected.

Note . . .

If staples are used, these should be set across the grain.

(6) If necessary, fit a covering of fabric or madapollam to butt-join the existing covering, and cover the butt joints with 2 in. strips of serrated fabric.

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SPLICED INSERTION REPAIR OF AN AEROFOIL PLYWOOD LEADING EDGE

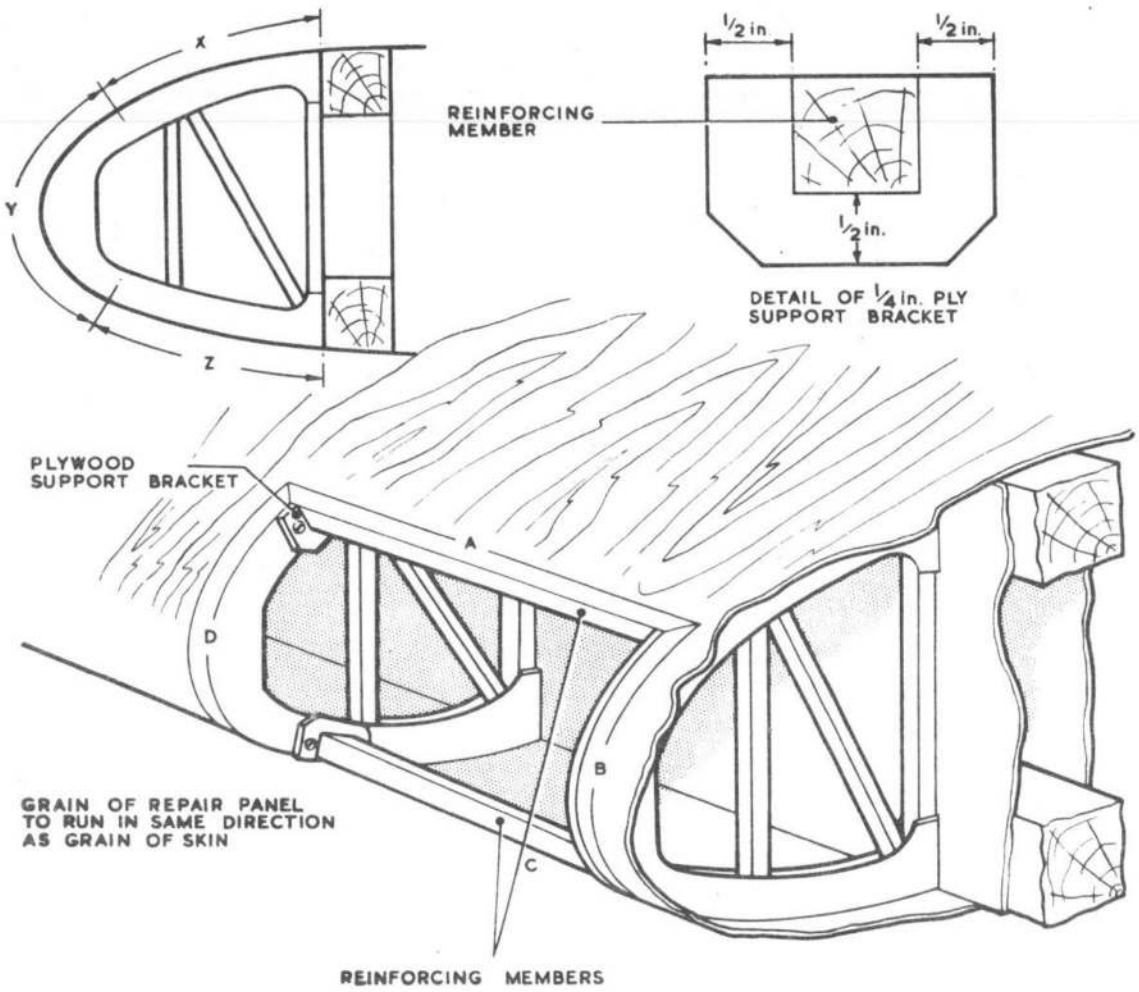

Fig. 1. Leading edge spliced insertion repair

General application

1. The repair instructions given in this scheme are applicable to plywood leading edges, of any thickness, where the following conditions exist:—

(1) The construction is such that there are no spanwise leading edge members.

(2) The damage extends less than half-way round the curvature of the leading edge, measured from the top boom of the front spar to the bottom boom; it may extend more than one rib bay spanwise.

(3) The rib construction is such that it will afford adequate support for spanwise reinforcing members to be fitted.

Note . . .

This type of repair must not be attempted on main planes which have a single main spar and torsion-box structure forming the leading edge, and a lightly-constructed auxiliary spar. In such a case, the appropriate repair scheme in the relevant aircraft Vol. 6 must be used.

2. When making the repair splices, the spanwise joints must never be made in the sharply curved portion of the leading edge (*distance Y in the detail drawing in fig.* 1). If damage has occurred in this portion, the plywood must be cut right back to allow the spanwise splices to be made in the upper and lower portions as shown at X and Z of fig. 1.

Repair procedure

3. With all necessary tools and materials close to hand, proceed as follows:—

(1) If the plywood is covered with fabric or madapollam, remove this carefully (*Scheme* 5.3.1, *para.* 14) to expose the area of damage.

SPLICED INSERTION REPAIR OF AN AEROFOIL PLYWOOD LEADING EDGE (*Continued*)

(2) Cut back the damaged plywood to ribs nearest to the area of damage in a spanwise direction (*fig.* 1, *items* B *and* D) and to suitable chordwise lines, which will clear the damage, as shown in fig. 1, items A and C.

(3) Face up the edges of the plywood at B and D and cut splice faces on them to a ratio of 9 to 1, supported by the ribs.

Note . . .

If necessary, the width of the ribs should be increased by the addition of reinforcing members to ensure a positive support of at least three-quarters of the splice length.

(4) From selected, straight-grain spruce, cut reinforcing members at least $\frac{3}{4}$ W wide (W is the spliced length) and $\frac{1}{2}$ in. or 4 T deep whichever is the greater (T is the plywood thickness). The members should be of sufficient length to fit snugly against the ribs.

(5) Cut U-shaped plywood support brackets to the dimensions shown in fig. 1.

(6) Face up the edges A and C and secure the reinforcing members to their inner surfaces with S.R. adhesive (*Chap.* 5.2), then glue and screw the plywood support brackets to the inner faces of the ribs (*fig.* 1).

(7) When the adhesive is dry and the reinforcing members are closely secured in the brackets, cut the splice angles as in operation (3).

(8) From plywood of the same specification grade, thickness and grain direction as the existing plywood, cut an insertion panel to the necessary close dimensions and cut a splice face, to a ratio of 9 to 1, on each edge.

Note . . .

If the grain direction is at 45 deg. to edges B or D, or if the curvature of the insertion panel is great, the insertion must be preformed to the approximate contour of the existing leading edge before fitting (*Scheme* 5.3.1, *para.* 12).

(9) With the insertion piece fitting snugly within the spliced area, apply S.R. adhesive and hardener to the faying surfaces. Allow the adhesive to become tacky, fit the insertion in position and secure it with brads or staples to the supporting members. Allow the appropriate setting time to elapse before commencing other work.

Note . . .

If staples are used, these should be set across the grain.

(10) If the plywood is covered with fabric or madapollam, cut a piece to butt-join the existing covering and cover the join with strips of 2 in., serrated fabric. If no covering exists, cover the splice joints with strips of 2 in., serrated fabric only.

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Chapter 5.4 SOLID MEMBERS

LIST OF CONTENTS

Scheme

GENERAL NOTES ON SOLID MEMBERS

Introduction

1. The term 'solid member' applies to a laminated member or to a member made from a single piece of wood. The basic solid members used in wooden airframe structures are generally made from Sitka spruce to B.S. Spec. V.37 and this chapter contains a number of repair schemes which apply only to the repair of spruce members, or to members made with the approved substitutes, i.e. Douglas or Noble Fir, or Oregon pine, to B.S. Spec. V.36.

2. If other types of wood are used in the construction of members, the specific repair instructions given in the relevant airframe Vol. 2, Part 3 or Vol. 6 must be effected, but if no instructions are available, the type of wood used in the members requiring repair must be identified and similar, good quality, straight-grain wood used in the repairs.

Selection of wood

3. When effecting repairs on any form of wooden airframe structure, the careful selection of the wood to be used for repairs is of great importance and therefore, only that which meets the specification of the wood used in the original structure, or its approved substitute, may be used.

4. All wood selected for effecting repairs must be closely examined before use to ensure that it is free from defects of all kinds. Detailed information on the identification of defects in all woods used in the construction of airframes is given in A.P.1464B, Vol. 1, Part 2, Sect. 4, Chap. 2. In addition, para. 5 covers the identification of defects which may be discovered in spruce.

Defects in Sitka spruce

5. The following defects which may exist in this type of wood are classified as dangerous to the strength of the wood and thus make it entirely unsuitable for use in the repair of any airframe structure:—

Dote

(1) This, or any other form of decay in the wood, is a disease which takes the form of pockets of brown, crumbling rot extending well into the inner fibres. In the early stages of infection the disease may be recognised by the presence of small yellow-brown spots on the surface of the wood, and any wood that is affected must be rejected immediately.

Shakes

(2) These are splits in the wood, or grain distortion occasioned by defects in the growing tree (*heart and cup shakes*) or shrinkage occurring during seasoning, thus setting up numerous radial clefts in the wood (*seasoning shakes*). They are recognised by apparent ruptures in the edge grain of the wood.

Resin pockets

(3) Formed during the growth of the tree or, later, during seasoning, these pockets are immediately recognised on examination of the wood, making it unworkable if a pocket cannot be removed.

Knots

(4) Large knots or knots on the edges of planks or battens of the wood are usually caused by branches being cut or torn from the growing tree. They disrupt the even grain lines, cause cross-grain to develop and make the wood unworkable.

Inclined grain or fibres

(5) These defects are caused by the young, growing tree having its trunk twisted by exposure to high winds. Identification of

inclined or twisted grain on small battens of wood is difficult, but as straightness of grain and fibres has an important bearing on the strength of spruce, the grain direction can be checked, where doubt exists, by applying a drop of ink on the wood and watching the direction in which it runs.

wood, the information given in A.P.1464B (*para.* 4 *of this Scheme refers*) should be studied, but if this air publication is not available, the following Table should be used to compare the physical properties of various types of wood to assist in a suitable selection:—

TABLE 1

Comparable data on selected woods

Type of wood	Compressive strength in lb. per sq. in. (parallel to grain)	Shear strength in lb. per sq. in. (parallel to grain)	Weight in lb. per cu. ft.	Bending order of preference
Sitka spruce	4,000	750	27	—
Walnut	5,700	1,000	39	1
Ash	5,250	1,380	41	2
*Douglas fir	5,600	810	34	4
Mahogany	4,880	860	34	3
*Noble fir	4,080	690	27	5

*Approved substitutes for spruce

Use of alternative woods

6. When the wood which is required for a repair is being selected, every effort must be made to obtain wood of the same type as that in the original structure, but where this is not possible, an alternative wood will have to be used. In choosing a suitable alternative

Construction and repair of wooden members

7. Members of heavy section are usually built up of several laminations of similar wood to ensure high-grade material being used throughout and to facilitate the manufacture of curved members. Such members, in general, have strength equal to, or greater than, that of non-laminated members of equal section, but the insertion repair procedure differs in that, in a laminated member, individual laminations which are damaged must be renewed separately. Repairs for minor damage (*e.g.*, *Scheme* 5.4.2) are similar on both types of member.

8. Formers and frames, together with mainplane tip bends, are curved members which are usually of laminated construction, except those of light section which can be easily pre-formed with solid wood.

9. Non-laminated wood members of medium section used as struts, e.g. in a Warren girder frame, are known as "pure struts", i.e. those which are not backed by plywood panels or any other form of stiffening. This type of member is uncommon in modern airframe component construction and is not dealt with in this chapter. If, however, damage has been sustained to a structure employing pure struts, the method of repair can only be decided on consideration of the individual structure involved. Thus, no standardisation of the method of repair is considered possible and the tradesman must follow the specific instructions for the type of repair necessary for the particular member given in the relevant airframe Vol. 2, Part 3 or Vol. 6.

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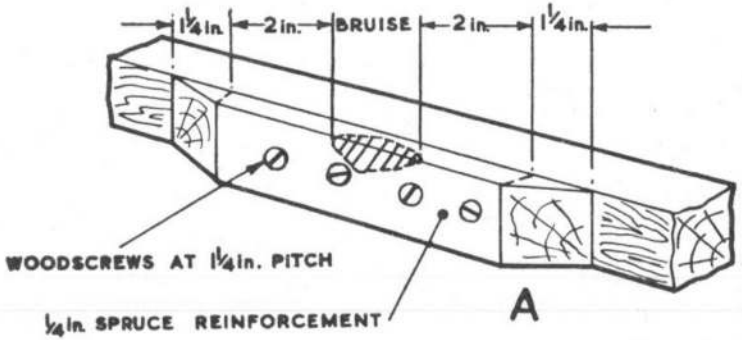
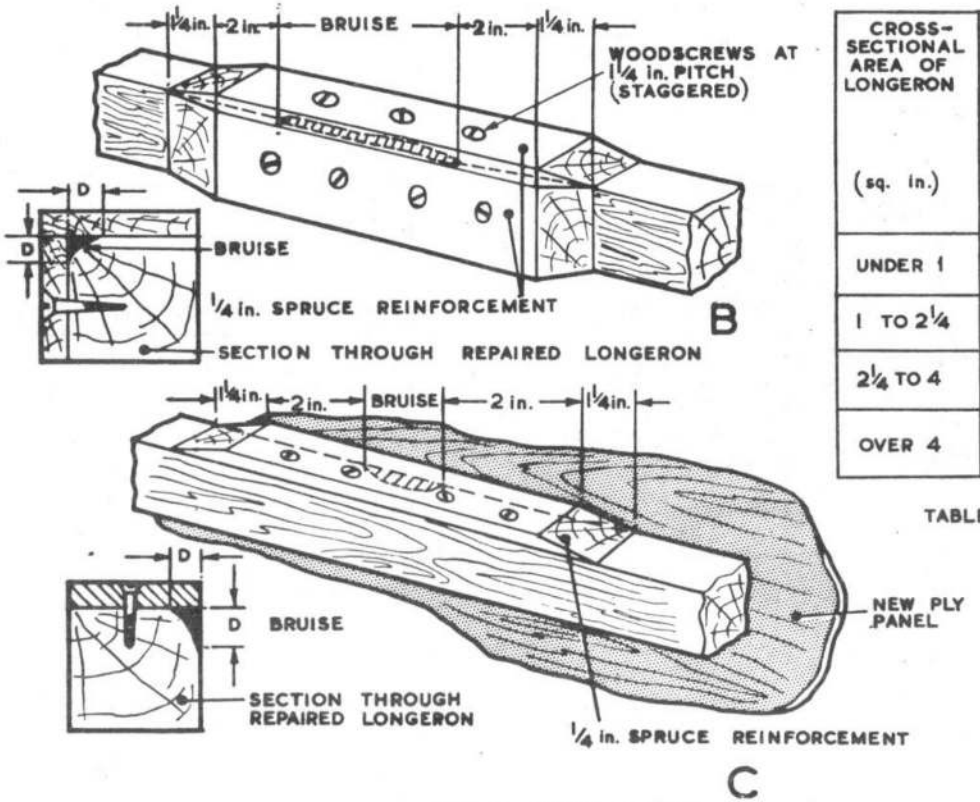
PATCH REPAIR OF LONGERONS



CROSS-SECTIONAL AREA OF LONGERON (sq. in.)	MAXIMUM DEPTH D OF BRUISE (in.)
1 TO 6¼	1/8
OVER 6¼	3/16

TABLE 1



CROSS-SECTIONAL AREA OF LONGERON (sq. in.)	MAXIMUM DEPTH D OF BRUISE (in.)
UNDER 1	1/8
1 TO 2¼	3/16
2¼ TO 4	¼
OVER 4	5/16

TABLE 2

Fig. 1. Patch repairs

General information

1. This method of repair should be employed if a longeron has been bruised and the depth of the bruise does not exceed the appropriate depth given in Table 1 or 2 of fig. 1, the surface area of the bruise is not greater than the cross-sectional area of the longeron and the inboard faces of the longeron are not covered with plywood.

2. In fig. 1, the details show the repairs necessary for damage to one of the exposed faces of the longeron (A), to an exposed edge (B) and to an edge of the longeron which is adjacent to a plywood panel (C). In the last case, the plywood panel will be damaged and will have to be removed to gain access for the examination of that face of the longeron next to the panel; therefore, the renewal of the panel must be effected as instructed in the appropriate Scheme in Chap. 5.3.

Repair instructions

3. Prior to the commencement of the repair, spruce to the correct specification, with the same grain direction as that of the longeron to be repaired, must be selected for making the reinforcing members and all equipment required for effecting the repair should be assembled near the job; then proceed as follows:—

(1) If considered necessary, raise the fuselage and place it on trestles at the approved trestling points.

(2) From the selected wood, cut the required number of reinforcing members, according to the type of repair indicated in fig. 1, A, B or C, to the dimensions given.

(3) Clean off the affected faces of the longeron and the inner faces of the reinforcing members with sandpaper and mark off the position of the screw holes at 1¼ in. pitch.

Note . . .

Where the face under repair is between ½ in. and ⅞ in. wide, size 6 × ⅝ in. countersunk screws should be used. On a longeron face greater than ⅞ in. wide, size 4 × ⅝ in. countersunk screws are required.

(4) Drill and countersink the screwholes in the reinforcing members.

(5) Ensure that the S.R. adhesive is correctly mixed and within the shelf life of the mix (*Chap.* 5.2 *refers*) and apply it to the faces of the longeron.

(6) While waiting for the adhesive to become tacky, apply a coat of hardener to the inner face of each reinforcing member; fit the members centrally over the bruised area and insert and tighten the screws until the reinforcing members and longeron faces are in complete contact.

Note . . .

The screws are to remain in position as part of the repair after the adhesive has set.

(7) Allow the appropriate setting time to elapse, then complete the further stages of the repair and, if necessary, remove the trestles from beneath the fuselage.

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5.4.3

INSERTION REPAIR OF LONGERONS

General information

1. When a longeron sustains extensive damage which is such that a patch repair (*Scheme* 5.4.2.) would be inadequate to restore the strength of the member, the spliced insertion method of repair must be employed, as shown in fig. 1.

2. As it is not permissible for main fuselage frames to be cut back to accommodate the necessary spruce reinforcing blocks on the feather edge of each splice, two vertical splices, one in each separate bay, must be cut and reinforced as shown in method A of fig. 1 if the damage occurs in the vicinity of these frames. Cut the splices such that the longer face of the insert faces outward, for ease of replacement. Where the damage occurs between fuselage formers or intermediate frames, it is permissible for these members to be cut back, if necessary, and for horizontal splices to be cut in the longeron and reinforced in the manner shown in method B.

Repair procedure

3. With the fuselage suitably supported on trestles to take the load off the longerons in the vicinity of the damage and at the same time, to prevent distortion, assemble the necessary equipment and tools on site and proceed with the repair in the following sequence of operations:—

(1) Remove the plywood skin panels in the vicinity of the damaged longeron(s).

(2) Cut through the longeron on each side of the damage, carefully breaking any adjacent glued joints; remove the damaged portion, together with any packing blocks or wedges.

(3) On each end of the remaining portion of the original longeron, cut a 15 to 1 scarf for either a vertical or horizontal splice, as applicable (*para.* 1).

(4) From spruce of the same grade specification, grain direction and cross-section as the existing longeron (laminated or non-laminated), cut the insertion piece to the required length and scarf the ends to mate with those cut in operation (3).

(5) Cut spruce reinforcing members, from wood of the same grade and grain direction as the original longeron, to the dimensions shown in fig. 1.

Note . . .

A reinforcing member will be required for each feather edge of splices not backed with plywood.

(6) If method B of fig. 1 is used, prepare any formers or intermediate frames which have to be cut back to accommodate the spruce reinforcement members.

(7) Where appropriate (*method B*), pack lightening holes in the formers or frames as necessary, with spruce blocks glued in position.

(8) Apply S.R. adhesive and hardener (*Chap.* 5.2) to the appropriate scarfs on the insertion piece and existing longeron and make the spliced joints, securing with screws; then apply the same technique for attaching the reinforcing members.

(9) With the spliced insertion piece securely fitted in the frames and formers, cover the intermediate frames, which have lightening holes filled with spruce blocks (*operation* (7)), with plywood reinforcing strips as shown in fig. 1, method B.

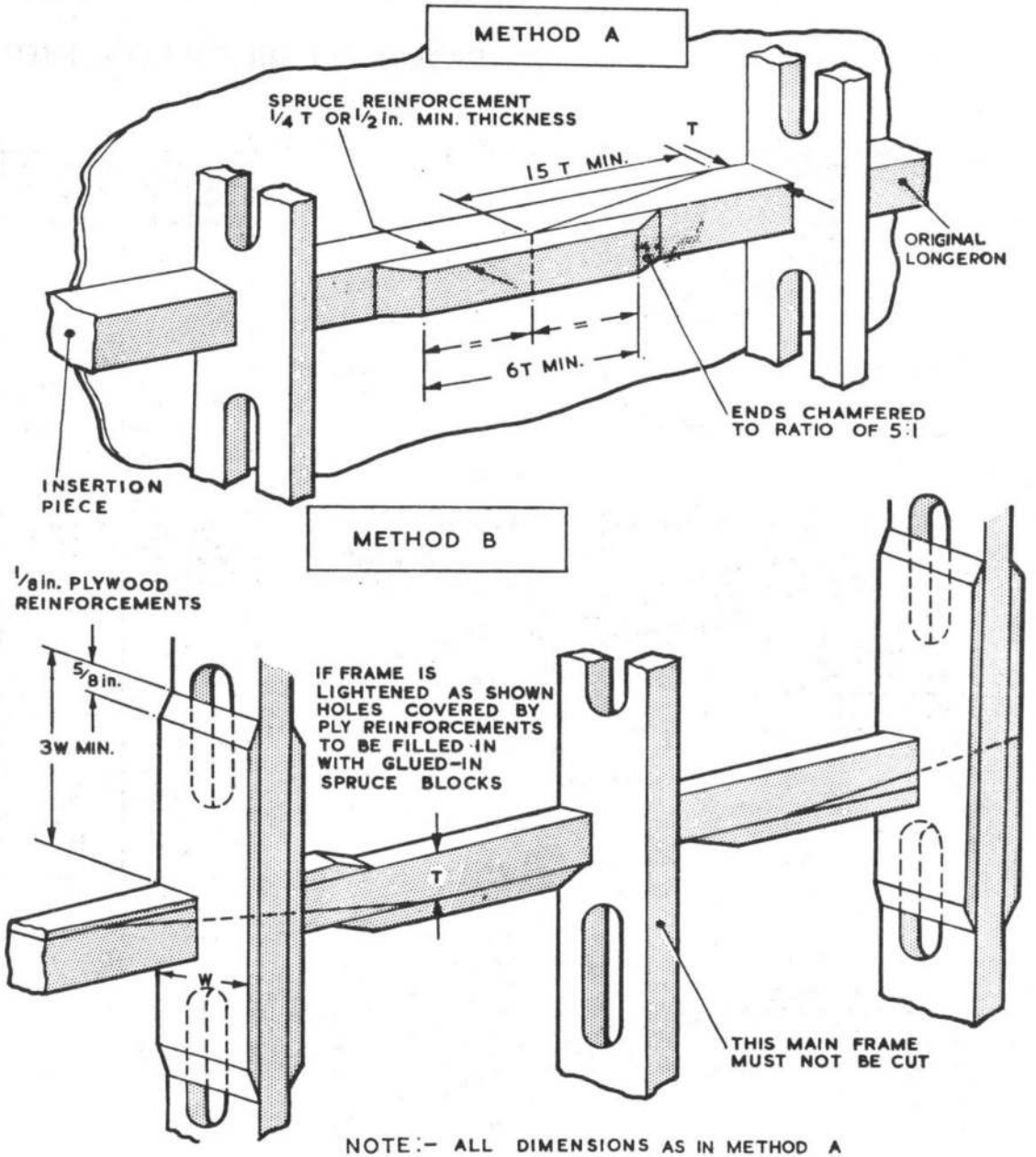

Fig. 1. Spliced insertion repairs

(10) Refit any packing blocks or wedges removed in operation (2), and the plywood skin panel removed in operation (1). The panel should be refitted as shown in Scheme 5.3.9.

(11) Allow the appropriate setting time of the adhesive (*Chap.* 5.2) to elapse before the trestles are removed or the repaired structure is subjected to loading in any way.

REPAIR OF MINOR DAMAGE TO LAMINATED MEMBERS

5.4.4

General information

1. This type of repair should be effected when the damage is not greater than half the depth of the former (*fig.* 1). Where a member is more extensively damaged, refer to Scheme 5.4.5 for repair instructions.

2. To estimate the depth of damage on the outer face of a member, a straight edge should be placed just below the damage (*fig.* 1, *sketch* C) and the distance Z measured. If the ratio Z : T (*where T equals the thickness of a lamination*) is greater than 15 : 1 on the outer laminations, scarf in a laminated section along the line shown in sketch C; if the ratio is less, separate laminations should be scarfed in as shown in sketch A.

3. Where the inner face of a member is damaged, the laminations should be scarfed in as shown in sketch B. If the curvature of the member is such that it is impossible to obtain the dimensions X equal to T, and Y equal to or greater than 15T, a new length of wood must be spliced into position (*Scheme* 5.4.5) or the entire member renewed.

Repair procedure

4. With the airframe suitably supported in the vicinity of the damage and all tools and equipment close to hand, proceed with the work in the following sequence of operations:—

(1) Gain access to the area of damage, cutting back adjacent plywood skin panels and removing any obstacles to the repair as necessary.

(2) Cut away the damaged portion of the member as shown in the appropriate sketch in fig. 1, ensuring that the scarf dimensions Y or Z are adequate and that the dimension X (*sketches A and B only*) is equal to 2T.

(3) From spruce of the same specification, grade and grain direction as the original member, cut the insertion laminations to the same thickness and width as the original material.

(4) Shape the lamination constituting the insertion piece and prepare the necessary scarfs to a ratio of 15 : 1 (*sketches A and B*) or to mate with the cleaned up surface of the former (sketch C).

(5) Apply S.R. adhesive and hardener to the appropriate surfaces of the insertion pieces (*Chap.* 5.2) building up the section from the separate laminations and cramping the whole insert securely in position.

(6) Cut the reinforcing strips (*fig.* 1, *item P*) from $\frac{1}{8}$ in. plywood to the approved specification grade and, with the same grain direction as the existing member, shape them to the contour of the member, chamfering the ends to a ratio of 5 : 1.

(7) Apply S.R. adhesive and hardener to the appropriate faces of the member and reinforcing strips, then securely cramp the latter centrally over the insertion piece on each side of the former.

(8) Allow the joint to remain undisturbed until the appropriate setting time has elapsed (*Chap.* 5.2), then remove the cramps and finally clean up the joint.

(9) Refit the plywood skin panel and any other structure removed in operation (1). The skin panel should be refitted as shown in Scheme 5.3.9.

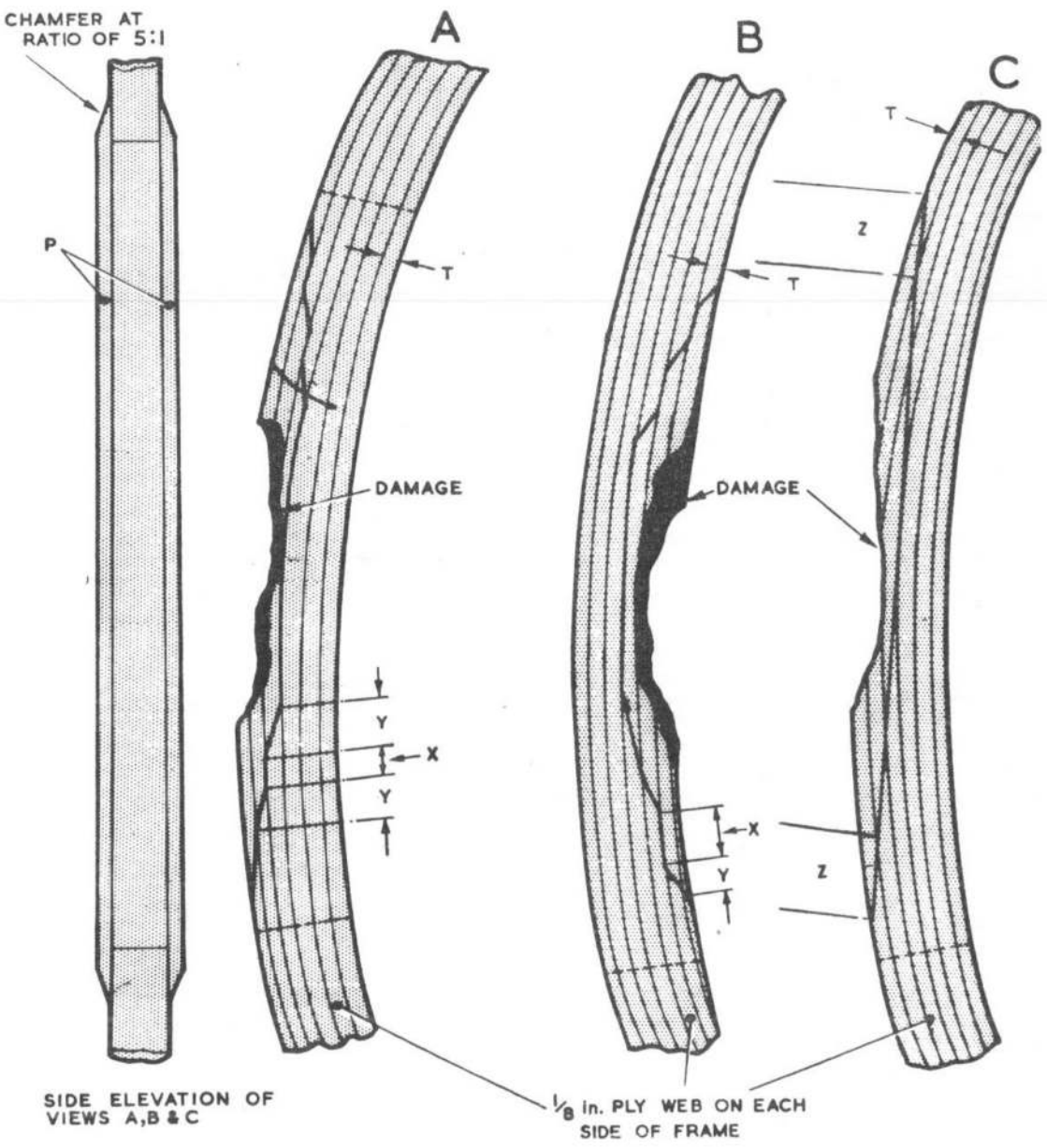

Fig. 1. Minor insertion repairs

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5.4.5

REPAIR OF MAJOR DAMAGE TO LAMINATED MEMBERS

General information

1. This repair method should be used when the information given in Scheme 5.4.4 cannot be applied because the depth of damage is greater than half of the depth of the member, or the curvature of the member is too great to permit separate laminations to be scarfed in. In such cases, the damaged portion must be cut out and a new length of similar, laminated spruce spliced in as an insertion piece (*fig.* 1).

Repair procedure

2. Before commencing the repair work, a jig must be prepared to set the laminations of the insertion piece to the correct curvature during the build-up. When this is done and all tools and equipment necessary for the job are assembled near the job, proceed as follows:—

(1) Suitably support the airframe in the vicinity of the damage, if this is considered necessary.
(2) Gain access to the area of the damage, removing the plywood skin panels and all obstructions around the damage as necessary.
(3) Cut out the damaged length of the member and during its removal, carefully break any glued joints attached to it.
(4) Prepare the cut ends of the existing former with 15 : 1 scarfs.
(5) From spruce of the same specification, grade and grain direction as the damaged member, cut the required number of laminations, which must be equal in thickness and width to those in the original member, to build up an insertion piece.
(6) Apply S.R. adhesive and hardener to the appropriate faces of the laminations (*Chap.* 5.2), set them in the jig and cramp up securely; leave the laminated insertion piece in the jig for twice the normal cramping time and then allow the appropriate setting time to elapse before removing it from the jig.
(7) Remove the insertion from the jig and scarf the ends to mate with those prepared in operation (4).
(8) Apply adhesive and hardener to the appropriate surfaces of the scarfs on the existing member and the insertion piece, allow the adhesive to become tacky and securely cramp the insert in position on the member.
(9) Prepare the necessary reinforcing members, from an approved grade of $\frac{1}{8}$ in. plywood, to the dimensions shown in fig. 1 and chamfer the ends to a ratio of 5 : 1.
(10) Apply adhesive and hardener as in operation (8) and securely screw the reinforcing members centrally over the feather edges of the spliced joints.
(11) Allow the appropriate cramping and setting times of the adhesive to elapse (*Chap.* 5.2), then remove the clamps and clean up the job.
(12) Re-make and clean up any glued joints removed in operation (2) and refit any plywood skin panels or internal structure removed in operation (1). The skin panels should be refitted as instructed in Scheme 5.3.9.

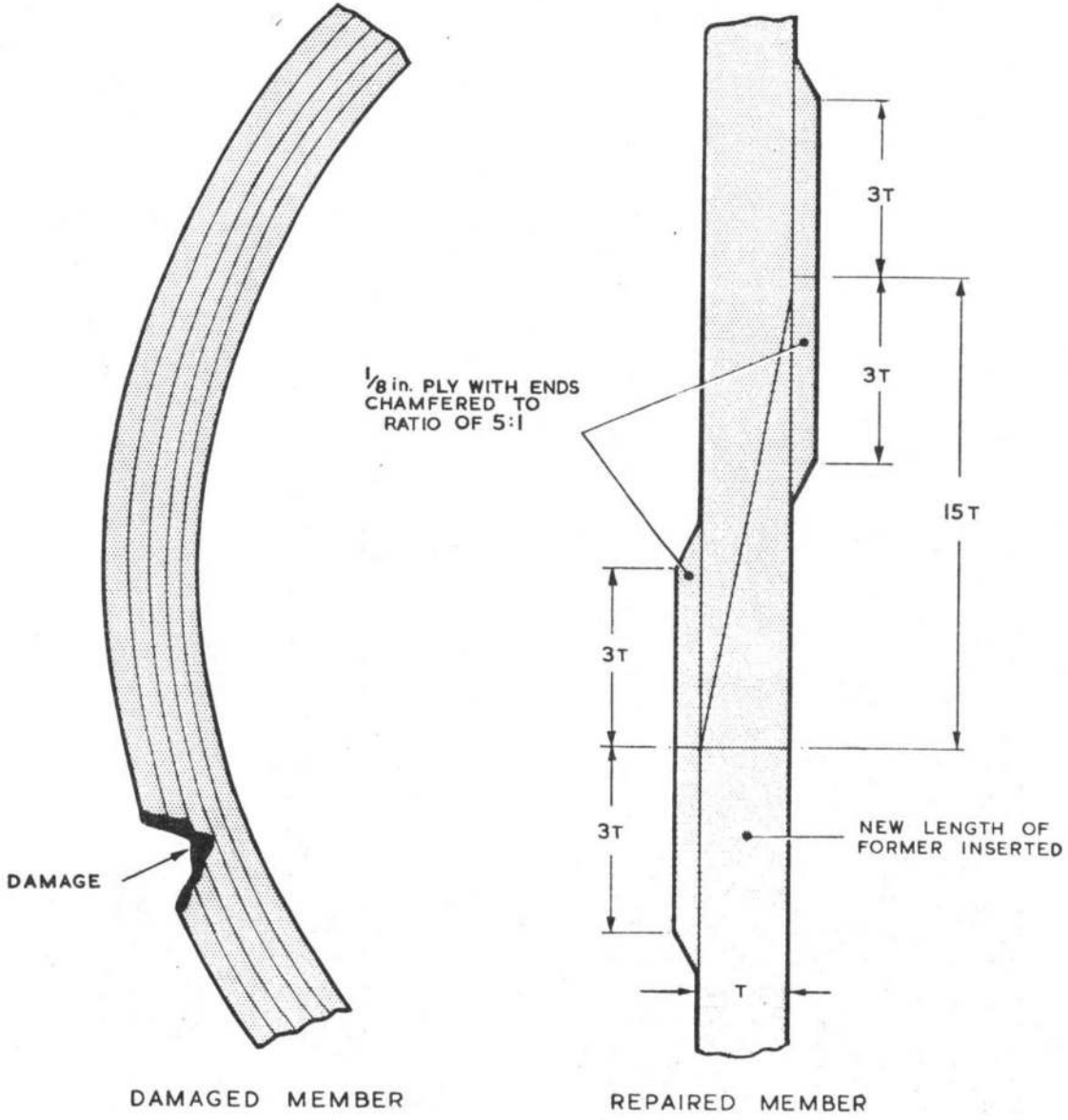

Fig. 1. Major insertion repair

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INSERTION REPAIR OF PLYWOOD-COVERED MEMBERS

5.4.6

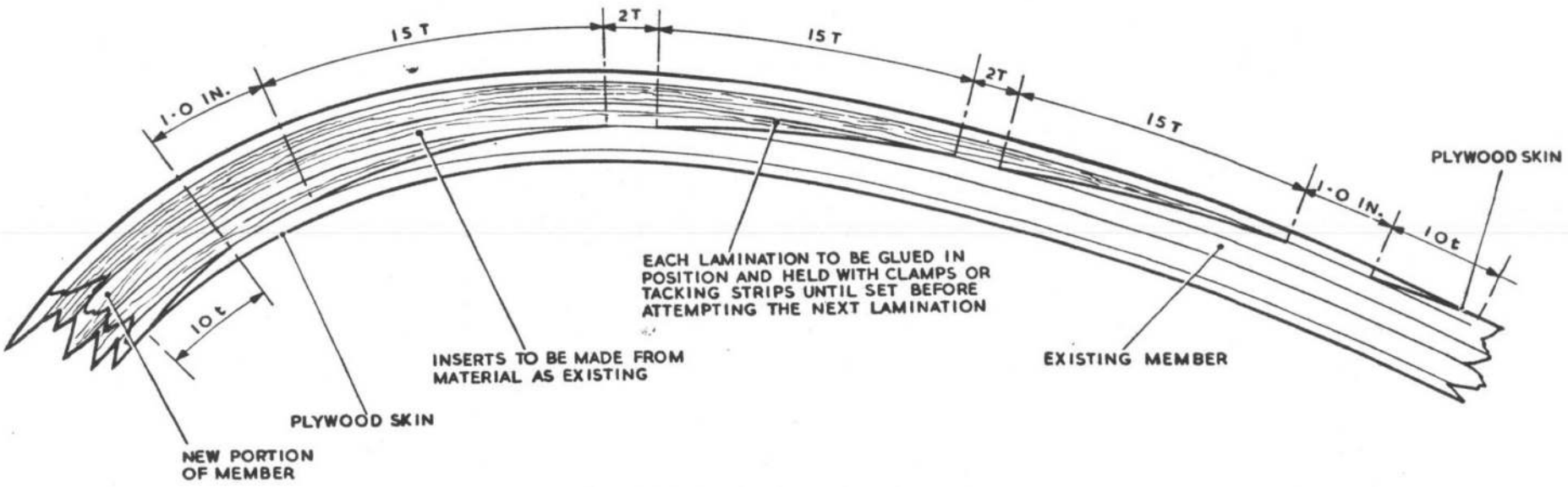

Fig. 1. Multiple spliced insertion repair

Application

1. The type of repair illustrated in fig. 1 may be applied to a damaged member bounded by inner and outer plywood skin panels, and this Scheme should be used in conjunction with Schemes 5.2.1, 5.2.2, 5.4.4, 5.4.5 and 5.4.7, which give information on the methods of cramping, application of adhesive, cramping and setting times, manufacture of jigs, etc.

Laminated members

2. The illustration shows a complete insertion repair to a laminated member and its inner and outer plywood skins. If the damage does not affect the complete section of the member, only the damaged laminations and the affected skin should be renewed.

Non-laminated members

3. When a non-laminated member is damaged, the affected length of the member should be cut out and an insertion piece made of the same wood as the existing member. The ends of the existing member and the insert must be scarfed to a ratio of 15 : 1, the skin joints being positioned as shown in the illustration.

Repair method

4. The method of inserting the new laminations and the dimensions necessary to ensure correct scarf positions are shown in the illustration, in which the symbol T equals the thickness of each lamination and symbol t the thickness of the plywood skin panels.

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5.4.7 REPAIR OF MAJOR DAMAGE TO NON-LAMINATED MEMBERS

General application

1. The instructions given in this repair scheme are equally applicable to straight or curved non-laminated wooden members, either with or without plywood covering.

2. When straight or slightly curved members are damaged, an insertion repair should be made, the scarfs of the insertion piece and existing member being cut across their depth as shown in fig. 1, method A.

3. This method should be adopted whenever possible, but if the curvature of the member is of small radius, the required scarf ratio of 15 : 1 will be impossible and the splices will have to be made across the width of the member as shown in method B.

Repair procedure

4. Before the repair work is commenced, obtain selected spruce of the same specification, grade and grain direction as that of the existing member, to use as the insertion piece and reinforcing members, assemble all necessary tools and equipment on site and proceed in the following sequence of operations:—

(1) Support the damaged member, as necessary.

(2) Gain access to the damage, cutting back any adjacent plywood skinning or panels and removing any structure likely to obstruct the repair work.

(3) Cut away the damaged length of member and scarf the ends to a ratio of 15 : 1.

(4) Cut the insertion piece to the same dimensions and grain direction as the length of member removed in operation (3).

(5) Scarf the ends of the insert to a ratio of 15 : 1 to mate with the scarfs cut on the ends of the existing member.

(6) Ensure that the faying surfaces of the splices mate correctly and apply S.R. adhesive and hardener to the appropriate faces (*Chap.* 5.2).

(7) When the adhesive has become tacky, fit the insertion piece to the ends of the member and secure the joints firmly in position with cramps which must not be removed until the approved cramping time has elapsed (*Chap.* 5.2).

(8) From wood of the same specification and grade as that used for the insertion piece, with the grain direction matching that of the existing member, cut the required number of reinforcing members to the dimensions shown in the illustration, where symbol T equals the thickness and symbol W the width of the member, respectively. These members are necessary to cover the feather edges of spliced joints which are not backed with plywood.

(9) Apply adhesive and hardener to the appropriate faces of the spliced member and the reinforcing members; when the adhesive is tacky, fit the latter members centrally over the feather edges of the splices and secure them firmly in position with cramps which must not be removed until the appropriate cramping time has elapsed.

(10) Allow the joints to remain undisturbed until the setting time has elapsed then clean up the job and refit any structure or plywood skinning removed in operation (2). The skin panels should be refitted as instructed in Scheme 5.3.9.

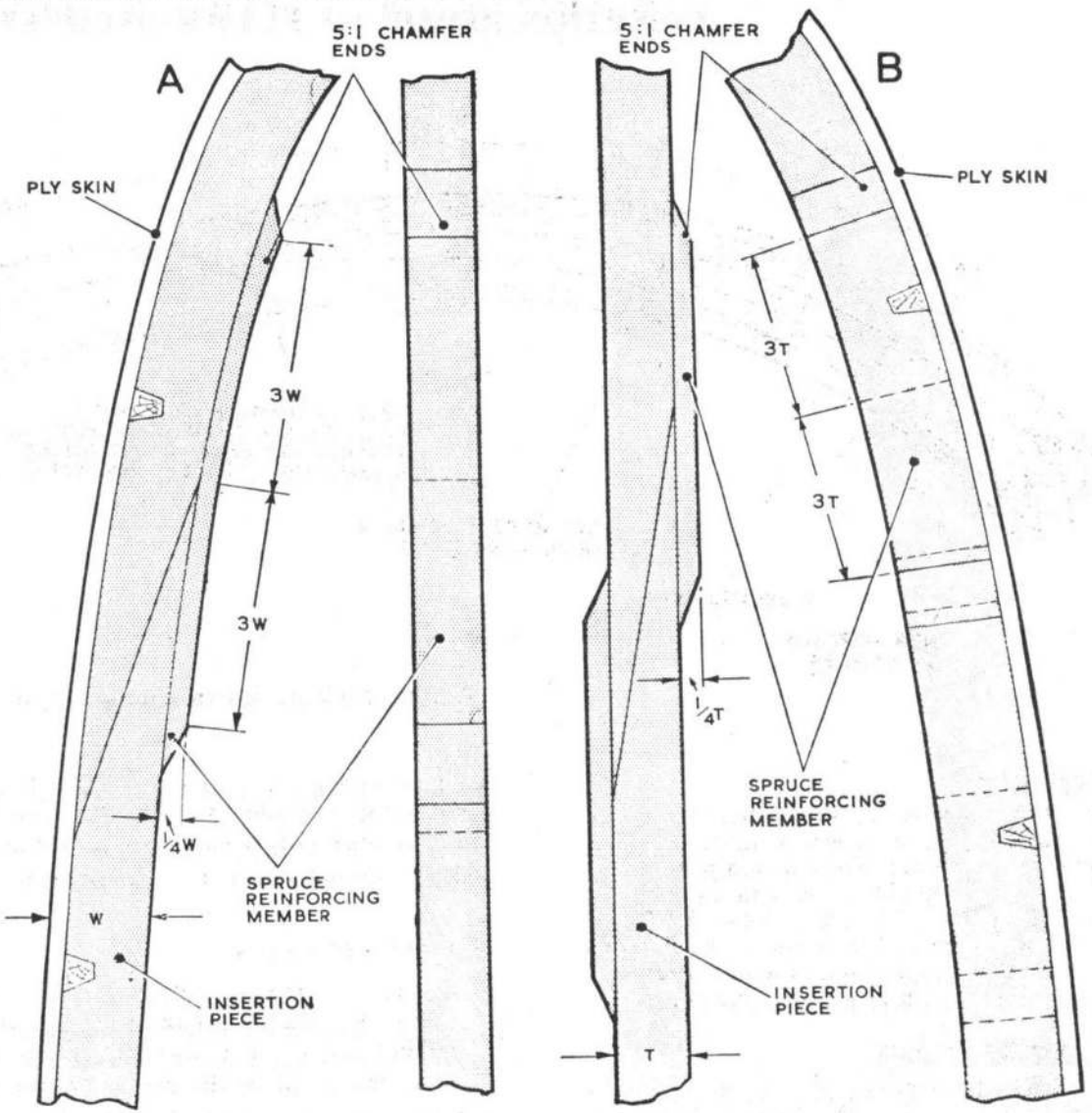

Fig. 1. Spliced insertion repair of non-laminated members

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INSERTION REPAIR OF STRINGERS

General information

1. This method of repair should be employed when a stringer is damaged in excess of that quoted as negligible damage in the relevant airframe air publication Vol. 2, Part 3, or Vol. 6.

2. The wood used for the insertion piece should be selected spruce of the same specification, grade and grain direction as the original stringer and when cut, the insert must be shaped to the same cross-section as that member.

3. Whenever possible, the scarf joints should be made between the frames or formers as shown in fig. 1, but if this is not practicable and the scarfed section of a stringer has to be cut on one of these members, great care must be taken to ensure that the member is not cut while preparing the scarf. This precaution is necessary to avoid weakening the member.

Repair procedure

4. With the necessary equipment on site, proceed with the repair in the following sequence of operations:—

(1) Gain access to the damaged area by cutting back the plywood skinning, if necessary, and removing any light structure likely to obstruct internal access.
(2) Cut the damaged section of stringer away and scarf the ends of the existing wood to a ratio of 15 : 1.
(3) From selected spruce, cut the insertion piece to the required length, with the same grain direction and cross-section as the original stringer (*para.* 2).
(4) Scarf the ends of the insertion piece to a ratio of 15 : 1, ensuring a snug fit.
(5) Apply S.R. adhesive and hardener to the appropriate faces of the scarf. Allow the adhesive to become tacky, then mate the faying surfaces of the stringer and insert and cramp them securely in position.
(6) Cut strips of $\frac{1}{8}$ in. plywood of approved specification and grade to the required length of 6T (*T equals the thickness of the stringer as shown in the illustration*) to form reinforcing strips to cover the feather edges of the splices, on members of square or rectangular section, which are not backed with plywood skinning.
(7) Chamfer the ends of the reinforcing strips to a ratio of 5 : 1.
(8) Apply adhesive and hardener to the faying surfaces of the stringer and plywood strips; when the adhesive is tacky, fit the strips centrally over the feather edges and secure with screws. Allow the repair to remain undisturbed until the specified setting time has elapsed.
(9) Refit all internal structure and plywood skinning removed in operation (1). The skin panel should be refitted as instructed in Scheme 5.3.8 or 5.3.9.

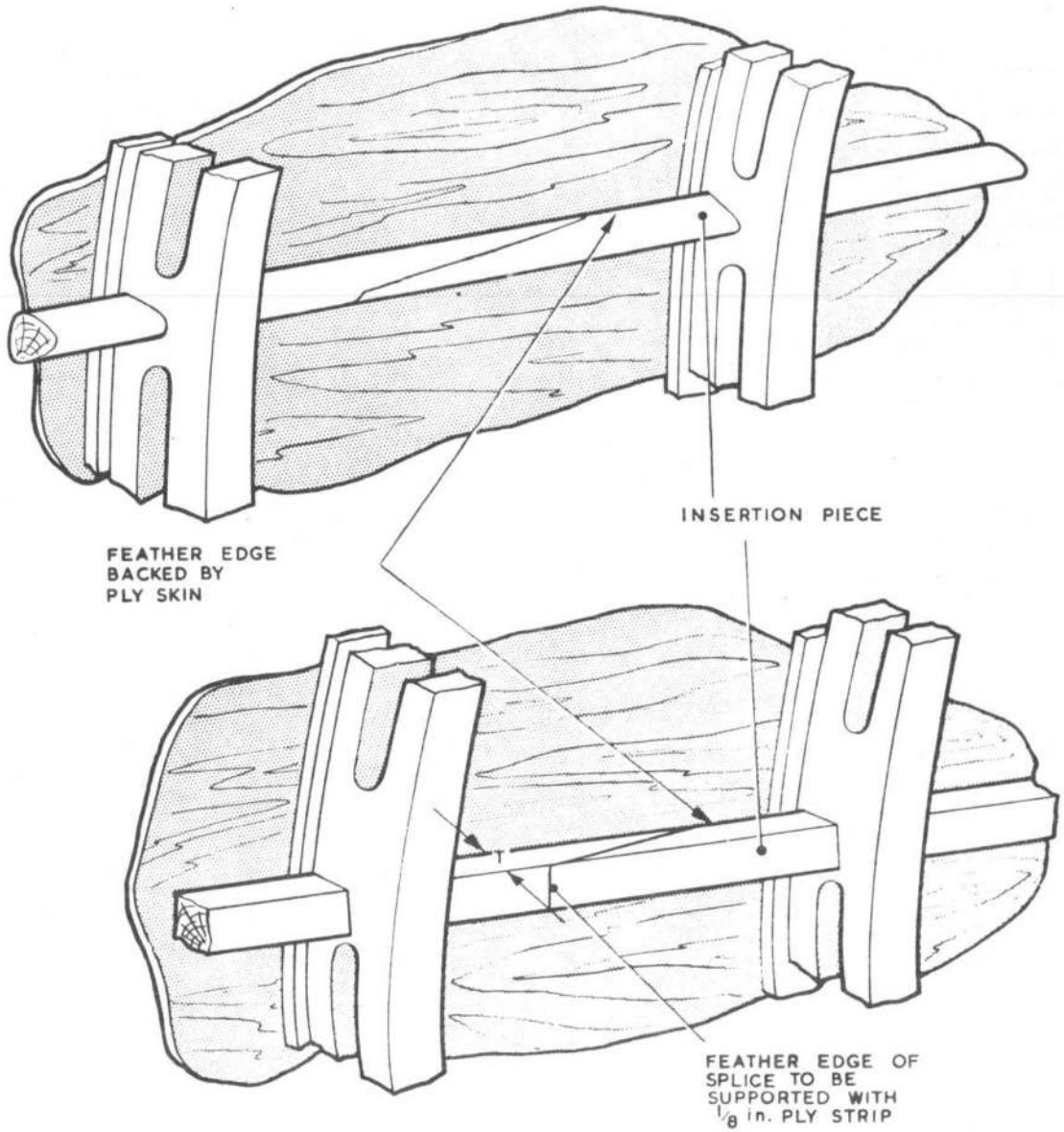

Fig. 1. Insertion repairs

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REPAIR OF LEADING OR TRAILING-EDGE MEMBERS

General application

1. The repair instructions given in this Scheme are applicable to two types of damage which may be sustained by aerofoil leading or trailing edges, viz.: slight damage which does not affect the plywood skin panels and may be repaired by the method shown in fig. 1, sketch A, or more extensive damage, which necessitates the renewal of a section of the edge member and the plywood skin panels, by the methods shown in sketches B and C of fig. 1.

Repair procedure

2. The first method should be used to cover a bruise which is not greater than $\frac{1}{8}$ in. deep, $\frac{1}{4}$ in. wide and 2 in. long, provided that all the fibres in the area of damage are unbroken.

3. A quick and effective repair of this type of damage can be made by filling in the bruised wood with plastic wood (*or any other approved wood filler*), restoring the member to its original contour and covering the area with a serrated fabric patch large enough to overlap the damage area by $1\frac{1}{2}$ in. in each direction (*sketch* A).

4. Before commencing the second method of repair, illustrated in sketches B and C, it will be necessary to obtain sufficient material to the same specification, grade and grain direction as that of the existing plywood skinning and edge member. Assemble all equipment on site and proceed as follows:—

(1) Cut back the plywood skin panels on the top and bottom surfaces in the area of damage to the nearest structural members (*sketch* C).
(2) Cut out the damaged section of the edge member and scarf the remaining ends to a ratio of 15 : 1 (*sketch* B).
(3) From wood to the same specification and grain direction as the original member, cut an insertion piece to the required length and shape it to the same cross-sectional dimensions as the member being repaired.
(4) Scarf the ends of the insertion piece to mate with those cut in operation (2).
(5) Apply S.R. adhesive and hardener to the appropriate faces (*Chap.* 5.2) of the original member and the insertion piece. When the adhesive becomes tacky, fit the insert snugly in position on the member and cramp up. Allow the joints to remain undisturbed for the appropriate cramping and setting times (*Chap.* 5.2).
(6) If the feather edges of the splices are not backed by another member, reinforcing strips must be fitted centrally over them. The strips should be cut from $\frac{1}{8}$ in. plywood, of approved specification, to a length of 6T (*T equals the thickness of the member*) and chamfered to a ratio of 5 : 1 at the ends.
(7) Glue and screw the strips securely in position, using adhesive and hardener as in operation (5).
(8) Renew the plywood skin panels, removed in operation (1), as instructed in Scheme 5.3.8.

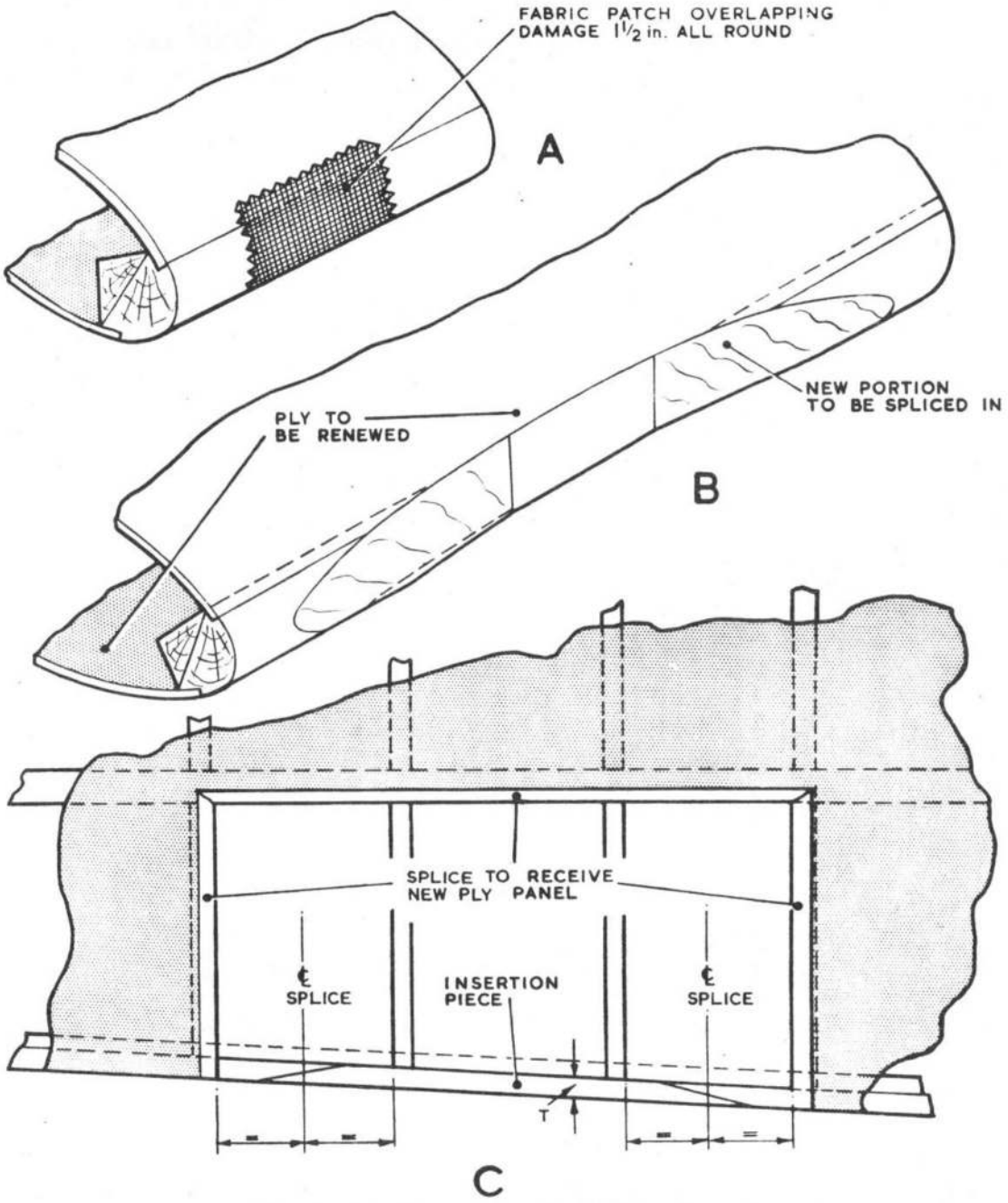

Fig. 1. Insertion repairs of member and panel

TYPICAL INSERTION REPAIR OF RIB BOOMS

5.4.10

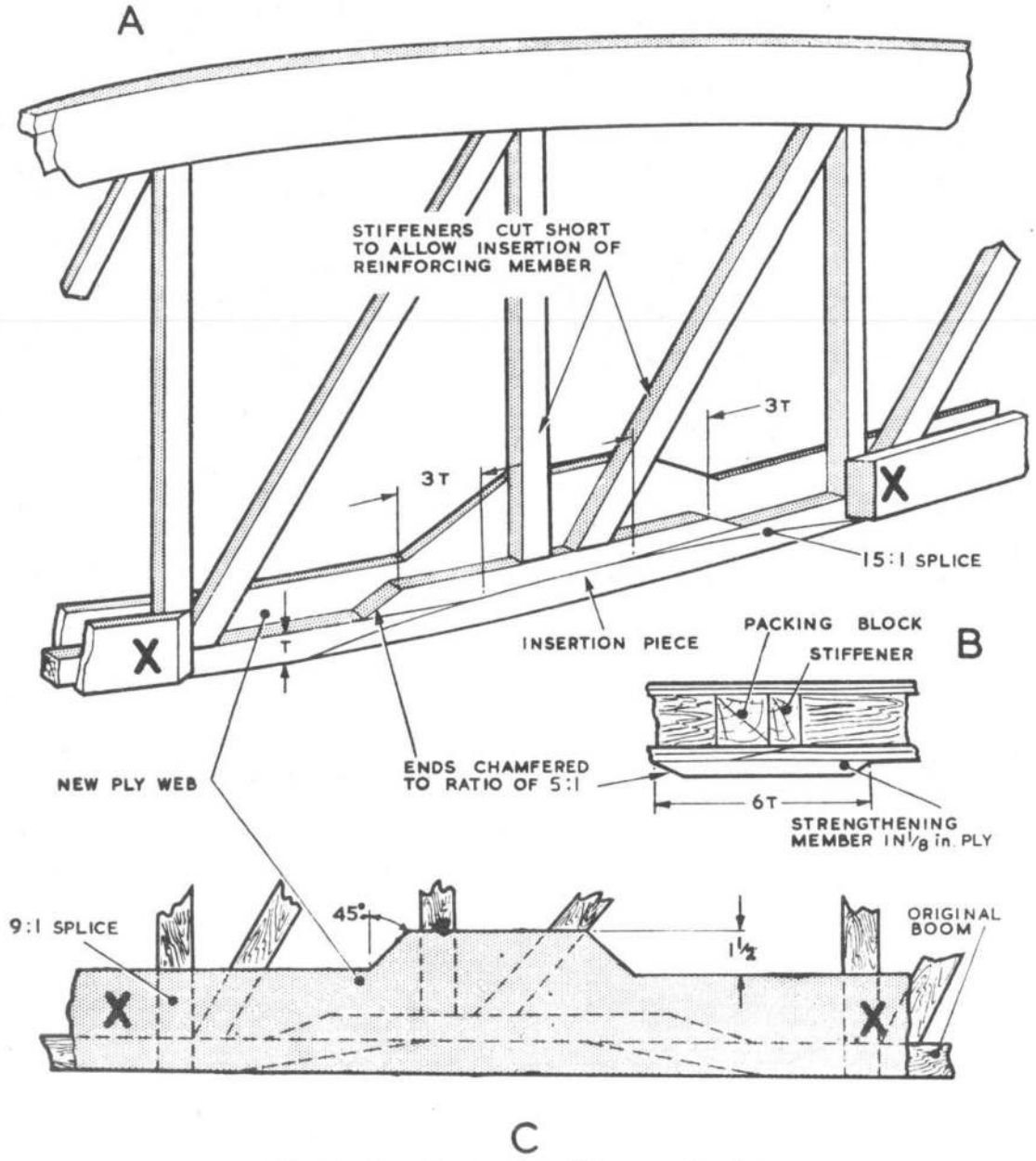

Fig. 1. Insertion repairs of boom and webs

General application

1. The instructions given in this repair scheme cover the renewal of a damaged section of a typical rib boom braced by Warren girder-type stiffeners or struts between the booms and reinforced with plywood webs on each side of the booms. Where the stiffeners are also damaged, they must be removed and completely new members fitted between the booms before the insertion of the new length of boom is spliced into position.

2. The repair procedure Scheme, illustrated in fig. 1, is equally applicable, in principle, to the repair of booms of other types of rib construction.

Repair procedure

3. With all the necessary equipment close to hand, proceed with the repair in the following sequence of operations:—

(1) Gain access to the damaged boom by cutting back the plywood skin panel to the nearest structural members adjacent to the damaged member. Do not cut the spanwise stringers unless these have been damaged.

(2) Cut back to the nearest stiffeners, both boom plywood webs adjacent to the damage and scarf the ends to a ratio of 9 : 1 (*sketch* A).

(3) Cut away the damaged length of the boom and scarf the remaining ends to a ratio of 15 : 1 (*sketch* A).

(4) Remove any damaged stiffeners. Where an undamaged stiffener will prevent a reinforcing member being fitted on top of the splices of the boom insertion piece, it must be cut short as shown in sketch A.

(5) From selected spruce to the same specification, grade and grain direction as the boom, cut the insertion piece to the required length and cross-section dimensions.

(6) Scarf the ends of the insertion piece to mate with those cut in operation (3).

(7) Apply S.R. adhesive and hardener (*Chap.* 5.2) to the appropriate faying surfaces of the scarfs; when the adhesive becomes tacky, fit the insertion piece to the prepared ends of the boom and securely cramp the joints in position. Allow the joints to remain undisturbed for the approved cramping time.

(8) From the same wood used in operation (5) and having the same cross section and grain direction as the boom, cut a reinforcing member to the required length of a 3T overlap on each splice feather edge which is not backed by plywood.

Note . . .

T equals the thickness of the boom and the overlap does not include the 5 : 1 *chamfer at each end of the reinforcing member, as indicated in sketch A.*

(9) Apply adhesive and hardener to the faying surfaces of the members as instructed in operation (7) and secure in positions with cramps, allowing the appropriate cramping time to elapse before moving them.

(10) Renew any damaged stiffeners, cutting the new members to the same dimensions as the existing members from wood to the same specification as that used in operation (5). Secure in position with adhesive and hardener as in operation (7).

(11) Where necessary, build up the width of the stiffeners with spruce blocks so that the splices to be made in the plywood webs are backed for at least $\frac{3}{4}$ of their width as shown in the sectional sketch B.

(12) If the stiffeners have not been shortened, cut plywood webs, from material of the same specification, grade, thickness and grain direction as that of the original webs, to the required dimensions and scarf the ends to mate with those prepared in operation (2).

(13) If the stiffeners have been shortened (*operation* (4) *and sketch A*), proceed as in operation (12), but cut the webs to the dimensions shown in sketch C.

(14) Apply the adhesive and hardener as in previous operations and cramp the plywood splices securely in position until the appropriate cramping time has elapsed.

(15) From the specified $\frac{1}{8}$ in. plywood, cut strengthening members to the required length of 6T and chamfer the ends to a ratio of 5 : 1. Apply adhesive and hardener as in previous operations and cramp these members centrally over the splices as shown in sketch B.

(16) If sections of stringers have been removed, make similar insertion repairs as instructed in previous operations.

(17) Renew the plywood skin panels removed in operation (1). The new panels should be fitted as instructed in Scheme 5.3.8 or 5.3.9.

Note . . .

Ensure that all glued joints remain undisturbed until the appropriate setting time has elapsed.

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Chapter 5.5 PLY SANDWICH

LIST OF CONTENTS

GENERAL INFORMATION ON PLY SANDWICH STRUCTURES

Introduction

1. In the manufacture of wooden aircraft components such as pressurized cabin skinning and cockpit floors of the Vampire and Venom aircraft variants, ply sandwich construction is used to provide light but rigid structures with good strength/weight characteristics. These structures are easily built up and may be bent or curved to any required contour; this advantage would not be gained if solid or multi-ply structure are used for the same purpose.

2. A typical ply sandwich structure consists of a balsa-wood centre fitted within a frame of solid or laminated spruce members, with the outer faces of the balsa and solid members covered with plywood panels. Repairs to this type of structure are given in Schemes 5.5.2 and 5.5.3. Other types of filling such as foamed synthetic materials (*e.g.*, *Onazote*) are used on some aircraft.

3. To provide additional strength at attachment positions, etc., in a balsa-ply structure, the balsa is replaced by spruce multi-ply or laminated spruce reinforcing blocks.

4. For repair purposes, balsa wood is available in thicknesses of $\frac{7}{16}$ in. and $\frac{3}{4}$ in. (*reference numbers* 31A/99 *and* 100 *respectively*) and other thicknesses should be made up from these as required. Plywood panels to the correct specification, grade and grain direction are available in various thicknesses (*Chap.* 5.3) according to requirements.

Repair technique

5. This is of a simple nature, involving only five types of repair, according to the severity of the damage, as follows:—

(1) Patch repair, where plywood panels and balsa have been penetrated, as in the case of a bullet hole or small shell splinter with maximum dimensions of 1·8 in. × 0·6 in., which will necessitate only fabric patches being doped on both plywood panels, without balsa filling being inserted (*Scheme* 5.5.2, *fig.* 1, *repair method A*).

(2) Patch repair, for a group of holes as in (1), the damage being within a 6 in. maximum diameter circle, which will require only an external plywood patch on each side of the damage. Replacement of the filling is unnecessary. (*Scheme* 5.5.2, *fig.* 1, *repair method B*).

(3) Patch repair, for a single hole through plywood and balsa, the hole not exceeding 3 in. diameter when cleaned out. The balsa filling is not replaced, but the external plywood patches must be of a greater thickness than the existing skins (*Scheme* 5.5.2, *fig.* 2, *repair method C*).

(4) Combined filling and patch repair, where the diameter of the cleaned-out hole in the skins and filling of the balsa-ply structure does not exceed 8 in., and it is necessary for new balsa filling to be inserted so that it completely fills the space between two plywood patches of the same thickness as the existing skins (*Scheme* 5.5.2, *fig.* 2, *repair method D*).

(5) Insertion repair, where the sandwich structure has sustained extensive damage which necessitates the renewal of the plywood skinning, balsa filling and any reinforcing members within the sandwich, and also involves the fitment of additional reinforcing members to enable the scarfing of the plywood skins to be effected. The plywood insert in each skin must be spliced to a ratio of 9:1, the minimum distance between the reinforcing members for top and bottom skin splices being 3 in. (*Scheme* 5.5.3, *fig.* 1).

6. Where any of these repair methods are employed, the wood required for the repair must be selected from that which conforms with the approved specification. In all cases, the wood must be fitted with the grain running in the same direction as that of the original structure. To ensure that this is done when spruce filling is renewed, notes should be made showing the grain direction of the damaged wood before it is removed and this information applied during the repair operations.

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PATCH REPAIR OF PLY SANDWICH STRUCTURE

Application

1. The information given in this repair scheme is applicable to any ply sandwich structure that has sustained slight damage in areas where external patches are permissible.

2. The four drawings contained in fig. 1 and 2 of this Scheme illustrate repair methods A, B, C, and D which, together with instructions given in the text, will enable any minor damage, within the maximum areas given, to be satisfactorily repaired, the application of the repair methods being outlined in Scheme 5.5.1.

Repair instructions

3. Before commencing any repair work, a close examination must be made of all surrounding structure in the vicinity of the apparent damage to ensure that no damage of a secondary nature has occurred. Then proceed as follows:—

(1) Clean out all damaged structure according to the requirements of the appropriate repair method.

(2) Where repair methods A or B are being used, brush on a coat of waterproof cellulose paint to the edges of the holes before the patches are applied.

(3) Dope fabric patches over the holes (method A) or glue and brad plywood patches in positions as shown in method B.

(4) If method C is employed, the damaged balsa filling should not be renewed, but plywood patches $\frac{1}{32}$ in. greater in thickness than the existing plywood panels must be glued and bradded on each side of the damaged member as shown in the illustration.

(5) In repair method D, the damaged balsa filling must be renewed and plywood patches of equal thickness to the existing plywood must be securely glued and bradded as shown in the illustration.

Notes . . .

(1) *All dimensions given in the four illustrations are in inches and are applicable only when all the damaged areas are cleaned out.*

(2) *All plywood patches used must be to the approved specification and grade and must be fitted with the grain running in the same direction as the existing plywood.*

(3) *S.R. adhesive and hardener* (*Chap.* 5.2.) *must be used to glue the plywood patches to the skin.*

(4) *All brads used to secure the patches after being glued must be clenched across the grain.*

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PATCH REPAIR OF PLY SANDWICH STRUCTURE (*Continued*)

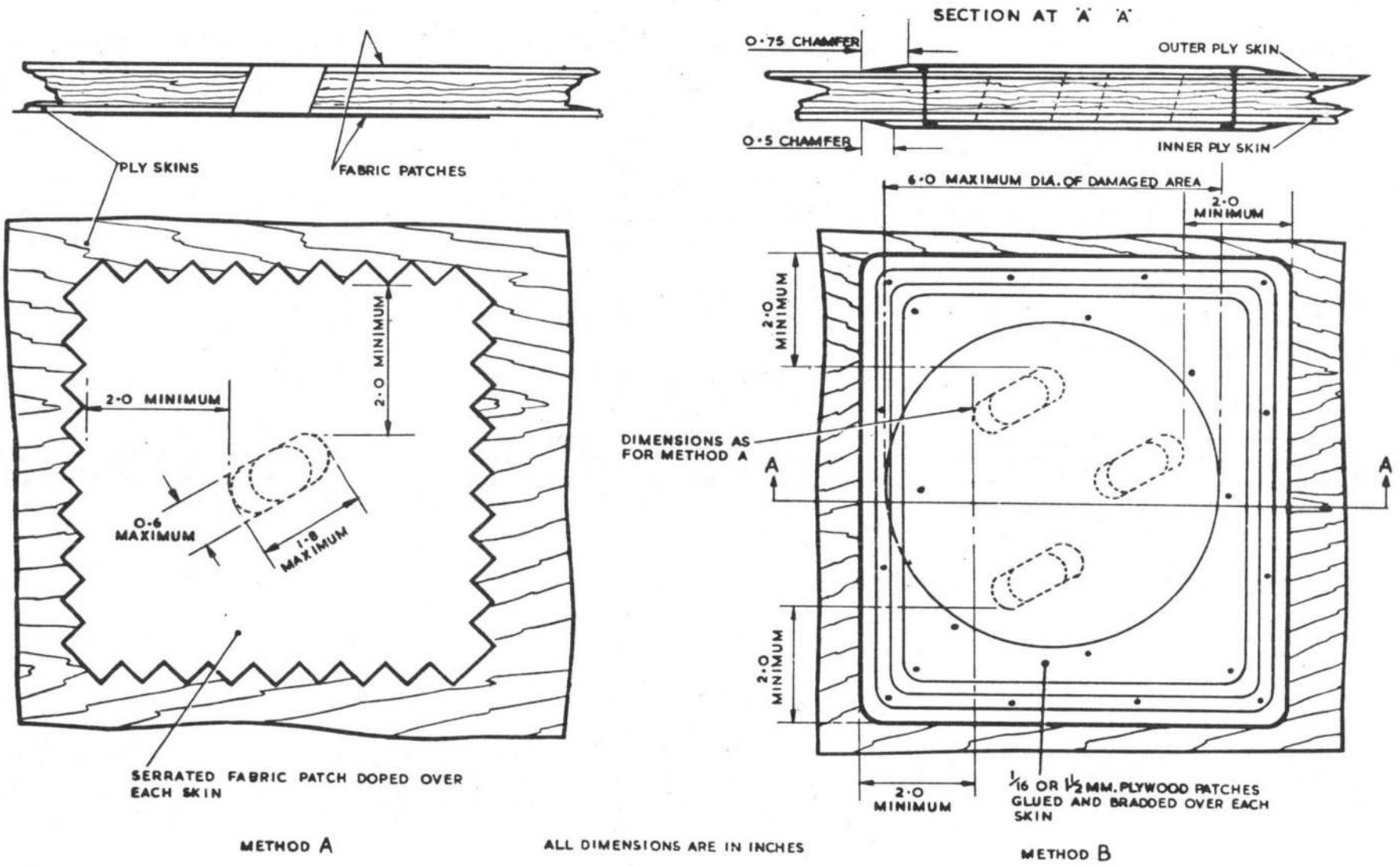

Fig. 1. Patch repairs for small holes

PATCH REPAIR OF PLY SANDWICH STRUCTURE (*Continued*)

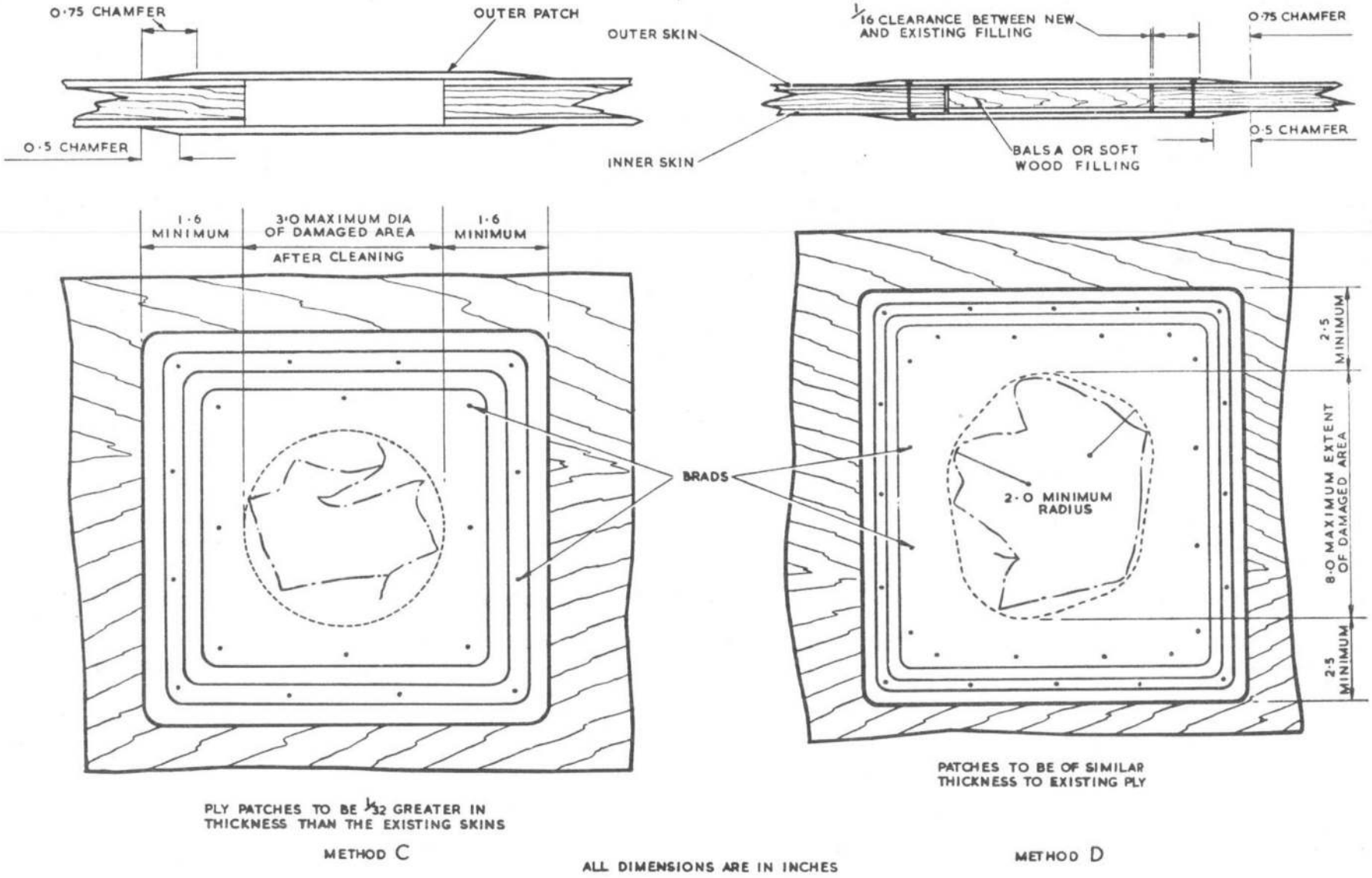

Fig. 2. Patch repairs for large holes

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5.5.3 INSERTION REPAIR OF PLY SANDWICH STRUCTURE

General information

1. This scheme deals with the repair of extensive damage to balsa-ply structure which necessitates the renewal of the balsa filling, the plywood skins and any spruce or multi-ply reinforcing blocks or other members. The scheme also covers the insertion of additional reinforcing members, where there are none in the vicinity of the repair, to provide support for the scarfs which must be cut in the existing skin and in the plywood insertions, as shown in fig. 1.

2. In this repair scheme, a single skin insertion piece may be used if only one skin is damaged, provided that suitable reinforcing members exist or can be introduced (*para.* 4(1)) to form supports for the plywood scarfs and that any damaged filling is replaced.

Repair procedure

3. Before repairs are commenced, the manner of doing the work to the best advantage, thus reducing the size of the repair must be decided. If possible, the larger skin insert should be made on the more damaged side of the structure, but convenience of working or lack of accessibility may be the overriding factors which prevent this.

4. With the fuselage suitably supported, if necessary, and with all equipment assembled on site, proceed in the following sequence of operations:—

(1) Cut out the damaged section of the first skin to be repaired and then examine the interskin members for damage. If no damage is apparent, and the other skin is undamaged, cut 9:1 scarfs on the edges of the existing plywood where supporting members are suitably located within the sandwich.

(2) If there are no support members in the damaged area, cut out the balsa within the area of the hole in the skin and cut back the balsa between the two skins to a distance of 1·2 in., plus $\frac{1}{16}$ in. to $\frac{1}{4}$ in. clearance, to accommodate the new members. If necessary, make up a suitable cutting tool to prevent damage to the inner surfaces of the skins. Prepare new support members for insertion between the skins and secure them in position. The space framed by these members must be filled with balsa (*fig.* 1).

Note . . .

When the hole is narrow, the support members for the shorter sides must have the 1·2 *in. overlap at each end* (*fig.* 1) *to allow for insertion and these members must be inserted first.*

(3) Cut an insertion piece from plywood to the same specification and grade, with the same grain direction as the existing material, and prepare scarfs to mate with those cut in operation (1).

(4) Apply S.R. adhesive and hardener (*Chapter* 5.2.) to the faying surfaces of the existing skin and the insertion piece and secure them with brads clenched across the grain.

(5) If the examination detailed in operation (1) reveals that the balsa filling, interskin members and the second skin have all sustained damage, the damaged section must be completely cut out, care being taken to avoid cutting any undamaged members and to ensure that only the smallest cuts are made to reduce the area to be repaired.

(6) Where necessary, scarf in new sections of any interskin members which may have been damaged.

(7) If no support members are fitted in the vicinity of the damage cut new spruce members as detailed in operation (2), and fit them securely in position (*fig.* 1).

(8) Cut 9:1 scarfs on the edges of the bottom skin and cut an insertion piece to mate with the scarfs cut in the existing skin (*operation* (3)) and secure the joints as detailed in operation (4).

(9) Fill in the spaces left between the interskin members with balsa filling of a thickness equal to the depth between the skins.

(10) Cut 9:1 scarfs on the edges of the existing top skin and then cut and prepare an insertion piece as in operation (3) and (8), firmly securing the insert to the existing skin as detailed in operation (4).

(11) Allow the appropriate setting time of the adhesive to elapse (*Chap.* 5.2) and then clean up the job.

5. The foll: wing Table shows the approved scarf lengths to be cut, relative to the thickness of the plywood, and also indicates the minimum permissible distance between top and bottom skin scarf joints as shown in the illustration

Note . . .

The grain direction of all skin insertion pieces must be the same as that of the existing skins.

Table 1

Scarf lengths and distance between joints

Thickness of plywood (inches)	Dimension A (inches)	Dimension B (inches)
$\frac{1}{16}$	0·6	3·0 minimum
$\frac{5}{64}$	0·8	
$\frac{1}{8}$	1·2	

INSERTION REPAIR OF PLY SANDWICH STRUCTURE *(Continued)*

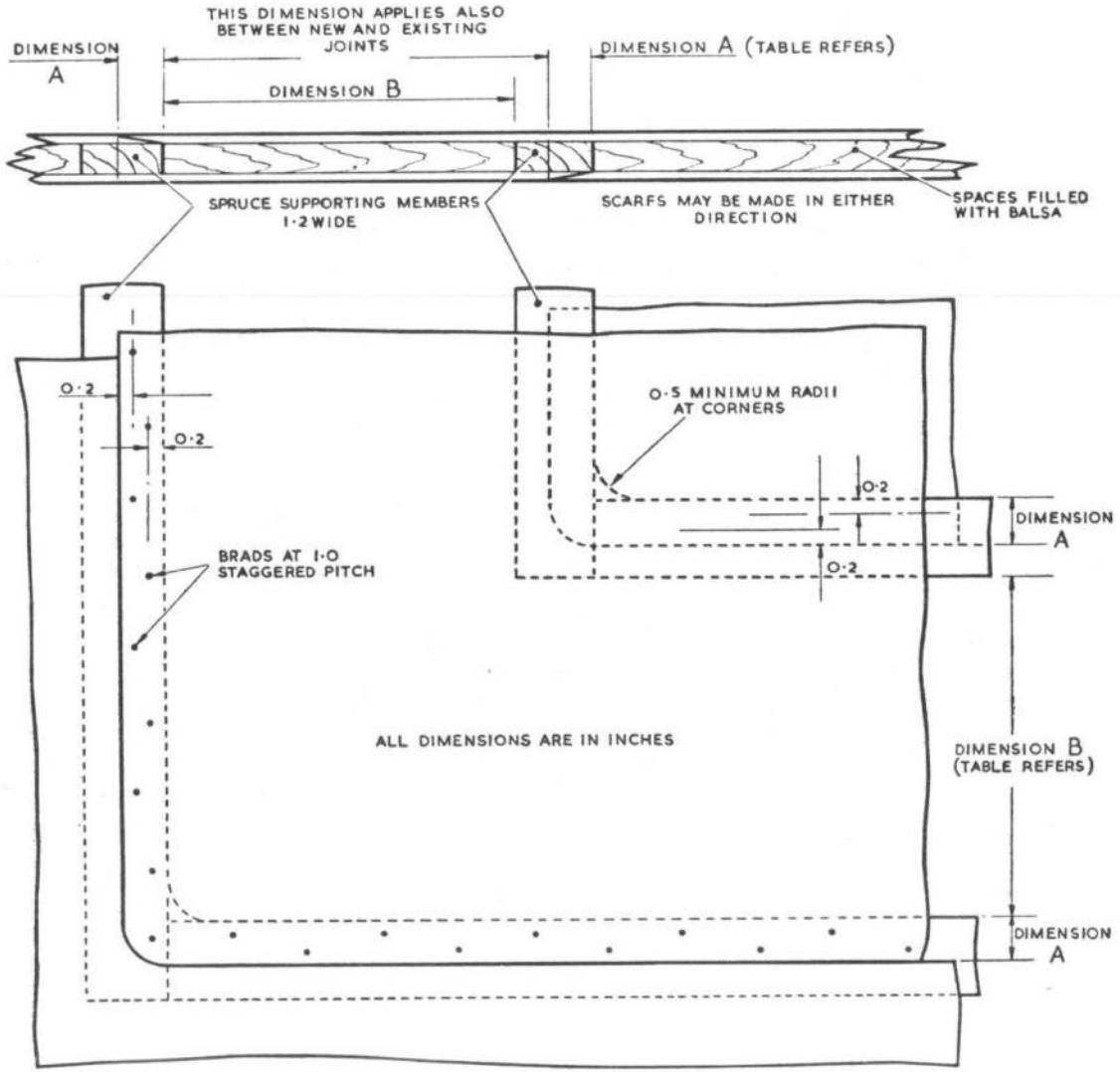

Fig. 1. Insertion repair

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Chapter 5.6 BOX MEMBERS

LIST OF CONTENTS

GENERAL INFORMATION ON BOX MEMBERS

5.6.1

Introduction

1. Box members are used in the construction of wooden airframe components, such as aerofoil spars, major interspar ribs, fuselage frames and other built-up structures, because of the high strength/weight and stiffness characteristics of these members by comparison with those of solid members of the same material cross-sectional areas.

Construction

2. The usual construction of a box member consists of a combination of solid or laminated spruce booms and plywood webs or side panels. In some types of box members a clearance of between $\frac{1}{16}$ in. and $\frac{1}{8}$ in. is allowed between the inner face of the plywood skin attached to the boom and the upper edges of the plywood webs (*fig.* 1). The purpose of this clearance is to prevent a failure of the joint between the skinning and the boom due to unequal shrinkage of the solid boom and the plywood webs or panels. This practice is not applicable to all aircraft.

Associated schemes

3. The schemes contained in this chapter deal with typical repairs of box members and should be used in conjunction with appropriate schemes in Chap. 5.3 (*Plywood*) and Chap. 5.4 (*Solid members*) of this Section. The information dealing with the selection of suitable repair wood and the detection of defects which may exist in spruce (*Scheme* 5.4.1) is also applicable to woods used for the repairs given in this chapter.

4. When repairing box members which have a clearance between the plywood skin and webs (*para.* 2), it is essential that the required clearance is maintained when the repair is being made. If, however, there is no clearance in the original structure, the upper edges of the webs must be cut flush with the outer surfaces of the boom to enable the maximum glue area between the booms, webs and skinning to be maintained, thus ensuring a full-strength repair.

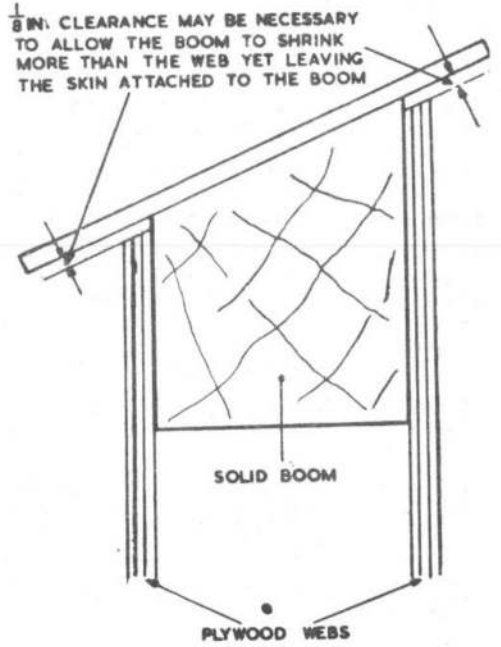

Fig. 1. Clearance between spar webs and skin

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5.6.2 PATCH REPAIR OF MINOR DAMAGE TO PLYWOOD SPAR WEBS

Application

1. This repair scheme should be used to deal with damaged spar webs involving bruises and abrasions less than ¼T (*where T equals the thickness of the web*), provided that the spar boom and vertical stiffeners are undamaged.

2. As indicated in fig. 1, the repair patch must be at least four times the length of the damaged area, or as long as the full depth of the spar (whichever is the greater) and may be secured by screws, brads or staples after the application of S.R. adhesive and hardener (*Chap.* 5.2) to the faying surfaces of the plywood web and patch.

Repair procedure

3. Before the repair is commenced, ensure that sufficient mixed S.R. adhesive (*which has been prepared for at least* 24 *hours*) and all necessary equipment is available for the job. Then proceed in the following sequence of operations:—

(1) Gain access to the damaged spar web by removing all plywood skinning in the area as necessary.

(2) From the plywood of the same grade and thickness as the existing web, cut a patch to the dimensions shown in fig. 1, with the same grain direction as the web.

(3) Chamfer the vertical edges of the patch to a ratio of 5 : 1.

(4) Ensure that the damaged area is smooth and that the patch will fit flat on the surface of the web.

(5) Apply the adhesive and hardener to the mating surfaces of the web and patch (*Scheme* 5.2.2). When the adhesive is tacky, fit the patch centrally over the damage and secure it firmly with screws, brads or staples, suitably positioned to avoid any existing screws or brads.

Note . . .
When brads and staples are used, they must be clenched across the grain.

(6) Allow the appropriate setting time to elapse, then clean up the external faces of the repair.

(7) Renew any plywood skin panels which were removed in operation (1). The new panels should be fitted as instructed in Scheme 5.3.8 or 5.3.9.

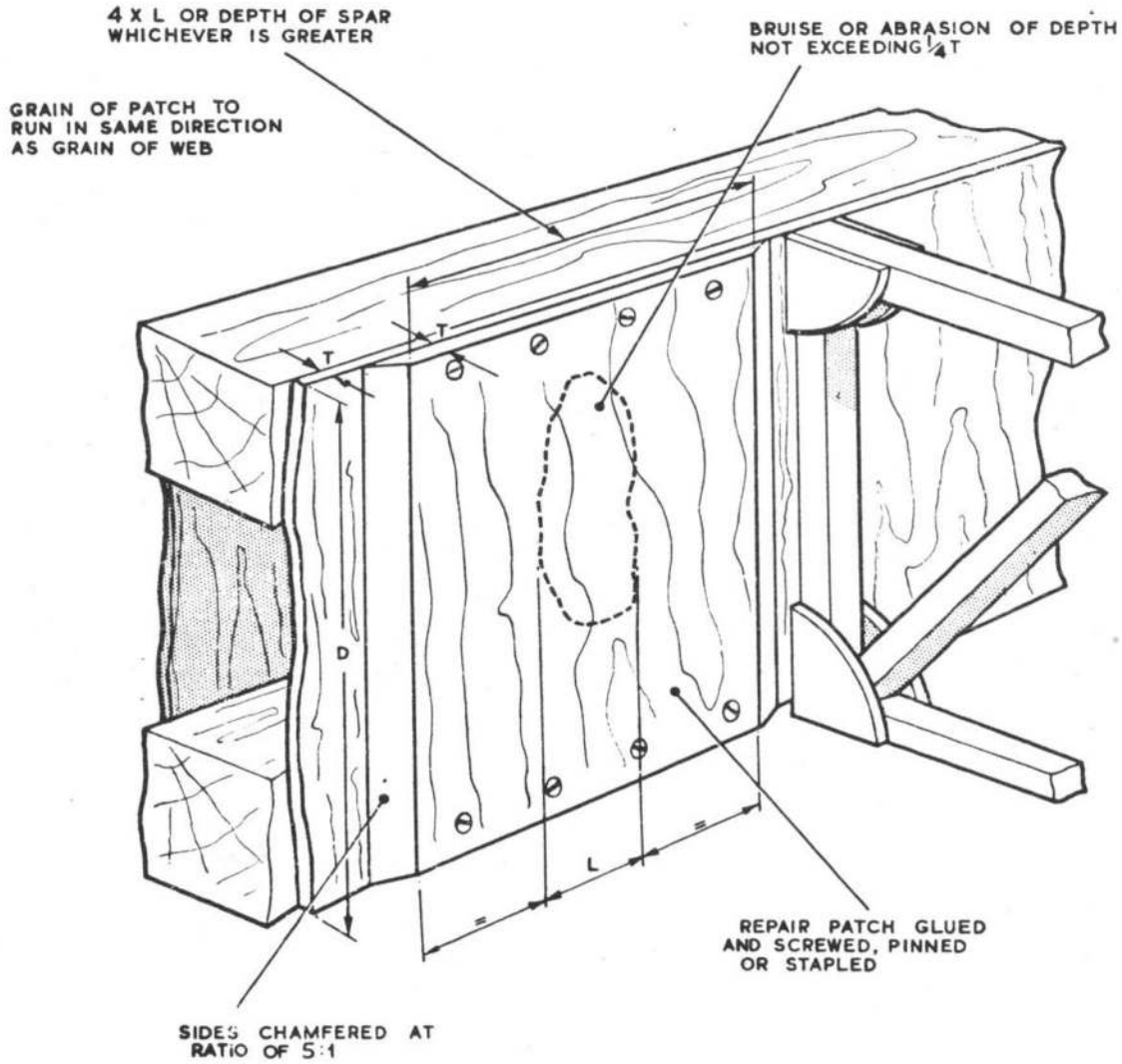

Fig. 1. Repair patch location and dimensions

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INSERTION REPAIR OF PLYWOOD SPAR WEBS

General information

1. This type of repair is applicable to spar webs which have sustained damage greater than ¼ T deep (*where T equals the thickness of the spar web*) and damage to the spar booms does not exceed that classified as negligible in the appropriate airframe air publication Vol. 6 or Vol. 2, Part 3.

2. The repair (*fig.* 1) may be effected on both webs at any point along the length of the spar, provided that the splice joints in opposite webs are staggered at least 12 in. apart.

3. The plywood used in the repair must conform with the same specification and grade as that used in the original webs and skinning, and must also be of the same thickness.

Repair procedure

4. With all the necessary equipment assembled on site, proceed as follows:—

(1) Remove all plywood skinning necessary to gain access to the damaged spar.

(2) Cut away the damaged section of web to the full spar depth and examine the spar booms in the vicinity of the damage to ascertain that it does not exceed negligible classification.

(3) Check the width of the vertical stiffeners exposed between the spar booms. If this is not sufficient to provide adequate support for scarfs cut at a ratio of 9:1, reinforcing blocks, cut from spruce of the same specification as the stiffeners, must be glued to these members as shown in fig. 1.

Note . . .

To enable the smallest length of web to be cut out which will permit adequate supported scarf lengths, it may be advisable to prepare and secure an additional stiffening member where required, as shown in the illustration.

(4) Where new vertical stiffeners are required, these must be cut from spruce of the same specification as the existing members, have similar lightening holes if required, have a width of at least ¾W (*W equals the length of the splice to be supported*) and, when finally prepared, fitted in position with the same grain direction as the other vertical members.

(5) Cut back the plywood web under repair to the nearest existing stiffener, or to the position of any additional vertical member fitted for support of the web splices, and scarf the ends of the existing web to a ratio of 9:1.

(6) From material (*para.* 3) of the same depth and thickness as the spar web, and with the same grain direction, cut an insertion piece and scarf the ends to mate with those prepared in operation (5).

(7) Apply S.R. adhesive and hardener (*Chap.* 5.2) to the faying surfaces of the scarfs, the sides of the spar booms and the boom contact areas of the insertion piece.

(8) Wait for the adhesive to become tacky, then fit the insertion piece in position and secure the joints firmly with evenly pitched screws.

Note . . .

The screws are to be left permanently in position as part of the repair.

(9) Allow the appropriate setting time (*Chap.* 5.2) to elapse and clean up the job, repeating the procedure where similar repairs are necessary on other webs.

(10) Renew the plywood skinning removed in operation (1). The new panels should be fitted as instructed in Scheme 5.3.8 or 5.3.9.

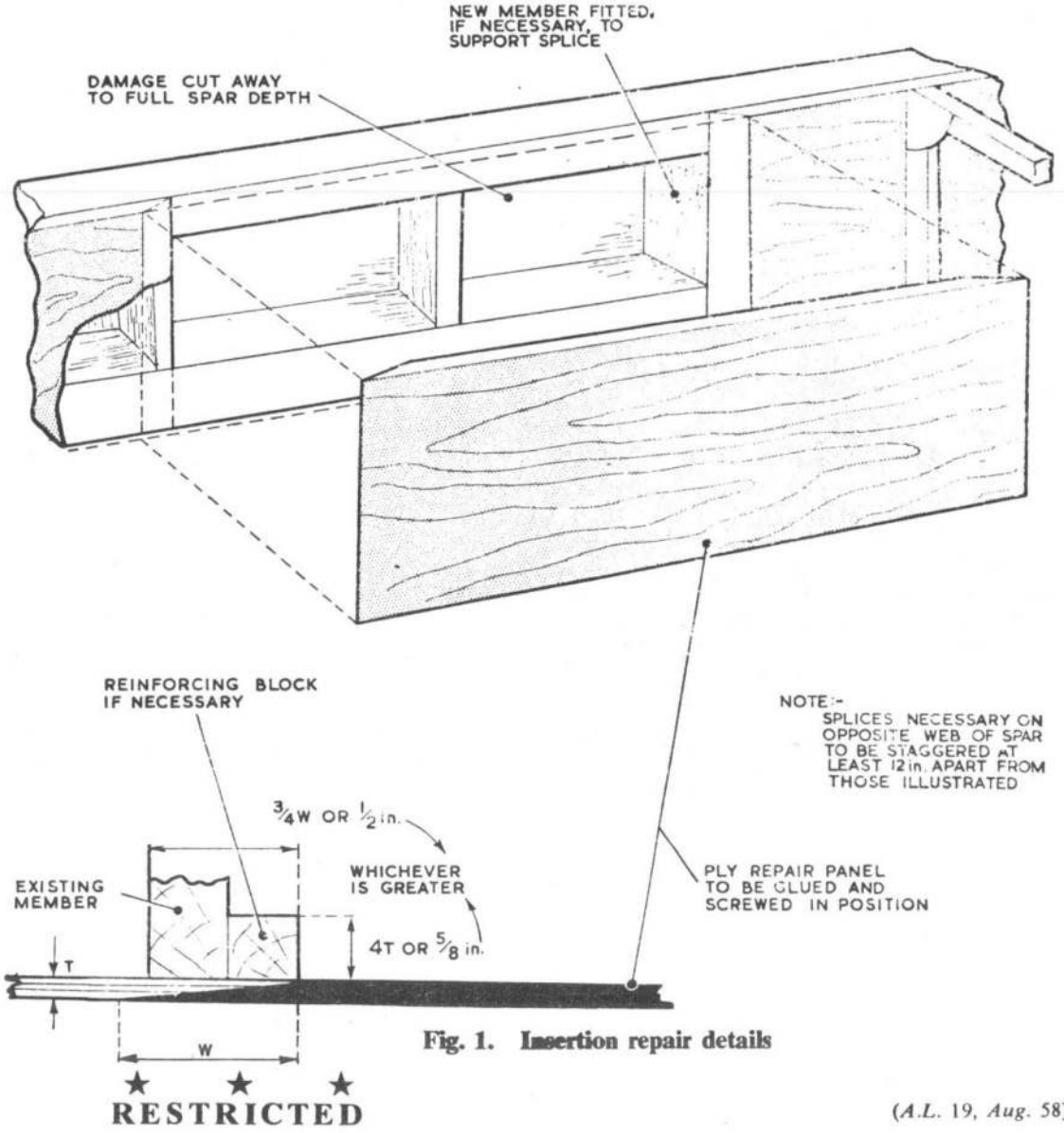

Fig. 1. Insertion repair details

5.6.4 REPAIR OF DAMAGE TO SPAR BOOMS NOT EXCEEDING ONE-THIRD DEPTH

Applicability

1. The information given in this Scheme may be applied to the repair of various types of spar booms that have received damage which does not extend beyond one-third of their depth.

2. The repair scheme is not generally applicable to all types of airframe spars and, therefore, must not be used unless sanctioned in the relevant airframe Vol. 6 or Vol. 2, Part 3.

3. This repair scheme is equally applicable to spar booms of either laminated or solid wood construction and the methods of repair are shown in fig. 1. The working dimensions for the repair of a laminated boom are given in diagram A (*method A*) and those for the repair of a solid boom are given in diagram B (*method B*).

Repair procedure

4. With the damaged spar adequately supported on rigid trestles and the necessary repair materials and tools assembled on site, proceed with the repair in the following sequence of operations: —

(1) Gain access to the damaged boom by removing the plywood skinning and sections of the spar webs as necessary.

(2) Cut out the damaged portion of the spar boom.

Note . . .
The cut must be parallel to the longitudinal axis of the boom but must not exceed one-third of its depth.

(3) Cut scarfs to a ratio of 15 : 1 in the boom to receive the laminated insertion pieces (*method A*) or the solid insertion piece (*method B*) as shown in fig. 1.

(4) From spruce or other wood of the same specification, grade and grain direction as the original boom, cut laminations or an insertion piece, as appropriate, to the dimensions shown in fig. 1, the overall length of each insert being cut to include the length of the scarfed ends.

Note . . .
When using method A, the insert must be built up from laminations of the same thickness and width as those in the original member and the 15 : 1 *ratio must be based on the thickness of the appropriate lamination.*

(5) Apply S.R. adhesive and hardener (*Chap.* 5.2) to the faying surfaces of the laminations (*method A*), or to the solid insert (*method B*), and the boom. When the adhesive becomes tacky, fit the insert into the cut-out section of the boom, cramp the joints securely in position and clean off excess adhesive from the sides of the boom.

(6) Remove the cramps when the required cramping time (*Chap.* 5.2) has elapsed and clean up the joint.

Note . . .
If method B is employed, a reinforcing block must be fitted on the opposite face of the boom as instructed in operations (7), (8) *and* (9) *and shown in fig.* 1, *diagram B.*

(7) From similar material to that used in operation (4), cut the reinforcing block to the dimensions shown in diagram B, ensuring that the grain direction is the same as that of the original boom.

(8) Apply the adhesive as in operation (5) and secure the block firmly in position with woodscrews evenly pitched throughout its length.

(9) If fitting the reinforcing block has necessitated the removal of inter-boom stiffeners, these must be shortened to accommodate the block and then securely refitted in position.

(10) Renew the plywood spar webs removed in operation (1), scarfing in the new lengths as instructed in Scheme 5.6.3.

(11) Renew the plywood skinning removed in operation (1). The new skin panel should be fitted as instructed in Scheme 5.3.8. or 5.3.9, as appropriate.

(12) Allow full setting times for all joints to elapse (*Chap.* 5.2), then remove the trestles.

REPAIR OF DAMAGE TO SPAR BOOMS NOT EXCEEDING ONE-THIRD DEPTH (*Continued*)

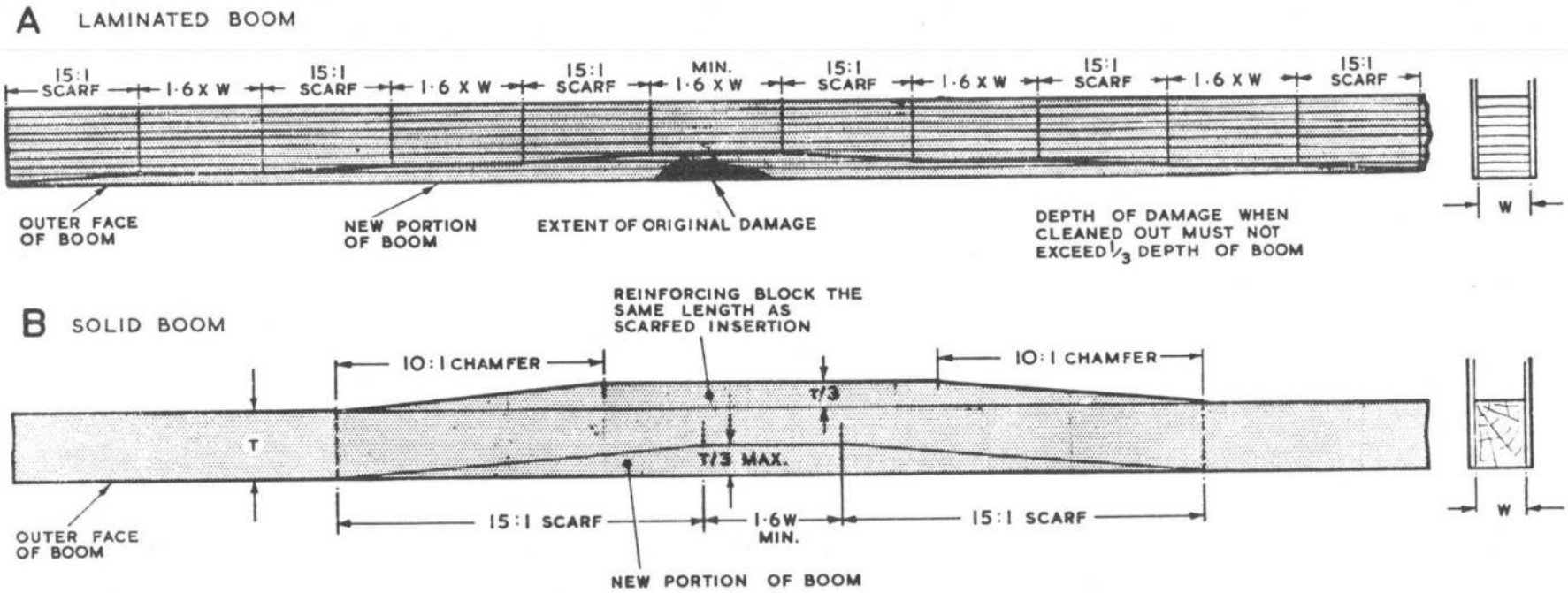

Fig. 1. Details and dimensions of boom repair

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5.6.5

INSERTION REPAIR OF SPAR BOOMS

General information

1. The instructions given in this scheme deal with the repair of a spar boom that has sustained damage in excess of the limit quoted in Scheme 5.6.4; they apply equally to either laminated or solid wood spar booms and the repair dimensions and details are shown in fig. 1.

2. The scheme is not generally applicable to the repair of all types of wooden airframe spar booms and must not be used unless it is sanctioned in the relevant airframe Vol. 6 or Vol. 2, Part 3.

Repair procedure

3. With the damaged spar adequately supported by suitable trestles, and all repair materials and tools assembled near the job, proceed with the repair as follows:—

(1) Cut back the plywood skin covering the damaged boom and remove the sections of spar webs, as necessary, to gain access to the damage.

(2) Cut the boom on each side of the damage, carefully break any glued joint to inter-boom stiffeners and remove the damaged section.

(3) Prepare the ends of the existing boom and cut a scarf to a ratio of 15 : 1 on each end.

Note . . .
There must be a spanwise distance of at least 12 *in. between any two scarfed joints, whether they are in the same or in opposite booms; the positioning of the scarfed joints must be planned accordingly.*

(4) From wood of the same specification, grade and grain direction as the original boom, cut insertion pieces for a laminated boom, or a single insertion piece for a solid boom. The insertion pieces must be cut to the same dimensions, plus the additional length required for scarfing, to match the damaged section of the boom.

Note . . .
A laminated insert must be pre-formed from the appropriate number of laminations of the same thickness and width as those in the original member, to produce the equivalent of a solid insert. After the application of adhesive and hardener (Chap. 5.2) *to the laminations, they must be cramped together and allowed to remain undisturbed, except for the removal of excess glue, until the approved cramping time has elapsed (Chap.* 5.2), *after which the laminate may be prepared for scarfing as for a solid member.*

(5) Cut scarfs on the ends of the insertion piece to mate with those cut in operation (3).

(6) Apply S.R. adhesive and hardener (*Chap.* 5.2) to the faying surfaces of the original boom and the insert, and cramp the joints securely in position; allow the joints to remain undisturbed, except for the removal of excess glue, until the full cramping time has elapsed.

(7) From spruce of the approved specification and grade, cut reinforcing members to the dimensions given in fig. 1, diagram A, where the thickness of the members is shown as one-third of the thickness of the top and bottom booms ($a_1 = \frac{1}{3}T_1$ and $a_2 = \frac{1}{3}T_2$). The reinforcing members must be cut with the same grain direction as the booms, chamfered to a ratio of 10 : 1 on each end and supported by at least one diaphragm.

Note . . .
Where splices in the same boom are less than a splice length apart, a continuous reinforcing member should be fitted.

(8) Cut back the inter-boom stiffeners, or reduce the size of any blocks, as shown in fig. 1, diagram B, to accommodate the new reinforcing members. If the stiffeners are constructed with lightening holes, they should be removed and replaced by solid but otherwise similar members.

(9) Apply adhesive and hardener to the mating surfaces of the reinforcing members and boom, 15T and $7\frac{1}{2}$T from the inner feather edge of each splice (*fig.* 1, *diagram A*). When the adhesive is tacky, position the reinforcing members and firmly secure them with evenly-pitched woodscrews.

(10) Renew the sections of plywood spar webs removed in operation (1) by scarfing the ends of the inserts and original webs as instructed in Scheme 5.6.3.

(11) Renew the plywood skinning removed in operation (1). The new skin panel should be fitted as instructed in Scheme 5.3.8 or 5.3.9.

(12) Allow full setting times for all joints to elapse (*Chap.* 5.2), then remove the trestles.

Marking splice centre lines

4. Before the plywood skin panels are fitted over the completed insertion repair of a spar boom, the centre line of each spliced joint must be marked on the plywood web of the spar as shown in fig. 1, diagram C. This procedure is necessary to enable the position of all existing splices to be quickly located, and thus assist in planning the positioning of other splices which may be required in any future repairs of the same section of spar.

INSERTION REPAIR OF SPAR BOOMS (*Continued*)

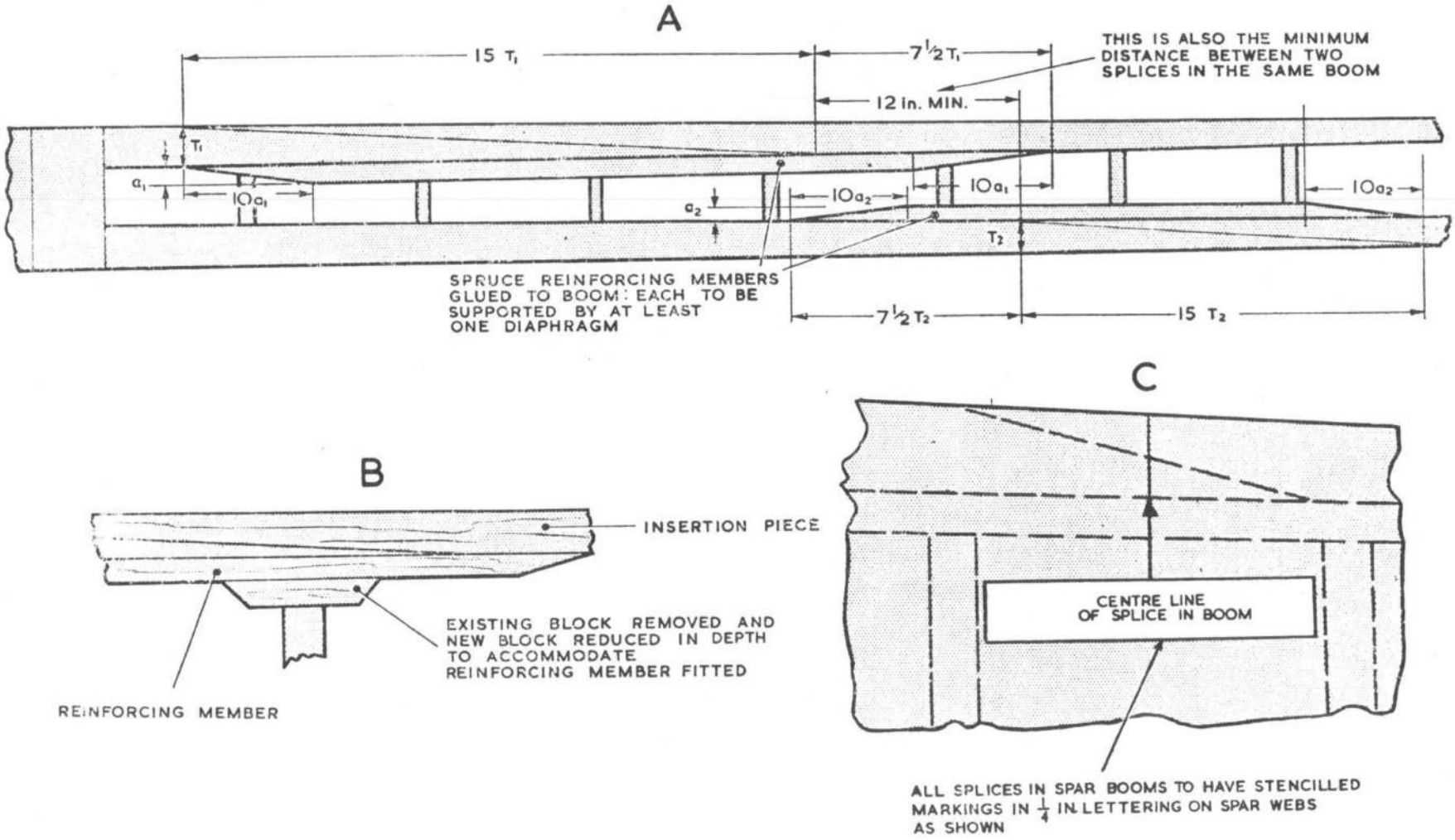

Fig. 1. Repair dimensions and details

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