STANDARD REPAIRS FOR AIRFRAMES

This leaf issued July, 1944

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A·P 2662A

NOTES TO READERS

The repair instructions given in this Air Publication are approved for application to any aircraft except where overridden by the Volume II, Part 3 or 4 for the type of aircraft concerned.

The instructions may be altered or added to from time to time by Amendment List action. Where the amendment is made by the insertion of new leaves, the number of the Amendment List will be found at the top of each page affected.

Amendments introducing an important change in the technical matter will be indicated by a vertical line in the outer margin against the matter amended or added. Vertical lines relating to previous amendment to a page will not be repeated when a further change is made nor will they be used when an amendment is made by gummed-on slips.

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AMENDMENT *Record Sheet*

THE INCORPORATION OF AN AMENDMENT LIST in this publication must be recorded below by inserting the Amendment List (A.L.) number, signing in the second column and entering in the third, the date of making the amendment.

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Standard Repairs for Airframes

SECTION 1

A·P 2662A

GENERAL PRINCIPLES APPLYING TO REPAIRS

1102 — WHAT TO DO BEFORE STARTING A REPAIR SCHEME

BEFORE STARTING a repair scheme of any description you must, first of all, investigate the full extent of the damage. This investigation, which must be undertaken with extreme care, should include the structure surrounding the damage, to ensure that no secondary damage, i.e. that arising from the initial damage, remains unnoticed. Secondary damage occurs even at a considerable distance from the point of initial failure, caused by the transmission of force from one end of a member to its opposite end, resulting in buckled plates and drawn rivet or bolt holes. Secondary damage may also occur due to fatigue failure following weakening of the structure by the initial damage.

EXAMINE THE STRUCTURE for signs of cracks, buckling, tears, etc. The detection of cracks is outlined in A.P.880B, Vol. 1, and one of the methods described must be used if cracks are suspected in any part of the structure—none must be allowed to remain undetected. Drawn rivet and bolt holes may be revealed by cracks in, or flaking of, the surrounding paint film. A feeler gauge should be inserted under riveted plates to ascertain whether rivets have failed or stretched leaving their heads intact—any suspect rivets should be replaced. During the examination, look out for signs of corrosion, as the extent of any found must be borne in mind when deciding the method of repair. Corrosion may reveal itself in the form of coloured deposits or discoloration of the paint. Your examination, however, must be extremely close as the only indication of quite extensive corrosion may be a tendency for paint to crack when pressed with the finger. To check the structure for deformation, its alignment should be "tried" with straight edges, clinometer, trammels, plumb bobs,etc., as applicable. If out-of-true, the cause of the error must be found and corrected. As each defect is found, it should be ringed with chalk or pencil so that there is no possibility of it being overlooked during the repair operations.

CLEAN UP ALL DAMAGE, with the exception of flat depressions which fall within the limits of negligible damage given in the aircraft Vol. 2 or Vol. 6, before measuring its extent. Except where the initial treatment is peculiar to a particular repair, it should be as follows:—

(1) *Distortion and severe dents* in metal skins or members formed from sheet should be dressed back to the correct profile with a mallet and a block of soft wood, after the adjacent rivets have been removed. Dents in extrusions which distort the opposite surface should be treated as punctures (sub-para. (4) below).

(2) *Abrasions* should be rubbed with worn, fine emery cloth into smooth-surfaced depressions of fair contour.

(3) *Deep scores, tears and cracks* should have $\frac{1}{8}$ in. dia. holes drilled at their ends.

(4) *Punctures* should be cleaned out to leave smooth-edged holes of any simple regular shape (not necessarily the same as in the repair illustration) with corner radii as large as possible. When cutting out skin damage over or near a member, protect the member by interposing a piece of metal between it and the skin.

(5) *Broken edges* should be cut out to leave smooth recesses of fair contour. When such damage affects the flange of a member made from sheet metal, and packing is to replace the cut-away portion, the cut-away should be rectangular with radiused corners. Otherwise it should form an arc, which in extrusions should not be deeper than one-third of its length.

(6) *Chipped corners of extrusions* should be smoothed out to fair curves.

(7) *Tubes more than negligibly bowed* should be straightened, if possible, to within the negligible limits, failing which the centre portion of the tube should be cut as in (8) in preparation for the appropriate repair, or the tube should be renewed.

(8) *Other damage to tubes* should be cleaned out to circular or elliptical holes, provided that there would be sufficient undamaged surface left for the patch overlap. Alternatively, the tube should be cut through square to its axis, and on either side of the damage, and the remaining ends filed smooth; it would then be ready for an insertion repair.

CLASSIFY THE CLEANED-UP DAMAGE into one of the following categories:—Negligible, Repairable or Necessitating Replacement. If the damage is repairable, consult the relevant chapter of the aircraft Vol. 2 or Vol. 6 to ascertain whether there are any special considerations applicable to the repair. If no such considerations apply, reference will be made there to a repair scheme in this publication. If, however, a standard repair cannot be applied, special instructions will be found in the aircraft Vol. 2 or Vol. 6.

PLAN THE REPAIR CAREFULLY. The repairs given herein and in the particular aircraft repair scheme are necessarily generalised—they cannot cater for every possible type and location of damage. Two or more of them must, therefore, often be combined in order to deal with damage which affects both skin and internal members.

SUPPORT THE STRUCTURE ADEQUATELY whilst it is being repaired, unless the repair is a very minor one, so as to relieve the affected and adjacent parts from excessive loads and to prevent further damage. Trestles for specific aircraft are usually listed in the Vol. 1 of the aircraft handbook, whilst details of standard trestles will be found in A.P.1464G, Vol. 1, Part 2, Sect. 5, Chap. 9. Adequate support can usually be obtained by the judicious use of trestles, wedges, cramps, and lengths of timber. It should, however, be noted that over-supporting, i.e. the distortion of the structure in the opposite direction to that for normal loading, is equally disastrous in repair work. The alignment of the structure should be therefore checked as described in the second paragraph of this instruction after the supports have been placed in position. The importance of correct support during the cutting out of damage cannot be stressed too highly and it is essential to keep the structure in correct alignment during this operation. When supporting a structure on soft ground, trestles have an unhappy knack of sinking or slipping, turning a Cat. A aircraft into Cat. B in a very few seconds. When operating on soft ground, guard against this by supporting the trestle legs on wood planks—it will save a lot of bother.

PIPES AND CABLES in the immediate vicinity of damage must be removed carefully to avoid damage during the repair work.

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STANDARD REPAIRS FOR AIRFRAMES

A.P. 2662A

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STANDARD REPAIRS FOR AIR FRAMES

A.P. 2662A 1011

Section I GENERAL CONSIDERATIONS

CHAPTER II

1101—AIRFRAME REPAIRS AND SAFETY IN FLIGHT

REPAIR SCHEMES PREPARED for any aircraft designed for Service use must comply with the strength requirements laid down for the aircraft in question. It will be appreciated that it is impossible to cover every repair by a standard method. You will therefore find specific repair instructions given in aircraft handbooks, Vol. 2, Part 3, or Vol. 6, dealing with damage which cannot be repaired by standard methods.

FOR A PARTICULAR AIRFRAME, the preparation of the repair scheme is comparatively straightforward, as the manufacturer's design staff concerned will know the maximum load that any member of the structure will be called upon to carry under normal service conditions. Using this load as the basis, the repair can be designed with a pre-determined margin of strength in hand. The strength of a member divided by the maximum load it will be called upon to carry, is called the reserve factor and this, for normal repair work, is maintained at a minimum value of 1·2.

FOR GENERAL APPLICATION, repairs cannot be based on the maximum loads that the structure concerned is likely to carry, as the loads will vary for different aircraft. Standard repairs have therefore to be based on the restoration of the structure to its original strength. In certain instances this will, of course, entail excessively robust repairs to members which do not carry their structurally maximum loads, with consequent wastage of time and material; this is the price that must be paid for standardisation.

THE INHERENT DISADVANTAGE of standard repair procedure can, to a certain extent, be overcome by giving Structure Classification Diagrams for a given airframe which categorise every member and area of skin under the headings Primary, Secondary, or Tertiary, in accordance with the definitions given below. These diagrams, which are being issued progressively for all airframes in extensive use in the Service, will be incorporated in the aircraft, Vols. 2, Part 3, or Vol. 6.

Primary Structure: All portions of the structure in which a single failure, whether in flight, landing, or take-off, might cause structural collapse, loss of control, failure of motive power, unintentional release of bombs, torpedoes, pyrotechnics or any other items of jettisonable equipment, or serious injury to members of the aircrew.

Secondary Structure: (i) Those portions of the structure which would normally be regarded as Primary Structure but which unavoidably have such a reserve of strength over design requirements that appreciable weakening may be permitted without risk of failure, and (ii) structure which, if damaged, would not impair the safety of the aircraft in any manner specified above for Primary Structure.

Tertiary Structure: All portions of the structure in which stresses are low but which for various reasons cannot be omitted from the aircraft.

FROM THE DEFINITIONS of the three classifications of structure, it will be apparent that Secondary and Tertiary structures need not be restored completely to their original strength. The repairs at present given in this book can be used for all categories of structure, since they are based on Primary Structure requirements. At a later date, when Structure Classification Diagrams are issued for a reasonable number of aircraft, further repair schemes will be incorporated in this book which will apply only to the repair of Secondary and Tertiary structures.

1103 — POINTS TO REMEMBER ON COMPLETION OF A REPAIR SCHEME

AS EACH STAGE OF THE REPAIR is completed, you must check the work against the relevant repair instructions. Patch material and thickness, rivet diameter and pitch, correct dimensions and positioning of reinforcing members, etc., should be compared with the repair drawings and instructions. The alignment of the structure, if involved, should be checked against datum points with trammels, plumb bobs, clinometer, etc., and any distortion due to the repair work eliminated or made good.

PROTECTIVE TREATMENT will have already been applied to those parts of the repair which become hidden during the assembly operation, but any protective treatment on the outer surfaces of the repair and the surrounding structure, which has been removed or damaged, must be made good. Any signs of corrosion if not already dealt with should, of course, be treated and the protective film made good.

PIPES AND CABLES will often have been removed to gain access to damaged parts of the structure. You may not be able to refit these components exactly in their original position, due to modification of the structure during the repair work. If this is so, the pipes or cables should be fastened as nearly as possible to the original points of attachment, making sure that pipes are not excessively strained and that cables follow the same line as before. The alignment of control cables must not be altered unless authorised specifically by the aircraft Vol. 2, Part 3 or Vol. 6 (as issued).

DRAINAGE HOLES perform a very important function in certain airframe structures. You must therefore make sure that no such holes are obstructed by any material added in making the repairs. If this has happened the drainage hole must be continued through the addition, provided this will not cause structural weakening; alternatively new drainage holes should be cut as near as possible to the original positions. It is a good plan to check the efficiency of all drain holes in a repaired component whilst you are on the job. Furthermore if drainage holes were present in any part of the airframe which has been removed, they should be duplicated in the replacement part.

BONDING STRIPS may become fractured or may have to be removed during the course of a repair. If broken a new length of strip should be soldered to the existing ends; if removed the original strip should be resoldered into position.

CONTROL SURFACES which have been repaired must be considered from the point of view of mass balance. If the centre of gravity of the control surface is brought outside the limits laid down in the aircraft repair scheme, there is a risk of flutter developing in flight and this would probably prove fatal. The procedure to be adopted will be found in Chapter 12 of this book and the importance of following these instructions cannot be over emphasised.

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1104 — FINISH OF REPAIR WORK IN RELATION TO OPERATIONAL EFFICIENCY

THE FINISH, i.e. the final protective covering and aerodynamic cleanliness of an aircraft, has an important bearing on its range, maximum speed and manoeuvrability. This effect becomes more marked as the speed increases and so the following notes apply particularly to fighter and high speed bomber aircraft. Some idea of the importance of this effect can be gathered from the fact that a 3 per cent. increase in the top speed of a fighter will require, approximately, a 10 per cent. increase in engine power and yet this improvement can be off-set easily by deterioration of the aircraft's smooth finish.

THE DESIGNER pays a great deal of attention to this question of finish. He makes sure that as little as possible protrudes outside the clean lines of the aircraft—even irregularities one thousandth of an inch deep, if there are sufficient of them, will have an appreciable effect on performance. On high-performance aircraft he will usually stipulate that all exterior rivet heads shall be flush with the adjacent skinning surface. This will be done by countersinking the rivet heads or dimpling the skinning, dependent on the thickness of the skinning being used. The designer may decide to use filler to even out all irregularities on the surface of the skinning. All his efforts to produce a smooth finish may mean many extra man-hours being expended during production and so every effort must be made to maintain the surface of the aircraft in its original condition. As far as repair work is concerned, the operator can help in two ways; firstly by ensuring that exterior repairs, on completion, present as smooth a finish as possible and, secondly, by preventing damage to the finish during repair work. Both of these aspects are elaborated in the following notes.

DAMAGE TO THE FINISH can be caused by walking over the airframe in rough soled boots or shoes or by permitting ground equipment such as ladders or trestles, to score or chip the finish. Whenever possible, rubber soled shoes should be worn when working on airframes and ground equipment should be suitably padded with felt or similar material. During repair work, avoid denting the skinning but, should this happen, carefully beat out the deformation so that the original contours of the structure are restored.

REPAIR TECHNIQUE should in every case fulfil the smooth finish requirements of the aircraft in question. On low-performance aircraft these requirements will be reasonably simple but on high performance aircraft they may entail extensive additional work. The more important points to remember are:—(*a*) Air leaks between the exterior and the interior of the airframe are detrimental to performance and should therefore be avoided as far as possible. (*b*) Exterior patches should be made to fit closely to the original skin and wherever possible should be of the flush type. If this is impracticable, the edges, particularly those in the line of airflow, should be chamfered and beaten down gently to ensure close fitting to the original skin. Remember that excessive beating stretches the metal and only makes matters worse. (*c*) If the original structure is flush riveted, this type of rivet must be used in all repair work and they must be made to fit snugly in the countersunk holes or dimples.

DAMAGED FAIRINGS AND COWLINGS are one of the major causes of loss of performance and so when removing such parts, either for or during repair, be careful not to dent or distort them. When refitting, make sure that they fit closely to the contour of the original structure. Fasteners of all types should never remain proud of the surrounding panels when in their secured position—anything which protrudes into the airstream will cause loss of performance. The remarks on riveting and patches given in the previous paragraph apply, of course, to cowlings and fairings as well.

CONTROL SURFACE SHROUDS, if distorted or damaged, will prove detrimental to the manoeuvrability of an aircraft. Therefore, after completing a repair to these parts, make sure that their final profile is correct—if you haven't the necessary drawings you can probably find a similar but undamaged structure on the same airframe or one of the same type.

WHEN TOUCHING-UP DAMAGED PROTECTIVE TREATMENT you should get as smooth a finish as possible. The easiest technique for doing this is described in detail in Section 9, Chapter 2, of A.P.2656A, Vol. I—"External Finish of Aircraft" and reference should be made to this book.

PERSPEX. It is not sufficiently realised that the efficiency of observation from an aircraft is greatly reduced by even fine scratches on the transparent panels concerned. These fine scratches produce a haze effect, particularly when looking towards the sun, thus reducing the range of vision of the observer considerably. It has been found that if perspex is rubbed, even with a clean handkerchief, a sufficient number of fine scratches are produced to form an undesirable haze. It will be appreciated that quite serious deterioration of visibility will be caused by touching perspex with dirty hands or overalls. Observation through transparent panels will also be spoilt by specks of dust or paint adhering to the surface as this tends to cause confusion when searching for distant aircraft or objects. Furthermore tools or aircraft parts dropped on transparent panels will not improve matters for the pilot or observer; When doing painting jobs near to transparent panels, avoid splashing them with paint—if you try to remove the splashes you will probably damage the surface of the panels and if you leave them it will only confuse an observer, as already mentioned.

BY USING A LITTLE CARE, you can give your pilot an aircraft having the maximum possible efficiency, so that he has the best chance of seeing the enemy first and then bringing the ensuing action, whether offensive or evasive, to a successful conclusion. Read Section 13 of A.P.2656A, Vol. I and apply the principles set out there.

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STANDARD REPAIRS FOR AIRFRAMES

A.P. 2662A

Section 1
CHAPTER 12 MASS BALANCE OF CONTROL SURFACES

GENERAL NOTES ON MASS BALANCE

TO PREVENT FLUTTER OF A CONTROL SURFACE during high speed flight, its centre of gravity (c.g.) must lie forward of a specific line parallel to the hinge line of the component. The sketch in scheme 1202, overleaf, gives an example. Furthermore, so that the Pilot's controls shall be satisfactory from the handling point of view, the c.g. of the control surface must lie aft of another specific line parallel to the hinge line. Both of these limit lines may be either fore or aft of the hinge line or they may lie on opposite sides of this line, depending on the design of the control surface and of the aircraft to which it is fitted. For the purposes of this chapter, a control surface will be said to be mass balanced when its c.g. lies on the forward limit line and partially mass balanced if between the forward and aft limit lines. It should be realised that the scientific conception of mass balance is much more involved than the above definition but we are not concerned here with "higher mathematics" and our definition has been adopted for reasons of simplicity. Normally, control surface structures are designed primarily from consideration of the stresses involved and mass balance requirements are later satisfied by attaching a weight (called a mass balance weight) to a predetermined part of the structure.

WHEN REPAIRING A CONTROL SURFACE, a certain amount of weight will usually be added, due to the repair material used. If this additional weight "w" is multiplied by "d" the distance of its centre from the hinge line, the resulting value is a measure of the effect on the control c.g. ("wd" is called the repair moment). One extensive repair or the cumulative effect of several small repairs can produce a moment sufficiently large to move the c.g. of the control surface outside the limits mentioned in the above paragraph. In these circumstances the control surface will no longer be mass balanced. So that the c.g. of the control surface can be returned to within the specified limits, most control surface mass balance weights are made so that they are easily adjustable. This adjustment is made by adding to or subtracting from the mass balance weight an amount calculated from the bench check described in Scheme 1204. For those control surfaces with non-adjustable mass balance weights, the procedure to be adopted is described in Scheme 1206.

THE BENCH CHECK FOR MASS BALANCE necessitates the removal of the control surface from the airframe. As this is often a fairly lengthy procedure, it is obviously desirable to keep the number of bench checks necessary to a minimum. With this in view, a method is introduced in this chapter whereby all "in situ" repairs (repairs which can be done without removing the control surface from the air-frame), with repair moments over a certain value, are recorded on the control surface mod. plate (see Scheme 1203). A bench check for mass balance then only becomes necessary after a certain number of repairs in this category have been made. "In situ" repairs with moments less than this specified value are ignored—even their cumulative effect on the control surface c.g. will be negligible. Repairs necessitating the removal of the control surface from the airframe will usually be more extensive than "in situ" repairs and a bench check (and adjustment if necessary) must always be carried out in these circumstances. This will not cause an appreciable increase in repair time as the control surface will be removed from the airframe anyway.

THE SIMPLIFIED CONCEPTION OF MASS BALANCE, although much easier to deal with than the scientific conception, involves a number of symbols and several simple calculations. To make this method as workable as possible, a list of symbols used in this chapter is attached to the second page of Scheme 1207. This list can be thrown clear of the rest of the book so that you can refer to it while reading any of the schemes in the chapter—you should not have to keep referring backwards and forwards in the chapter to identify the various symbols. Furthermore, typical calculations are set out in Scheme 1207, showing what you will have to cope with when dealing with this work.

YOU CAN SAVE YOURSELF A LOT OF TIME by keeping to a minimum all added weight due to repairs on control surfaces. By doing this, the movement of the component's c.g. is kept as low as possible and you will not have to make a bench check so frequently.

Turn out the folder on Scheme 1207 for the symbols used in this chapter

1202 - MASS BALANCE DATA IN AIRCRAFT VOLS. II. PART 3

CONTROL SURFACES FOR DIFFERENT AIRCRAFT will, as mentioned in the previous scheme, have different mass balance properties. For this reason instructions can only be given in this book for carrying out the mass balance procedure and you will have to refer to the aircraft Vol. II, Part 3, for data referring to any specific control surface. A summary and explanation of the data which will usually be found (and always in the future) in the aircraft Vol. II, Part 3, is given in the following paragraph.

THE LIMITS BETWEEN WHICH THE C.G. of the control surface must lie, will, in general, be given in the form of two limiting out-of-balance moments. The relationship between the c.g. limits and their equivalent out-of-balance moments is as follows:—

Where **Q** is the total weight of the control surface (including the mass balance weight), in ounces.

D_1 is the distance between the control surface hinge line and the forward limiting position of its c.g. (see sketch).

D_2 is the distance between the control surface hinge line and the aft limiting position of its c.g. (see sketch).

b_1 is the forward limiting out-of-balance moment (inch-ounces).

b_2 is the aft limiting out of balance moment (inch-ounces).

Then $b_1 = Q \times D_1$ and $b_2 = Q \times D_2$

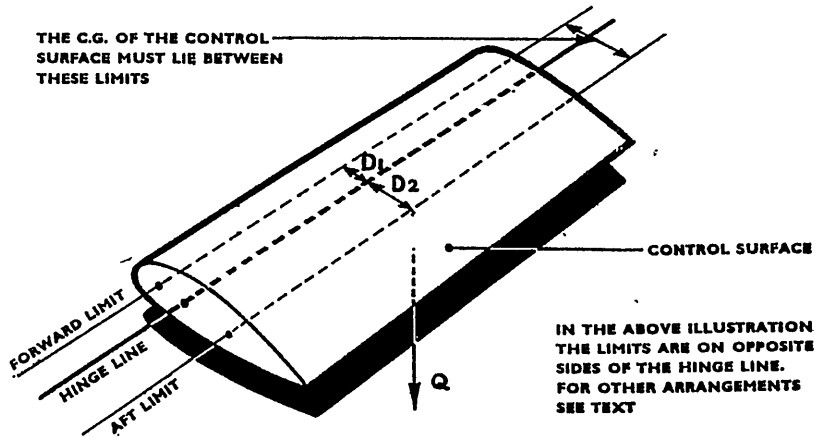
NOTE: b_1 and b_2 may be such that they both cause nose or tail heaviness but usually b_1 causes nose heaviness and b_2 tail heaviness. The effect of these out-of-balance moments depends on whether the relevant distance D_1 or D_2 is measured fore or aft from the hinge line.

THE OUT-OF-BALANCE RANGE "B" will be given for use in some of the calculations given later in this chapter. This range "B" is obtained by adding the two limiting out-of-balance moments for the condition where the limits are on opposite sides of the hinge line and by taking the difference of the limits where both are on the same side of the hinge line.

A DATUM WEIGHT "H" is used in the bench check for mass balance (Scheme 1204) so that the control surface balances horizontally when, without the datum weight, its c.g. lies at the forward limiting position. To satisfy this condition, the datum weight must be placed in a certain position on the control surface and this, together with its value, will usually be given in the aircraft Vol. II, Part 3.

THE C.G. OF THE MASS BALANCE WEIGHT will, generally speaking, remain at a set distance from the hinge line of the component, whatever the value of the weight itself. This distance "a" is used in a calculation (see Scheme 1204) and will therefore usually be given (and always in the future) in the Aircraft Vol. II, Part 3 If, however, this value is not given, you have only to measure the distance between the centre of the mass balance weight and the hinge line—don't forget that you want this value in inches for substitution in the formula.

MASS BALANCE WEIGHTS clearly must not be increased too much (see Scheme 1204) and therefore the maximum permissible value "Z" will also be found in the aircraft Vol. II, Part 3.



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1203 - MASS BALANCE IN RELATION TO REPAIR WORK

★ ★ ★ Before using this scheme, ascertain whether there is a letter "C" stamped or scribed on one of the bottom two lines of the control surface mod. plate (see Scheme 1204). This symbol indicates that the mass balance procedure introduced by this chapter is already in operation. If you find a letter "C", go ahead and use this scheme; if not, obtain instructions from the aircraft Vol. II, Part 3.

IMPORTANT:—For all repairs to a control surface necessitating its removal from the airframe, whether the repair is fore or aft of the hinge line, a bench check for mass balance (Scheme 1204) must be made before refitting the component to the airframe or before putting it into stores as a serviceable spare. This instruction overrides anything else given below.

YOU MUST DISCRIMINATE between repairs to control surfaces done forward of the hinge line and aft of the hinge line. This is because repairs forward of the hinge line will have an opposite effect on the mass balance of the component to those aft of the hinge line. Repairs in these two categories are dealt with separately in the following paragraphs.

REPAIRS FORWARD OF THE HINGE LINE will never create a tendency for the control surface to flutter but excessive nose heaviness will affect the handling qualities of the aircraft controls. Therefore when repairing damage to a control surface forward of the hinge line, with the component "in situ", the repair moment should be estimated by multiplying the additional weight "w" due to the repair (including paints and dopes used but less the weight of any material removed from the structure) by its distance "d" from the hinge line. Where this repair moment is less than $\frac{1}{3}$B (where "B" is the out-of-balance moment range, as given in the Aircraft Vol. II, Part 3, and as defined in Scheme 1202), no further action is necessary. If, however, the repair moment "wd" is greater than $\frac{1}{3}$B, one of the symbols "X" found on one of the bottom two lines of the control surface mod. plate should be erased. If there is no symbol "X" marked on the mod. plate, the control surface will have to be removed from the airframe and its mass balance checked in accordance with the instructions given in Scheme 1204.

REPAIRS AFT OF THE HINGE LINE may increase the risk of flutter so special care is necessary. Therefore when repairing a control surface aft of the hinge line and "in situ" the repair moment should be estimated as described in the paragraph alongside. Where this repair moment is less than $\frac{1}{3}$B (where "B" is the out-of-balance range, as given in the aircraft Vol. II, Part 3 and as defined in Scheme 1202), no further action is necessary. If, however, the repair moment "wd" is greater than $\frac{1}{3}$B, then the symbol "X" should be scribed or stamped on one of the bottom two lines of the control surface mod. plate. When required, a second repair involving a repair moment greater than $\frac{1}{3}$B may be carried out and a second "X" put on the mod. plate: but in the event of a further repair of ***any*** description becoming necessary (the symbol "XX" marked on the bottom of the mod. plate will indicate that it is a third repair), the control surface must be removed from the airframe and its mass balance checked as described in Scheme 1204.

CONTROL SURFACE TABS having mass balance weights fitted to them are not, generally speaking, repaired when damaged but are renewed. For instructions dealing with this type of component you should refer to the aircraft Vol. II, Part 3.

1204 - BENCH CHECK AND CORRECTION OF MASS BALANCE

A BENCH CHECK FOR MASS BALANCE of a control surface must be carried out under the conditions given in Scheme 1203, whenever the component is removed from the airframe, whether for repair or for any other reason and on a new component before it is fitted to an aircraft.

THEORY OF BENCH CHECK. When a control surface is fully mass balanced it may be either tail or nose heavy, depending on the position of the forward c.g. limit. To make checking as simple as possible, a datum weight "H" of specified value and at a specified position on the control surface is used so that the component balances horizontally when its c.g. (excluding the datum weight) is on the forward limit. The value and position of the datum weight will usually be found (and always in the future) in the aircraft Vol. II, Part 3. The state of horizontal balance is obtained by moving a weight "M" (see sketch) across the surface of the component in a fore and aft direction (perpendicularly to the hinge line). The distance "S" between the centre of the weight "M" and the hinge line is measured in inches and then multiplied by the weight "M" in ounces. The resulting product "MS" is called the out-of-balance moment and is a measure of the extent to which the control surface is out-of-balance.

THE MAGNITUDE OF "MS" will determine the action to be taken. Usually the c.g. of the control surface is returned to the forward limit so that the resulting out-of-balance moment is b_1 (see Scheme 1202). This is done by adding a calculated weight to, or subtracting it from, the mass balance weight, as applicable. However, for reasons given later in this scheme, it is not always possible to return the c.g. of the component to its forward limit and the action necessary in such a case is given in Scheme 1206.

SOME MASS BALANCE WEIGHTS cannot be adjusted owing to their design. This, however, does not mean that mass balance considerations can be ignored when dealing with this type of control surface. The bench check as described later in this scheme must still be made and the instructions given in Scheme 1206 applied.

THE ALTERATION TO THE MASS BALANCE WEIGHT necessary to return the c.g. of the control surface to the forward limit is found as follows:—

Where "MS" is the out-of-balance moment for the control surface (inch-ounces).
"G" is the weight required to adjust the mass balance weight (ounces).
"a" is the distance of the mass balance weight c.g. from the hinge-line (inches).

Then $MS = Ga$ and $G = \frac{MS}{a}$

If the weight "M" has to be placed forward of the hinge line to obtain a state of horizontal balance, the weight "G" must be added to the mass balance weight; if "M" has to be placed aft of the hinge line, the weight "G" must be subtracted from the mass balance weight.

A MASS BALANCE WEIGHT must not be increased beyond a certain limit where the factor of safety of its attachment, under a given acceleration, falls below a stipulated figure. The maximum permissible value for a specific mass balance weight will be found in the relevant aircraft Vol. II, Part 3, and when adjusting a mass balance weight you must always make sure that this maximum value is not exceeded. If this instruction is not followed, the aircraft is liable to break-up in the air . . . so don't forget.

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1204 - BENCH CHECK (CONTINUED)

PRACTICAL INSTRUCTIONS FOR THE BENCH CHECK are as follows:—

A.—CONTROL SURFACE WITH SHROUDED HINGES (Sketch A refers)

(i) Remove the control surface from the airframe.

(ii) Put the pins back in the outer hinges.

(iii) Clamp two steel strips "P" (see sketch) to the flange of a heavy girder or to the top of a bench so that they are horizontal and at the same level. The strips should be the same distance apart as the outer hinges of the control surface.

(iv) Position the control surface so that the hinge pins roll on the steel strips.

(v) Place the datum weight "H" in the correct position on the control surface (obtain the value and position from the relevant aircraft Vol. II, Part 3).

(vi) Place the weight "M" on the surface of the component so that it is equidistant from the outer hinges. Move this weight in a fore and aft direction until the control surface is balanced horizontally. Alternatives to this operation are given in Scheme 1205.

(vii) Measure the distance "S" between the centre of the weight and the hinge line in inches.

(viii) Multiply "S" by the weight "M" (in ounces), thus obtaining the out-of-balance moment for the control surface. Divide "MS" by the distance "a" between the centre of the mass balance weight and the hinge line (measure "a" in inches). The result obtained is the weight "G" ounces which is required to adjust the mass balance weight. If the weight "M", in the balanced position is forward of the hinge line, the weight "G" must be added to the mass balance weight; if aft of the hinge line, subtracted.

(ix) Make sure that in adding "G" ounces to the mass balance weight, you do not exceed the maximum permissible weight. If this would happen, refer to Scheme 1206 for instructions.

(x) Provided that the maximum value is not exceeded, adjust the mass balance weight as instructed by the relevant aircraft Vol. II, Part 3, and erase any symbols "X" found on the bottom two lines of the control surface mod. plate (see Scheme 1203).

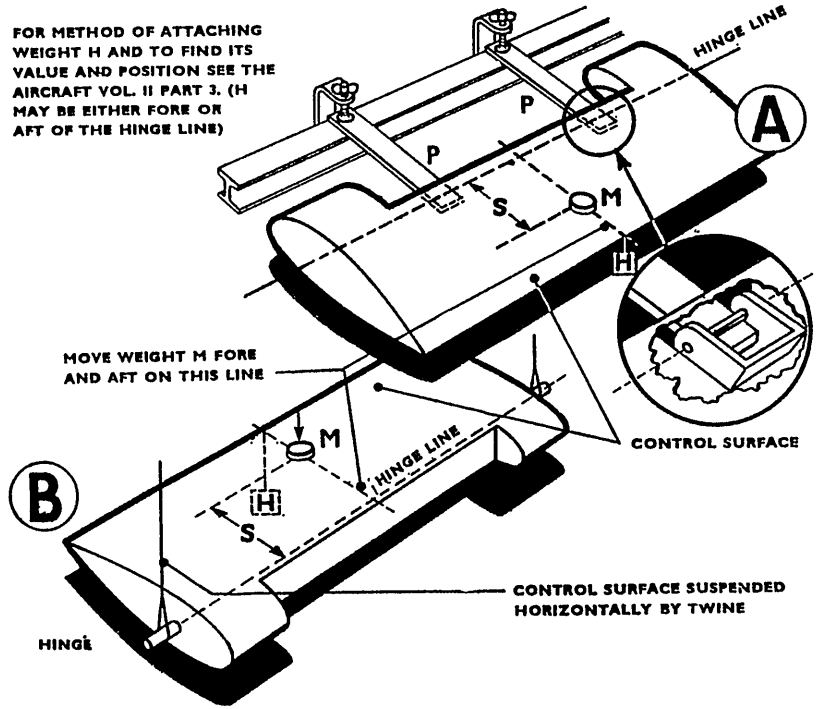
(xi) Stamp or scribe the symbol "C" on one of the bottom two lines of the control surface mod. plate if this has not already been done.

B.—CONTROL SURFACES WITH EXPOSED HINGES (Sketch B refers)

(i) Remove the control surface from the airframe.

(ii) Support the control surface by twine or flexible wire from the outer hinges. Alternatively the control surface can be balanced on knife edges placed under the outer hinge pins.

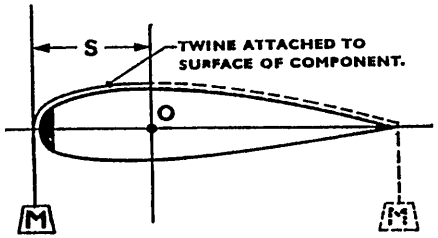
(iii) Carry out instructions (v) to (xi) as given above for components with shrouded hinges.



1205 - ALTERNATIVE FORMS OF MASS BALANCE CHECK

NOTE:—In all the sketches given in this scheme, the hinge line of the control surface passes through the point "O" shown.

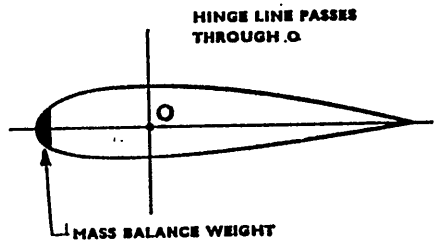
THE STANDARD BENCH CHECK for mass balance is given in scheme 1204 but it may be more convenient to use one of the three variations given below, depending on the facilities available. The general instructions given in Scheme 1204 should, however, be followed.



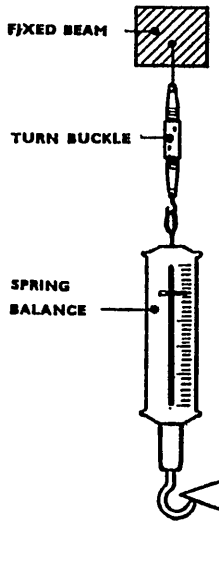
A The weight "M" used in the bench check is suspended over the nose or trailing edge of the control surface by a length of thin twine or thread attached to the top surface of the component. By varying the value of the weight "M", horizontal balance can be obtained. The arm of the weight, i.e. its distance from the hinge line is shown by the length "S" in the above sketch.

This method is particularly useful in conditions of tail-heaviness, when the curved portion of the component cannot be used to carry the balancing weight "M"

Manufacturers sometimes drill a hole in the leading edges of control surfaces to assist in checking the mass balance of the component. The hole is used by threading the twine supporting the weight "M" through it, thus eliminating the often difficult task of attaching the twine to the top surface of the component.



B In cases of tail heaviness, a piece of plasticine can be placed directly on the mass balance weight and its weight varied until horizontal balance is obtained. The plasticine is then weighed, this value being the actual weight to be added to the mass balance weight. (This is because the plasticine is the same distance from the hinge line as the mass balance weight). The mass balance weight is still restricted to a maximum permissible figure if this method is used, so don't forget to check up with the aircraft Vol. II, Part 3.

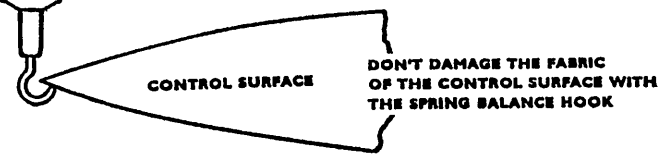


C If you have an accurate low reading spring balance available, you can use it conveniently to check the mass balance of a control surface.

For the condition of tail heaviness, the spring balance is hooked under the trailing edge of the component and raised until the latter is horizontal. The value of "M" is then read off the spring balance. Wherever possible, the spring balance should be supported by a turnbuckle attached to a fixed point. By adjusting the turnbuckle until the control surface is horizontally balanced, a very accurate reading of "M" can be made.

For the condition of nose heaviness, the procedure is as described in the previous paragraph except that spring balance is pulled downwards.

In both cases the arm of the out-of-balance force "S" is the distance between the hinge line and the point of contact between the spring balance hook and the trailing edge of the control surface.



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1206 PARTIAL CORRECTION OF MASS BALANCE

USE THIS SCHEME:—

(*a*) Where the weight "G", required to be added to the mass balance weight would cause the latter to exceed the maximum permissible value given in the aircraft Vol. II, Part 3.; or

(*b*) Where the mass balance weight cannot be adjusted due to its design.

CASE (*a*)—GO AHEAD AS FOLLOWS:—

(i) Adjust the mass balance weight to its maximum permissible value "Z" (obtain this value from the aircraft Vol. II, Part 3).

(ii) Check the mass balance of the control surface again and find the new out-of-balance moment "Ms" (don't forget to put the datum weight in position again—see Scheme 1204).

(iii) ***Condition A:*** Where "Ms" is greater than "B" (where "B" is the out-of-balance moment range—see the relevant Aircraft Vol. II, Part 3), the control surface's c.g. will be beyond the aft limit and the component will have to be replaced by one which is satisfactorily mass balanced.

Condition B: Where "Ms" is between $\frac{3}{4}$ B and B, scribe the required number of symbols "X" on the bottom two lines of the control surface mod. plate so that the symbols "XX" are left.

Condition C: Where "Ms" is between $\frac{3}{4}$B and $\frac{1}{4}$B, erase or scribe the symbol "X" on one of the bottom two lines of the control surface mod. plate so that the symbol "X" is left.

Condition D: Where "Ms" is between zero and $\frac{1}{4}$B, any symbols "X" should be erased from the bottom two lines of the control surface mod. plate.

(iv) For Conditions B to D, the control surface can be refitted to the airframe after the appropriate action has been taken.

IMPORTANT: When removing any sumbols "X" from a mod. plate, you must be particularly careful not to erase the symbol "C". Should this happen accidentally, it will mean that an otherwise unnecessary Bench Check will have to be made at a later date.

CASE (*b*)—GO AHEAD AS FOLLOWS:—

(i) Measure the out-of-balance moment "Ms" of the control surface as described in Scheme 1204 (don't forget the datum weight).

(ii) If the control surface is nose heavy, i.e. if the weight "M" has to be placed aft of the component's hinge line to obtain the condition of horizontal balance, the control surface will have to be replaced by one which is satisfactorily mass balanced. This is because the c.g. of the component is forward of the forward limit and therefore would be unsatisfactory in flight.

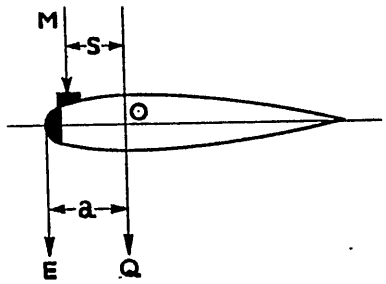
(iii) If the control surface is tail heavy, i.e. if the weight "M" has to be placed forward of the hinge line to obtain the condition of horizontal balance, compare the out-of-balance moment "MS" with the value "B" (where "B" is the out-of-balance range—see the aircraft Vol. II, Part 3), and follow the instructions set against the applicable condition given in sub-paragraphs (iii) to (iv) for Case (*a*) above. (Substitute "MS" for "Ms" in these sub-paragraphs.)

1207 TYPICAL MASS BALANCE CALCULATIONS

FOR THE SYMBOLS USED IN THESE CALCULATIONS SEE FOLDER ATTACHED TO THE OPPOSITE PAGE

THE THREE EXAMPLES GIVEN IN THIS SCHEME ARE BASED ON:—

(i) The mass balance weight is forward of the hinge line.
(ii) The maximum permissible mass balance weight "Z" = 44 ounces.
(iii) The hinge line passes through the point "O" given in the sketches below.

SKETCH	DATA	CALCULATION	REMARKS AND ACTION
	The following results are obtained from a mass balance check. "M" = 10 ounces. "S" = 4½ inches. "a" = 5 inches. ★"E" = 40 ounces. "B" = 60 inch-ounces. ★ "E" is the weight of the mass balance weight during the bench check (ounces).	Out-of-balance moment = MS = 10 × 4½ = 45 inch-ounces. Therefore the weight required to adjust the mass balance weight $= \frac{MS}{a} = \frac{45}{5} = 9$ ounces. Therefore "G" = 9 ounces.	As the weight "M" is forward of the hinge line, the component must be tail heavy and 9 ounces will have to be added to the mass balance weight which will then become E + 9 = 40 + 9 = 49 ounces. But this value is greater than "Z," the maximum permissible value. The mass balance weight having been adjusted to its maximum permissible value the out-of-balance moment will then be found to be 25 inch-ounces from the second mass balance check. As described in Scheme 1206, this moment is then compared with "B" and it will be found to be between ⅓B and ⅔B (Condition C, Scheme 1206), i.e. between 20 and 40 inch-ounces. Symbols must be scribed or erased from the control surface mod. plate so that the symbols "CX" are left. The component can then be refitted to the airframe.

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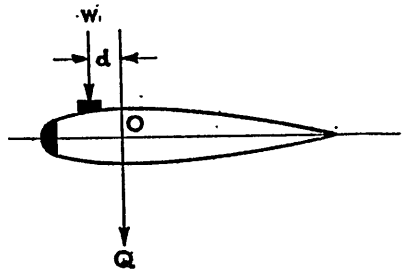
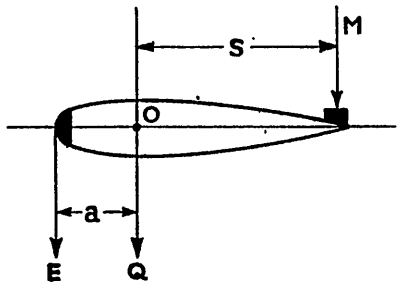
1207 - TYPICAL CALCULATIONS (CONTINUED)

SKETCH	DATA	CALCULATION	REMARKS AND ACTION
	After repairing a control surface forward of the hinge line, the repair moment "wd" was estimated "w" = 6 ounces. "d" = 4½ inches. Note: The control surface mod. plate is marked with the symbol "C" indicating that the mass balance procedure has been started but no symbol "X" is marked. This means that the control surface c.g. is on the forward limit.	The repair moment = wd ≐ 6 × 4½ = 27 inch-ounces.	As given in the data column, the c.g. of the control surface is on the forward limit. This means that the additional weight due to the repair will cause further nose heaviness of the component, moving its c.g. forward of the forward limit. The control surface must therefore be replaced by one which is satisfactorily mass balanced—see Scheme 1203.
	The following results are obtained from a mass balance check:— "M" = 4 ounces. "S" = 12 inches. "a" = 6 inches. ★"E" = 40 ounces. ★ "E" is the weight of the mass balance weight during the bench check (ounces).	Out-of-balance moment = MS = 4 × 12 = 48 inch-ounces. Therefore the weight required to adjust the mass balance weight = $\frac{MS}{a} = \frac{48}{6} = 8$ ounces. Therefore "G" = 8 ounces.	As the weight "M" is aft of the hinge line, the component must be nose heavy and 8 ounces will have to be subtracted from the mass balance weight, which will then become E — 8 = 40 — 8 = 32 ounces. This, of course, is less than "Z" and is therefore permissible. After this adjustment has been made, the component can be refitted to the airframe. (Don't forget to mark the symbol "C" on the control surface mod. plate if this has not already been done).

OPEN THIS FOLDER CLEAR OF THE REST OF THE BOOK SO THAT THE LIST OF SYMBOLS USED IN THIS CHAPTER IS VISIBLE WHILE YOU ARE READING ANY OF THE SCHEMES ON MASS BALANCE. THIS SHOULD SAVE YOU REFERRING BACKWARDS AND FORWARDS IN THE CHAPTER TO IDENTIFY THE VARIOUS SYMBOLS USED.

P19792 M40068/120M/C 11/51 500 C&P Gp. 1

This leaf issued with A.L. No. 10, November, 1949

Section I

CHAPTER 13

PROTECTIVE TREATMENT

1301—NOTES ON PROTECTIVE TREATMENT OF REPAIR WORK

In accordance with current requirements (as set out in A.D.M.615 and subsequently in A.P.970, Chap. 801, issued with A.L. No. 38) all aircraft have to be given, during manufacture, thorough anti-corrosion protection to the standard known as Class I Treatment. This chapter tells you what to do on all repair work in order to conform as closely as possible with these requirements. Schemes 1302, 1303 and 1304 are arranged as schedules with specific instructions for the treatment of steels, non-ferrous metals, and wood components respectively; the requirements for miscellaneous items are given in Scheme 1305. The necessary materials and the various process specifications involved are listed in Scheme 1306, with references to the Air Publications where full details can be found should they be needed. Protective treatment is dealt with at greater length in A.P.1464D, Vol. I, Part 2, Sect. 1, Chap. 1, to which reference may be made if necessary.

PROTECTIVE TREATMENT is given in manufacture to all parts of an airframe as a preventive against corrosion and deterioration. In the past (as a matter of wartime expediency) three classes of treatment were in use, but in future all aircraft, for which contracts were placed subsequent to the issue of A.D.M.615, will be fully Class I treated and the log books for any such aircraft will be endorsed thus:—"This aircraft conforms to the requirements of A.D.M.615". Airframe components and parts which are fully Class I treated but are otherwise identical with those delivered before the issue of A.D.M.615 will be marked "C.I.T". This marking will also appear on the packages of A.G.S. or other small parts. "C.I.T." parts should always be used when repairing Class I treated components.

WHEN MAKING REPAIRS it is most important that this high standard of protection be maintained. Even parts that have been produced to a lower standard should be given Class I treatment on repair.

WHERE LACK OF FACILITIES prevents Class I treatment being given, the best possible substitute must be used, the area so treated being suitably marked (see Scheme 1302).

TO DETECT THE EXISTING PROTECTIVE FINISH (if not marked "C" for cellulose or "S" for synthetic) rub the area with a clean cloth moistened with dope thinners (Stores Ref. 33B/904 or 451). If the cloth is readily stained with the colour, the finish is cellulose; if only after vigorous rubbing, it is synthetic. NORMALLY USE "C" on "C" and "S" on "S". "S" may be used on "C" but never "C" on "S".

THE EXCLUSION OF WATER is clearly most important and every care must be taken to prevent water leaking or being driven into covered components either on the ground or in flight. Windows, doors, etc., must be sealed effectively. Particular care must be taken to prevent water reaching electrical components or heat and sound-proofing materials (*see A.P.1464B, Vol. I, Part 2, Sect. 4, Chap. 7*).

DRAINAGE HOLES are provided when complete sealing is impossible, to ensure that accumulations of moisture can drain away freely. They must always be kept clear. If "lost" during repair, suitable new holes must be made. They must not be less than $\frac{1}{4}$ in. dia. (preferably $\frac{1}{2}$ in.) and free from internal raised lips or burrs. See Vol. I, Sect. 4, Chap. 3 of the particular aircraft handbook for a diagram of the positions of the drainage holes.

THE ONSET OF CORROSION is much accelerated when two dissimilar metals are in contact in the presence of moisture (particularly sea water) due to the electrolytic action set up. Corrosion will usually be shown up by cracking of the finish, or the finish will flake off when pressed with the finger. When corrosion is detected the area must be carefully examined to determine its full extent; a hand lens will help.

WET ASSEMBLY is essential, i.e., the contacting surfaces of built-up fittings and of metal patches, whether of the same or different materials, must always be coated with pigmented varnish jointing compound and assembled while it is still wet. In general, the excess compound should be squeezed out to form a fillet and should be wiped off only from the external surface of a flush patch. Wet assembly obviously cannot be applied to welded joints, nor to close tolerance fits where the wetting process would prevent assembly. This requirement may be waived also on riveted joints in Alclad sheet (D.T.D.390) made in situ on R.A.F. aircraft (except on joints that must be watertight).

FABRIC COVERING over a framework, as used mainly on the lighter types of aircraft, is dealt with in Chapter 14.

1302–SCHEDULE OF CLASS I PROTECTIVE TREATMENT AND REQUIREMENTS FOR STEEL PARTS

1 MATERIAL OR COMPONENT	2 METHOD OF REMOVING OLD TREATMENT OR CORROSION	3 APPROVED PRIMARY TREATMENT	4 APPROVED PROTECTIVE FINISH	5 REMARKS
STEELS (except for springs, tinned steel and *non-corrodible steel) *This requires no protective treatment except wet assembly (see *Scheme 1301*) **Note.** — Ball and roller bearing and other lubricated moving parts require no treatment.	**TO REMOVE PROTECTIVE FINISH:—** (1) Wash with soap and water. (2) Clean with degreasing liquid (Thinners, primer, Stores Ref. 33B/906 or 512), using a stiff brush on seams and rivet heads. (3) Coat with extra-strength paint remover (Ref. 33B/637 or 638) and leave for 10–20 minutes. With a hardwood scraper, remove the softened paint down to the primary-treated surface. ***Notes.***—(*a*) A respirator should be worn when using paint remover. (*b*) After local removal of existing paint, the edges of the cleaned-out area should be "feathered" with a waterproof abrasive paper wrapped round a cork block. (4) Remove any corrosion by scratch brushing, polishing with emery, or (on heavy-gauge material only) by shot or abrasive blasting. (5) Repeat operation (2). **TO REMOVE METALLISED ALUMINIUM COATING** (essential before welded repair):— Remove by filing or with a solution of caustic soda crystals dissolved in twice their weight of water. Apply the solution by brush or from a can with a spout; avoid splashing your skin or clothes, or the interior of tubes. Wash off any excess, and dry. **TO REMOVE NICKEL PLATING:—** See A.P.880B, Vol. 1, Sect. 3, Chap. 2 **TO REMOVE CADMIUM PLATING:—** See A.P.1464B/14.	CADMIUM PLATING to D.T.D.904 or METALLISING WITH ALUMINIUM to Spec. D.T.D.906 (not suitable for light-gauge sheet) or SHERADISING to Spec. D.T.D.908 (only where the high temperature of the process will not affect the material properties). **SPECIAL ITEMS:—** (a) Exhaust systems *Manifolds and stub pipes*:— ALUMINISING to D.T.D.907 or (on R.A.F. aircraft only) NICKEL PLATING to D.T.D.905 *Tail pipes and exhaust rings (external surfaces only)*:—METALLISING to D.T.D.906 or (on R.A.F. aircraft only) NICKEL PLATING to D.T.D.905. (b) Non-stainless bolts, pins, etc.—CADMIUM PLATING ONLY. (c) Bullet-proof parts need no primary treatment, and may be coated with rust preventive (Solution, Lanolin resin, pigmented, Stores Ref. 33C/584, 576 or 585) instead of the protectives specified in the next column. FOR ALL THE ABOVE PROCESSES SEE A.P.1464D, VOL. 1, PART 2, SECT. 1, CHAP. 1.	Immediately after final cleaning in accordance with Spec. D.T.D. 901, apply one of the following in accordance with Spec. D.T.D.902 (see *A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1*):— **FOR R.A.F. AIRCRAFT** (a) Primer and pigmented oil varnish to D.T.D.260 (b) Stoving enamel to D.T.D.56 (c) Primer and cellulose finish to D.T.D.63 (d) Primer and cellulose finish (matt or glossy) to D.T.D. 754 (e) Primer and matt pigmented oil varnish to D.T.D.314 (f) Primer and matt pigmented synthetic resin finish to D.T.D.517 *(g) Matt one-coat enamel to D.T.D.658 (h) Light-weight finish (cellulose base) to D.T.D.766 (i) Light-weight finish (synthetic base) to D.T.D.802 *For use by contractors on new aircraft, subsequent refinishing is to D.T.D.314. **Note . . .** When camouflage treatment is required, one of the protectives specified in (e) to (i) should be used. If in doubt as to the protective to apply, use primer and matt pigmented synthetic resin finish to D.T.D. 517. **FOR NAVAL AIRCRAFT** Primer and matt pigmented synthetic resin finish to D.T.D.517 followed by one coat of clear varnish (Stores Ref. 33B/841 or 842).	(1) Wet assembly is always a requirement (see *Scheme 1301*). (2) For surfaces to which fabric is to be doped, treat with two coats of universal primer (Stores Ref. 33B/). This requirement does not apply to surfaces to which fabric is to be attached by an adhesive. (3) Parts of exhaust systems with different metallic finishes should not be in contact. (4) Bolts in contact with timber should be [illegible] stainless steel (5.8 [illegible] unless also in contact with light alloy, when they should be of cadmium-plated non-stainless steel.

***Notes* . . .**

(a) Where metallising equipment is not available protective finish only can be applied, but it must be taped over the top and the tape painted red (so that the absence of Class I treatment is apparent) and the full treatment must be applied at the first opportunity.

(b) Exhaust system spares are supplied protected with rust preventive (Solution, lanolin resin, pigmented, Stores Ref. 33C/576, 584 or 585).

(c) Non-stainless bolts, pins, etc., should be treated, together with the surrounding structure, with protective finish after assembly.

Note . . . See also Scheme 1305 for instructions on miscellaneous items.

1303

1303—SCHEDULE OF CLASS I PROTECTIVE TREATMENT AND REQUIREMENTS FOR NON-FERROUS METALS

1 MATERIAL OR COMPONENT	2 METHOD OF REMOVING OLD TREATMENT OR CORROSION	3 APPROVED PRIMARY TREATMENT	4 APPROVED PROTECTIVE FINISH	5 REMARKS
ALUMINIUM AND ALUMINIUM RICH ALLOYS (except for rivets and tubing supplied in coils)	(1) Wash with soap and water. (2) Clean with degreasing liquid (as for steel, see column 2 of *Scheme 1302*). (3) Remove paint with paint remover (as for steel, see column 2 of *Scheme 1302*). (4) Remove any corrosion with a cloth soaked in dope thinners (Ref. 33B/904 or 451) or paraffin. Fine emery or a wire brush may be used at the discretion of the Engineer Officer. (5) Again clean as in operation (2) for steel.	DEOXIDINE 202 (see *A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1*) or where facilities are available *ANODISING to Spec. D.T.D.910 or CHROMIC PICKLING to Spec. D.T.D. 915A (for alclad only) *In the case of structural tubing, the internal surfaces need not be anodised.	After cleaning in accordance with Spec. D.T.D.901, apply protective as for steels on R.A.F. and Naval aircraft, respectively. Metal surfaces within planes and control surfaces may, however, be treated instead with one coat of rust preventive to Spec. D.T.D.279 (Solution, lanolin resin, pigmented, Stores Ref. 33C/576, 584 or 585). **Note . . .** Hulls and floats should receive one coat of white zinc oxide to Spec. D.T.D.420 (Stores Ref. 33B/367) followed by one coat of matt pigmented lanolin - resin to Spec. D.T.D.420 (Stores Ref. 33B/).	(1) Wet assembly is always a requirement (see *Scheme 1301*). (2) For surfaces to which fabric is to be doped, treat with two coats of universal primer (Stores Ref. 33B/). This requirement does not apply to surfaces to which fabric is to be attached by an adhesive.
MAGNESIUM RICH ALLOYS	(1) Wash with soap and water. (2) Clean with degreasing liquid (Thinners primer, Stores Ref. 33B/906 or 512). (3) Remove paint with a stiff brush or soften the paint with paint remover and scrape lightly. (4) Remove corrosion with a stiff brush and then by swabbing with a solution of chromic acid* for selenious acid treatment or a solution of acid chromate* for acid chromate treatment. (5) Wash thoroughly with clean water. *These solutions are made up as instructed in A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1.	SELENIOUS ACID TREATMENT Swab with a solution of selenious acid* until a brown or brown-black colour appears on the surface of the metal. ACID CHROMATE TREATMENT Apply a swab of acid chromate solution* for 10 to 15 seconds, wash thoroughly and dry or apply chromate treatment to Spec. D.T.D.911 (See *A.P.2656A, Vol. 1, Sect. 5, Chap. 2*).	After cleaning in accordance with Spec. D.T.D.901, apply magnesium alloy primer (Stores Ref. 33B/213 or 560) and finishing coats as for steels on R.A.F. and Naval aircraft, respectively, to all surfaces except the interior of fuel and oil tanks. **Note . . .** Zinc shims, in addition to rust preventive or jointing compound, must always be used between magnesium alloy and wood.	As above for aluminium, etc. **WARNING** **Do not allow the selenious acid or acid chromate solutions to come into contact with the skin or clothing of personnel**
COPPER AND COPPER BASE ALLOYS	(1) Wash with soap and water. (2) Degrease with trichlorethylene (Ref. 33C/547 or 836) or other organic solvent, and clean in accordance with Spec. D.T.D.901.	(1) CADMIUM PLATING to D.T.D.904. **Note . . .** For R.A.F. aircraft only, tin plating may be employed as an alternative. (2) Again clean in accordance with Spec. D.T.D.901.	After cleaning in accordance with Spec. D.T.D.901, apply protective as for steels on R.A.F. and Naval aircraft, respectively.	

Note . . . See also Scheme 1305 for instructions on miscellaneous items.

1304—SCHEDULE OF CLASS I PROTECTIVE TREATMENT FOR WOODEN COMPONENTS

(A) METHOD OF REMOVING OLD TREATMENT

TO REMOVE PROTECTIVE FROM FABRIC-COVERED PLYWOOD:—

(1) Clean the area with degreasing liquid. (Thinners, primer, Stores Ref. 33B/906 or 512).

(2) Remove the dope with dope thinners until only a thin filling of the basic dope is left in the fabric. Where the fabric has to be removed, clean down to the bare wood and smooth the surface with fine glass paper.

Should the finish be synthetic it must be removed from an area extending 2 to 3 in. beyond the damage to eliminate the danger of putting cellulose dope on top of the synthetic. This finish can be removed by carefully rubbing with waterproof abrasive paper, or a cloth moistened with dope thinners.

TO REMOVE PAINT FROM WOOD:—

(1) Apply paint remover.

(2) Smooth down with fine glass paper.

(3) If necessary, remove all traces of oil and grease from the surrounding area with degreasing liquid.

(B) PROCEDURE FOR LOCAL RESTORATION

TO RESTORE FINISH WHEN WORN AWAY LOCALLY, LEAVING THE FABRIC INTACT:—

(1) Clean the area with degreasing liquid. (Thinners, primer, Stores Ref. 33B/906 or 512).

(2) Proceed as in operation (7) of column (C)

TO PARTIALLY REPLACE FABRIC AND RESTORE FINISH LOCALLY:—

(1) After pulling back the fabric clear of the damaged area, trim it squarely with scissors or a knife. DO NOT USE a knife bearing on the plywood, or you may do serious damage, but protect the plywood by inserting a strip of metal between it and the fabric.

(2) Cut new fabric to butt squarely against the trimmed edges.

(3) Proceed as in operations (1) and (2) of column (C).

(4) Brush or spray on a second coat and attach the fabric by the alternative method described after operation (5) of column (C). Use the same method to cover the joints with serrated tape mitred at 45 deg. at the corners.

Note . . . For small areas, serrated tape will not be required but the fabric patch must overlap 2 in. all round. *(For examples see Schemes 3204 and 3211.)*

(5) Finish as in operation (7) of column (C).

(C) METHOD OF TREATMENT AFTER REPAIR

PROCEDURE AFTER COMPLETING REPAIRS AS DESCRIBED IN CHAPTER 32:—

(1) Smooth the plywood surface with No. 1 abrasive paper and remove the dust. Fill any holes or crevices with stopper.

(2) Brush on a full coat of transparent tautening dope and allow to dry.

(3) Brush or spray on a second coat and allow to dry.

(4) Stretch Madapollam fabric as tightly as possible over the surface and tack in position, leaving sufficient overlap to dope subsequently over all free edges of the plywood. Alternatively, use serrated tape along the edges, in which event no fabric overlap is needed.

(5) Immediately brush on a coat of transparent tautening dope to a convenient area and thoroughly work it in to fill the interstices of the fabric. (Alternatively, a coat thinned with two or three parts of dope thinners may be used to ensure better penetration.) Each area must show a clean edge of applied dope so that adjacent areas can be properly bonded to it. Remove all air bubbles by smoothing with a fabric pad damped in dope thinners.

As an alternative to (4) and (5), stretch the fabric over the surface while the second coat (applied at (3)) is still wet, tack where necessary, and smooth out as quickly as possible with a fabric pad damped in dope thinners. Follow with a coat of transparent tautening dope.

(6) Apply serrated tape by the same method.

(7) Apply three or four even coats of aluminium non-tautening finish (allowing each coat to dry before adding the next), followed by one or two coats of pigmented non-tautening finish (camouflage colours) as necessary. If a glossy finish is required, add one or two coats of transparent cellulose finish.

Note . . . FOR INTERNAL SURFACES of ply-covered components and hollow members, protection is only necessary where a colour is required, and will not be applied to a surface which is later to be glued. End grain of members (such as spars) within ply-covered components should be protected with bituminous paint. (Solution, bitumen, Stores Ref. 33A/250 or 595).

(D) REMARKS

All wooden framework structures carrying fabric covering, such as wheel wells, bomb bays, planes, and control surfaces, should be treated with one coat of primer and two coats of aluminium pigmented cellulose enamel, followed, where necessary, by camouflage finish. Surfaces to which fabric is to be doped are then to be treated with two coats of universal primer. (This requirement does not apply to surfaces to which the fabric is attached by adhesive.)

Floors and cat-walks:—Treat with creosote (Stores Ref. 33A/227), or as above

Bolt holes:—Treat with rust preventive (Stores Ref. 33C/527 or 932).

Bilges of wooden hulls:—Treat with bituminous paint (Solution, bitumen, Stores Ref. 33A/250 or 595).

THE DOPES must be the following, applied as instructed in column (C) to give approx. the weights specified:—

Stores Ref.	Description	Wt. in oz. per sq. yd.	No. of coats normally required
33B/873 or 802	Transparent tautening dope	2	3 or 4
33B/879 or 654	Aluminium non-tautening finish	2	3 or 4
See note below	Pigmented non-tautening finish	1	1 or 2
33B/885 or 805	Transparent cellulose finish	1	1 or 2

Note . . . For Stores Ref. of colour required see A.P.2656A, Vol. 1, Sect. 1, Chap. 2, Appendix 2.

1305—NOTES ON THE TREATMENT OF MISCELLANEOUS ITEMS

FUEL AND OIL TANKS

(a) Tinned-steel tanks are left unpainted internally. All flux must be removed by thorough washing with hot water, and drying.

(b) Magnesium-alloy tanks are also left unpainted internally. Externally the treatment is as stated in Scheme 1303.

(c) Aluminium-alloy tanks are anodised internally and externally before riveting or after welding.

(d) All fuel tanks of aluminium, aluminium-alloy or magnesium rich alloy require an inhibitor cartridge containing calcium chromate to Spec. D.T.D.495.

A.P.1464D, Vol. 1, Part 2, Sect. 5 gives particulars of tank repairs.

DRINKING WATER TANKS of aluminium alloy require a coat of clear varnish to Spec. D.T.D.234 over the anodised interior surfaces.

TANK STRAP PACKINGS are to be treated with a protective finish.

PIPES, CLIPS AND PACKING MATERIAL

(a) Packings between light-alloy pipes and clips must be one of the following:—

(i) Mould-resisting cork to D.T.D.789

(ii) L.T. varnished insulating tubing to D.T.D.320

(iii) Vulcanised fibre to D.T.D.37.

(b) Pipes must be given their final protective coating before being clipped in position, except for tubing supplied in coils which may be run into position on the aircraft and then painted in situ. Pipes used for conveying liquids or gases should not be painted internally.

(c) Any portions of metal pipes in contact with flexible end connections must be painted with a protective finish.

(d) Screwed unions in fuel, oil, hydraulic and pneumatic systems do not need "wet assembly".

ACCUMULATOR STOWAGES

Accumulator stowages and adjacent parts are to have two coats of the appropriate material specified below. Application may be on unpainted woodwork or on top of the normal protective coating:—

For acid accumulators—acid-resisting paint.
For alkaline accumulators—bituminous paint.

HYDRAULIC MECHANISMS

External surfaces of parts containing hydraulic fluid to Spec. D.T.D.641, and neighbouring parts likely to come into contact with the fluid, require final protection by a coat of primer and cellulose enamel to Spec. D.T.D.399, or an approved primer and finishing coat. Ram rods and plunger tubes are hard chromium plated, and must not be painted.

CABLES

Flexible cables, unless of stainless steel, are to be soaked in rust preventive to Spec. D.T.D.121 before assembly in an aircraft. Any excess must be removed from parts which will come into contact with pulleys or fairleads, to obviate adhesion of dust or grit.

BONDING

Any damage to protective treatment, resulting from making proper electrical contact for bonding, must be made good by applying the appropriate coat of primer and two of finish. The bonding clips must be similarly protected.

1306—LISTS OF PROCESSES AND OF MATERIALS FOR CLASS 1 PROTECTIVE TREATMENT

PROCESS	SPECIFICATION	REFERENCE
Cleaning of metals before protective treatment	D.T.D.901	A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1
Use of organic protective	D.T.D.902	A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1
Cadmium plating	D.T.D.904	A.P.880B, Vol. 1, Sect. 3, Chap. 6
Nickel plating	D.T.D.905	A.P.880B, Vol. 1, Sect. 3, Chap. 2
Metallising with aluminium	D.T.D.906	A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1
Aluminising	D.T.D.907	—
Sherardising	D.T.D.908	A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1
Anodising (anodic oxidation)	D.T.D.910	A.P.880B, Vol. 1, Sect. 3, Chap. 10
Protection of magnesium rich alloys	D.T.D.911	A.P.2656A, Vol. 1, Sect. 5, Chap. 2
Protection of external surfaces of plywood	D.T.D.912	See Scheme 1304
Chromic pickling (cleaning of aluminium)	D.T.D.915	A.P.2656A, Vol. 1, Sect. 5, Chap. 1
Deoxidine 202	—	A.P.1464D, Vol. 1, Part 2, Sect. 1, Chap. 1
Selenious acid treatment for repair of chromate film	—	
Acid chromate treatment for repair of chromate film	—	

MATERIAL	SPECIFICATION	STORES REF.
Compound, pigmented varnish jointing	D.T.D.369	33C/885 or 886
Cotton fabric, strip	—	32/B (a)
Creosote, coal tar	—	32A/227
Deoxidine, No. 202	—	33C/748 or 884
Dope, tautening, transparent	D.T.D.751	33B/873 or 802
Enamel, cellulose	D.T.D.63	33B/ (b)
Enamel, stoving, black	D.T.D.56	33A/333
Enamel, synthetic	D.T.D.260	33B/ (b)
Fabric, madapollam	D.T.D.343	32B/556 or 569
Fibre, vulcanised, sheet	D.T.D.37	5F/ (c)
Finish, light-weight, cellulose base	D.T.D.766	33B/859
Finish, light-weight, synthetic base	D.T.D.802	33B/922 or 923
Finish, pigmented, lanoline resin, matt, white	D.T.D.420	33B/464 or 579
Finish, pigmented, lanoline resin, matt, zinc oxide, white	D.T.D.420	33B/367
Finish, synthetic	D.T.D.314	33B/ (b)
Finish, synthetic	D.T.D.517	33B/ (b)
Finish, cellulose	D.T.D.754	33B/ (b)
Packing, joint, Langite, tropical	—	32B/ (c)
Paint, anti-sulphuric	B.S.S.X.19	33A/ (d)
Paper, rubbing, waterproof	—	33C/645, 646, 647 or 648
Primers, universal	—	33B/ (b)
Primers, magnesium alloy	D.T.D.911	33B/213 or 560
Remover, paint, Type B	D.T.D.266	33B/637 or 638
Rust preventive	D.T.D.121	33C/527 or 932
Soda, caustic, crystals	—	33C/180
Solution, bitumen	B.S.S.X.9	33A/250 or 595
Solution, lanolin resin, pigmented	D.T.D.279	33C/584, 576 or 585
Stoppers, oil base	—	33B/534
Thinners, dope, anti-chill	D.T.D.83	33B/904 or 451
Thinners, primer	—	33B/906 or 512
Trichlorethylene	—	33C/547 or 836
Tubing, insulating, L.T.	D.T.D.320	5F/ (e)
Varnish, clear	—	33B/841 or 842

Notes . . .

(a) Reference number according to width
(b) Reference number according to colour and whether for home or overseas
(c) Reference number according to thickness
(d) Reference number according to colour and size of container
(e) Reference number according to colour and internal diameter

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Section I

FABRIC REPAIRS

CHAPTER 14

GENERAL NOTES ON THE USE OF FABRICS

THE USE OF FABRIC as a covering for airframe structures, though not universal as in the early days of flying, is still widespread on light-weight and slower-speed types, and on control surfaces. Its use for the external finish of ply-covered structures is essentially part of the plywood protective treatment and is accordingly dealt with in Chapter 13 of this publication (see Scheme 1305).

FABRIC COVERING, as considered in this chapter, maintains the external shape of the aircraft, carries the air loads and transmits them to the structure as well as giving protection from the weather. Its good condition is therefore vital to the efficiency of the aircraft and the safety of its crew.

BEFORE OPENING UP FABRIC prior to repair or to inspect internal structure, consider the purpose for which the opening is required. When it is obvious that structural repairs are needed, a large opening must be made. Cut along the centre-line of a rib and along the trailing edge seam, or elsewhere at right-angles to the rib, but do not cut along a lap or balloon seam. Repair the cuts to Scheme 1403 and renew the stringing, which has the effect of strengthening the repair; the surface should be as smooth as it was originally. Smaller holes may be made by L or X-shaped cuts, preferably on the undersurface of a wing, at least 2 in. clear of existing seams. These cuts should be parallel to the warp or weft of the fabric, which may be fitted straight or on the bias. In the former case the warp and weft are parallel to the main members, in the latter at 45 degrees.

INSPECTION OPENINGS are provided where considered necessary by the manufacturer, but if you find you have to open up frequently in another place, fit a frame as described in Scheme 1404. The fabric patch doped on over the opening can be removed and renewed as often as required.

BE CAREFUL NOT TO DAMAGE INTERNAL STRUCTURE when making cuts in fabric.

SPECIAL METHODS OF ATTACHMENT, as distinct from the normal stringing, are often used. Instructions for repair of such schemes will be found in the Vol. II, Part 3 of the handbook for the aircraft concerned.

ALL JOINS IN FABRIC must be covered with serrated-edge fabric doped in position. The outer edge of a lap joint must never be exposed to the airstream (except, of course, the edge of the covering fabric). All single-thickness edges must be serrated with pinking shears, or where these are not available frayed to a depth of $\frac{1}{4}$ in.

DRAINAGE HOLES are provided at all points where moisture might collect, the fabric being reinforced by doped-on plastic eyelets. It is most important that these holes are kept clear and that, where they are removed in making repairs, new eyelets are fitted in the appropriate positions.

SURFACES OF WOOD OR METAL likely to come into contact with fabric during doping must be protected with a paint which will not be affected by the dope. This requirement is covered in Chapter 13 (see Scheme 1303 for metal and 1304 for wood).

CORRECT DOPING TECHNIQUE is most important if repairs are to be satisfactory. Fabric patches must not be doped direct on to synthetic camouflage finish because it would be impossible to obtain adequate adhesion. The finish must be cleaned off down to the basic coat of dope (see Scheme 1407).

SMOOTH FINISH OF FABRIC REPAIRS may be of paramount importance, particularly on high-performance aircraft. This point is referred to in general terms in Scheme 1104. Detail instructions are given in A.P.2656A.

1402 — MATERIALS AND TOOLS USED

FABRIC USED IN AIRFRAME REPAIRS may be of the following grades:—

(1) Linen fabric—an unbleached Irish linen to Specification D.T.D.540 in widths of 38, 48 and 54 in., generally used for covering airframe parts (Stores Ref. 32B/147, 614 or 615).

(2) Madapollam fabric—a bleached cotton material to Specification D.T.D. 343 in widths of 40 and 50in., lighter in weight than (1) and used mainly for direct covering on plywood surfaces (see Scheme 1305).

These fabrics are woven from yarns, those extending lengthwise being called "the warp", and those crosswise "the weft". The fabric is supplied in lengths or "bolts" of 75 to 125 yds., one of the lengthwise edges (called the selvedge) being specially woven to prevent fraying.

FABRIC WILL DETERIORATE unless properly stored. It should be kept in racks in a dry place at an even temperature of about 70 deg. F, where strong sunlight is excluded.

INSPECT EACH LENGTH OF FABRIC before use for signs of acid or oil stains, or any other discoloration such as iron mould. Major weaving defects will be found marked by red cotton stitches in the selvedge. If such fabric has to be used for repairing large areas, cut out the defective parts and patch by one of the methods given later in this chapter; it is obviously preferable however, to avoid the need for such work by using the material for making patches, leaving the defective areas in the waste.

OTHER MATERIALS USED in fabric repair work, apart from the two grades of fabric previously mentioned, include:—

(1) Egyptian tape (Stores Ref. 32B/686)—a 1 in. wide cotton tape used for binding ribs etc., and for reinforcing fabric prior to stringing.

(2) Fabric strip (Stores Ref. 32B/751–758)—of linen fabric in widths varying from 2¼ in. to 12 in. The lengthwise edges are serrated so that the strip is ready for use in the covering of seams and the repair of cuts, etc.

(3) No. 40 linen thread (Stores Ref. 32B/659)—for hand stitching used doubled and well waxed, but for machine stitching single and unwaxed.

(4) Beeswax (Stores Ref. 33C/10)—for thread when hand stitching.

(5) Braided stringing cord (Stores Ref. 32A/94)—for stringing fabric to airframe structures.

(6) Kite cord (Stores Ref. 32A/4–10)—for lacing fabric where repeated access to the interior of an airframe structure is required.

(7) Drainage eyelets— of cellulose acetate, to provide outlets for moisture and fumes and to equalise inside and outside air pressures at varying altitudes.

The shielded type (Stores Ref. 28N/5409) are for use on sea-going aircraft, the plain type (Stores Ref. 28N/473) on other aircraft.

(8) Inspection (Woods') frames (Stores Ref. 27H/1193 and 1194)—see scheme 1404.

"TOOLS" USED FOR FABRIC REPAIRS.—In addition to the tools found in a flight mechanic's normal kit, you will also need:—

(1) Needles in various sizes—straight (Stores Ref. 1B/1614—1620) for hand stitching; circular (Stores Ref. 1B/) for hand stitching enclosed flat surfaces; upholsterers (Stores Ref. 1B/1634–8) for stringing.

(2) Tailors' shears (Stores Ref. 1C/2586)—for normal trimming and cutting out.

(3) Serrating shears (Stores Ref. 1C/5501)—for serrating or "pinking" the edges of patches to prevent fraying and to aid adhesion between patches and the original fabric.

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1403 — REPAIR OF CUTS AND TEARS (HERRINGBONE STITCH)

USE THIS METHOD where:—

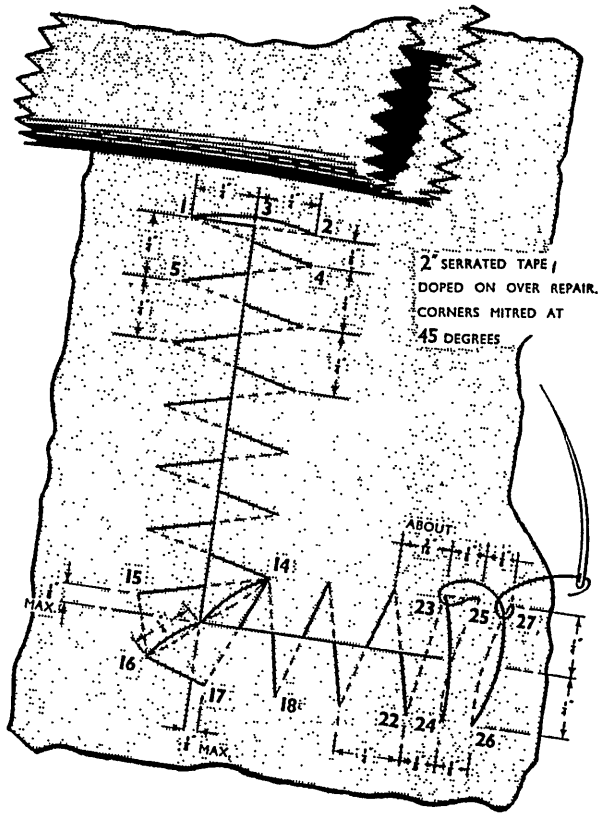
(1) The tear or cut is straight, L or X-shaped.
(2) It affects less than ¼ of the smallest dimension of the damaged panel.
(3) No part of the tear is closer than 2 in. to a seam or stringing.
(4) The fibres of the fabric are not bruised or damaged so as to render the repair unsatisfactory.

More severe damage will necessitate a patch or partial replacement of the panel (see Scheme 1404).

GO AHEAD AS FOLLOWS:—

(1) Start with an OVERSTITCH: use No. 40 linen thread, waxed. In accordance with the dimensions shown in the illustration, pass the knotted thread up through 1, down through 2, up through the tear at 3, down through 1 again, and up through the tear to 4.
(2) Continue with the HERRINGBONE STITCH, down through 4, up through the tear, down through 5 and so on at about ¼ in. pitch.
(3) Where necessary to turn a corner, after going down at 14, up through the tear and down at 15, come up at 16, down through the tear at the corner and up through 14 again, down through the corner once more and up at 16; go down at 17, up through the tear and down at 14 once again, up through the tear and continue the herringbone through 18. Adhere to the dimensions given in the illustration.
(4) Finish off with an overstitch and two HALF HITCHES. Having taken the thread down at 22, go almost straight across and up at 23. Go down at 24, up at 25 and pass the thread under the loop (23 to 24); repeat this at 26–27.
(5) It is not normally necessary to remove existing dope; if the amount is excessive, it should be cleaned off with dope thinners.
(6) Brush on a coat of red dope over the entire repair area.
(7) Apply serrated-edge tape or a serrated-edge patch so that it covers the repaired tear by at least 1 in. all round.
(8) Rub red dope through the tape or patch with a pad of waste rag.
(9) Apply a further coat of red dope.
(10) Make good the finishing coats, using the appropriate colour "C" materials.

IMPORTANT—When sewing up a tear, pull the edges closely together but not so tightly as to cause the fabric to pucker.



Note.—The above dimensions are for general guidance, but should not be exceeded.

1404 — REPAIR OF SMALL HOLES

HOLES UP TO A MAXIMUM OF 2 IN. SQUARE may be repaired by darning, though the use of a reinforcing frame as given below may be more convenient.

(1) Use No. 40 thread, waxed and doubled.

(2) Stitches should be $\frac{1}{4}$ in. apart and at least $\frac{1}{4}$ in. from the edge of the tear; the edges need not be trimmed.

(3) Follow the line of the weft and warp and interweave the stitches. Do not use excessive tension.

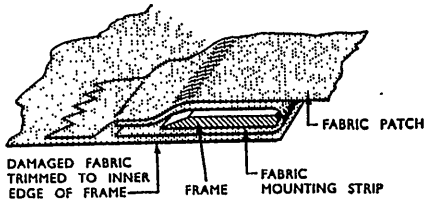
(4) Dope on a fabric patch overlapping by $1\frac{1}{2}$ in. all round the damage.

FOR HOLES UP ABOUT 4 IN. SQUARE the repair should be made by doping on a reinforcing frame and then cutting out the damaged fabric up to the inner edge. This method is more convenient than darning or sewing in a patch. The frames should be circular or square with rounded corners; they are normally made of cellulose acetate not less than 0·03 in. thick and 1 in. wide with the outer edges chamfered. Alternatively, they may be made of dural or aluminium not thinner than 24 s.w.g. This must be mounted on fabric carried round from the underside through the frame and over the top so that the two thicknesses coming together outside the frame can be doped down to the main fabric. Frames must be fitted clear of existing seams or attachments. Owing to the bumps they form on a wing surface, they are not suitable for use on high-speed type aircraft and their use on the upper surfaces of wings should be avoided on any type if performance is of importance. On such aircraft, repairs should be done by patching according to Scheme 1405.

TO FIT A REINFORCING FRAME go ahead as follows:—

(1) Clean off the camouflage and the dope down to a clean surface of red dope for $2\frac{1}{2}$ in. to 3 in. all round the damage.

(2) Dope on the frame with its straight edges (when using a square frame) in line with the warp and weft of the fabric.



ATTACHMENT OF METAL FRAME

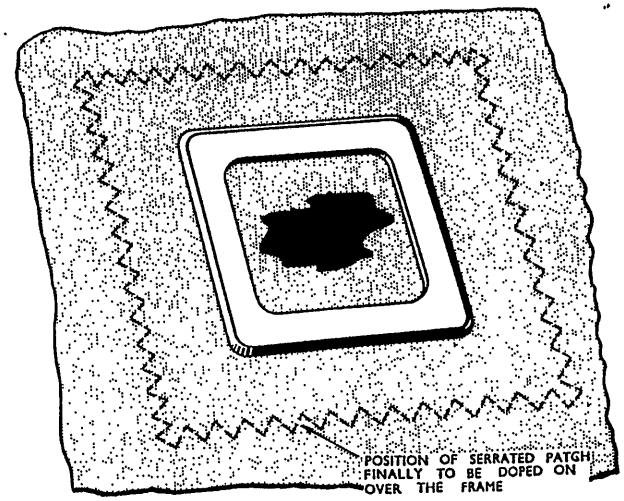
(3) When dry, cut out the damaged fabric to the inner edges of the frame.

(4) Dope on a fabric patch overlapping the frame by $1\frac{1}{2}$ in. all round.

(5) Restore doping scheme.

Note.—The outer edges of frames should be chamfered.

TO REMOVE A FABRIC PATCH for inspection, make an X-shaped cut in the opening in the frame and rip the fabric off outwards. This is better than trying to lift the corners with a penknife.



CELLULOSE ACETATE FRAMES AVAILABLE FROM STORES

Stores Ref.	27H/1193	27H/1194
Part No.	A.G.S.583	A.G.S.582
Size of hole	2 in. square	$4\frac{5}{8}$ in. square
Size overall	4 in. square	$6\frac{5}{8}$ in. square

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1405 — REPAIR OF HOLES BY PATCHING

FOR DAMAGE GREATER THAN 4½ IN. SQUARE and up to that needing renewal of a complete width of panel, a new piece of fabric must be sewn in.

THE STEPS IN THIS REPAIR ARE:—

(1) Cut out the damage with cuts parallel to the warp and weft of the fabric.

(2) Clean off all old dope till the fabric is moderately flexible.

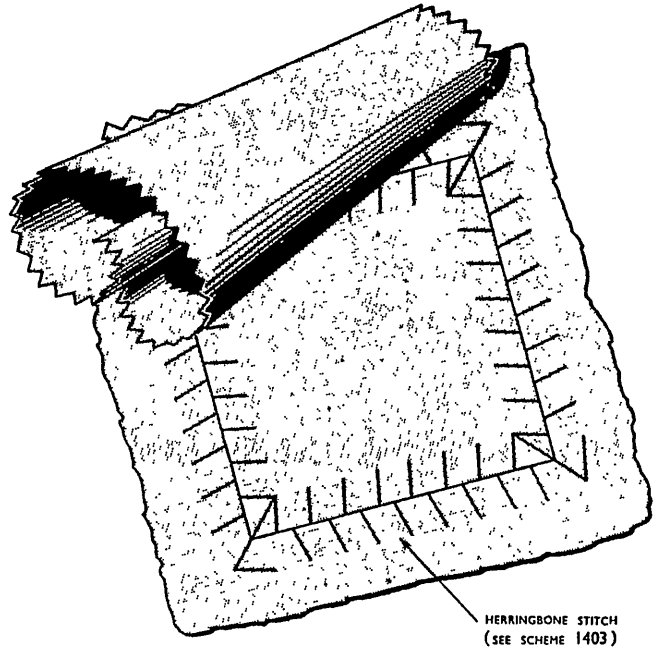
(3) Cut about ⅝ in. diagonally into the corners and fold under ½ in. all round. Tack or hem in position (see Scheme 1406).

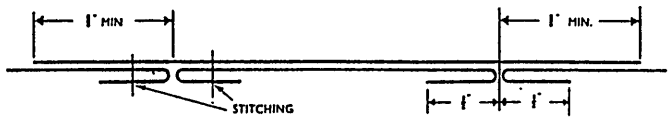
(4) Cut a patch to fit the hole with ½ in. to spare all round, and fold this ½ in. under and secure by tacking.

(5) Sew all round to join patch to fabric with herringbone stitches at about four per inch (see Scheme 1403) and draw the thread tight enough to just close the gap without puckering.

(6) Dope on a fabric covering patch, with serrated edges, to overlap the join 1 in. all round. If its size would be greater than about 8 in. square, use strips of 2 in. wide serrated tape along each seam instead, mitring at 45 deg. for the corner joints.

(7) Restore doping scheme.





SECTION THROUGH REPAIR

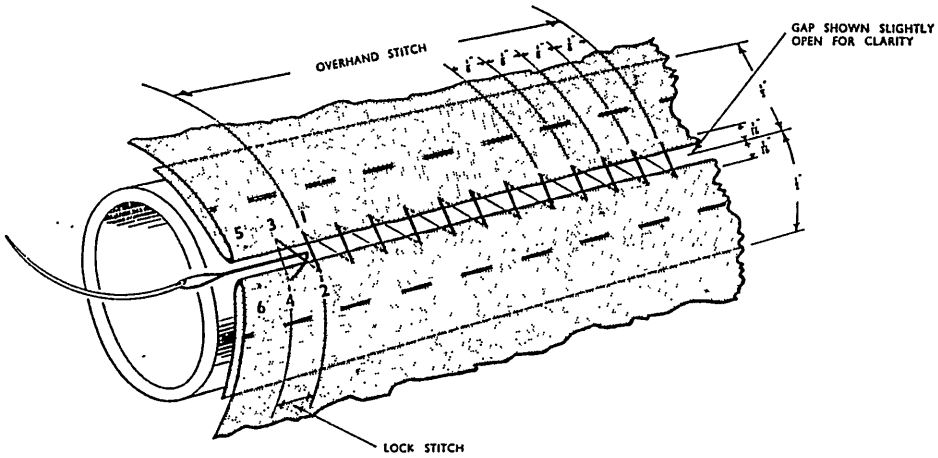
1406 — SEAMS FOR LARGE REPAIRS

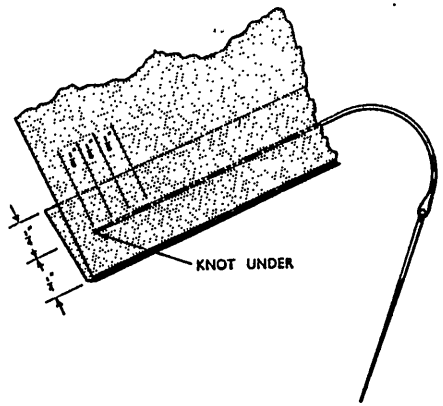
OVERHAND STITCH

Use this stitch for joining fabric at the edges of a component (along a trailing edge for instance). First turn back the edges of the fabric $\frac{1}{4}$ in. and hem or tack in position (see below). Bring the thread (double and waxed) up through the folded fabric about $\frac{1}{16}$ in. from the fold, take it straight across over the gap and down again. Bring it up $\frac{1}{8}$ in. from the first stitch and straight across again. The advance of $\frac{1}{8}$ in. for each stitch is made entirely on the underside. As each stitch is made, draw it just tight enough to close the gap without overlapping. Prevent the thread from slipping by holding it with the thumb while you make the next stitch.

LOCK STITCH

Make a lock stitch in the overhand seam at intervals of about 2 in., to prevent the seam pulling out if the thread breaks anywhere. After coming up at 1 make an overstitch down at 2, up through the gap and down again at 3; go up through 4, down in the gap between 1–2 and 2–3 and under the two threads (2–3 and 3–4). Continue overstitch up through 5 and down at 6, and so on.





HEMMING STITCH

Use this stitch to sew a fold along the edge of a piece of fabric to provide a smooth, straight and non-fraying edge. Use No. 40 thread well waxed and doubled. Make straight stitches up and down through the material at $\frac{1}{8}$ in. pitch and $\frac{1}{4}$ in. from the edge of the $\frac{1}{2}$ in. fold as shown in the above sketch. As this form of stitch can pull out if the thread should break, take an occasional back stitch to lock it.

TACKING STITCH

Use the tacking or basting stitch to hold two pieces of fabric or a fold temporarily in position. Take a single thread through the material as in hemming but at from $\frac{1}{4}$ in. to 1 in. intervals, and pull it out when you have finished the subsequent seam.

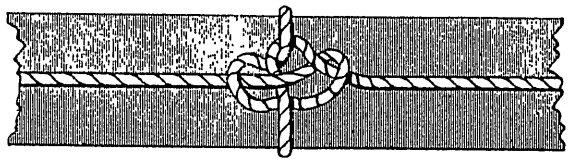
1407 — STRINGING

STRINGING IS THE USUAL METHOD of attaching fabric to aircraft structures. Essentially it consists of tying the fabric down to ribs or similar members, using No. 1 braided cord to Spec. BSS. F.35 (Stores Ref. 32A/94) thoroughly beeswaxed to make it waterproof.

TO REINFORCE THE FABRIC where pierced by the stringing cord, a strip of Egyptian tape is used overlapping the rib boom by $\frac{3}{8}$ in. each side. In addition, where chafing may occur, a similar strip under the main fabric is tacked round the rib boom or attached by gluing. Finally a strip of serrated-edge fabric or tape is doped on to cover the stringing.

SPECIAL METHODS of holding fabric to ribs by wire or cord passing through eyelets or by gluing it down direct are not dealt with here, but will be found in the Vol. II, Part 3 or 4 for the aircraft concerned.

THE FORM OF KNOT to use is shown in the sketch below. Some aircraft will have double knots at intervals to give greater security. Copy the existing stringing when doing repairs. Knots may be on top or bottom surfaces as convenient, and preferably at the side of the rib. The stringing must fit snugly against the side of the rib.

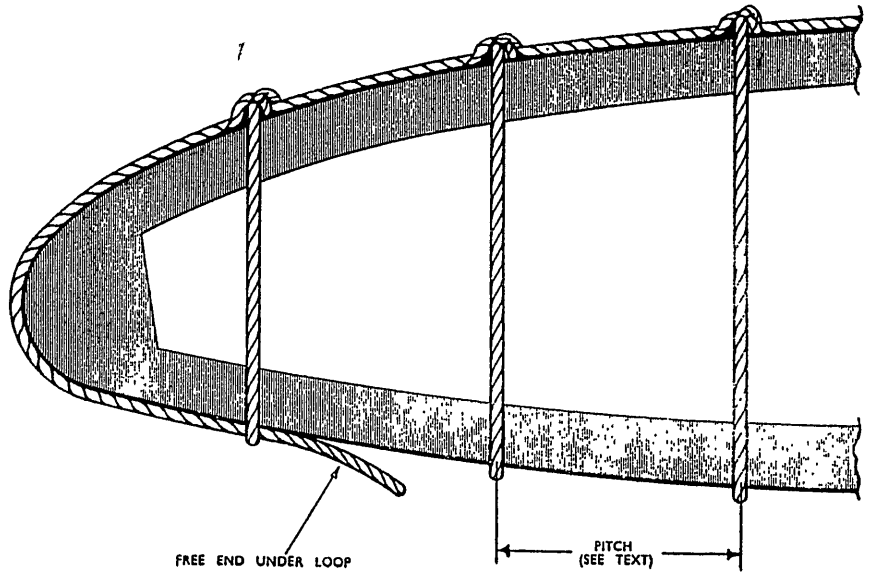


STRINGING KNOT

THE LOOPS of the stringing on shallow aerofoils (up to about 6 in. deep) go round the full depth of the rib. On medium depth aerofoils (6 in. to 14 in. deep) alternate loops are taken round the boom only. On deeper aerofoils (over about 14 in. deep) all loops go round the boom except, of course, on diaphragm-type ribs where all loops must be full depth whatever the dimension. The stringing must be tight but not so as to distort the ribs.

AEROFOILS UP TO 6 IN. DEEP

STRINGING FULL DEPTH OF RIB



1408 — DOPES AND DOPING SCHEMES

THE FUNCTIONS OF THE DOPE FINISH for fabric covering are these:—

(1) To tauten and strengthen the fabric so that it will maintain its shape, yet remain sufficiently flexible,

(2) To make the covering airtight,

(3) To make the covering waterproof and oilproof,

(4) To protect the fabric from deterioration by sunlight, and

(5) To present a smooth surface to the airflow.

DOPES SHOULD BE OF CELLULOSE MATERIAL and each fabric-covered component should be marked with the letter "C" to denote the finish used. Occasionally materials of the synthetic class have been used for the camouflage coats, identified by the letter "S" instead of "C".

TO IDENTIFY THE FINISH, when there is any doubt, rub a small area with a clean cloth moistened with dope thinners; if the finish is "C" the colour will immediately stain the cloth; if "S" only after vigorous rubbing. Don't be misled by dirt discolouring the cloth.

MINOR REPAIRS as described in Schemes 1403 and 1404, may usually be done without removing the old dope, but if a synthetic material has been used for the camouflage coats it must be removed, as cellulose will not adhere to it properly and will spoil its adhesion. Clean off the synthetic coats from an area sufficiently large to allow you to redope over the repair, and use synthetic finishes to match the original treatment.

THE DOPING SCHEME for repairs which involve removal of the old dope, or on areas of new fabric, will be one of the following:—

Scheme of Low Tautness to Spec. D.T.D.751 (used on light aircraft)			Scheme of Medium Tautness to Spec. D.T.D.752 (used on most aircraft)			Scheme of High Tautness to Spec. D.T.D.753 (used on geodetic aircraft, or where a high tension is necessary)		
Material	Weight in oz./sq. yd.	No. of coats	Material	Weight in oz./sq. yd.	No. of coats	Material	Weight in oz./sq. yd.	No. of coats
Transparent tautening dope	2	3 or 4	*Pigmented finish*:—			*Pigmented finish*:—		
			Red oxide tautening dope	2	3	Red oxide tautening dope	¾	1
Aluminium non-tautening finish	1	2	Aluminium tautening dope	1	2	Clear tautening dope	4½	6 or 7
			Pigmented non-tautening finish	1	1 or 2	Aluminium tautening dope	1	2
Pigmented non-tautening finish	1	1 or 2				Pigmented non-tautening finish	1	1 or 2
			Aluminium finish:—			*Aluminium finish*:—		
			Red oxide tautening dope	3	4	Red oxide tautening dope	¾	1
			Aluminium non-tautening finish	1	2	Clear tautening dope	5¾	8
						Aluminium non-tautening finish	1	2

Where a glossy finish is required, add 1 or 2 coats of transparent, non-tautening finish to give about 1 oz./sq. yd. For further details see A.P.2656A, Vol. I.

Standard Repairs for Airframes

SECTION 2

A·P 2662A

REPAIR OF METAL STRUCTURES

This leaf issued with A.L. No. 8, February, 1948

STANDARD REPAIRS FOR AIRFRAMES

A.P. 2662A

Section 2 REPAIR OF METAL STRUCTURES

*CONTENTS

CHAPTER 21—RIVETS AND RIVETING

SCHEME

2101 General notes on rivets and riveting
2102 Details of solid rivets
2103 Details of Chobert rivets
2104 Details of Tucker pop rivets

CHAPTER 22—SHEET METAL REPAIRS

SCHEME

2201 General notes
2202 Details applicable to all sheet metal repairs
2203 Flush repairs to small damage in clear areas
2204 Insertion repairs
2205 External patches

★ Chapters will be added to this Section if further standardization of sheet metal repairs is found possible.

★ For the explanation of the Chapter and Scheme numbering system, see the Introduction to this book.

This leaf issued with A.L. No. 4, April, 1947

GENERAL NOTES ON RIVETS AND RIVETING

2101

PERMANENT JOINTS in metal airframe structures are almost always made with rivets, and their extensive use has led to a large measure of standardization in rivet design.

ALL STANDARD TYPES OF RIVET are dealt with in this Chapter, with the one exception of de Bergue rivets; these are used only in tank construction and are already fully covered in A.P.1464D, Vol. I, Part 2, Sect. 5, Chap. 2. Tubular rivets (as distinct from the hollow Tucker pop or Chobert rivets) are employed almost solely in tubular members, and they will be dealt with in Chapter 24, "Repairs to tubular members". Other rivets which have limited applications, e.g. plug and plug-pop rivets, are catered for in Volume II, Part 3 of the Air Publication for the particular aircraft.

METHODS OF RIVETING, faults to avoid in riveting, and the removal of rivets are described in Standard Technical Training Notes, A.P.1982A and 3042A, and are not repeated here.

THE SIZES OF THE RIVETS used in an aircraft structure are determined by the designer from the relative strengths of the rivets and of the metal to be joined but diameters over $\frac{1}{4}$ in. are seldom used owing to the difficulty of closing them with hand tools. The maximum rivet diameter dealt with in this Chapter, therefore, is $\frac{1}{4}$ inch.

THE TYPE OF RIVET TO USE in repair work will vary with the type of repair but will always be specified in the appropriate repair scheme, either in this Publication or in the aircraft Vol. II, Part 3. Details of the various types are given in Schemes 2102 to 2104.

SOLID RIVETS ARE STRONGEST and therefore preferable, but they can only be used where there is access to both sides of the work. The less strong hollow rivets, on the other hand, can be fitted where only one side is accessible.

ALTERNATIVE RIVETS to those called for in the airframe repair schemes may be employed in repairs to Secondary and Tertiary structures at the discretion of the Engineer Officer; they must never be used in Primary structures unless specifically authorised.

HOLES FOR ALL RIVETS must be drilled slightly larger than the rivet shank, in order to allow for its expansion when the second rivet-head is formed. Correct sizes are:—

Dia of rivet	$\frac{3}{32}$ in.	$\frac{1}{8}$ in.	$\frac{5}{32}$ in.	$\frac{3}{16}$ in.	$\frac{1}{4}$ in.
No. of drill	40	30	20	11	Letter F
Dia. of drill	0·098 in.	0·1285 in.	0·161 in.	0·191 in.	0·257 in.

HOLES FOR COUNTERSUNK-HEAD RIVETS must either be cut-countersunk or dimpled to receive the rivet head, according to the thickness of the plating and the diameter of the rivet. The following table indicates which method is generally used in each case, though these requirements may be varied in specific repair schemes.

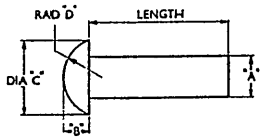
Gauge of plating	*Rivet dia. (in.)* $\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$
24 s.w.g. and thinner	D	D	D	D
22 s.w.g.	D	D	D	D
20 s.w.g.	C	D	D	D
18 s.w.g.	C	C	D	D
16 s.w.g. and thicker	C	C	C	C

C = Cut-Countersunk
D = Dimple

Cut-countersinking should be done either with a large drill accurately ground to the required angle, or a rose-countersink, care being taken to ensure that the correct depth is achieved so that the rivet head will be flush with the surface. Dimpling is effected with hand tools.

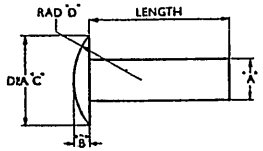
2102 — DETAILS OF SOLID RIVETS

Specification	AS. Type No.
L.36	155
L.37	156
D.T.D.303	157
D.T.D.327	2227



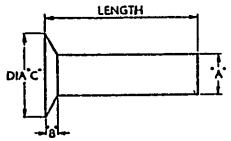
SNAP-HEAD

Specification	A.S. Type No.
L.37	158
D.T.D.303	159
D.T.D.327	2228



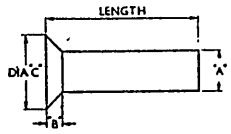
MUSHROOM-HEAD

Specification	A.S. Type No.
L.36	163
L.37	164
D.T.D.303	165
D.T.D.327	2230



120° COUNTERSUNK-HEAD

Specification	A.S. Type No.
L.36	160
L.37	161
D.T.D.303	162
D.T.D.327	2229



90° COUNTERSUNK-HEAD

ALL DIMENSIONS ARE INCHES

DIA. "A"	3/32	1/8	5/32	3/16
"B"	.06	.08	.09	.11
DIA. "C"	.16	.22	.27	.33
RAD. "D"	.09	.12	.15	.18

DIA. "A"	3/32	1/8	5/32	3/16
"B"	.038	.05	.063	.075
DIA. "C"	.21	.28	.35	.42
RAD. "D"	.17	.22	.27	.33

DIA. "A"	3/32	1/8	5/32	3/16
"B"	.027	.036	.045	.054
DIA. "C"	.188	.250	.313	.375

DIA. "A"	3/32	1/8	5/32	3/16
"B"	.035	.047	.059	.070
DIA. "C"	.164	.218	.273	.328

THE STRENGTHS OF THE RIVETS shown here vary according to their size, type of head and material. Given equality in size and material, the snap-head is strongest. Mushroom-head rivets, which are generally used as substitutes for countersunk-head rivets, are the next strongest. Countersunk-head rivets, though weaker than the others, are used extensively to achieve the flush external finish which is so vital to 100% performance. The 120 deg. countersunk-head rivet is preferable to the 90 deg. type, as its head has a larger bearing surface on the metal into which it fits; furthermore, a 120 deg. countersink does not weaken the metal as much as the deeper 90 deg. countersink.

THE RIVET SHANK MUST PROJECT approximately 1½ rivet diameters beyond the surface of the material to be joined in order to form a satisfactory snap head. When very thick plates have to be joined a rather longer projection is necessary, owing to the greater shortening of the shank when it expands. For countersunk heads the projection beyond the surface should be about ¾ rivet diameter.

RIVET SPECIFICATIONS may be identified by the colour of the rivet or the marking on the rivet head, viz.—

Aluminium, L.36	Black	Marked A or a dimple
Duralumin, L.37	Plain	Marked D
Magnesium aluminium alloy, D.T.D.303	Green	Marked X
Aluminium alloy, D.T.D.327	Violet	Marked S

The specification of the alloy rivets will determine whether or not they must be normalized before use. Rivets to Specification L.37 must always be normalized and used within an hour of such treatment; rivets to Specification D.T.D.303 or 327 do not need normalizing but are less strong.

SOLID RIVETS ARE LISTED on the "Stores Vocab.," A.P.1086, Part 12, Section 28Q. Their Part Nos. commence with the A.S. Type No., which denotes the specification and the type of head; following this, the first digit is the shank diameter in 32nds of an inch and the next two digits denote the length in sixteenths of an inch, e.g.—

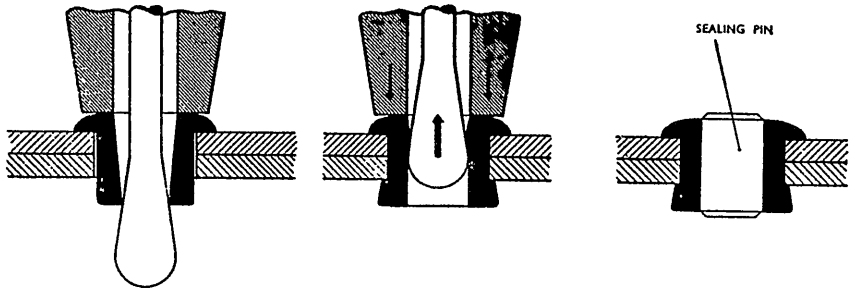
A.S.157/305 is a sn/hd. rivet to D.T.D.303, 3/32 in. dia. × 5/16 in. long
A.S.2230/510 is a 120 deg. csk/hd. rivet to D.T.D.327, 5/32 in. dia. × 5/8 in. long

Note from the sketches how the rivet lengths are measured.

Mild steel and stainless steel rivets have a limited application and are therefore not dealt with separately in this Chapter.

This leaf issued with A.L. No. 7, November, 1947

2103 — DETAILS OF CHOBERT RIVETS



RIVET PLACED AND READY FOR EXPANDING — MANDREL BEING PULLED THROUGH RIVET — RIVETED JOINT WITH SEALING PIN INSERTED

CHOBERT RIVETS ARE AVAILABLE in duralumin (Specification L.37), aluminium alloy (D.T.D.327) and steel (D.T.D.951), with either snap or countersunk heads. The material can be identified by the finish of the rivet, L.37 being anodised grey, D.T.D.327 anodised and dyed purple, and D.T.D.951 cadmium plated. Sealing pins may be inserted, after the rivets have been closed, to obtain increased shear strength or to render the rivets watertight.

BOTH RIVETS AND SEALING PINS ARE LISTED in the "Stores Vocab.", A.P. 1086, Part 12, Section 28Q, and their Part Nos. are determined from the following codes:—

$\frac{1}{8}$ in. and $\frac{5}{32}$ in. dia. rivets

First letter ("*T*") denotes Aircraft classification

Second letter = rivet shank diameter
(K = $\frac{1}{8}$ in., L = $\frac{5}{32}$ in.)

Figure following = rivet length in $\frac{1}{16}$ths inch, measured from under the head for snap-head rivets and overall for countersunk.

Third letter = type of head
(S = snap-head, C = countersunk-head)

Fourth letter = material
(D = duralumin, NA = aluminium alloy, S = steel)

Example: TL5SNA is a snap-head aluminium alloy Chobert rivet, $\frac{5}{32}$ in. dia. × $\frac{5}{16}$ in. long.

$\frac{3}{16}$ in. and larger dia. rivets

First letter ("*R*") denotes Heavy Duty classification

Number following = rivet shank diameter
(220 = $\frac{3}{16}$ in., 221 = $\frac{1}{4}$ in., 222 = $\frac{5}{32}$ in., 223 = $\frac{3}{8}$ in.)

Next figure = rivet length in $\frac{1}{32}$nds inch, measured as before

Second and third letters = type of head and material, as before

Example: R220/9CD is a countersunk-head duralumin Chobert rivet, $\frac{5}{16}$ in. dia. × $\frac{5}{32}$ in. long.

Sealing pins

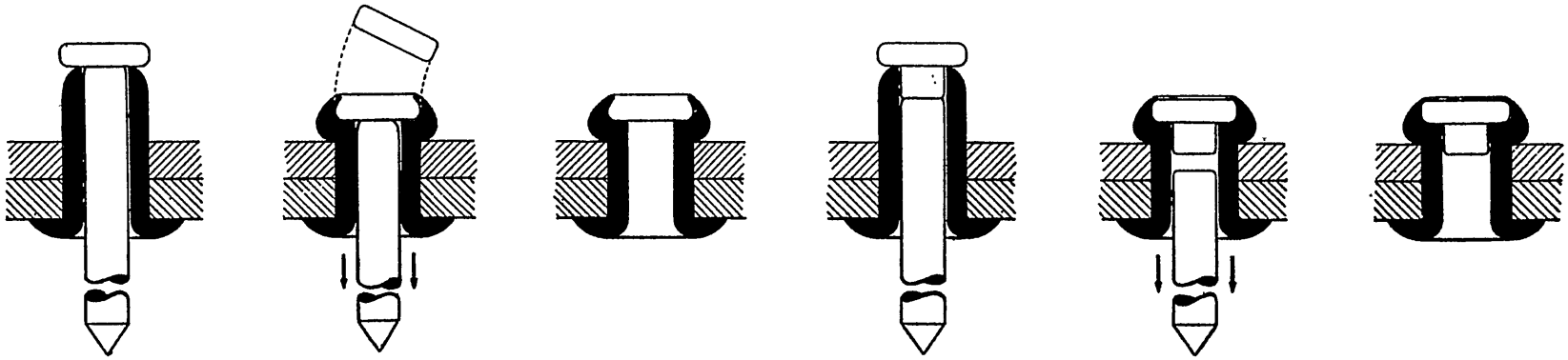
Part Nos. of sealing pins for snap-head rivets comprise the code letter for the rivet diameter, the code figure for the rivet length, the letter "P" (for sealing pin) and the code letter "D" for duralumin or "S" for steel. Duralumin sealing pins are used for both duralumin and aluminium alloy rivets. Thus the sealing pin for rivet TL5SNA is L5PD, and for R220/9SS it is R220/9PS. Sealing pins for countersunk-head rivets are similarly coded, but it is recommended that the preceding code length of pin is called for, e.g., an R220/7PD pin for an R220/9CD rivet.

AUTOMATIC HAND RIVETING TOOLS are listed in A.P.1086, Part 2, Section 1C, under Ref. Nos. 5820 to 5926. Operation and maintenance of the tools are described in A.P.1464B, Vol. I, Part 2, Chap. 9.

Rivet dia.	*Total thickness able to join (in.)*	*Code No. of rivet*	*Rivet dia.*	*Total thickness able to join (in.)*	*Code No. of rivet*
$\frac{1}{8}$ in.	Up to ·064	TK2	$\frac{3}{16}$ in.	Up to ·064	R220/5
	·064 — ·125	TK3		·064 — ·125	R220/7
	·125 — ·188	TK4		·125 — ·188	R220/9
				·188 — ·250	R220/11
$\frac{5}{32}$ in.	·064 — ·125	TL3		·250 — ·312	R220/13
	·125 — ·188	TL4		·312 — ·375	R220/15
	·188 — ·250	TL5		·375 — ·437	R220/17
	·250 — ·312	TL6		·437 — ·500	R220/19
	·312 — ·375	TL7			

2104 — DETAILS OF TUCKER POP RIVETS

2104



RIVET IN POSITION

MANDREL BEING WITHDRAWN AFTER RIVET HAS BEEN SET; HEAD OF MANDREL HAS BROKEN OFF AND DROPPED OUT

RIVETED JOINT

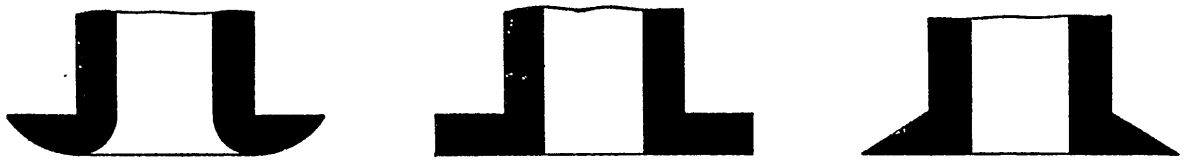
RIVET IN POSITION

MANDREL BEING WITHDRAWN AFTER RIVET HAS BEEN SET, MANDREL STEM HAS BROKEN JUST BENEATH HEAD, LEAVING HEAD PORTION IN RIVET

RIVETED JOINT

BREAK-HEAD TYPE

BREAK-STEM TYPE



DOME-HEAD

FLAT-HEAD

COUNTERSUNK-HEAD

This leaf issued with A.L. No. 4, April, 1947

2104 – DETAILS OF TUCKER POP RIVETS (CONTINUED)

POP RIVETS ARE AVAILABLE in nickel alloy, aluminium alloy, and mild steel, with break-head and break-stem mandrels and with domed, flat and countersunk heads. Nickel alloy pop rivets are approximately as strong as aluminium alloy solid rivets of the same diameter. Break-stem type rivets are used when the mandrel heads which fall from the break-head type, would be trapped within the structure.

POP RIVETS ARE LISTED in the "Stores Vocab", A.P.1086, Part 12, Section 28Q, and their Part Nos. are determined from the following code:—

"T" = Tucker	"P" = Pop type
"L" = Nickel alloy	"D" = Dome-head
"A" = Aluminium alloy	"K" = Countersunk-head
"M" = Mild steel	"F" = Flat-head

AL 13

* Diameters are indicated by the first digit, which represents $\frac{1}{32}$nds in., thus:— 4 = $\frac{1}{8}$ in., 5 = $\frac{5}{32}$ in., 6 = $\frac{3}{16}$ in., 8 = $\frac{1}{4}$ in.

Lengths (measured from under the head in all types) in $\frac{1}{100}$ths of an inch are indicated by the last two digits, thus:—

425 = $\frac{1}{8}$ in. dia. × 0·25 in. long

Suffix "BH" = break-head and "BS"=break-stem.

Example: TLP/K/519/BH is a Tucker nickel alloy pop rivet, countersunk-head, $\frac{5}{32}$ in. dia. × 0·19 in. long, with a break-head mandrel.

TO ENSURE WEATHERTIGHTNESS when pop. rivets are used externally, coat their interiors with jointing compound (Stores Ref. 33B/214) and whilst this is still wet plug them with a filling composed of putty and jointing compound; alternatively, break-head rivets may be sealed with a wooden plug (e.g. a match-stick) dipped in Bostik the plug being cut off when the Bostik has set.

AUTOMATIC HAND RIVETING TOOLS are used and are listed in A.P.1086, Part 2, Section 1C, under Ref. Nos. 5607 to 5914. Their operation and maintenance will later be described in A.P.1464.

Dia. of rivet	Total thickness to be joined (inches)	Part No.			
		Nickel alloy		Aluminium alloy	
		Dome/hd. TLP/D	Csk/hd. TLP/K	Dome/hd. TAP/D	Csk/hd. TAP/K
$\frac{1}{8}$ in.	0·05	416	413	417	414
	0·07	419	416	420	417
	0·10	422	—	423	420
	0·12	424	422	—	—
$\frac{5}{32}$ in.	0·06	519	—	518	—
	0·08	—	519	—	—
	0·10	—	—	—	518
	0·11	—	—	523	—
	0·12	524	—	—	—
	0·14	—	524	—	—
	0·15	527	—	—	523
	0·17	—	—	529	—
	0·18	530	527	—	—
	0·21	—	530	—	529
$\frac{3}{16}$ in.	0·10	624	621	625	—
	0·12	—	—	—	621
	0·13	627	624	—	—
	0·14	—	—	629	—
	0·15	630	—	—	—
	0·16	—	627	—	625
	0·18	633	630	—	—
	0·19	—	—	—	629
	0·20	—	—	635	—
	0·21	636	633	—	—
	0·23	639	—	640	—
	0·25	—	636	—	635
	0·28	—	—	—	640

* Note.- The Diameter of a Tap/D or Tap/K rivet with '6' as the first digit is 0·2 in. not 3/16 in.

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Section 2

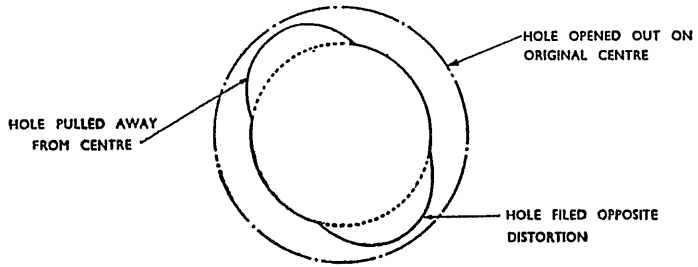
SHEET METAL REPAIRS

CHAPTER 22

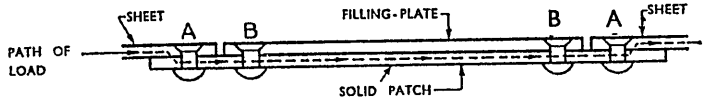
GENERAL NOTES

THE REPAIRS IN THIS CHAPTER APPLY TO light alloy sheet to D.T.D.610 or 390, although the repairs given here are equally applicable to other metals provided that the repair material used is to the same specification as the damaged sheet and that the attachments are of the same metal. The repairs cater only for flat or slightly curved sheets such as metal skins or floorings. They do not apply to plate webs or bulkheads, as these present special problems and are therefore dealt with in the appropriate aircraft Vol. II, Part 3.

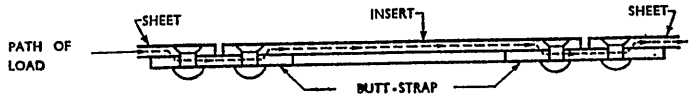
BEFORE COMMENCING A REPAIR, clean up the damaged area. Prevent cracks from spreading by drilling $\frac{1}{8}$ in. dia. holes at their ends, being very careful to ensure that the holes definitely do terminate the cracks. Cracks in skin sheeting above internal members may be an indication that the members themselves are damaged, so that it may be advisable to cut away the skin in order to inspect the members. Dress local distortion back to shape with a mallet, or a hammer with wooden blocks, afterwards examining the sheet for any cracks that may have been started as a result. Cut out and file all holes to smooth-edged regular shapes, preferably rectangular for ease of fitting, with large corner radii. Open up enlarged rivet holes to within the maximum diameter specified in the Vol. II, Part 3 for the particular aircraft; where they have pulled away from centre, first file them with a round file on the side opposite the elongation so that the final drilled hole will be on its original centre (*sketch below*).



REPAIRS FOR VERY SMALL DAMAGE are concerned more with restoring the panel's original stiffness than with carrying the load across the hole; the riveting for these repairs can therefore be designed quite independently of the load the sheet has to carry. The path of the load through the patch-and-filling-plate type of repair (given in Scheme 2203) is shown below, and it will be seen that rivets B serve merely to hold the filling-plate to the patch and therefore need not be as strong as the load-carrying rivets A. The purpose of the filling-plate is simply to ensure continuity of the sheet's profile. When the filling-plate is omitted, as in Scheme 2205, the repair is no less strong and the path of the load is the same. The term "filling-plate" is always applied in this Chapter to an inserted piece of sheet which does not carry any load, whilst a load-carrying inserted portion is termed an "insert."



REPAIRS TO LARGER DAMAGE must always restore the lost strength of the sheet. The aircraft designer will have determined the rivet pattern at the edges of the sheet to suit the loads it will have to carry (and the load across the sheet may be different from the load along it), so that the repair riveting must reproduce the existing riveting in the nearest parallel edge of the sheet. This may be a single or double row, and if there are two rows the rivets in each may be in line or staggered relative to each other. Treble-row riveting is not often used, but, where it is, special instructions will be found in the aircraft Vol. II, Part 3 or 4. If one edge of the sheet has single-row riveting and the one at right-angles to it has double-row, the repair should copy it. Note that only the sheet edge riveting should be copied, and not the rivets used to attach members to the skin. These repairs to larger damage employ an insert and a butt-strap, and the sketch below shows that both these parts are used to transfer the load, so that all the attachments must be of the same strength.



2202—DETAILS APPLICABLE TO ALL SHEET METAL REPAIRS

2202

THE FOLLOWING DETAILS ARE APPLICABLE TO ALL REPAIRS, except for the specific instructions given in the two minor repairs shown in Scheme 2203.

THE REPAIR MATERIAL must be to the same specification as the damaged sheet. Filling plates, patches and inserts must be the same gauge as the sheet, and butt straps must be two gauges thicker (e.g., a 16 s.w.g. butt-strap for an 18 s.w.g. sheet). If the sheet has any appreciable curvature, pre-form the repair parts to suit.

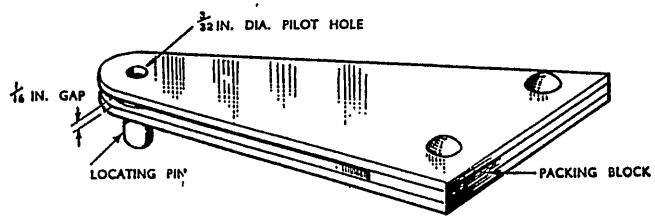
THE RIVETS must be solid rivets to D.T.D.327 for light-alloy sheets, or L.37 rivets if L.37 were used in manufacture. Where, however, lack of access prevents the use of solid rivets, nickel-alloy pop rivets may be used at $\frac{3}{4}$ the solid pitch, provided that this reduced pitch is not less than 4 x the diameter of the rivets. For other metals, use rivets of the same material as the sheet. Details of rivets and riveting are given in Chapter 21.

PIGMENTED VARNISH JOINTING COMPOUND (Stores Ref. 33C/885) must be applied to the mating faces of all sheets and repair parts, in accordance with Chapter 13, Protective Treatment.

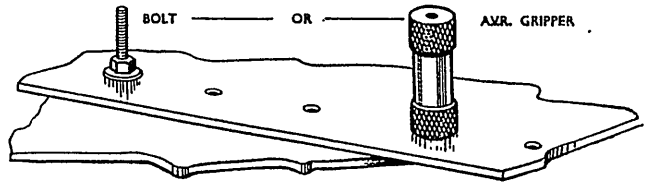
APPROVED PROTECTIVE TREATMENT must be given to the repair parts and to the completed repair in accordance with Chapter 13, and if any of the original protective treatment has been removed as a result of the repair it should similarly be restored.

THE RIVETING must copy that in the nearest parallel edge of the sheet, i.e., the rivets must be of the same diameter and type, be pitched at the same distance apart, and be in the same number of rows and in the same pattern, as those which secure the nearest parallel edge of the sheet. If they are countersunk-head rivets they must utilize the same type of countersunk hole (i.e., dimpled or cut-countersunk) as the edge rivets. Rivet landings—distances between centres of rivets and edges of material—must not be less than twice the rivet diameter.

WHEN EXISTING HOLES HAVE TO BE PICKED UP (e.g., when a joint of an insertion repair is made on an existing skin joint) and it is not practicable to drill from underneath, the holes can be located in the sheet by means of a jig of the type shown below. Make the jig from 16 s.w.g. mild steel strip, case-harden it locally at the pilot hole, and rivet to it a locating pin of suitable diameter for the holes which it is to pick up. Radius the end of the pin so that it will go easily into the holes and not scratch the protective treatment on the sheet beneath it. The length of the jig will of course depend upon the distance it is required to reach from the edge of the sheet.



DRAW THE SHEETS FIRMLY TOGETHER BEFORE RIVETING, and so ensure correct alignment of holes, by fitting A.V.R. grippers (Stores Ref. 1B/4270—4272) or bolts with copper washers, at frequent intervals.



FIT THE CORNER RIVETS FIRST, then the middle ones, and proceed by halving the space each time. The reason for adopting this sequence is that the action of riveting stretches the sheet, so that if holes were riveted consecutively from one end of a row to the other the final few holes would not line up.

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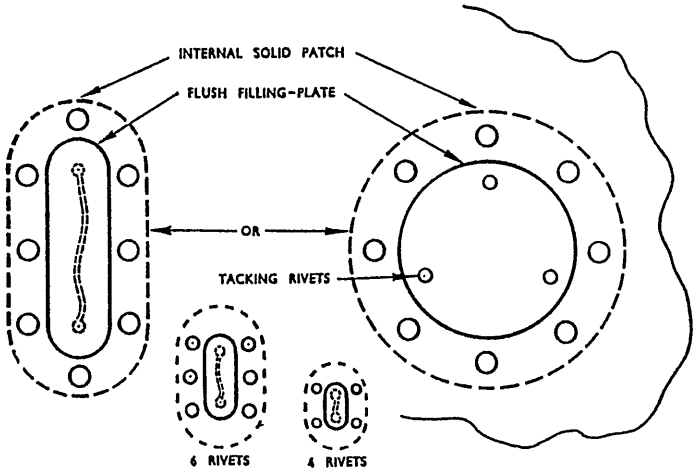
2203—FLUSH REPAIRS TO SMALL DAMAGE IN CLEAR AREAS

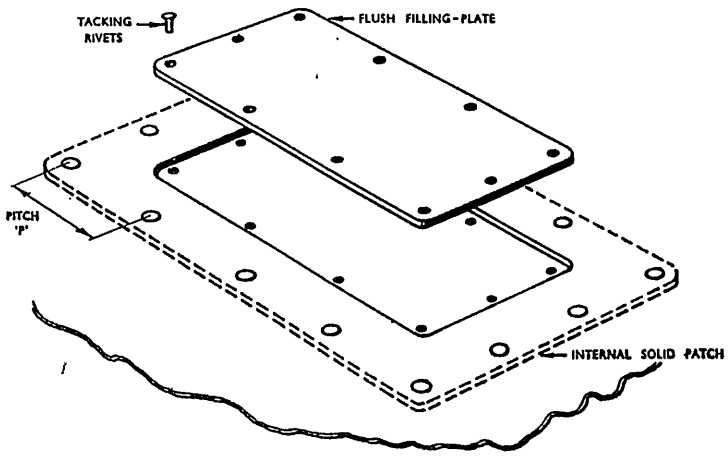


All rivets to be equally spaced. Use 8 rivets for damage up to 2 in. in any direction, 6 rivets for damage up to 1½ in., and 4 rivets for damage up to 1 in.

Gauge of sheet (s.w.g.)	*Rivet dia.*
24	$\frac{3}{32}$ in.
22 and 20	$\frac{1}{8}$ in.
18 and 16	$\frac{5}{32}$ in.

DAMAGE UP TO 2 in. MAXIMUM DIMENSION

NOTE.—Neither of these repairs must be applied if the width of the damage is more than $\frac{1}{6}$th of the width of the panel in which it is contained.



The patch and filling plate may be circular if preferred, the maximum diameter of the filling plate being 3 in.

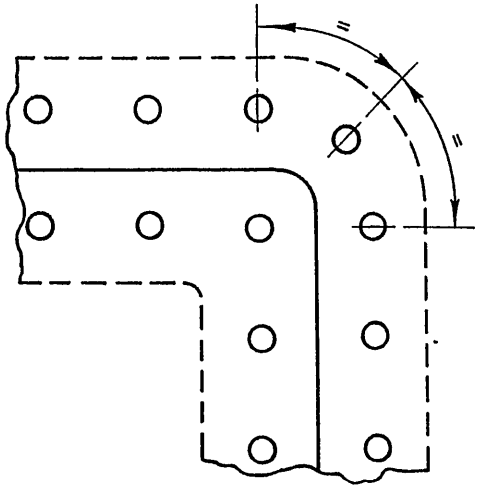
Gauge of sheet (s.w.g.)	*Rivet dia.*	*Pitch 'P'*
24	$\frac{3}{32}$ in.	$\frac{5}{8}$ in.
22 and 20	$\frac{1}{8}$ in.	$\frac{3}{4}$ in.
18 and 16	$\frac{5}{32}$ in.	$\frac{7}{8}$ in.

DAMAGE FROM 2 IN. TO 3 IN. MAXIMUM DIMENSION

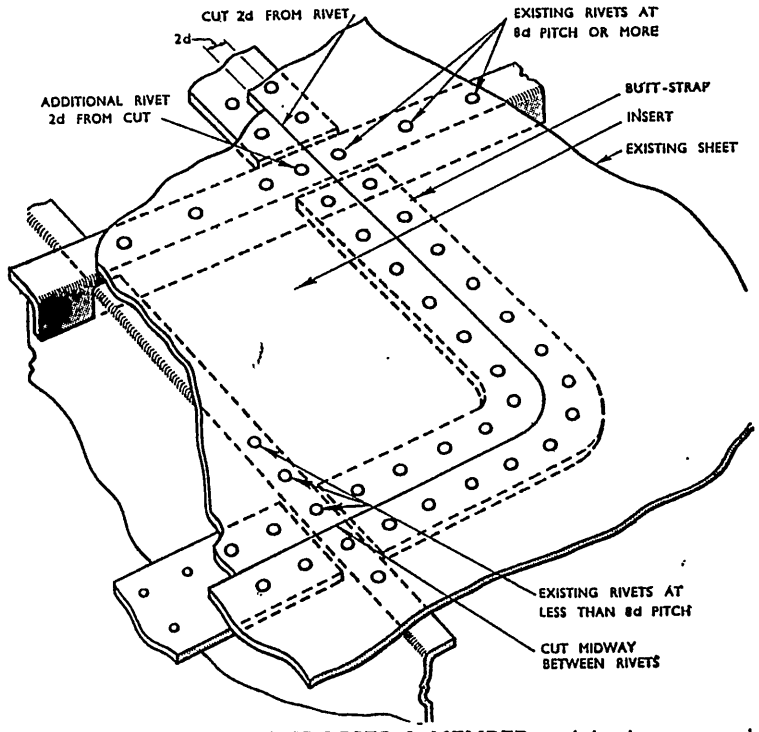
(Cracks, tears and deep scores should be repaired as shown above for holes, except that a filling plate will of course not be required unless the damaged portion of sheet is cut out.)

2204—INSERTION REPAIRS

THE REPAIR ILLUSTRATED HERE employs single-row riveting, but the same method is equally applicable to double-row or to a combination of single and double. The butt-strap should be in the minimum number of pieces to accommodate internal members, and a gap of $\frac{1}{16}$ in. should be maintained between butt-strap portions and the member between them. The gap between sheet and insert must not exceed $\frac{1}{16}$ in. A typical example of riveting at a corner is shown below. The rivet pitch at a corner may be shorter than the normal pitch, if necessary, but must not be less than 4d (d = rivet diameter).



EXISTING RIVET HOLES for securing sheet to members should be picked up wherever possible. If the damage is near to an existing sheet joint, cut it out to the edge of the sheet and make the insertion joint on the original joint. This type of repair would constitute a partial replacement of the panel.



WHERE THE DAMAGE CROSSES A MEMBER, and the sheet-to-member rivets are at 8d pitch or more, make the cut in the sheet at a distance of 2d from an existing rivet and insert an additional rivet at 2d from the other side of the cut (top of the above illustration). Where the existing pitch is less than 8d there will not be room for an extra rivet and the cut must be made midway between two existing rivets (bottom of the above illustration).

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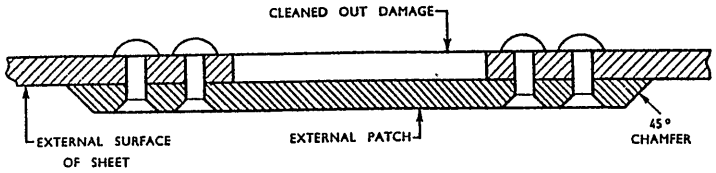
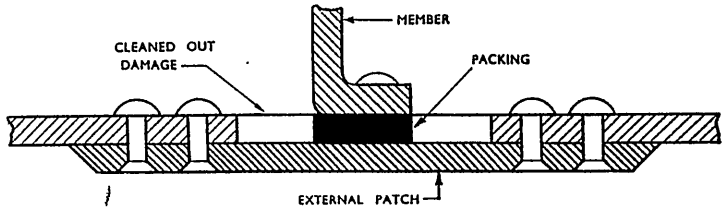
2205—EXTERNAL PATCHES

WHERE FLUSH PATCHES ARE NOT ESSENTIAL, e.g., on internal sheets such as bulkheads or on those parts of the skin which are not exposed to the airflow, patches may be fitted which overlap the damage and do not present a flush exterior surface, thus:—

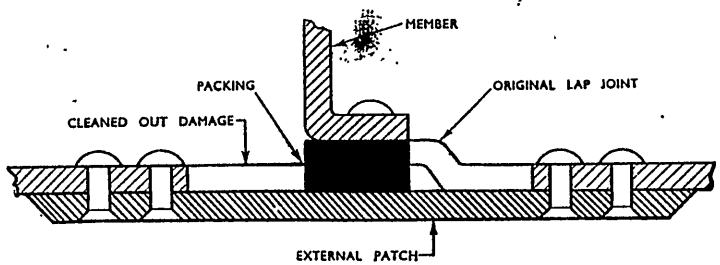


RIVETS SHOULD BE ARRANGED as shown for flush patches in Schemes 2203 and 2204. For example, an external patch for damage to a sheet which has single-row riveting in its nearest parallel edges should be riveted in the same manner as the insert in Scheme 2204.

PATCHES IN SHEET OVER MEMBERS must employ packing equal in thickness to that of the damaged skin, as shown below. Existing rivet stations in the member should be picked up, and additional tacking rivets spaced between them.



PATCHES OVER SKIN LAP JOINTS must employ packing of thickness equal to that of both skin sheets, as shown below. Existing rivet stations in the member beneath the lap joint should be picked up, and additional tacking rivets spaced between them.



Standard Repairs for Airframes

SECTION 3

A·P 2662A

REPAIR OF WOODEN STRUCTURES

Wood

This leaf issued with A.L. No. 10, November, 1949

STANDARD REPAIRS FOR AIRFRAMES

A.P. 2662A

Section 3 REPAIR OF WOODEN STRUCTURES

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★For the explanation of the Chapter and Scheme numbering system, see the Introduction to this book

BEETLE CEMENT W.I.D.
MEMORANDUM

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BEETLE CEMENT

(1) INTRODUCTION:

This memorandum is issued to provide information on the introduction and use of Beetle Cement when required on all wood components of D.H. or other aircraft. It gives the procedure when this material is being introduced in lieu of casein glue, detailing the process of gradually changing over from small components and progressing eventually to the main gluing assembly operations. The reason for this change in glue is that joints made with Casein glue whilst being water resistant, are not waterproof and are greatly weakened under damp or wet conditions. The new gluing materials - or cement, as it is usually called - are however completely waterproof and do not break down even after long immersion in water.

(2) DESCRIPTION:

The glue to be introduced is known as "Beetle Cement". It is a urea-formaldehyde cold setting synthetic cement and is always used in conjunction with a hardener. The cement is a thick brown syrupy liquid, while the hardener is a thin liquid for identification and observation of application. It is important to note that the cement commences to set as soon as it comes into contact with the hardener, A chemical reaction takes place which is greatly influenced by the prevailing temperature. It is therefore essential that a close check is kept upon the temperature, as upon this depends the time during which any particular mixing may be used, and also the time in which the job being glued must be kept under pressure.

Beetle Cement is manufactured by Beetle Products Co. Ltd., a division of British Industrial Plastics Ltd. - Local manufacture is carried out by Beetle Elliott Plastics Pty. Ltd.

(3) TYPES OF MATERIALS:

The types of materials to be used are as follows:-

	Cements		Hardeners
(1)	Beetle "A"	(1)	Violet V.15
(2)	Beetle "AF"	(2)	Yellow GP.30
		(3)	Blue 2B.

(4) USES:

Beetle "A" is for general use - the only occasion on which Beetle "AF" is to be used is when large areas of balsa wood have to be covered (see paragraph 15.4). Beetle "AF" is a thinner type of cement and hence flows more easily when used for this purpose. For small balsa jobs, however, Beetle "A" is quite satisfactory.

The Violet V.15 hardener should be used for all small jobs or laminated work and in cases where the joint can be shut and pressure applied within 10 minutes after assembly. For jobs requiring longer time - up to 30 minutes for glue operations and delayed clamping the Yellow GP.30 hardener is recommended. Although this gives more latitude in gluing up, it also requires more time for drying while in the clamps. For jobs requiring longer gluing and clamping time still, and if the temperature is high, then Blue 2B hardener should be used, (see paragraph 14.5).

(5) STORAGE OF CEMENT

The life of Beetle Cement is approximately three months from date of manufacture when stored below 70° F, and containers are marked by the suppliers with the date up to which the cement may be used. Under no circumstances shall the cement be used after this date unless sampling and examination by the supplier or other authority shows that it is in a suitable condition for gluing. Notwithstanding this, the authorized inspector may reject any batch within the three months period if he considers that the glue has thickened excessively within that period. A store temperature of 60° F. or less should be the aim. For the detailed control of storage generally see W.I.D. No. 78.

(6) METHODS OF APPLICATION:

There are three methods of application.

METHOD A - Where only light pressure is available, a mixture is made of cement and hardener which is applied to both surfaces.

METHOD B - When sufficient pressure is available to give close and even contact of the surfaces, the mixture is applied to one surface, preferably the harder.

METHOD C - Where a thin glue line can be obtained with certainty, separate applications of cement and hardener can be made.

Methods A & B are the systems that will be used here for the present (see para. 14.2). Method C should only be used when both methods A & B are found by practice to be unsuitable for the particular job in hand (see para. 14.4).

(7) GLUE CONTROL ROOM:

7.1 Location - Each shop should have its own glue control room. Adjacent shops may however use the same room if convenient. This will be determined by practice. The glue control room should be a separately enclosed room suitably located to enable distribution of glue with minimum of delay and portage.

7.2 Ventilation - The glue mixing and control room must be ventilated to the rest of the shop or to the outside atmosphere as the fumes of the hardeners would be detrimental to the health of the operators in the glue room, if inhaled in undiluted form.

7.3 Personnel - NO unauthorised personnel will be allowed access to the glue control room. Authorised personnel include mixing hands as directed by the Plant Superintendent and inspectors as directed by the Inspector-in-Charge at the plant concerned. The mixing and working of the control MUST be restricted to staff chosen for the purpose and casual mixing by operators and foreman is strictly forbidden.

7.4 Equipment -

(1) Sink with hot and cold running water. The sink should be of the deep type so that pails can be readily filled with water.

(2) Shelf over the sink with space for 3 large glass jars for hardeners. Space on shelf or elsewhere also for 3 spare jars.

(3) Class jars for hardeners - 2 to 3 gallons each (6 off).

These jars should have ground glass taps at their base so that the hardener fluid can easily be run out into measuring flask.

(4) A 10 oz. glass measuring flask - for proportioning hardener.

(5) Scales to weigh fairly accurately quantities 1 to 14 lbs. or ½ to 28 lbs. depending on quantity required at any one time by the shop. This is for weighing out the cement.

(6) Mixing vessels - various sizes.

(7) Stirring rod or mixing machine, depending on shop concerned.

(8) Ladle for extracting cement from drums. This ladle must not be used with mixed cement.

(9) Rubber gloves for mixing personnel and rags for cleaning.

(10) Clock - preferably fixed to wall and electrically operated.

(11) Wet and dry bulb thermometer.

(12) Books for keeping records (a) each mix
(b) Temperatures, wet and dry bulb.

(13) Stock of coloured glue containers - as for Casein glue-blue, green, red and yellow.

(14) Clock Control board consisting of :-

(a) Set of four clock dials painted blue, green, red and yellow (as above) with movable black hands.

(b) A hook or nail above each of the four clocks.

(c) Discs coloured and lettered as follows:-

Purple	disc	lettered	V.15 in white
Yellow	"	"	GP.30 " black
Blue	"	"	2B " white

This board should be situated outside but adjacent to the glue control room so as to be visible to most people in the shop. This board should be duplicated in other shops if they are all served from the one glue control room.

IMPORTANT NOTE:- Items 6,7& and 12 come in contact with the cement. Only certain materials are suitable for this contact, viz: iron, tin plate, glass enamel, glazed earthenware or paper cartons. The following materials are unsuitable and MUST NOT be used under any circumstances for containers.

i.e., copper, brass, aluminium or aluminium alloy.

(8) SHOP EQUIPMENT:

In addition to the equipment listed above the following additional equipment is required for use in the shops themselves - to be used by operators as distinct from glue room personnel.

(1) Rubber gloves for operators.

(2) Pails of water and rags - for wiping off surplus glue and washing operator's hands, etc. (see paragraph 15.2)

(3) Special rollers for spreading glue over large areas (see paragraph 14.2).

(4) Sanding equipment for plywoods and hardwoods (see paragraph 11.1).

(5) Wet and dry bulb thermometers at suitable locations.

(9) CHANGE OVER PROBLEMS:

9.1 Jigs - Casein glue is strongly alkaline, no alkali of any description must come in contact with Beetle Cement in the unset conditions. Before any jig previously employed using Casein glue can be worked on, the following operations MUST be carried out:-

(a) All accumulations of Casein glue must be thoroughly scraped off

(b) Jigs are then washed down with a weak acid solution made up as follows:-

5% by volume Hydrochloric Acid.
5% " " Industrial Alochol
90% " " Water.

When using Beetle Cement every care must be taken to keep cement off the jigs, as it is very difficult to remove. After some time, experience will indicate where it will be necdessary to face existing jigs - at vulnerable joints - with metal, bakelite or fibre.

9.2 Tools - Allowance must be made for increased wear on all cutting tools - both machine and hand - as Beetle Cement is much harder than Casein glue.

9.3 Components - It follows from the above that Beetle Cement must not be used on any structure near joints that have been made with Casein glue. Casein glue may however be used over jobs glued up with Beetle Cement either in repair or production operations on glued components. Thus the introduction of Beetle Cement into any project must commence from the primary components, e.g ., laminated members, and gradually progress to subsequent components, e.g., ribs with ply sides glued to laminated booms. For fuller details see paragraph 10 on Condition of Timber.

(10.) CONDITION OF TIMBER:

There are two factors that govern the condition of the timber - acidity and moisture content. In production work the natural acidity of timber need not be questioned and the moisture content of new timber released for production is always within correct limits. However, in repair work these two factors need further consideration.

10.1 Acidity - Beetle Cement must NOT be used on timber that has had its natural acidity neutralised by other cements, such as Casein which is of an Alkaline nature. Therefore, before deciding upon the use of Beetle upon a particular job, the condition of the timber where the Beetle is to be applied must be ascertained. Should it be certain that the part had previously been made with Beetle Cement, then Beetle can be used without hesitation, but if Casein had been used, or if there is some doubt, then a simple test will indicate the condition of the timber.

10.2 Use of Indicator - The test consists of wetting the surface to be tested with B.D.H. Universal Indicator made by the British Drug Houses Ltd., or an approved substitute available from Messrs. Elliotts and Australian Drug Co., This can be put on either with a brush or by the cork from the bottle. This liquid indicates by its colour the degree of acidity or alkalinity present. The colours usually met with range from blue-green, to red with intermediate tones of greenish yellow, yellow, yellowish red. If the colour is blue, green or yellow tinged with green, then the surface is unsatisfactory for Beetle Cement, but yellow to red, and any combination of tones of these two colours, indicate that the timber is suitable. It should be noted that although Beetle and other synthetic cements are used with coloured hardeners which give the cement a characteristic colour, it does not follow that any coloured cement is synthetic, as some aircraft constructors make a practice of colouring Casein for indetification of batches. The only reliable check is with the Universal Indicator previously mentioned. The PH value of the wood should not exceed 6.5 by the Universal or other form of indicator.

10.3 Special Cases - It is permissible in some cases to use Beetle Cement in repairs, even although Casein was used in the original manufacture, providing that the area of alkalinity is very small, for example, a plywood skin glued to a spruce member will show with a Universal Indicator a thin line of green reaction directly adjacent to the glue line, but if the remainder of the surface to be glued shows a yellow to red reaction, then very little of the area will be unsuitable for Beetle. The use of Beetle under these circumstances must be considered on the merits of the case, bearing in mind that when a green reaction is shown, the resultant gluing at this point will be of very poor quality indeed.

10.4 Moisture Content - Beetle Cement is satisfactory on timber having a moisture content up to 25%. Excess moisture delays the setting time to an unpredictable amount. When repairing aircraft that have been water-logged, it is essential, whatever type of cement or glue is used, that the moisture content is reduced to a reasonable figure by allowing to dry out naturally or

by the application of artificial heat.

(11) PREPARATION OF TIMBER:

11.1 Roughness of Surface - To obtain the optimum results the following must be observed:-

(a) Plywood - Must be sanded with the grain or across the grain. This is MOST IMPORTANT.

(b) Hard Woods - if smooth sawn, may be used as it is, but if planed then it must be sanded with the grain. Hard woods are those such as coachwood, mountain alpine and silver ash, maple, walnut, etc.

(c) Soft Woods - may be used with smooth sawn or planed finish. Soft woods are those such as spruce, douglas fir, balsa, etc.

Sanding operations may be carried out either by hand or by mechanical means and with a medium grade of sand-paper.

11.2 Cleanliness - The surface to be glued must be free from all dirt, dust, grease and finger marks. Care must be taken particularly with plywood to see that all sawdust is removed after sanding.

11.3 Contact - Contacting surfaces should give intimate contact and every effort must be made at all times to achieve this contact. Inequalities are acceptable however, up to 0.02".

(12) PREPARATION OF CEMENT:

12.1 Responsibility - the mixing and distribution of the cement is the responsibility of the shop, supervision who should make themselves fully acquainted with the characteristics of the cement. All operations are subject to Inspection Department check with periodical laboratory check (see para. 17) All time control is the responsibility of Inspection Department.

12.2 Solection - The shop supervision will specify the quantity of cement to be made up at any time depending on the type and quantity of work. They will also select the type of hardener according to the type of job and the shop temperature. Naturally the control is simplified if only one type of hardener is in use during any period.

12.3 Proportions - No matter what type of hardener and what type of cement are used the proportions are always 1 in 16, i.e.

1 oz. Hardener to 1 lb. Cement.

12.4 Measuring - (a) The cement is ladled out of its container into a mixing vessel and weighed to give the desired quantity.

(b) The hardener is run out of the bottom of the appropriate glass jar into the glass measuring vessel to the correct quantity to agree with (a).

12.5 Mixing - The hardener is added slowly to the cement whilst stirring thoroughly. Stirring should continue until uniform (approximately 5 minutes) It is essential that the cement adhering to the sides of the container be mixed with the hardener. If this is not done and the last dregs are scraped out of the container to finish a job an unsatisfactory joint will result. For large quantities a mixing machine is more convenient.

12.6 Distribution - Cement is then poured into suitable containers as described elsewhere (see paragraph 7.3) and then distributed to where it is to be used. The BLUE containers are used first and subsequent mixes are put into the other three coloured containers in turn - green, red, yellow. The colour scheme is then repeated ad lib.

12.7 Control - the control of the usable time of the cement is described in the following paragraph.

(13) CONTROL OF USABLE TIME OF CEMENT:

13.1 Factors - the two factors controlling the usable time of the cement area:-

(1) Type of hardener used.
(2) Temperature of surrounding air.

13.2 Table of Usable Time - The following table sets out usable times according to the variables mentioned above. After this time has expired the cement is rejected together with any jobs on which cement has been applied but no pressure applied. Under NO circumstances will the time be extended as the times given are MAXIMA.

USABLE TIMES HOURS

From Mixing to Clamping

Temperature Degrees F.	Type of Hardener		
	Violet V15	Yellow GP30	Blue 2B
110	N.R.	N.R.	30 mins.
105	N.R.	N.R.	40 "
100	N.R.	N.R.	45 "
95	N.R.	N.R.	60 "
90	N.R.	N.R.	90 "
85	N.R.	N.R.	105 "
80	½ hr.	1¼ hr.	135 "
75	¾ hr.	1¾ hr.	3¼ hr.
70	1 "	2¼ hr.	4½ hr.
65	1¼ hr.	3 "	6 ".
60	1½ hr.	4 "	N.R.
55	1¾ hr.	5 "	N.R.
50	2 hr.	7½ "	N.R.
45	2¾ hr.	N.R.	N.R.
40	4 hr.	N.R.	N.R.

NOTE:- N.R. means NOT RECOMMENDED.

13.3 Control - Immediately mixing commences the appropriate coloured clock face is set at the appropriate time to indicate the end of the usable time of the mix of cement, i.e., the latest clamping time. Also the appropriate hardener disc is hung above the clock face. Should the temperature vary during the life of the cement the clock must be altered accordingly - at the same time advising the shop supervision and inspectors where the glue is being used, of the change. This control is done by the Inspector in Charge of the glue room.

13.4 Records - Records are kept by the Inspector in Charge of the glue room as follows:-

(1) Record of temperatures of each thermometer in the plant throughout the day at regular intervals. Wet and dry bulb readings.

(2) Record of each mix showing -

(1) Date
(2) Type of Cement.
(3) Type of Hardener.
(4) Time of Mix.
(5) Colour scheme for mix.
(6) Temperature in glue room, at time of mix (Wet and dry bulb.)
(7) Temperature in shop at time of mix.
(8) Usable time at time of mix.
(9) Remarks - in which any alterations of usable time may be recorded.

(14) USE OF CEMENT:

14.1 Spreading Methods - As mentioned previously there are three methods available for use. Only two of these are applicable to mixed cement as has been described in previous paragraphs - namely, Method A and Method B (see paragrapg 8). Method C is not applicable here, but it is described below.

14.2 Spreading Operations:

(1) Spread by method A or B using either -

(a) Stiff bristle brush.
(b) Piece of wood.
(c) Hand rollers with feed trough attached.
(d) Power driven rollers.

(2) Rate of spread - 1 lb. cement to each 23 sq. ft. surface approximately Sufficient should be used go fill all gaps.

(3) If using Method B.and plywood is one of the surfaces then this should be the one to receive the application of cement.

(4) After spreading allow to air dry, where applicable, for a time indicated below (para. 14.3)

(5) Place components together.

(6) Apply pressure (see para. 15) within the times laid down below - called closed assembly times, not to be confused with open times.

14.3 Open Times - or preferably referred to as total assembly times. This is the time between starting the spreading of the glued surfaces and finally clamping or applying pressure or screwing. They must not be exceeded. Open or total assembly time may be considered as the sum of "spreading and airdrying" time and "Closed assembly time".

T.A. Time = S.A.D. Time + C.A. time

The spreading and airdrying time includes the time allowed after spreading to air dry the cement to permit it becoming tacky. This air drying period will lessen as the usable time (or pot life), increases. On large areas it is unnecessary . The closed assembly time is that between mating the glued surfaces and final clamping.

TEMP. Degrees F.	TYPE OF HARDENER								
	V. 15			G.P. 30			2B		
	SADT	CAT	TAT	SADT	CAT	TAT	SADT	CAT	TAT
110	-	-	-	-	-	-	5 m	5 m	10 m
105	-	-	-	-	-	-	5 m	10 m	15 m
100	-	-	-	-	-	-	5 m	15 m	20 m
95	-	-	-	-	-	-	10 m	20 m	30 m
90	-	-	-	-	-	-	20 m	40 m	1. hr.
85	-	-	-	-	-	-	25 m	50 m	1¼ "
80	5-10m	10 m	20 m	5-10 m	30 m	40 m	30 m	1 hr.	1½ "
75	5-10m	10 m	20 m	5-10 m	30 m	40 m	40 m	1¼ "	2 "
70	5-10m	10 m	20 m	5-10 m	30 m	40 m	1. hr.	2 "	3 "
65	5-10m	10 m	20 m	5-10 m	30 m	40 m	1¼ "	2¾ "	4 "
60	5-10m	20 m	30 m	5-10 m	50 m	1 hr.	-	-	-
55	5-10m	20 m	30 m	5-10 m	50 m	1 "	-	-	-
50	5-10m	20 m	30 m	5-10 m	50 m	1 "	-	-	-

SADT = Spreading and Air Drying time. CAT = Closed assembly time.
TAT = Total assembly time (= OPEN TIME)

14.4 Method C - As mentioned in para. 6 Method C may be used where a thin glue line can be obtained with certainty, in which case the hardener and cement are spread separately. The operations are as follows:-

(1) Hardener is applied to one surface by means of a rubber sponge or soft brush. Note - if one surface is plywood and the other spruce or similar wood, the hardener is applied to the plywood.

(2) Rate of s pread - one pound per 100 sq. ft.

(3) Allow to dry thoroughly - at least 30 minutes.

(4) The hardener coated surfaces may be stored for several days before use if required.

(5) When about to use they must be dusted before use but must never be rubbed down or sanded.

(6) Cement is then applied to the other surface with a stiff bristle brush.

(7) Rate of spread - 4 lbs. per 100 sq. ft.

(8) Allow cement to thicken - approximately 15 mins. If spreading takes longer than 15 minutes for one man then another man should be put on to bring time within 15 minutes.

(9) Two surfaces are then brought in contact.

(10) Pressure is then applied within the following times:-

(a) Hardener V.15 - 20 min.
(b) Hardener GP.30 - 60 min.

(11) Clamping times are the same as for Methods A and B (see para.15).

(15) APPLICATION OF PRESSURE

15.1 Methods - Various methods are available for applying the necessary pressure:-

(1) Pins or brads.
(2) Tacking Strips
(3) Clamps and presses.
(4) Screws.

For small jobs method (1) is suitable. For larger jobs method (2) is suitable but brads should be closer than for Casein made joints.

For highly stressed joints and the assembly of thick laminations greater pressure is required which is most satisfactorily applied by means of screw clamps or in a press - i.e. method (3). A pressure of 50-60 lbs/sq. in. should be aimed at.

Where drawings call for "glue and screw" the same method as for Casein applies.

In general, joints made with Beetle Cement require the same pressing methods as those made with Casein. Sufficient pressure should be used to bring the two surfaces into contact and to expel air bubbles with the aim of producing as thin a glue line as possible.

The amount of pressure will depend upon the thickness of the wood and flatness of the surfaces, and it is not possible to specify the amount of pressure required.

15.2 Application - Pressure is applied by one or other of the above methods and it must be noted that all work MUST be under pressure, bradded or screwed, before the end of the working life of the cement at the temperature of the shop at the time it is being used, i.e., the time indicated on the appropriate clock face.

Excess cement which is squeezed out should now be wiped off with a damp rag as soon as possible. The pails of water and clean rags are provided for this purpose. The rag should be damp and not soaking wet as excess water tends to dilute the glue at the glue line. The cement sets hard and glassy and it is much harder to remove afterwards. The water in the pails should be either room temperature or preferably warmer as this water is also used by the operators to remove glue from their gloves and/or hands.

Once a joint is made it must be left undisturbed until the clamping time has expired. In this way it differs from Casein for which clamps need not necessarily be left in for the full time it takes to set.

15.3 Clamping Time - The "Clamping Time" is the time at which the cement is set sufficiently for removal of pressure, clamps or tacking strips. The table below sets out the times which varies accordingly to the type of hardener and temperature.

Temperature Degrees F.	Type of Hardener		
	Violet V.15	Yellow GP.30	Blue 2B
95	N.R.	N.R.	2.
90	N.R.	N.R.	2½
85	N.R.	N.R.	3.
80	2.	3.	4½
75	2½	3½	7
70	3	4	N.R.
65	4	5½	N.R.
60	5½	7	N.R.
55	6¾	9	N.R.
50	8½	N.R.	N.R.
45	10¼	N.R.	N.R.
40	12	N.R.	N.R.

NOTE: N.R. means Not Recommended.

These are minimum times. For intermediate temperatures the next longest time is taken. The pressing time given in the table above will be sufficient for small assemblies but for large important joints such as Spar Booms, a longer time is preferable. The recommended clamping times must be exceeded when:-

(a) Any deformation of the laminae takes place in the press.

(b) Long, Slender structures are being pressed which may be stressed in removal from the clamps.

(c) Glue lines tend to be thicker than .010".

(d) When conditions are such as to promote rapid drying of the glue, such as cold during in vacuum bags, etc.

(e) When there are present in the members to be glued traces of alkali such as scarfs or casein bonded or phenolic bonded laminations which may retard the chemical action of the hardeners.

15.4 Special Cases - Use of Beetle AF - When using the AF Cement the drying and clamping times shown above are revised, Beetle AF Cement is a thinner form of Beetle, which responds in exactly the same way to hardener and temperature as Beetle A. Its use at present is to be restricted to Fuselage Shell construction.

15.4 (Contd)

(a) Inner Skin to bulkheads and Scarf Joints, same as schedule given for Beetle A, with bands on all the time.

(b) Balsa Sandwich same as schedule for Beetle A, plus 50%. Then six hours with bands off. No cleaning or work to be done on the shell during this period.

(c) Outer Skin same as schedule for Beetle A plus 50%, then remove bands and leave for 12 hours before removal from jig.

The application of cement should be to both contact surfaces. The hardener used should be Yellow GP.30 but Blue 2B may be used for hot weather.

N.B. A special W.I.D. Memorandum will be prepared for these operations later. Reference W.I.D. NO. 81

15.5 Work after gluing - Generally, machining may be carried out after relieving the pressure on the joint. Machining of spar booms and such like members, however, should be delayed for 12-24 hours after removing clamps. Screwed joints should not be moved or heavily worked upon until clamping time has elapsed.

It is important to note that the optimum strengthof joint is not developed during the clamping times quoted but increases progressively until the maximum is obtained. Hence no joints should be stressed due to flying, taxiing or loading until at least 24 hours after the clamping time has expired.

(16) IDENTIFICATION :

All production items when submitted to Inspection Department for check should be part numbered. In addition the issue number is inserted after the part number. When Beetle Cement has been used in the gluing operations a special stamp showing the outline of a beetle must be stamped on the parts. These stamps will be supplied to Inspectors-in-Charge who will hand them over to the part numbering authority as required. It is the responsibility of the Inspector passing the parts to see that if Beetle Cement has been used then the insignia of the beetle is stamped thereon. This will assist in the problem set out in paragraph 9.3.

(17) CLEANING EQUIPMENT:

It is essential that all equipment be thoroughly cleaned after use and the sooner this is done the easier it is to do. Cement may be dissolved and washed off with warm or cold water as long as it is applied before cement has set. This is the only solvent for the cement and then only before the cement has set. Hot water should NOT be used as the heat may finally set the cement and render it even more difficult to remove. Operators should be provided with water and rags to clean the hands, if cement is allowed to dry on the skin, the resultant damage to the skin in removing the cement will create sore spots which on further contamination may lead to skin inflammation. The daily contact with Beetle Cement may cause dermatitis with some people, unless the hands are protected. The essential safeguard is cleanliness and frequent wiping of the hands with a damp cloth. Operators in England prefer Beetle to Casein as it has less effect upon the skin if it is removed, before drying.

(18) TESTING:

Periodic checks should be made on the gluing, preferably checking individuals, by requesting the operators to glue odd scraps of wood and ply, which, at the expiration of the time for the particular hardener, and temperature, are broken apart and the efficiency of the gluing judged by the appearance of the timber. Fibres from one or both parts should be seen on the other part, a magnifying glass is almost essential as often the fibres are vey fine and the appearance is deceptive.

In addition, until further notice periodical checks will be made on test pieces made up for Casein glue (see Spec. (E).D.831) which will be tested in tension to indicate a minimum of 1100 lbs/sq.in. shear strength in the glue line.

(19) REFERENCES:

1. De Havilland Aircraft England W.I.D. Nos. 47 and 57.
2. Beetle Handbook - Reprinted by C.S.I.R., Ref. AF.64
3. R.A.A.F. Specification K.24.
4. Notes on Beetle Cement from Canada, Ref. NAM.28325.

This leaf issued with A.L. No. 9, December 1948

RESTRICTED
AIR MINISTRY

STANDARD REPAIRS FOR AIRFRAMES

A.P. 2662A

Section 3 CHAPTER 31 GLUING

STANDARD REPAIRS FOR AIRFRAMES
This is A.L. No. 9 to A.P.2662A
Sect. 3, Chap. 31. *Remove and dispose of the leaf bearing Scheme 3101 and substitute this new leaf; make an entry in the Amendment Record Sheet at the beginning of the book.*

ENGINEER

GENERAL NOTES ON GLUING

GLUING UNDER PRESSURE is the usual method of making permanent joints in wooden aircraft structures.

THE GLUE FOR ALL AIRFRAME REPAIR WORK done by the Services is the synthetic resin (S.R.) adhesive, described in Scheme 3104. The weather-resisting properties of this adhesive are much superior to those of casein glue, but a little more care must be taken in its application and storage. Casein glue is no longer used for aircraft repair. Provided certain precautions are taken, joints originally made with casein glue can be re-made with S.R. adhesive and the necessary instructions are given in Scheme 3104. S.R. adhesive joints will usually be set by the application of heat, using one of the accelerated gluing methods outlined in Scheme 3105. There are several methods available, and the best for use under any particular circumstances can be assessed from the general notes given in Scheme 3105. In an emergency, however, when no heating appliances are available and provided the surrounding air temperature is above 50 deg. F., joints may be made without the use of an accelerating method at the discretion of the Engineer Officer. Methods of applying glue, and cramping and setting times will be found further on in this chapter.

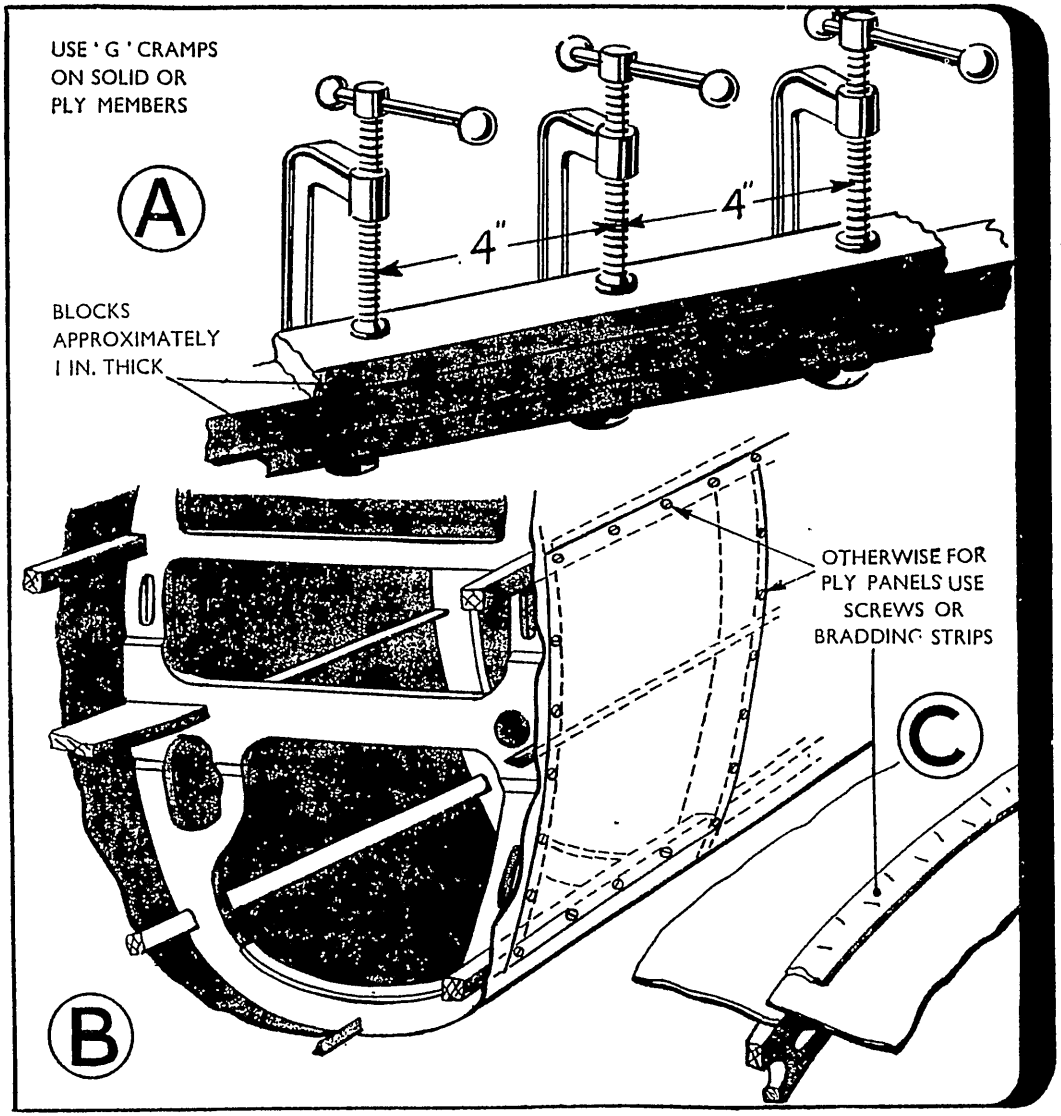
THE MAXIMUM SHADE TEMPERATURE at which repairs may be made is 90 deg. F. and this limit applies also to the temperature of the aircraft structure. Wooden aircraft structures exposed to the direct rays of the sun will reach temperatures considerably higher than the standard shade temperature; highest on the outer top skin and lowest on the inner surface of the bottom skin. Even the latter, however, may be much above the standard shade temperature.

IN OVERSEAS COMMANDS, therefore, repairs must not be made in the direct rays of the sun, but the aircraft must be moved under cover and kept there for some time to ensure that the temperature of the structure has fallen to the shade temperature.

THE CLOSED ASSEMBLY or "shuffling" time at 90 deg. F., is limited to 8 minutes and the work should be planned accordingly (see Scheme 3104, Part (b)).

BEFORE APPLYING GLUE make sure that the surfaces to be joined are smooth and free from protective treatment, grease, dirt, or old glue. The mating surfaces must be thoroughly sanded with medium paper before applying the glue—this is especially important when making a joint in plywood. The object of this sanding is not to score the surfaces but to remove loose fibres together with surface glaze which is found particularly on plywood. Do not sand too much, otherwise the joint will no longer fit—you need only remove a few "thou." of wood from the surface to get satisfactory results. Remember, ***sanding is essential,*** otherwise the glue joints will be under strength.

EXCESS GLUE, which is sometimes inevitable, may join together two surfaces which should remain separate. This accidental gluing can be prevented by shielding the surfaces concerned with waxed paper. An obvious use of this method is between a bradding strip and the plywood being glued. Wherever possible, remove all excess glue from around a joint before it sets hard, since, the wood concerned is to be planed, etc., later on, you will find that the dried glue blunts the cutting edge of the tool very quickly.



3102—GENERAL NOTES ON CRAMPING

APPLICATION OF PRESSURE to a glued joint will, in most cases, be made by one or other of the methods shown in the adjoining sketches. Whichever method is used, the primary aim must be to secure even pressure over the whole area.

USE CRAMPS wherever possible, in conjunction with wood packing blocks about an inch thick to distribute the pressure. If this is not practicable, your next choice should be **WOOD-SCREWS,** provided there is sufficient width of wood to prevent splitting and that they can remain in position after the glue joint has set. The use of screws in the manufacture of the structure being repaired, is a good indication that this is the best method of cramping.

BRADDING STRIPS will be used to provide the necessary pressure in cases where neither cramps nor wood-screws can be used. These strips will normally be of plywood about $\frac{3}{16}$ in. thick and the brads used will depend on the dimensions of the joint to be glued. When using these strips on a scarf joint a sufficient number of them must be applied (side by side) to cover the joint completely, with the brads in adjacent rows staggered. For normal repair work, brads should be placed at about $\frac{3}{4}$ in. centres, whether in single or staggered rows. Brads for $\frac{1}{16}$ to $\frac{3}{32}$ in. plywood should be $\frac{7}{8}$ in. long. 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 the hammer. At the completion of the cramping period the brads can be removed quite easily by levering up the bent end with a screwdriver and then extracted with pincers. In this way you will minimise the danger of damaging the structure and bradding strips during the removal operation. When applying pressure to a convex surface, it is often more satisfactory to use old machine belting instead of plywood strips for bradding.

CRAMPING TIME is the period during which pressure is applied to the joint by one of the above methods of cramping. The length of this period will depend on the type of glue being used and the rate at which water can escape from the joint. The second of these factors depends on the moisture content of the wood and the temperature and humidity of the surrounding air. Specific times for the various types of glues are given later in this chapter, under the separate instructions.

Casein is no longer used for the repair of aircraft structures and the instructions for its preparation and use have been removed from this publication. The correct adhesive for all airframe repair work, at home and overseas, is Glue, synthetic resin, type B.70, described in Scheme 3104.

3104 — S.R. GLUE, TYPE B.70 (AEROLITE 306)

PART (a)—GENERAL NOTES AND MIXING INSTRUCTIONS

AL 12 *

AEROLITE 306 is the gap filling synthetic resin (S.R.) ~~adhesive to be used for all repairs~~ to wooden airframe structures at home and overseas. ~~This adhesive, as supplied in powder form, will remain usable for two years at home and in N.W. Europe, and 18 months in all overseas commands, from the date of manufacture if stored in a dry, cool place.~~ The powder has to be mixed with water and methylated spirits and is then ready for use in conjunction with an acid hardener. Although the hardener does not react chemically with the adhesive, its presence is essential as a catalyst to start and then control the setting action. The function of the methylated spirits is to assist the freeing of air bubbles from the adhesive mixture, before the adhesive is used.

STORES REQUIRED for the mixing and use of Aerolite 306 adhesive. The following items will be required from Stores:

Stores Ref.

33C/972 (2¾ lb.) Glue, synthetic resin, type B.70—This is in powder form and is supplied
33C/1188 (5½ oz.) in tins. The 2¾ lb. tin contains the correct quantity for mixing with one pint of liquid (water and methylated spirits in the required proportions). The 5½ oz. tin requires ⅛ pint of this fluid to provide about ½ pint of made-up adhesive.

33C/973 Hardener, G.B.M.—Supplied in 2-gallon stone jars.

40D/654 Container, glue—This is a waxed paper carton for use as the working and storage container for the mixed glue. Both the lid and body of the carton are marked with the word "Glue".

40D/655 Container, hardener—This is similar to the above-mentioned glue container but is used for the hardener. Both lid and body of the carton are marked with the word "Hardener".

34D/209 Spirit, methylated, industrial.

3104

In addition to the above, spatulas for application and stirring, and a container for mixing the adhesive, will be required.

TO MIX AEROLITE 306, select a clean container of glass, earthenware, tin or wood; freedom from hardener and alkaline substances such as soap or casein glue is especially important. A dope thinners tin with the conical top removed is suggested for mixing the larger quantities.

Using 2¾ lb. tin

Measure out ⅛ pint of methylated spirits, using the appropriate mark on the inner surface of the waxed paper "glue" carton and pour into the selected container. Pour water into the same carton up to the 7/16 pint mark and add this to the methylated spirits. Repeat this second operation thus obtaining 1 pint of fluid. If you have a pint measure available, it may be easier to pour the methylated spirits into it and then fill up with water, pouring the mixture into the selected container.

Using 5½ oz. tin

Obtain a clean "glue" carton and measure into it approximately two teaspoons of methylated spirit. Add water until the mixture reaches the lower black line in the carton, i.e. ⅛ pint of fluid.

Stir the mixture thoroughly and then slowly add the complete contents of the appropriate size tin of Aerolite 306 powder, stirring constantly. Don't add the powder all at once as this will produce a lumpy mixture.

If it is not convenient to mix the above quantities and if weighing facilities are available, the following proportions (by weight) should be used:—

Aerolite 306 powder	100
Water	40
Methylated spirits	5

Note: The volumetric proportion of water to methylated spirits is not very critical.

AFTER MIXING the adhesive, it must be poured into clean, new, waxed paper "Glue" cartons, marking the date of mixing on the cartons and allowed to stand for 24 hours. If this standing period is omitted the adhesive will contain air bubbles which would produce a joint well under strength. Therefore look ahead and mix the adhesive at least a day before use. This period of standing need not interfere with speedy repair work, as the mixed adhesive will keep in good condition for one week if stored in a cool place, and in a waxed paper container with its lid on tightly and provided the lid is always replaced on the container immediately after use. If on reopening the container you find that a skin has formed on the surface of the liquid the adhesive can still be used provided the skin is first removed. Don't attempt to stir the skin into the liquid, as it will not dissolve.

HARDENER (a purple fluid) should be poured as required into a clean, new, waxed paper container marked with the word "Hardener". Check that correctly-marked lids are used. When pouring out the hardener, avoid getting splashes on the skin or clothes as it is acid.

GLUE ROOM. 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 of any one mix in the workshops. A suggested layout for a glue room is given in the Appendix (Scheme A.2). It will be seen that in designing the layout, the primary object has been to keep the adhesive and hardener strictly separate—an essential factor throughout the mixing and spreading operations.

WAXED PAPER CONTAINERS should not be used again having once been emptied.

READ THE WARNING GIVEN AT THE BOTTOM OF THE NEXT PAGE

* Aerolite 306 may be used irrespective of date of manufacture unless, when the tin is opened, the contents have blind to be lumpy, or the tin corroded.

PART (b)—INSTRUCTIONS FOR USING THE ADHESIVE

OBTAIN FROM THE GLUE ROOM, or glue store, sufficient mixed adhesive and hardener to do the job in hand. These should be contained in appropriately marked waxed paper cartons—look for the date on the glue carton to check that it has not been mixed for longer than 7 days. Clean spatulas and spreaders should also be obtained, together with a stirrer for the adhesive. It is essential to keep the hardener and hardener spreaders separate from the adhesive and adhesive tools.

BEFORE APPLYING THE ADHESIVE make sure that the surfaces to be joined are smooth and free from paint, grease, dirt or old adhesive. Plywood should be sanded with medium paper (see Scheme 3101). The joint should then be assembled dry and any gaps noted. All steps and gaps should be eliminated from scarf and butt joints. Before starting to spread the adhesive it should be given a final stir—do this gently to avoid the formation of air bubbles.

APPLY THE ADHESIVE in a thin even film to one of the surfaces to be joined, using a spatula of wood or one of the tools described in the Appendix (Scheme A.1). As a rough guide, the rate of application should be between four and five ounces for 10 sq. ft. You may have to exceed this rate of application in cases where uniform cramping pressure cannot be applied or where accurate mating of the surfaces is impossible. Allow the treated surface to become tacky.

APPLY THE HARDENER to the other surface of the joint, while you are waiting for the adhesive to become tacky. The hardener should be spread with one of the tools described in Scheme A.1 or with a soft brush.

MAKE THE JOINT immediately the hardener has been applied and the adhesive has become tacky and cramp up as quickly as you can. Don't "shuffle" the joint once it has been made or you will greatly reduce its ultimate strength. Should the adhesive have become nearly dry before you are able to finish cramping the joint, you will have to clean off all the adhesive and start again. Remember that as the temperature of the surrounding air increases, the shorter will be the time taken by the adhesive to become tacky and subsequently to dry. At 70 deg. F. you will have approximately 20 minutes to apply the adhesive and hardener and complete the cramping operation. At 90 deg. F., however, you will have only eight minutes to complete this work. Therefore if you are working when the atmospheric temperature is high, plan your cramping sequence so that you don't overshoot the time available for this operation. The use of one of the accelerated gluing methods will not, of course, affect the time available for making and cramping a joint.

UNDER NO CIRCUMSTANCES CLOSE A JOINT IF THE ADHESIVE OR HARDENER TREATED SURFACES HAVE BEEN ALLOWED TO DRY. SHOULD THIS HAPPEN, A FRESH APPLICATION OF ADHESIVE OR HARDENER, AS APPLICABLE, MUST BE MADE.

AN ALTERNATIVE METHOD OF APPLICATION may be used where one of the two surfaces to be joined is inaccessible. In such instances, apply the adhesive to the accessible surface as described in the paragraph above. After allowing it to become tacky, spread the hardener lightly over the same surface. Bring the adhesive plus hardener-treated surface into contact with the untreated surface of the joint as quickly as you can and apply cramping pressure.

CRAMPING TIMES. Normally all joints made with S.R. adhesive will be set by using one of the accelerated methods outlined in Scheme 3105. Thus, usually, the cramping and setting times to be used will be obtained from the Scheme dealing with the appropriate accelerating method. In an emergency, however, when no heating appliances are available and provided the atmospheric or hangar temperature, as appropriate, is above 50 deg. F., joints may be made without using one of the accelerating methods, at the discretion of the Engineer Officer. The relation of cramping time to atmospheric or hangar temperature is given in Table 1 below.

TABLE 1—Cramping times
(emergency conditions—see above)

Temperature (deg. F.) ...	50	60	70	80	90
Cramping time (hrs.) ...	12	5	3½	2½	2

SETTING TIME, i.e. the time to be allowed between the application of cramping pressure and the subsequent flying of the aircraft, is as follows:—

STRUCTURAL PARTS ... ... Twice the cramping time
NON-STRUCTURAL PARTS... ... ... The cramping time only

OLD CASEIN JOINTS can be remade with S.R. adhesive provided certain precautions are taken. Casein is alkaline in nature and will therefore tend to neutralise the acid hardener used with S.R. adhesive, should they come into contact with one another. If the hardener is neutralised to any extent, the joint will not set properly. To prevent this happening, go ahead as follows:—

(i) Clean the joint faces, removing all traces of old adhesive.
(ii) Apply a coat of hardener to each face of the joint and allow to dry.
(iii) Repeat operation (ii).
(iv) Go ahead as for a normal joint, applying the adhesive and a fresh coat of hardener.

Note. It is permissible to use S.R. adhesive across an old casein adhesive **line,** without adopting the above precautions, provided all surplus casein adhesive is removed before applying the hardener.

WARNING. (i) It is essential to prevent even traces of hardener from entering the "glue" container. Spatulas or brushes used for hardener must never be brought into contact with those used for adhesive, or vice versa. In this connection, you may find the carrier described in the Appendix (Scheme A.1) helpful.

(ii) Don't let the hardener splash your skin or clothes as it is an acid.

(iii) Before mixing or using S.R. adhesive, always rub Ointment, prophylactic (Stores Ref. 33D/363) or Rosalex C (Stores Ref. 33D/353) on your hands to protect the skin—wash your hands thoroughly as soon as you have finished the job. Keep your overalls clean and free from adhesive—the cuffs are particularly important as the skin on your wrists is comparatively delicate.

3105 — GENERAL NOTES ON ACCELERATED GLUING

ACCELERATED GLUING, i.e. the application of heat to a newly-made glue joint, is used either to offset the effect of low atmospheric temperature, or at normal temperatures to reduce the time taken for the adhesive to set and hence expedite the completion of a repair. There are several methods of getting the heat to the glue film, and as each tends to have a specialised application, a table is given below, setting out the main characteristics of each method. This table should enable you to select the method most suited to any particular job.

METHOD	STEEL FOIL (Scheme 3106)	ELECTRIC BLANKET (Scheme 3107)	HOT WIRE (Scheme 3108)	RADIANT HEAT (Scheme 3109)
BASIC PRINCIPLE	Electrical heating of a strip of steel foil clamped directly over the joint.	Electrical heating of a wire element built into a blanket which is lashed over the repair area.	Electrical heating of a fine copper wire which is buried in the glue joint itself.	Infra-red rays emitted from a standard electric light bulb, heats the repair area.
FOR USE IN	Workshops, dispersal or field.	Workshops, dispersal or field.	Workshops, dispersal or field.	Workshops (having mains electricity supply).
TYPE OF REPAIR	Straightforward repairs to plywood less than $\frac{3}{16}$ in. thick or to solid members less than $\frac{3}{8}$ in. square.	Repairs to plywood less than $\frac{3}{16}$ in. thick, of any degree of complication provided the repair area is less than 3 ft. 4 in. square.	Repairs to plywood greater than $\frac{3}{16}$ in. thick or to solid members of any size.	Repairs to plywood less than $\frac{3}{16}$ in. thick or to solid members less than $\frac{3}{8}$ in. square—particularly in inaccessible parts of a structure.
*EQUIPMENT REQUIRED	(*a*) 12 or 24-volt ground starter trolley. (*b*) Roll of steel foil. (*c*) Felt for lagging. (*d*) Resistance board (see Scheme A.3). (*e*) Adapter box (see Scheme A.4).	(*a*) 24-volt ground starter trolley. (*b*) Electric blanket. (*c*) Felt and tarpaulin for lagging. (*d*) Sheet of brown paper. (*e*) Adapter box (see Scheme A.4).	(*a*) Reel of 38 gauge bare copper wire. (*b*) 12-volt accumulator (in an emergency the aircraft accumulator may be used, at the discretion of the Engineer Officer). (*c*) Felt for lagging. (*d*) Ammeter or adapter box.	(*a*) A 40-watt electric light bulb mounted in a special reflector.

* The equipment listed excludes the normal gear required for making a glued joint.

FULL WORKING INSTRUCTIONS are given for the various accelerated methods, in the Schemes indicated in the table above.

TACKING is a specialised application of the Hot Wire accelerated gluing method (see Scheme 3108). The joint is subjected to heat for a period which, although very short, is sufficient to set the adhesive in the immediate vicinity of the heating elements. This partially set joint is sufficiently strong to permit the removal of the cramping pressure, without jeopardising its ultimate strength. It will be appreciated that this procedure is extremely useful when dealing with complicated repairs where the latter part of the repair would have to be held up until the cramps have been removed from joints done earlier in the repair sequence. Detailed instructions for "Tacking" will be found in Scheme 3108.

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3106 - STEEL FOIL ACCELERATED GLUING

PART (a)—GENERAL NOTES

STEEL FOIL FOR ACCELERATED GLUING is particularly suitable for dealing with straightforward repairs to plywood less than $\frac{3}{16}$ in. thick, provided the joint length is less than 17 ft. 6 in. or 35 ft., depending on the voltage of the accumulator available. From the aspect of equipment required, this method can be used in Workshops, Dispersal or the Field. The basic principle of the method is to place a strip of steel foil 1 in. wide and 0·002 in. thick (Stores Ref. 30A/2784) over the newly-made glue joint, keeping it in place with bradding strips. After applying pressure to the joint, either using these bradding strips or separate cramps, an electric current, supplied by a 12 or 24-volt starter trolley, is passed through the foil, generating heat. This heat is conducted through the structure to the glue film where it accelerates the setting process. With a fixed supply voltage the heating effect will depend on the length of foil in the joint and to keep this heating effect constant for different sized repairs, the foil is connected to the battery through an adjustable resistance.

THE RESISTANCE mentioned above should be made up from local resources to the instructions given in the Appendix (see Scheme A.3). It will be seen that the foil used in the resistance is tapped at intervals of 6 inches. To obtain the required temperature there must be a current through the foil of 18–20 amps., regardless of the size of the repair, and to obtain this, the length of foil in the joint plus that tapped off the resistance must always total 18 ft. for a 12-volt accumulator or 36 ft. for a 24-volt accumulator. Typical examples of circuits are given in Table 1 below.

TABLE 1—TYPICAL CIRCUITS

Length of foil in repair	Length of foil tapped off resistance	Total length of foil	Voltage of accumulator used
8 ft.	10 ft.	18 ft.	12
19 ft.	17 ft.	36 ft.	24
*25 ft.	11 ft.	36 ft.	24

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

FOR SKIN REPAIRS involving either lap or scarf joints, the steel foil must always be positioned centrally over the joint width under the bradding strips or cramping blocks. Joints up to 2 in. wide will only need one run of foil, but joints between 2 and 4 in. wide will need two parallel strips positioned equidistantly over the width of the joint. At the corners of a repair, the foil must be looped as shown in the illustrations given in Part (c) of this Scheme; the foil must never be folded under the bradding strips, as this would produce uneven heating at the corners. Furthermore, to prevent short-circuiting at the corners of a repair, between the runs of foil at right-angles, the bradding strips used should be at least $1\frac{1}{4}$ in. wide. When parallel strips of foil are being used, you must be sure to check that they do not touch one another and therefore short-circuit at any point in their run.

SOLID MEMBERS can be repaired using this method of accelerated gluing, provided they are less than $\frac{3}{8}$ in. square. For this type of repair, foil should be placed on opposite sides of the member, as shown in sketch "D" of the illustrations given in Part (c) of this Scheme. The foil should be held in position by bradding strips (brads at about $1\frac{1}{4}$ in. pitch) and pressure should be applied to the joint in the normal way with cramps. Don't place the foil along the sides of the member containing the feather edges of the scarf joint.

ELECTRICAL CONNECTIONS for making the circuit are indicated in the circuit diagram given on the next page. In addition to the resistance already mentioned, an adapter box must be used in the circuit for connecting the ground starter trolley to the resistance and heating circuit. This adapter box (see Scheme A.4) places an ammeter and switch in circuit, the former enabling the current to be checked from time to time. It should be noted that as the current taken by the foil and the resistance is fairly heavy, an accumulator of less capacity than a standard ground starter trolley, must never be used. Furthermore, the charger motor on the trolley must be kept running throughout the heating period—by doing this, the current supplied by the accumulator itself, will be kept within reasonable limits. Where separate lengths of foil are connected in series, Unicel 19 cable should be used (see sketch B at the end of this Scheme).

3106 - STEEL FOIL ACCELERATED GLUING cont.

PART (b)—WORKING INSTRUCTIONS

TO USE THIS METHOD OF ACCELERATED GLUING, go ahead as follows:—

(i) Make and glue the joint as for a normal repair.

(ii) Apply a measured length of foil in single or double runs, as appropriate for the width of joint, and place bradding strips over the foil as you go. If cramps are used on a skin repair, bradding strips are not needed as the foil can be placed under the cramping blocks. For solid members, however, bradding strips with extended brad pitch will be required to keep the foil in position—see sketch D on the next page. When you turn a corner with the foil, loop it over as shown in sketch A. At the ends of the foil, leave about 3 in. projecting from the bradding strip for making the electrical connections.

Note. If the foil has been used on previous jobs, you must make sure that it is not cracked, that there is not more than one brad hole in any one cross section and that the edges are free from notches deeper than $\frac{1}{16}$ in. If you neglect to carry out this examination, you are liable to get excessive heating at any such points of damage, with the attendant risk of fire.

(iii) Connect the foil through the resistance to the adapter box, as shown in the circuit diagram. The correct terminals on the resistance must be used as explained in Part (*a*) and Table 1 of these notes.

(iv) Place felt or sacking over the repair to prevent heavy heat losses during the heating period.

(v) Connect the starter trolley plug to the appropriate socket on the adapter board and switch on the circuit. Leave the repair for the appropriate heating period shown in Table 2, keeping the generator motor on the trolley running throughout this period. Check the reading of the ammeter on the adapter box from time to time—this should be between 18 and 20 amps.

(iv) At the end of the heating period switch the circuit off and break the electrical connections at the ends of the foil. Leave the lagging in position for a further $\frac{1}{4}$ hr.

(vii) At the completion of this cooling period, remove the lagging and cramps or bradding strips, together with the steel foil.

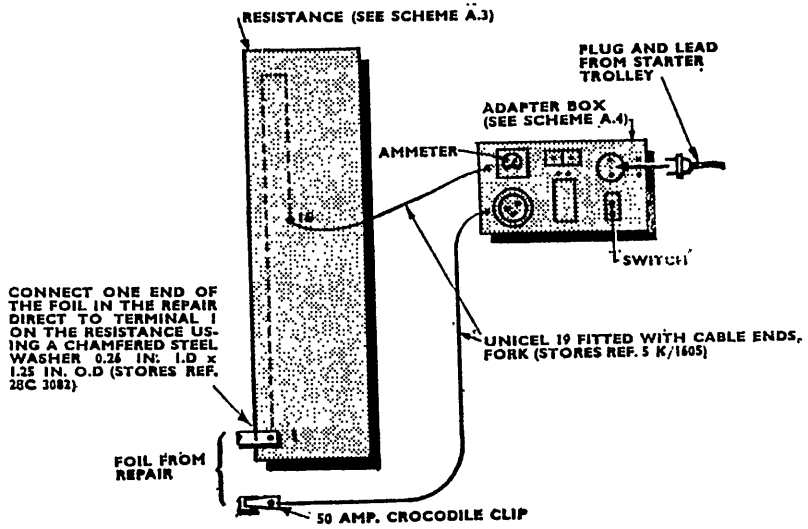
(viii) Make good the repair as instructed in the appropriate repair scheme.

(ix) If the foil is free from defects as mentioned in the note to sub-para. (ii) above, it should be rolled up carefully and stored for future use.

TABLE 2—HEATING AND COOLING TIMES

	CASEIN GLUE		S.R. GLUE	
	A (hours)	B (hours)	A (hours)	B (hours)
Heat for	$1\frac{1}{2}$	2	$\frac{3}{4}$	1
Leave cramped for further...	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
Total time	$1\frac{3}{4}$	$2\frac{1}{4}$	1	$1\frac{1}{4}$

Column A gives times for when the temperature is above freezing.
Column B gives times for when the temperature is below freezing.



CIRCUIT DIAGRAM

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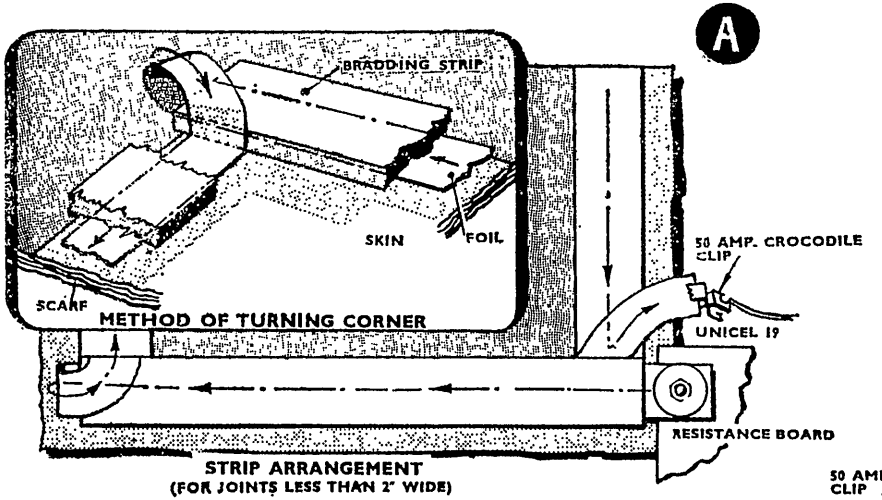
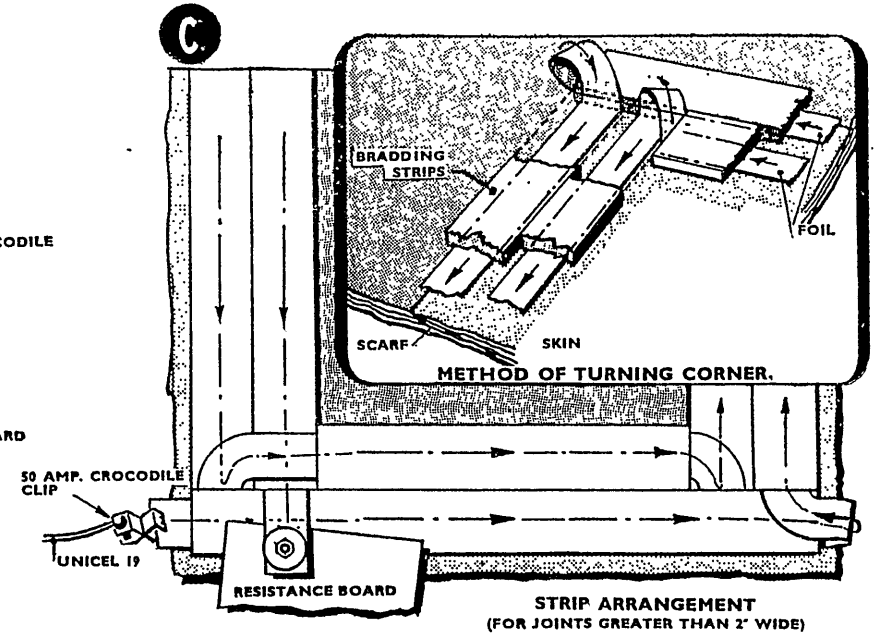
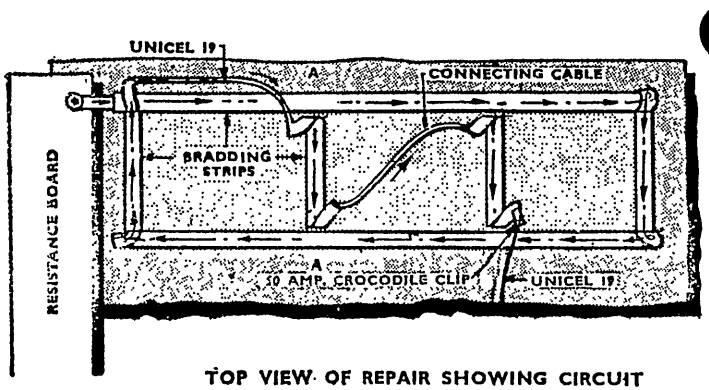
3106 - STEEL FOIL ACCELERATED GLUING cont.



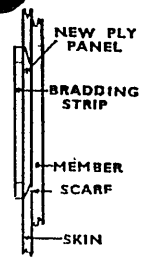
STRIP ARRANGEMENT
(FOR JOINTS LESS THAN 2" WIDE)



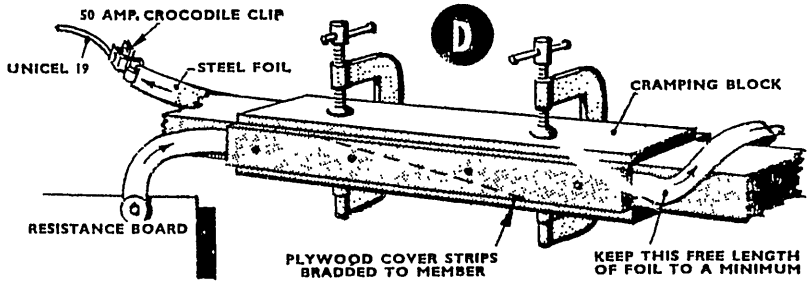
STRIP ARRANGEMENT
(FOR JOINTS GREATER THAN 2" WIDE)



TOP VIEW OF REPAIR SHOWING CIRCUIT



SECTION THROUGH A-A



3107 - ELECTRIC BLANKET ACCELERATED GLUING

PART (a)—GENERAL NOTES

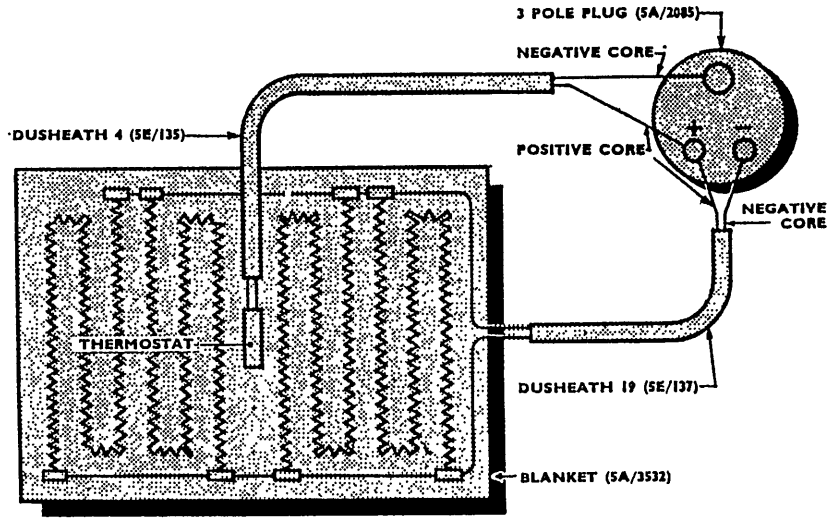
ELECTRIC BLANKET ACCELERATED GLUING is particularly useful for dealing with complicated repairs to plywood structures provided they are less than 3 ft. 4 in. square and the plywood less than $\frac{3}{16}$ in. thick. From the aspect of equipment required, this method is suitable for Workshop, Field or Dispersal repair work. The basic principle of the electric blanket method of accelerated gluing is to cover the newly-made glue joints for a specified period, with a blanket (Stores Ref. 5A/3532) containing electric elements which are heated by connection to a 24-volt ground starter trolley. The heat produced by these elements is conducted through the structure to the glue film where it accelerates the setting process. To keep the temperature constant at a predetermined constant level, the current passing through the elements is controlled by a thermostat built into the blanket.

THE BLANKET consists essentially of a pad 3 ft. 4 in. square containing the heating elements. This pad is backed with a layer of kapok for heat insulation and is enclosed by a 3 ft. 4 in. square of fine fabric stitched centrally to a 4 ft. square of waterproof canvas. The canvas cover is fitted with brass eyelets which take the cordage used for lashing the blanket in position. If the repair area is greater than 3 ft. 4 in. square, the blanket will have to be used successively in different positions until the whole area has been in contact with the heating pad for the specified time or more than one blanket will have to be used, each connected to a separate accumulator.

3107

***THE BLANKET, AS ISSUED,** will not be complete and you will have to fit a 3-pole, 25-amp. plug (Stores Ref. 5A/2085) to the electric cables leading from the blanket, before it is ready for use. It will be noticed that each blanket is fitted with two 2-core leads, one (of Dusheath 19 cable) being of greater diameter than the other (Dusheath 4 cable). Connect the positive core of the Dusheath 19 together with the positive Dusheath 4 core to the positive terminal on the plug. The negative core of the Dusheath 19 should then be connected to the negative terminal of the plug and the negative Dusheath 4 core to the third terminal of the plug (the one at the back of the larger diameter pin). See sketch "A" on this page for a diagram of these connections.

THE CURRENT taken by the blanket is fairly heavy and consequently, under no circumstances, may an accumulator of less capacity than a Standard 24-volt Ground Starter Trolley be used for the source of electricity. To connect the blanket to the starter trolley, an adapter box (see Scheme A.4) must be used. Initially, the current passing through the elements will increase to a maximum value and then fall to a steady value of about 13½ amps. as the elements heat up and the thermostat takes control. The charger motor on the trolley must be kept running while the blanket is being used, so that the accumulator itself will only have to supply about 5 amps. of the current required. During the heating period, the current through the circuit should be checked periodically with the ammeter on the adapter box to ensure that a failure does not go undetected. In this connection it should be noted that the thermostat and relay cuts off the current for a short period if the blanket gets too hot. Thus a zero reading on the ammeter should be ignored for a short period, but if the normal reading it not regained fairly soon, the circuit should be examined. If a failure of one of the blanket elements occurs, the current will fall to about 11 amps. The circuit diagram (B) given on the next page, shows the method of connecting the blanket to the accumulator.



CONNECTION OF BLANKET TO 3 POLE PLUG (A)

NOTE:—FOR REPLACEMENT OF LEADS, THE DUSHEATH CABLE SHOWN ABOVE OR THE EQUIVALENT DUCEL CABLE MUST ALWAYS BE USED.

**Note.—The initial issue of electric blankets will not be fitted with thermostats and the spade ends fitted to the two leads should be connected to terminals E and F of the adapter box when required for use. Thermostats, complete with leads, will be issued to units as soon as these are available. Connection to a 3-pole plug, as described above, should then be made.*

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PART (b)—WORKING INSTRUCTIONS

TO USE THIS METHOD OF ACCELERATED GLUING, go ahead as follows:—

(i) Place a sheet of tarpaulin on the ground near the repair and place the blanket on it, canvas side downwards. Cover the heating pad (which will be uppermost) with a sheet of felt or sacking. Don't tread or place heavy weights on the heating pad as the elements are very fragile.

(ii) Insert the 3-pole plug on the blanket leads and the 2-pole plug on the starter trolley leads into the appropriate sockets on the adapter box—see sketch B. The blanket will then start to heat up as soon as the current is switched on and should reach a steady temperature by the time you have completed operations (iii) to (v). Never connect the blanket to the accumulator while the former is rolled up.

(iii) Glue, make the joint and cramp as for a normal repair.

(iv) Wipe as much of the surplus glue from the joint as possible.

(v) Spread a sheet of paper over the joint to prevent any remaining surplus glue from sticking to the heating pad. Use waxed paper if you can—glue cannot stick to this.

(vi) Switch the current off and lash the blanket centrally over the repair, making sure that the heating pad is next to, and in close contact with, the whole repair area. Cramps, if used, should be so arranged that this requirement is satisfied.

(vii) Switch the current on again.

(viii) If the blanket is on the outside of a structure and if the temperature of the surrounding air is less than 50 deg. F., it should be covered with a sheet of sacking or felt to lag the repair, to minimise heat losses. Cover the blanket (and lagging if used) with a sheet of tarpaulin lashed in position. If the blanket is on the inside of a fuselage or similar structure, no lagging will be required but the heating pad must be kept in close contact with the repair area by a sheet of thin plywood supported with battens. **Important.** When this method is used on a built-up structure such as the Mosquito fuselage, a blanket is needed on both sides of the structure, the outer of which would require lagging. Alternatively you may have to repair the inner skin first by using one of the other accelerating methods and then use the electric blanket on the outer skin.

(ix) When the heating time (see Table I) has elapsed, switch off and disconnect the 3-pole plug from the adapter box but leave the blanket and lagging in position for a further half-hour. At the end of this cooling period, remove any lagging and the blanket from the repair and then carefully peel the sheet of paper from the structure.

(x) Remove the cramps or bradding strips from the joint and make good the repair as instructed in the appropriate repair scheme.

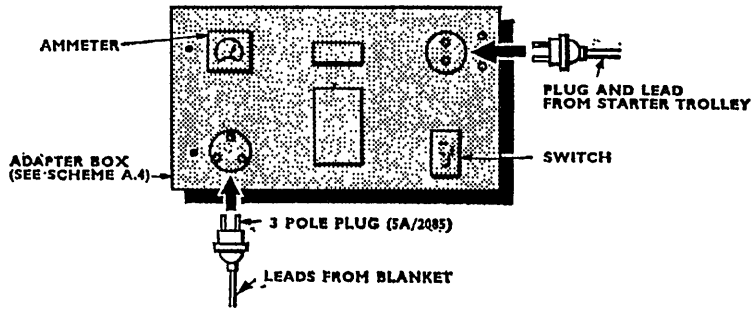
TABLE I—HEATING AND COOLING TIMES

	CASEIN GLUE		S.R. GLUE	
	A (hours)	B (hours)	A (hours)	B (hours)
Heat for	2	3	1	2½
Cramp for further	½	½	½	½
Total time	2½	3½	1½	3

Column A gives times for when the temperature is above freezing.
Column B gives times for when the temperature is below freezing.

DON'T fold the blanket—always roll it with the canvas on the outside and place it in a canvas container (to be made up locally).

ALWAYS handle the blanket with care to avoid damaging the elements and thermostat. Should the blanket become wet for any reason, dry it out as soon as possible and store it in a dry place—don't switch it on while wet.



CIRCUIT DIAGRAM (B)

3108 – HOT WIRE ACCELERATED GLUING

HOT WIRE ACCELERATED GLUING is the only satisfactory method for dealing with repairs to plywood greater than $\frac{3}{16}$ in. thick or solid members greater than $\frac{3}{8}$ in. square. The basic principle of this method is to bury a length of fine gauge bare copper wire in the glue joint, the wire being heated by connecting it to a 12-volt accumulator. The heat produced is conducted through the glue film, accelerating the glue setting process.

THE HEATING ELEMENT consists in every case of a 9 ft. length of 38 s.w.g. (0·006 in. dia.) bare copper wire (Stores Ref. 5E/2862) which when connected to a 12-volt accumulator will carry a current of about 4 amps. Where one heating element is inadequate to cope with the area of the joint being glued, you may use up to four elements connected in parallel to one accumulator, but if even these are insufficient, consult your electrician. If you have an adapter box available (see Scheme A.4) use this by connecting the ends of the heating elements to terminals E and F and the leads from the accumulator to terminals G and H.

REMEMBER THAT SEPARATE HEATING ELEMENTS MUST ALWAYS BE CONNECTED TO THE ACCUMULATOR IN PARALLEL.

THE SPACING OF THE ELEMENTS is not very critical. You must, however, follow the general principles shown in the sketches. Your aim in all cases should be to use as much as possible of the heating element in the joint within the limits set out in these diagrams. If, due to the position of the joint, the ends of the heating element will not reach the accumulator terminals, make the connections with two single-core leads with, say, 3/036 conductors.

TO USE THIS METHOD OF ACCELERATED GLUING go ahead as follows:—

(i) Cut 9 foot lengths of 38 s.w.g. bare copper wire (Stores Ref. 5E/2862) as required —check the gauge before cutting.

(ii) Lay the element(s) in the joint, using one of the methods shown. Make sure that short-circuiting does not occur, either between different parts of any one element, or between different elements. Typical wiring diagrams are given on the next page. Anchor the elements in position, if necessary, by passing them round the brads set temporarily just outside the joint (see sketch).

(iii) Plan your clamping scheme to avoid over-shooting the assembly time for the glue being used.

(iv) Apply the glue as for a normal joint.

(v) After carrying out the instructions for the glue being used, make the joint carefully to avoid disturbing the heating element(s) and cramp up as for a normal repair.

(vi) Place felt or sacking over the joint to minimise the heat losses.

(vii) Connect the heating elements to the accumulator through an adapter box if possible, but don't switch on until the cramping operation is complete.

(viii) After about 10 minutes check that the joint is heating up either by feeling with the hand or, better still, if the adapter box is being used, by checking the current in the circuit with the ammeter (it should be about 4 amps. for each element).

(ix) On completion of the heating period, disconnect the accumulator but leave the lagging in position for a further $\frac{1}{4}$ hr. At the end of this cooling period cut off the elements as near to the joint as possible.

TABLE I—HEATING AND COOLING TIMES

	CASEIN GLUE		S.R. GLUE	
	A (hours)	B (hours)	A (hours)	B (hours)
Heat for	1	1½	¾	1
Leave cramped for further...	¼	¼	¼	¼
Total time	1¼	1¾	1	1¼

Column A gives times for when the temperature is above freezing.
Column B gives times for when the temperature is below freezing.

HOT WIRE TACKING, which can only be used when the atmospheric or hangar temperature, as applicable, is above 50 deg. F., may be found useful for dealing with complicated repairs which include scarf joints in heavy members. This method sets the glue in the immediate vicinity of the heating elements after a very short period of heating. The joint will then be sufficiently strong to permit the removal of the cramping pressure and you will be able to get on with the remainder of the repair. It is stressed, however, that as the joint is probably less than 50 per cent. of its ultimate strength after this short period of heating, it is essential that the appropriate setting time given in Schemes 3103 or 3104 is allowed to elapse between tacking the joint and flying the aircraft.

TO USE HOT WIRE TACKING, go ahead as follows:—

(i) Carry out operations (i) to (vii) given for the hot wire accelerated gluing method.

(ii) Heat the joint for 10 minutes.

(iii) At the completion of this heating period, disconnect the accumulator and cut the heating elements as near to the joint as possible.

(iv) Allow the appropriate setting time to elapse before flying the aircraft (see above.

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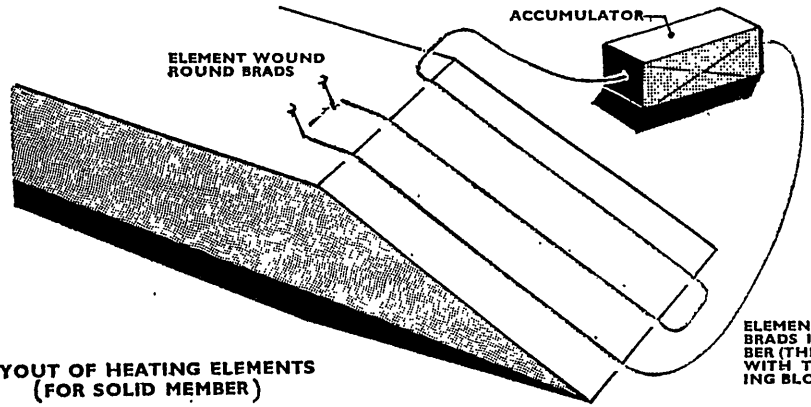
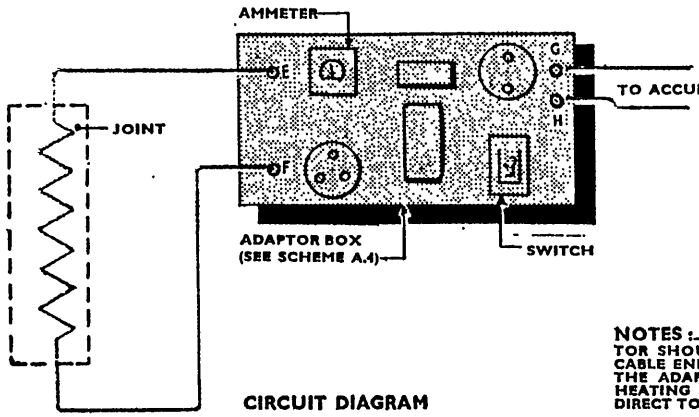


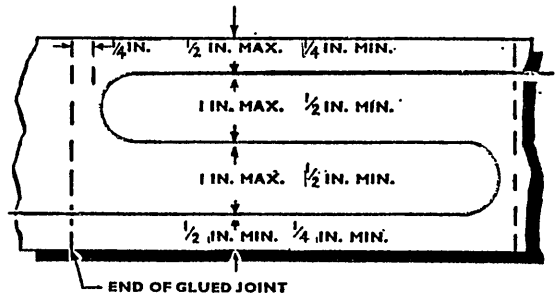
LAYOUT OF HEATING ELEMENTS (FOR SOLID MEMBER)

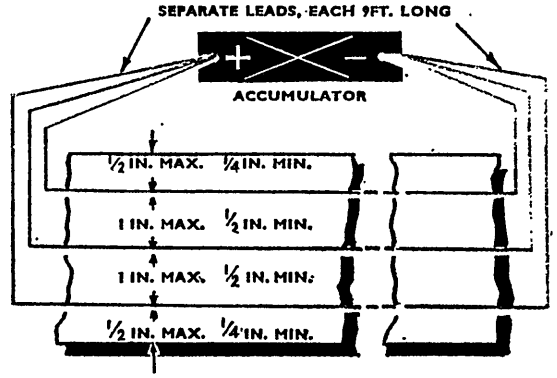
ELEMENT MAY BE WOUND ROUND BRADS IN LOWER SURFACE OF MEMBER (THE BRADS MUST NOT INTERFERE WITH THE POSITIONING OF CRAMPING BLOCKS)



CIRCUIT DIAGRAM

NOTES :—(I) THE LEADS TO THE ACCUMULATOR SHOULD BE FITTED AT G AND H WITH CABLE ENDS, FORK (STORES REF. 5LK/1605) (II) IF THE ADAPTOR BOX IS NOT AVAILABLE, THE HEATING ELEMENTS MAY BE CONNECTED DIRECT TO THE ACCUMULATOR.





SPACING OF HEATING ELEMENTS

3109 - RADIANT HEAT ACCELERATED GLUING

RADIANT HEAT ACCELERATED GLUING 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. square in inaccessible parts of a structure where it would be difficult to apply one of the other glue acceleration methods. One of the main advantages of this method is that the joints can be made quite independently of the heating arrangements. This method can only be used in the Workshops where there is a mains supply of electricity. The basic principle of radiant heat accelerated gluing is to place an aluminium reflector fitted with a standard 40 watt tungsten filament lamp over the repair area. The heat radiated from the lamp raises the temperature of the structure surrounding the joint and the glue film, thus accelerating the glue setting process.

THE REFLECTOR should be made up from local resources to the instruction given in the Appendix, Scheme A.5. As the base of the reflector is 10 in. square, several can be placed in line or to form a square to cover large repair areas. As mentioned above, the source of heat is a standard 40 watt tungsten filament electric light bulb to suit the mains voltage. ***On no account should a higher wattage bulb be used*** as this would probably cause the glue to bubble and produce a joint well under strength.

3109

TO USE THIS METHOD OF ACCELERATED GLUING, go ahead as follows:—

(i) Glue, make the joint, and cramp as for a normal repair.

(ii) Place the reflector over the repair area and cover it with felt or sacking to minimise the heat losses.

(iii) Connect the lamp to the mains with flex and heat the joint for the appropriate time given in Table I. It should be noted that no harm will be done if this heating period is over-shot.

(iv) At the completion of the heating period disconnect the lamp from the mains but leave the lagging and cramps or bradding strips in position for a further $\frac{1}{4}$ hour.

(v) At the completion of this cooling period remove the lagging and reflector from the repair.

(vi) Remove the cramps or bradding strips from the joint and make good the repair as instructed in the appropriate repair scheme.

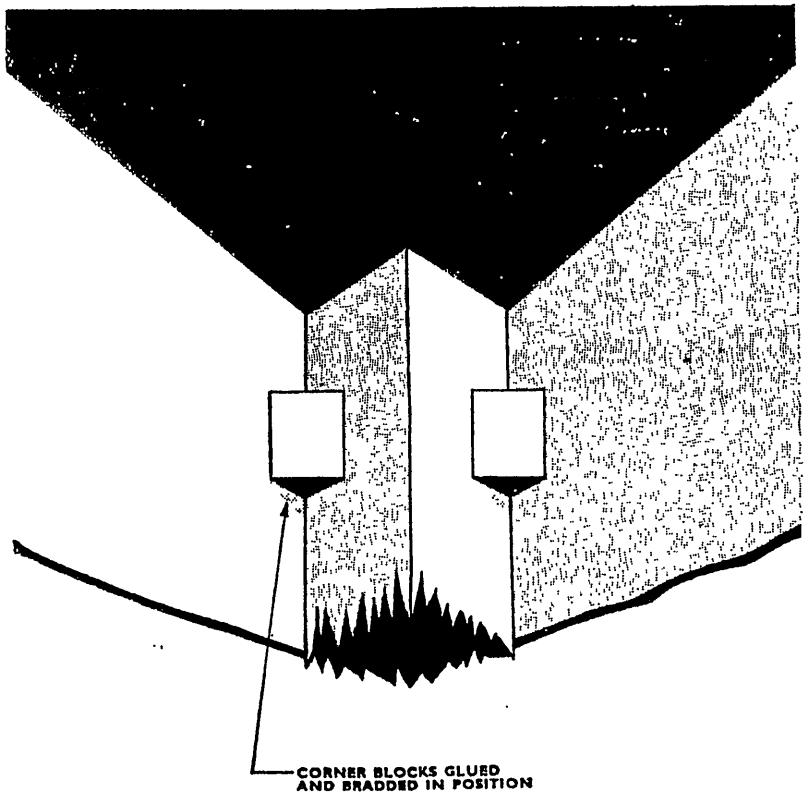
TABLE I—HEATING AND COOLING TIMES

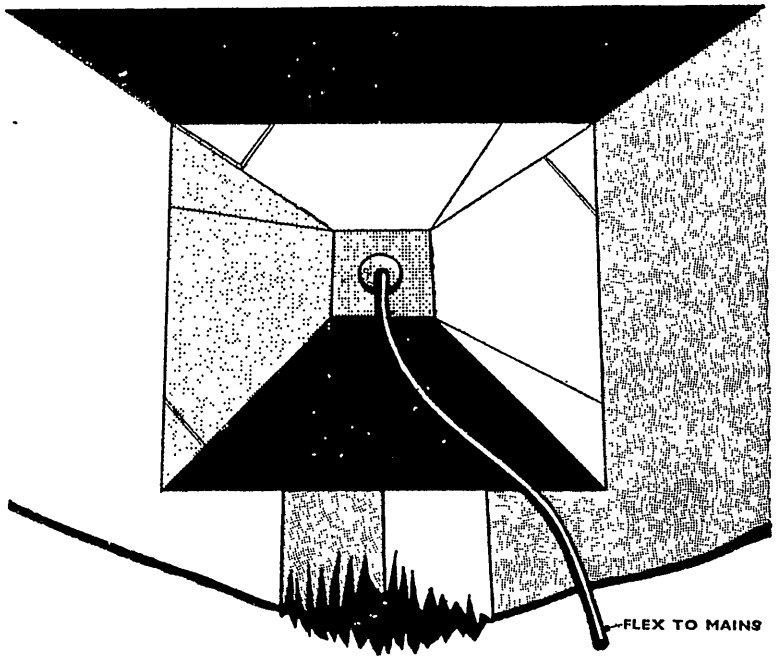
	CASEIN GLUE		S.R. GLUE	
	A (hours)	B (hours)	A (hours)	B (hours)
Heat for	$1\frac{1}{2}$	2	$\frac{3}{4}$	1
Leave cramped for further...	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
Total time	$1\frac{3}{4}$	$2\frac{1}{4}$	1	$1\frac{1}{4}$

Column A gives times for when the temperature is above freezing.

Column B gives times for when the temperature is below freezing.

3109 — RADIANT HEAT ACCELERATED GLUING cont.





REFLECTOR IN POSITION (FELT OR SACKING TO BE PLACED OVER THE REFLECTOR)

3109

TYPICAL USE OF RADIANT HEAT ACCELERATED GLUING

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STANDARD REPAIRS FOR AIRFRAMES

A.P. 2662A

Section 3

CHAPTER 32 — PLYWOOD

GENERAL NOTES ON PLYWOOD

THE USES OF PLYWOOD are many; the covering of airframes, flooring, fairings, and the webs of ribs and spars being the most important. Its use in spars and other box members is dealt with in Chapter 34.

BIRCH 3-PLY to B.S.I. Specification V.3 is the plywood normally used in airframe repairs. Suffixes to this specification number indicate the thicknesses of the plywood, the most useful of which are given in the table below. Where a repair scheme specifies a plywood thickness in inches and this is not available, the nearest equivalent in millimetres above the specified size should be used.

Specification	Stores Reference	Thickness—inches
V3/100	31A/78	$\frac{1}{32}$
V3/110	31A/81	$\frac{3}{64}$
V3/120	31A/27	$\frac{1}{16}$
V3/130	31A/83	$\frac{5}{64}$
V3/140	31A/28	$\frac{3}{32}$
V3/150	31A/29	$\frac{1}{8}$
V3/160	31A/30	$\frac{5}{32}$
V3/170	31A/31	$\frac{3}{16}$
V3/180	31A/32	$\frac{1}{4}$

LIGHTLY STRESSED PARTS may be repaired with plywood to D.T.D. Specification 427 or any "good commercial" grade. Before using these plywoods in an aircraft repair, you must, however, ***refer to the appropriate aircraft Vol. II, Part 3 or 4, to ascertain whether this is permissible*** as the specifications are less exacting than V.3 and hence must never be used in highly stressed parts.

DOUBLE THICKNESS CENTRE LAMINATION PLYWOOD will be found in some structures. It is simply 3-ply with the centre lamination twice the thickness of each of the outer laminations and is usually referred to as "DTCL". Unlike ordinary 3-ply, it has the same strength in any two directions at right angles, and is therefore used in members taking torsional loads.

WHEN MAKING REPAIRS, always remember that every part of the structure has been carefully designed for the loads it carries during use. So, when patching or renewing plywood, be sure that the patch, reinforcing ring, or renewed portion is always of the ***same thickness and specification as the original ply***—unless, of course, the Vol. II, Part 3 for the aircraft specifically instructs otherwise.

MATCHING THE GRAIN DIRECTION is also very important, as this often vitally affects the strength of the ply in its particular position on the aircraft.

SKINNING DIAGRAMS are normally given in the Vol. II, Part 3 of the relevant aircraft publication, and these should be used, wherever possible, to obtain the plywood thickness and the grain direction of the particular part of the structure you are about to repair.

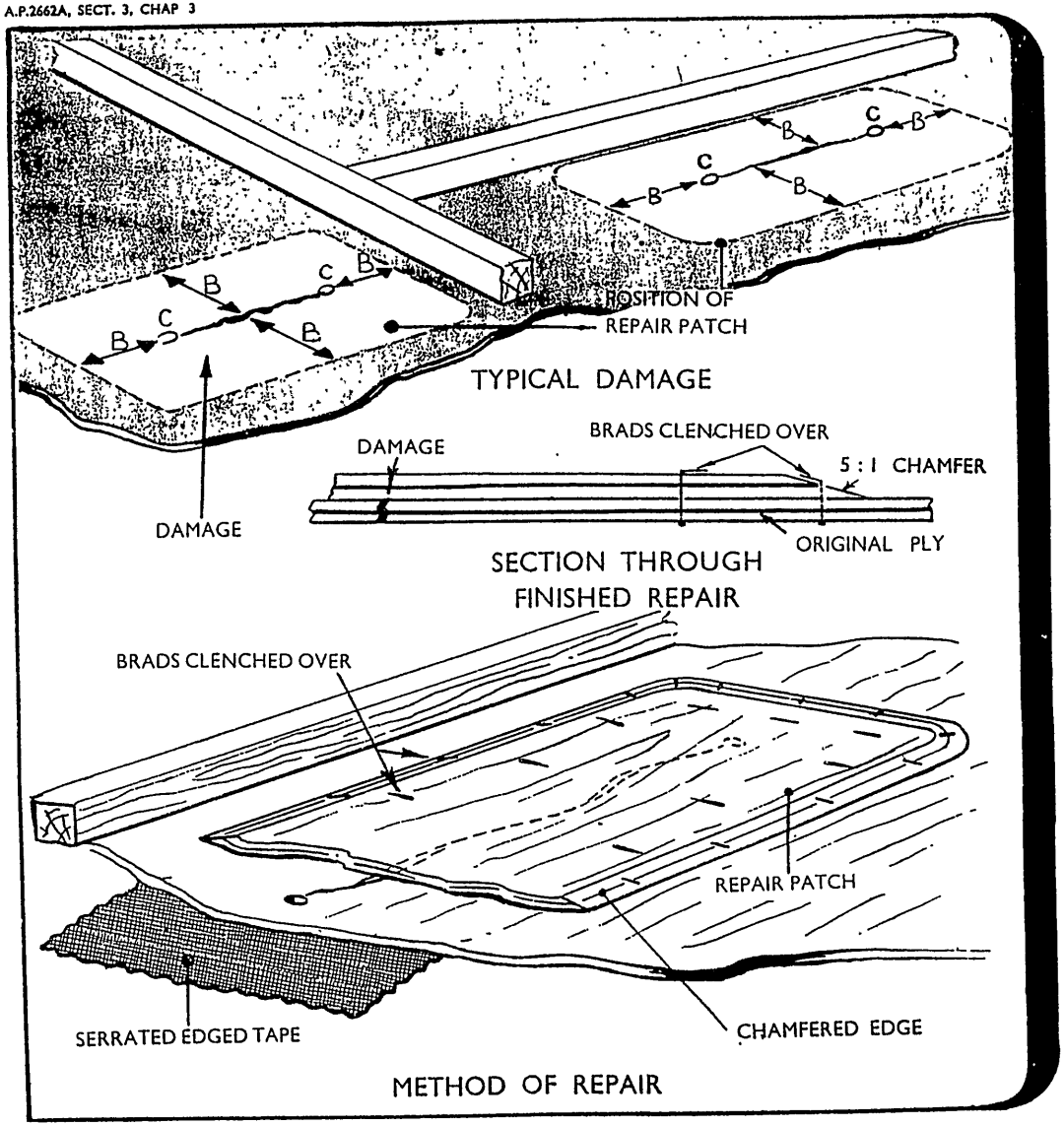
WHEN BENDING PLYWOOD, you may have difficulty in getting the required curvature without damaging the wooden structure to be covered. If so, the plywood should be pre-formed by one of the following methods:—

(a) Steaming or soaking in boiling water and cramping round a former ***until dry***; or

(b) gluing together laminations, building up to the required thickness, and cramping them round a former until the glue is dry.

Adjacent laminations in a built up member or panel must have their grain directions at right angles to one another. Plywood for bending should preferably be Grade A of the specification, but Grade B may be used provided care is taken to select a straight-grained piece, free from short grain on the surface.

REMOVING MADAPOLLAM or other fabric from plywood surfaces needs care: it is easy to damage the plywood unless certain precautions are taken.



3202—INTERNAL PATCH FOR CRACKS

USE THIS METHOD FOR CRACKS WHICH ARE:—

(i) In plywood $\frac{1}{8}$ in. thick or less,
(ii) Not longer than 12 in.,
(iii) In a position where an overlap "B" of at least 2 in. can be obtained all round the damage, and
(iv) Accessible from both sides through inspection covers, etc.

GO AHEAD AS FOLLOWS:—

(i) Clean up fabric on the outside if necessary.
(ii) Drill $\frac{1}{8}$ in. dia. holes, "C", at the extreme ends of the cracks to prevent them spreading.
(iii) Cut a patch:—
  (a) From the same grade and thickness plywood,
  (b) With the same grain direction as the damaged panel,
  (c) Having the required overlap,
  (d) With corner radii of at least $\frac{1}{2}$ in, and
  (e) With its edges chamfered to an angle of 5 : 1.
(iv) Clean the surface of the damaged panel, ready for gluing.
(v) Glue the patch centrally over the crack on the inside face of the damaged panel.
(vi) Secure with brads clenched over on the inside (across the grain), supporting the structure during driving and the heads during clenching.
(vii) Clean off any surplus glue.
(viii) The cracked surface of the original ply on the side which is not patched should be covered with 4 in. serrated-edged fabric if this is an external surface.

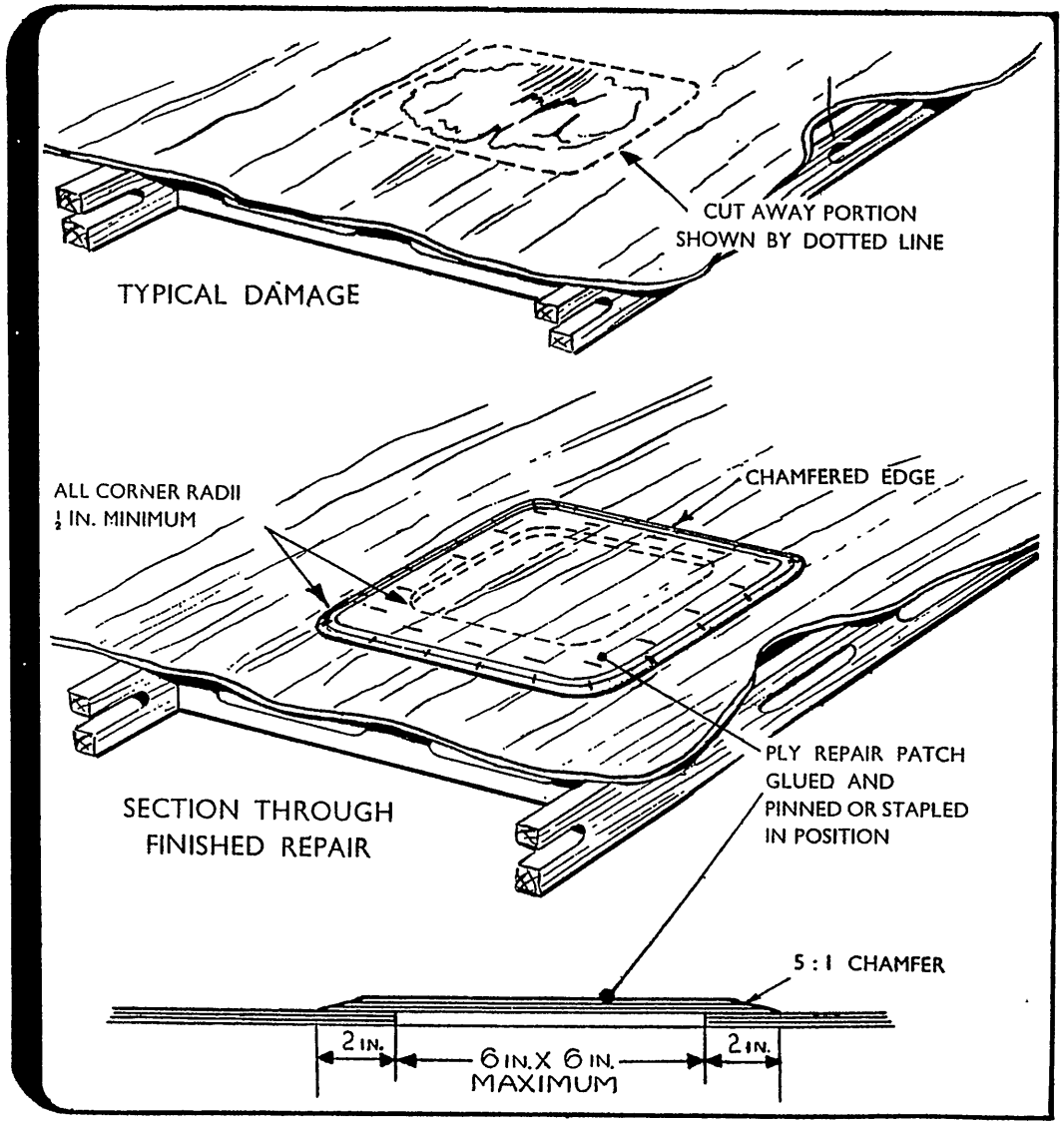
3203—RAISED PATCH REPAIR FOR INTERNAL PLY PANELS

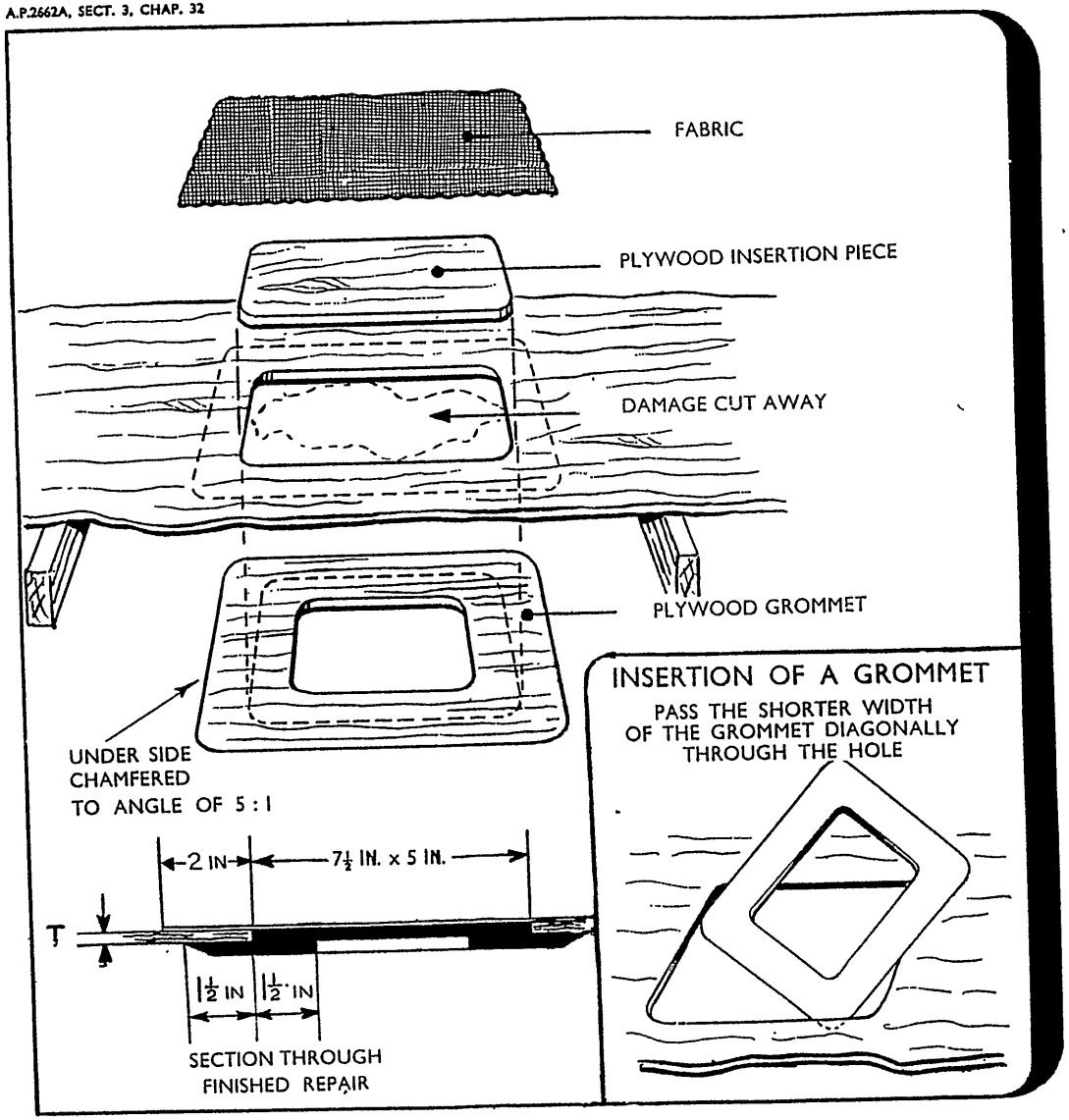
APPLY THIS METHOD TO DAMAGE WHICH IS:—

(i) In plywood $\frac{1}{8}$ in. thick or less,
(ii) Not exposed to the airflow,
(iii) Not greater than 6 in. square, and
(iv) Is accessible on both sides.

GO AHEAD AS FOLLOWS:—

(i) Cut away damage to the shape desired, leaving corner radii of at least $\frac{1}{2}$ in.
(ii) Cut a patch:—
  (a) From the same grade and thickness plywood,
  (b) With the same grain direction as the damaged panel,
  (c) Having an overlap of 2 in. all round,
  (d) With corner radii of at least $\frac{1}{2}$ in., and
  (e) With its edges chamfered to an angle of 5 : 1.
(iii) Clean the surface round the "cut-out" ready for gluing.
(iv) Glue and brad or staple the patch in position (clench brads over across the grain if used).
(v) Clean off any surplus glue.





3204—FLUSH INSERTION REPAIR
(NOT SCARFED)

USE THIS METHOD FOR DAMAGE WHICH IS:—

(i) In plywood $\frac{1}{8}$ in. thick or less,
(ii) Not larger than 5 in. across the grain and $7\frac{1}{2}$ in. along the grain,
(iii) Exposed to the airflow, and
(iv) Accessible on both sides.

GO AHEAD AS FOLLOWS:—

(i) Cut away the fabric (if any) and clean out the damage in the panel by cutting a rectangular hole 5 in. × $7\frac{1}{2}$ in. with corner radii of at least $\frac{1}{2}$ in.
(ii) Cut a plywood grommet:—
  (a) From the same grade and thickness plywood and with the same grain direction as the damaged panel,
  (b) To give overlaps of $1\frac{1}{2}$ in. as shown, with corner radii of at least $\frac{1}{2}$ in., and
  (c) With its edges chamfered to an angle of 5 : 1 (see sketch).
(iii) Cut a plywood insertion piece:—
  (a) From the same grade and thickness plywood and with same grain direction as the damaged panel,
  (b) To fit accurately in the hole prepared in operation (i).
(iv) Clean the surface of the original ply, round the hole, for gluing.
(v) Glue and brad or staple the grommet to the inside of the panel and cramp it (if brads are used clench over across the grain on the inside).
(vi) Clean off surplus glue.
(vii) Glue and brad or staple the insertion piece to the grommet (clench over brads across the grain if used). The ply should be supported during bradding or stapling.
(viii) Dope on a fabric patch with serrated edges and an overlap of 2 in. all round.

3205—FLUSH INSERTION REPAIR TO PLY (OVER MEMBER)

1. This is the same job as 3204 but adapted for use when a member comes into the area to be repaired.

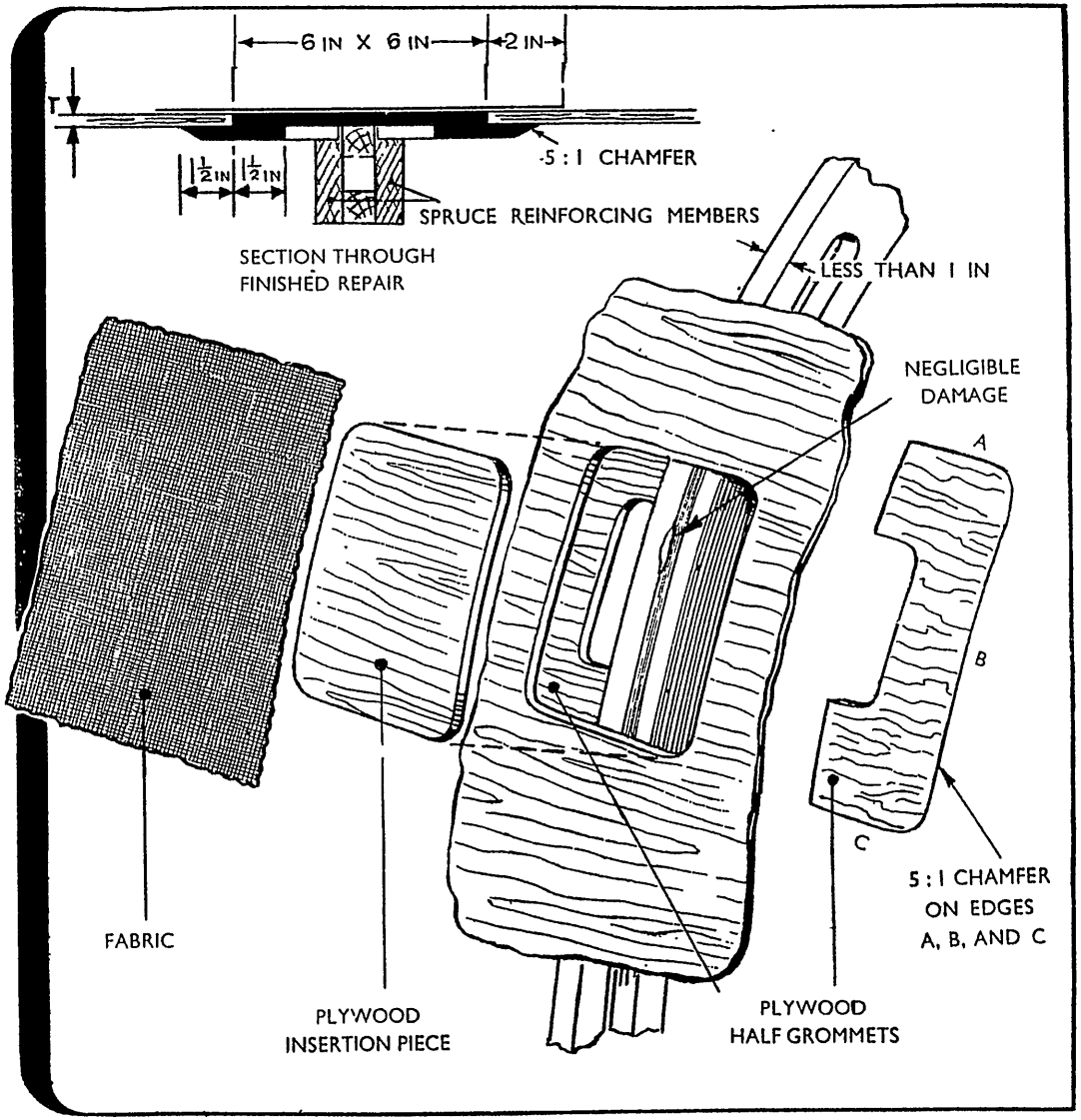
2. The member must be less than 1 in. wide (see sketch) and if damaged more than negligibly, it must have been repaired (see the relevant aircraft Vol. II, Part 3 and Chapter 33 of this book).

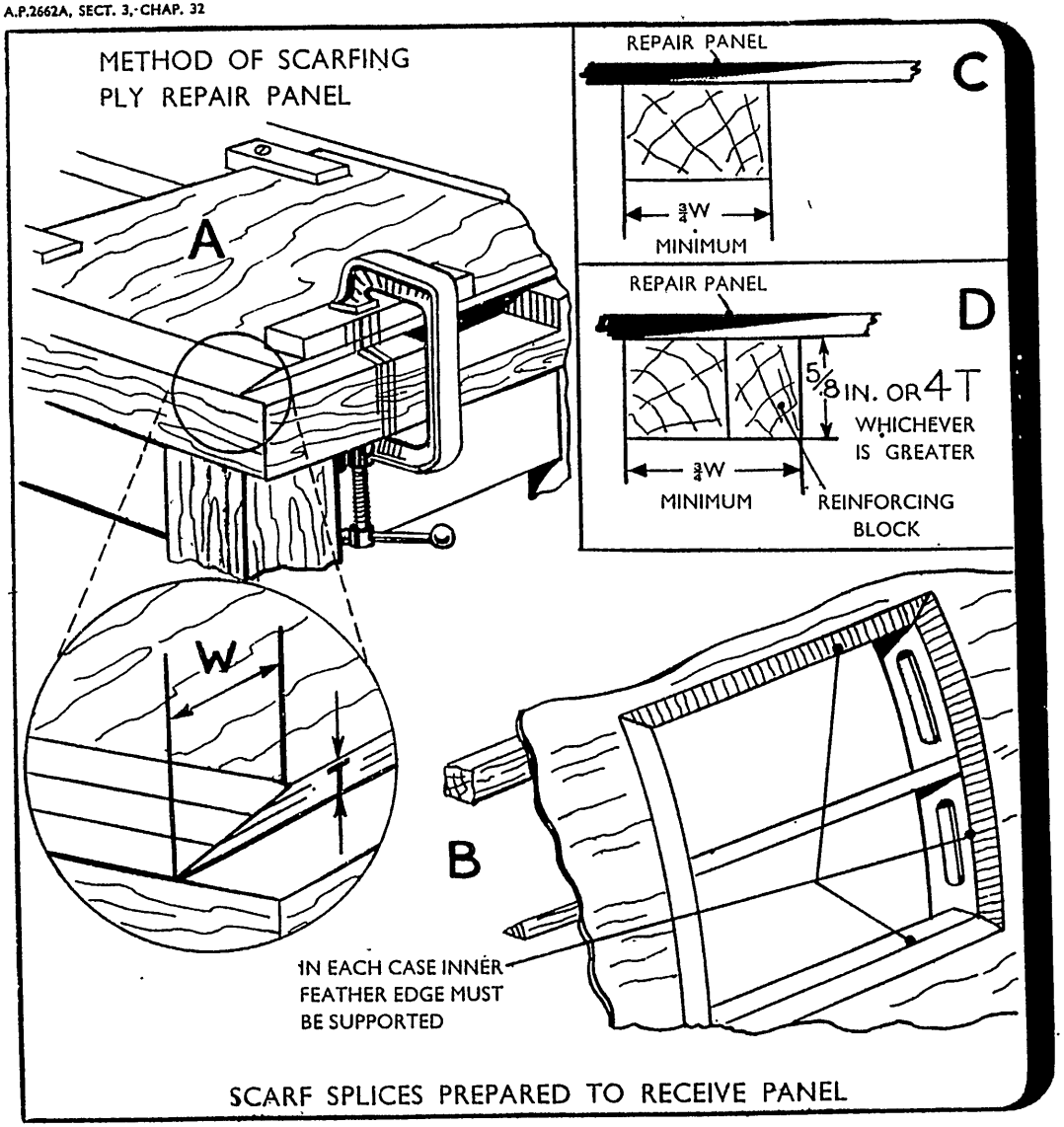
3. The grommet is made in two pieces so that it fits on each side of the member.

4. Spruce reinforcing members are glued and screwed on both sides of the member, symmetrically over the damage so that they support the inner edges of the half grommets. These members are $\frac{1}{4}$ in. thick and $8\frac{1}{2}$ in. long with each end chamfered to an angle of 5 : 1.

5. For general instructions see Scheme 3204 but note that the damage in this case is cut out to a hole 6 in. square with corner radii of $\frac{1}{2}$ in.

6. Remember that this repair only applies to $\frac{1}{8}$ in. ply or thinner.





SCARF SPLICES PREPARED TO RECEIVE PANEL

3206—SCARF SPLICES PREPARED TO RECEIVE PANEL

SPLICED JOINTS IN PLYWOOD should, in general, be made as set out in the following notes. Further instructions for specific repairs are given in later Schemes.

(i) The width "W" of the splice must be 9 times its thickness "T" (see sketch "A"). Careful work is essential to ensure an accurate fit.

(ii) The inner feather edge must always be supported by a member or reinforcing block at least ¾W wide. If the member is not wide enough, it must be built up with a reinforcing block (see sketch "D").

(iii) In certain cases a 15 : 1 splice may be specified in the appropriate aircraft Vol. II, Part 3 or 4, in which case this longer splice must be used.

DON'T CUT PLY RIGHT BACK TO A MEMBER when cleaning out damage. Check the width of the member first and if it is less than ¾W, allow for the reinforcing block. It will be easier to fit it on the side you can see than round at the back.

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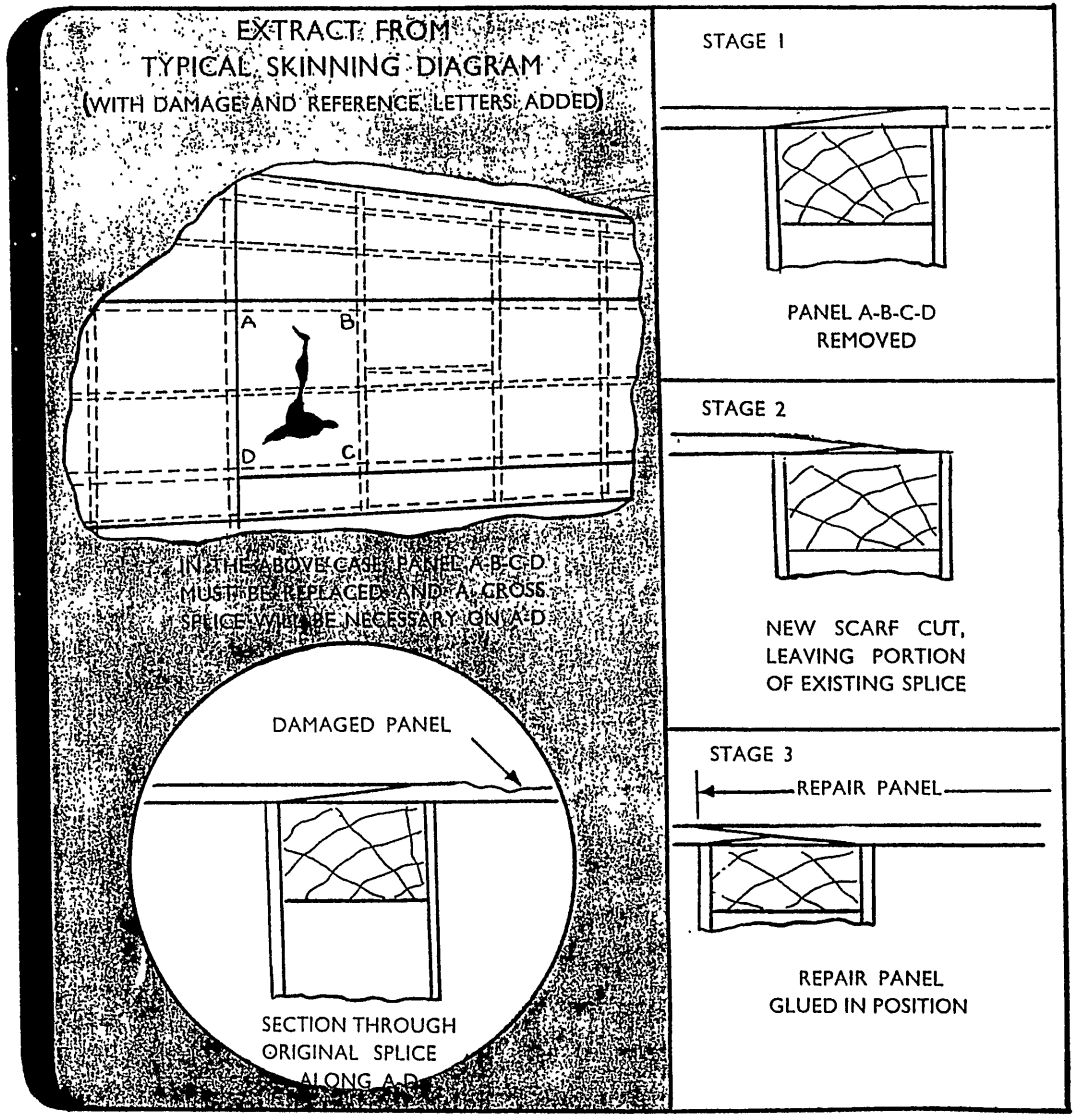
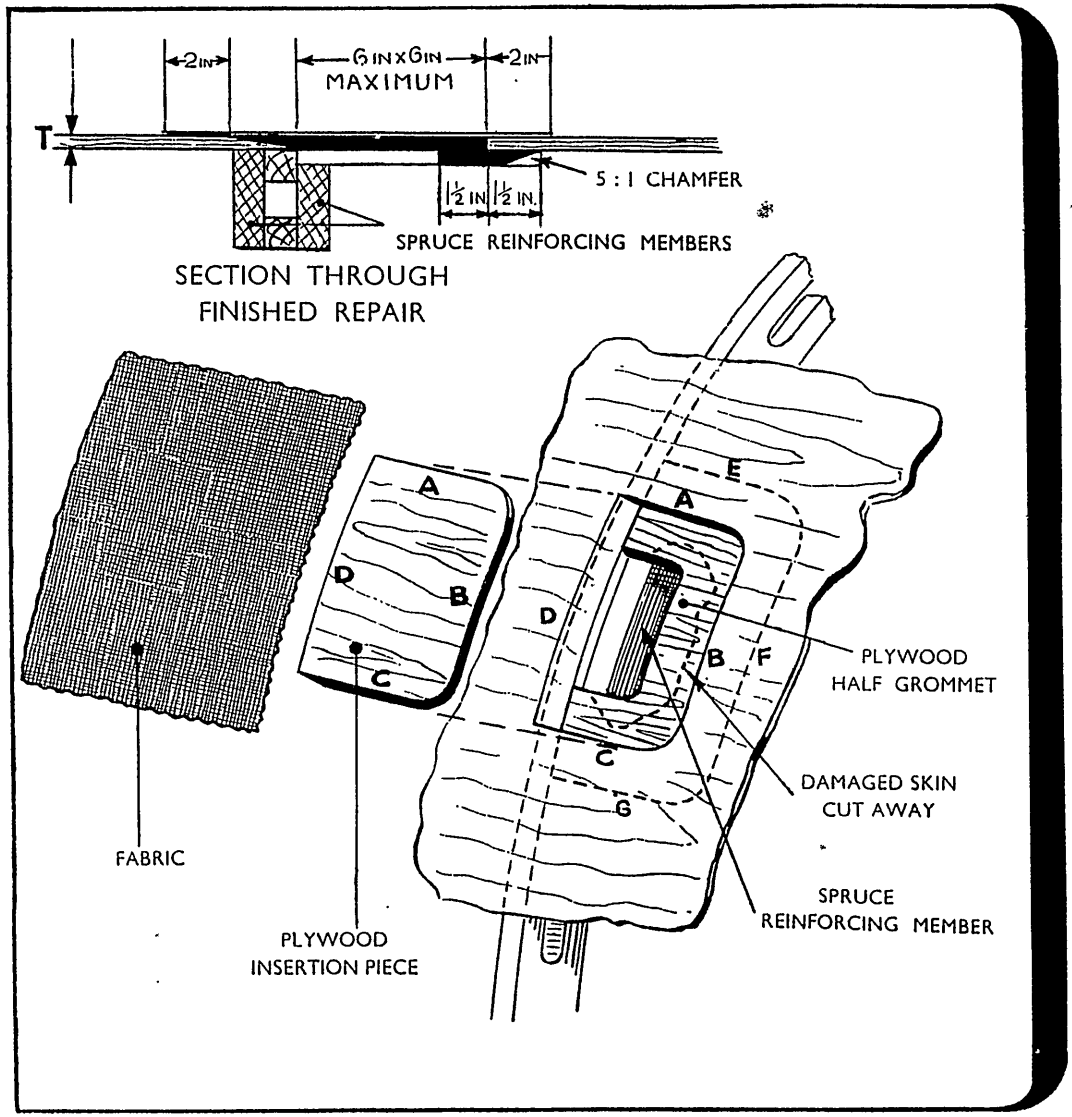
3207—CROSS SPLICES IN PLYWOOD

DON'T WORRY about the direction of the original splice joint when cutting away damage and preparing to insert a new panel.

GO AHEAD as in the adjoining sketch—the resulting joint will be amply strong.





3208—SPLICED AND BUTTED FLUSH INSERTION REPAIR TO PLY PANEL

USE THIS METHOD FOR DAMAGE WHICH:—

(i) Is in plywood $\frac{1}{8}$ in. thick or less,

(ii) Does not exceed 6 in. square,

(iii) Occurs close to a member, and

(iv) Where adequate pressure can be applied when gluing up.

This repair is a combination of the half-grommet arrangement of Scheme 3205 together with the splicing principles of 3206 and 3207, so that all the standard rules of material thickness, grade and grain direction, etc., apply.

DON'T FORGET that:—

(i) The corners of the butt jointed portion must have radii of at least $\frac{1}{2}$ in.

(ii) Edges "E", "F", and "G" of the grommet are chamfered to an angle of 5 : 1.

(iii) The corners of the spliced edge must be sharp.

(iv) Spruce reinforcing members, curved if necessary to the profile of the original member, $\frac{1}{4}$ in. thick and $8\frac{1}{2}$ in. long with 5 : 1 chamfered ends are required, one on each side of the member (see Scheme 3207).

(v) Careful work is necessary to ensure an accurate fit.

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3209—RENEWING A PORTION OF A LARGE PANEL

USE THIS METHOD FOR EXTENSIVE DAMAGE:—

(i) Which does not involve the complete panel, or

(ii) Where a portion of the panel must be removed to gain access to damage behind it.

THIS REPAIR uses the methods of 3206 and 3207, thus:—

(i) Cut away to existing members where convenient, or to a line such as "D" where a reinforcing member can be fitted.

(ii) Clean up edges "A", "B", and "C", and scarf them for a 9 : 1 splice.

(iii) Cut a spruce reinforcing strip $\frac{3}{4}$ W wide to support the splice at edge "D" as shown.

(iv) Cut U-shaped plywood support brackets as shown in the sketch.

(v) Ensure that there is sufficient solid material to which the U-brackets can be glued and screwed.

(vi) Glue the reinforcing member under edge "D" and glue and screw the brackets at each end of it to existing fixed members.

(vii) Prepare the edge "D" for a splice joint.

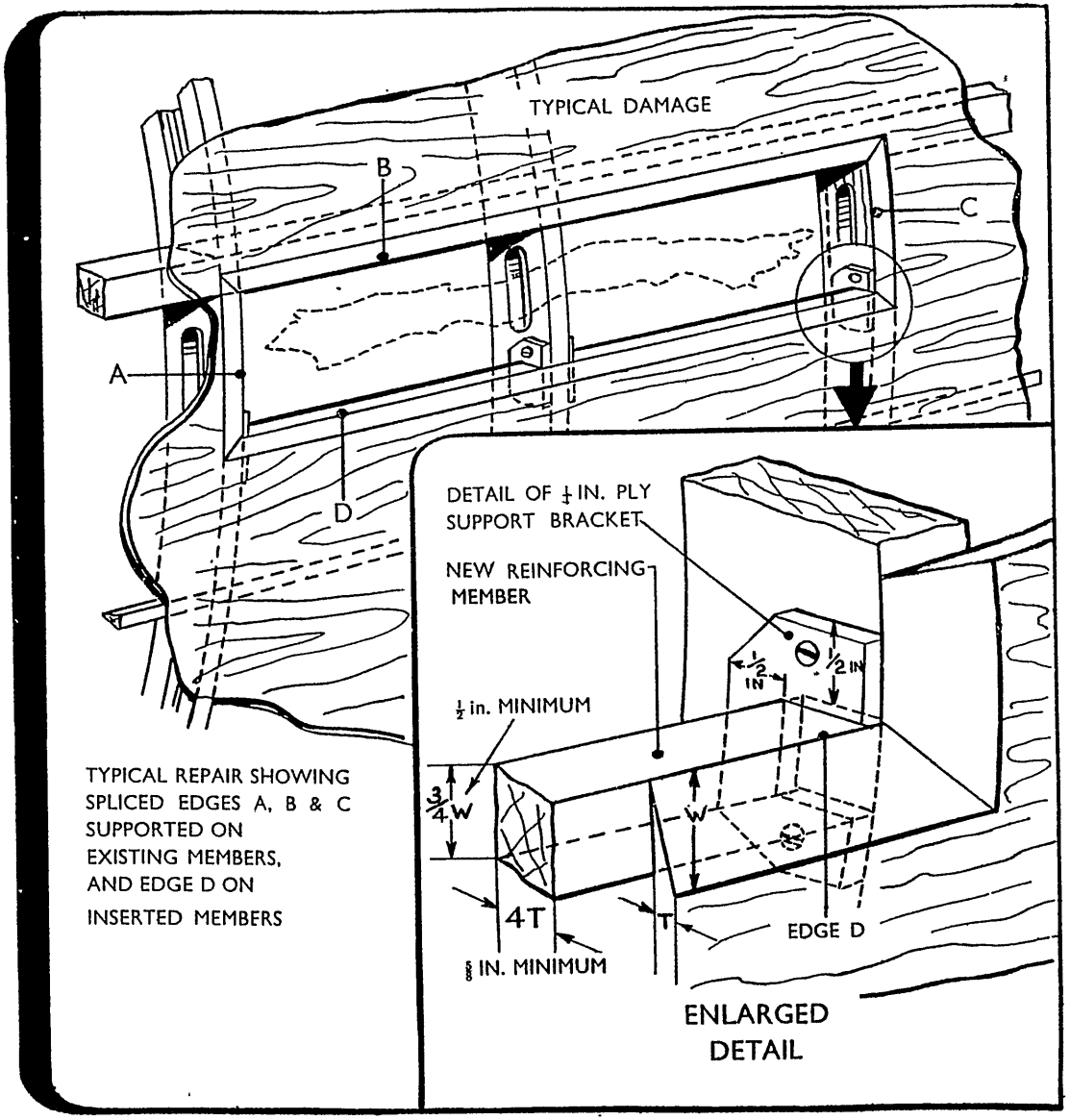
(viii) Cut an insertion panel:—

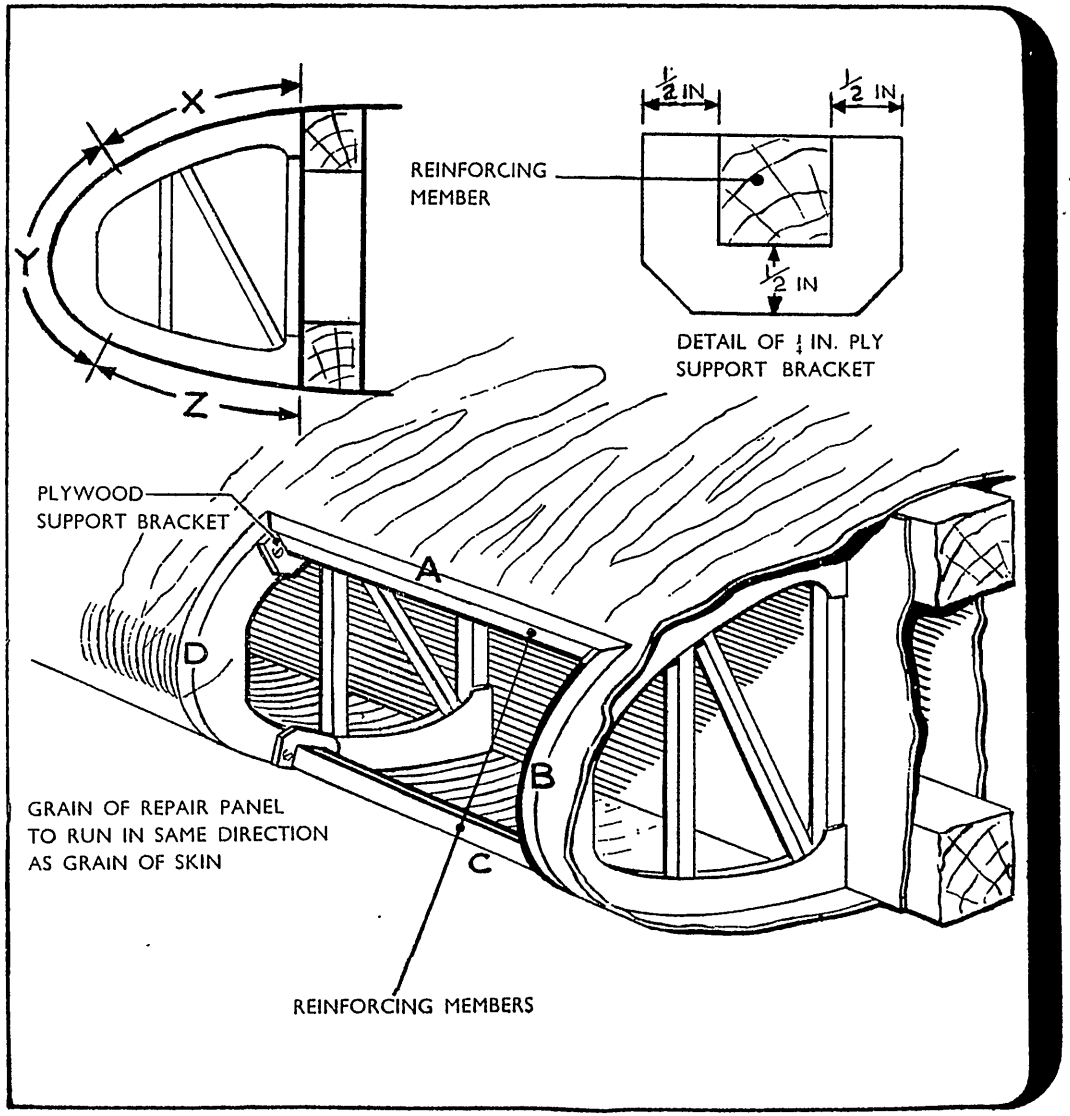
(a) From the same grade and thickness plywood and with the same grain direction as the damaged panel.

(b) With all four edges scarfed to a ratio of 9 : 1, to mate with the scarfs prepared in operations (ii) and (vii)

(ix) Glue and brad or staple the insertion panel in position.

(x) If ply is fabric covered, cut back the original fabric 2 in. from the edges of the scarf joints and cut a new piece of fabric to butt join it. Cover this butt joint with 2 in. serrated-edge tape. If the original structure was not fabric covered but is external, cover the scarf joint with 2 in. serrated-edge tape.





3210—INSERTION REPAIR TO WING LEADING EDGE

USE THIS METHOD WHERE:—

(i) The wing construction is such that there is no leading edge member,

(ii) The damage extends less than half way round the nose measured from the top boom of the spar to the bottom one (it may, however, extend more than one rib bay spanwise), and

(iii) Where the rib construction will afford support for the spanwise reinforcing members.

DON'T USE THIS REPAIR FOR WINGS which have a single main spar and "D" nose and a lightly constructed auxiliary spar. In such cases refer to the aircraft Vol. II, Part 3 or 4.

DON'T make the spanwise scarf joints in the sharply curved portion marked "Y" in the sketch. All scarf joints should be in the portions "X" or "Z".

GO AHEAD AS FOLLOWS:—

(i) Cut away fabric (if any) and damaged plywood skin to ribs such as "B" and "D" spanwise and to suitable lines "A" and "C".

(ii) Clean up the edges "B" and "D" and prepare them for a splice, supported by the nose ribs, packed out if less than ¾ W wide (where "W" is the width of the splice).

(iii) Cut reinforcing members of spruce ¾ W wide and with a thickness of ½ in. or 4 times the thickness of the ply skin (whichever is the greater).

(iv) Cut the U-shaped plywood supports as shown.

(v) Glue the reinforcing members inside the edges "A" and "C", and glue and screw the U-brackets against the nose ribs.

(vi) Scarf edges "A" and "C" for the splice joint.

(vii) Cut an insertion panel from plywood of the same grade and thickness material and with the same grain direction as the damaged ply. Scarf the four edges to a ratio of 9 : 1. If the grain direction is 45 deg. to edge "D" or "B", or if the curvature is great, the insertion panel must be pre-formed approximately to the contour of the leading edge before fitting (for method see Scheme 3201).

(viii) Glue and brad or staple the insertion panel in place.

(ix) Cut a new piece of fabric to overlap each edge by 2 in. and dope it over the renewed panel. Cover the edges of this fabric with 2 in. serrated-edge tape.

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3211—RENEWING A LARGE PLY PANEL

A LARGE PLY PANEL can be renewed by combining Schemes 3206 and 3207. This is done by splicing in a new panel over existing members which are either negligibly damaged, or already repaired.

GO AHEAD AS FOLLOWS:—

(i) Cut away the fabric (if any) and remove the damaged panel.

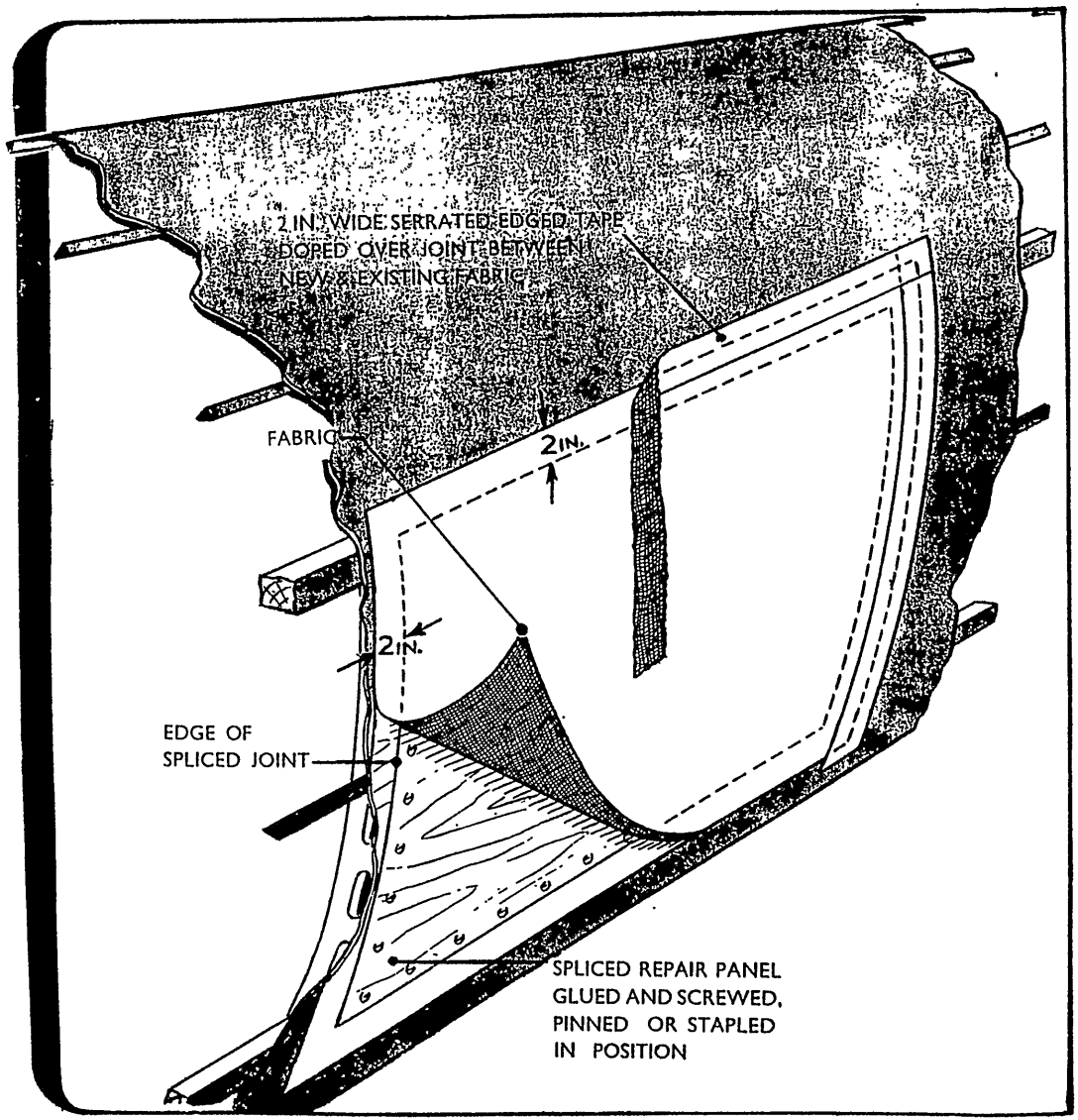
(ii) Clean up the edges and scarf them for a 9 : 1 splice joint.

(iii) If necessary, build up the width of the existing members to $\frac{3}{4}$ W (where "W" is the width of the splice).

(iv) Cut an insertion panel from ply of the same grade and thickness and with the same grain direction as the damaged plywood. Scarf the edges to a ratio of 9 : 1.

(v) Glue and brad, screw or staple the panel in position.

(vi) Cut the original fabric (if any) 2 in. back from the scarf edges and cover the renewed panel with fabric butted onto the original fabric. Cover this butt joint with 2 in. wide serrated-edge tape overlapping the joint 1 in. on each side. If there is no original fabric just apply the 2 in. tape over the feather edges of the scarf.



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STANDARD REPAIRS FOR AIRFRAMES

A·P 2662A

Section 3 CHAPTER 33 SOLID MEMBERS

GENERAL NOTES ON SOLID MEMBERS

SOLID MEMBERS used in aircraft construction, whether laminated or not, are generally made from spruce, and this chapter applies only to repairs of spruce (or approved substitute) members. If you come across members made in other woods, you should refer to the relevant aircraft Vol. II, Part 3 or 4, for specific instructions.

MEMBERS OF HEAVY SECTION are usually built up of several laminations, to ensure high grade material throughout. Generally speaking, you should treat such members as though they were solid and not laminated; but there are certain special cases where this does not apply. These are dealt with later on in this chapter.

CURVED MEMBERS, such as formers and wing tip bends, are also of laminated construction, except those of light section that can be pre-formed easily.

PURE STRUTS, i.e., those not backed by plywood panels, etc., are not dealt with in this chapter. You will only come across such struts occasionally, as they are not common in modern aircraft construction. The method of repair of pure struts can only be decided on consideration of the individual structure concerned. Thus no standardisation in the method of repair is possible, and you should refer to the particular aircraft Vol. II, Part 3 or 4, for repair instructions.

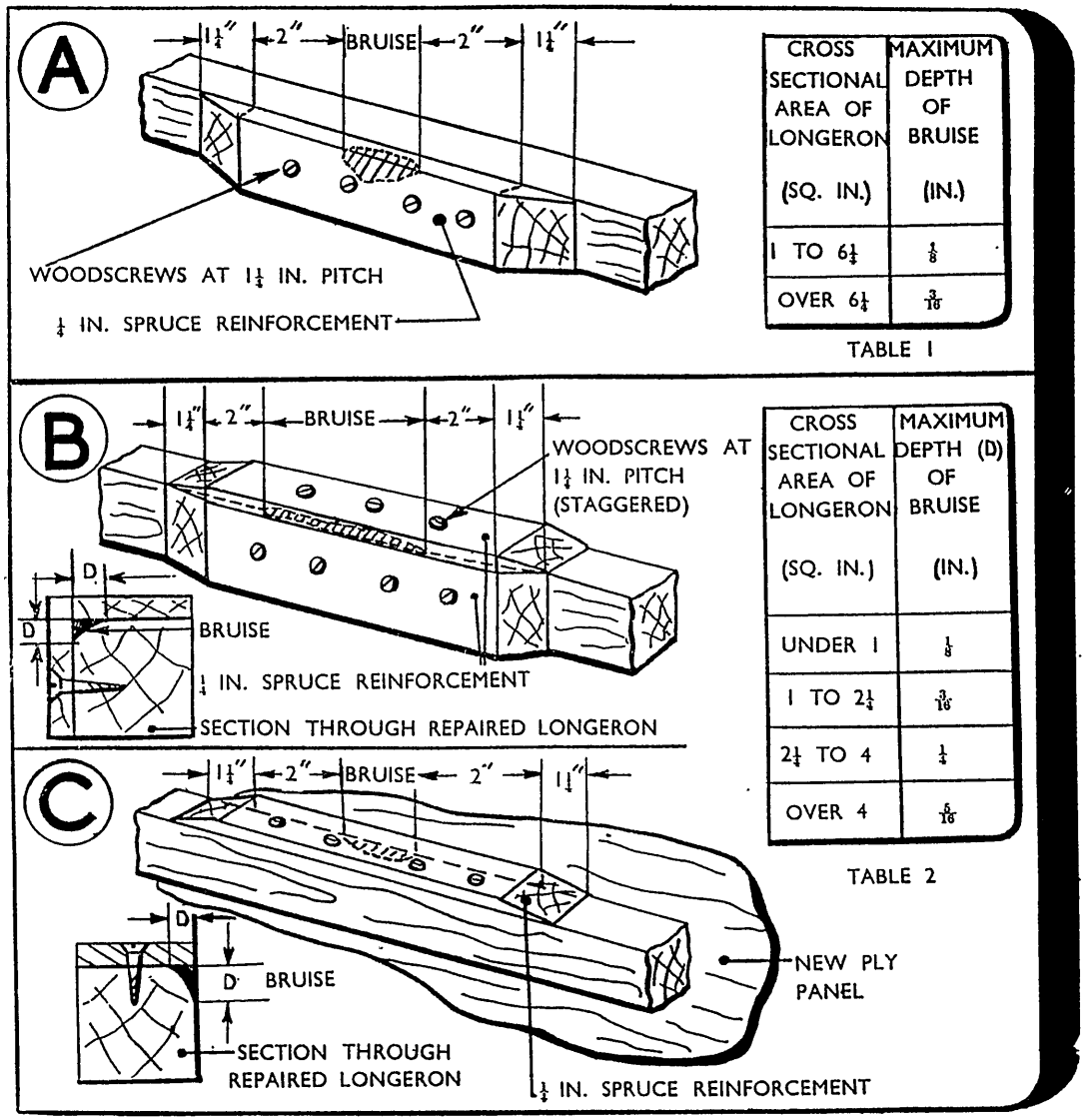
SELECT TIMBER WITH CARE.—This applies to all repairs. The timber in the original structure was selected to comply with a very rigid specification. Hence, to make the repaired structure as strong as the original, equally rigid rules must be applied when selecting timber to be used in repair. You will already be aware of the general defects to be guarded against in aircraft timber, but as you will be dealing mainly with spruce, defects you may discover in this timber are set out below.

DANGEROUS DEFECTS IN SPRUCE: (1) Dote (or any other form of disease or decay), (2) shakes, (3) large knots or knots at the edges of a member, (4) resin pockets, and (5) inclined grain or fibres. Dote is a disease which renders spruce absolutely useless as far as aircraft structures are concerned—any wood affected should be rejected immediately. You can recognise this disease by the presence of small yellow-brown spots on the timber surface. Shakes and resin pockets also render spruce unsuitable for use in aircraft repair work. The former defect can be recognised by apparent ruptures in the edge grain. Straightness of grain or fibres has a very important bearing on the strength of spruce and this can be checked by putting a spot of ink on the wood concerned and seeing which way it runs.

WHEN CHOOSING TIMBER, every effort should be made to obtain the particular kind called for, but in certain circumstances an alternative will have to be used. To assist in choosing suitable alternatives, a table is given below comparing the physical properties of various timbers.

TIMBER	COMPRESSIVE STRENGTH Lb. per sq. in. (Parallel to grain)	SHEAR STRENGTH Lb. per sq. in. (Parallel to grain)	WEIGHT Lb. per cu. ft.	BENDING Order of preference
Aircraft timber				
SPRUCE (Sitka)...	4000	750	27	—
WALNUT ...	5700	1000	39	1
General timber				
ASH	5250	1380	41	2
*DOUGLAS FIR	5600	810	34	4
MAHOGANY	4880	860	34	3
*NOBLE FIR...	4080	690	27	5

* Approved substitutes for spruce



CROSS SECTIONAL AREA OF LONGERON (SQ. IN.)	MAXIMUM DEPTH OF BRUISE (IN.)
1 TO 6¼	⅛
OVER 6¼	3/16

TABLE 1

CROSS SECTIONAL AREA OF LONGERON (SQ. IN.)	MAXIMUM DEPTH (D) OF BRUISE (IN.)
UNDER 1	⅛
1 TO 2¼	3/16
2¼ TO 4	¼
OVER 4	5/16

TABLE 2

3302

3302—PATCH REPAIR TO LONGERONS

USE THIS METHOD WHERE:—

(i) The face of the longeron is not ply covered,

(ii) The bruise does not exceed the appropriate depth given in table 1 or 2 alongside,

(iii) The surface area of the bruise is not greater than the cross-sectional area of the longeron.

GO AHEAD AS FOLLOWS:—

(i) Refer to the relevant diagram, i.e.

(a) Diagram "A" if the bruise is on one of the exposed faces of the longeron,

(b) Diagram "B" if at an exposed edge,

(c) Diagram "C" if at an edge next to the plywood backing.

(ii) Select material for the reinforcing member(s) from spruce with the same grain direction as that of the longeron and cut it to the dimensions shown in the appropriate diagram.

(iii) Glue and screw the reinforcing member(s) centrally over the bruise (use 6 × ⅝ in. screws where the face of the longeron is between ¼ in. and ⅞ in. wide; and 4 × ⅝ in. screws where greater than ⅞ in. wide).

NOTE:—(a) The screws should remain in position after the glue has set.

(b) In the case of diagram "C" the ply panel will usually be damaged and will have to be renewed as set out in chapter 32.

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3303—INSERTION REPAIRS TO LONGERONS

USE THESE METHODS FOR DAMAGE beyond that covered by Scheme 3302.

REMEMBER that main frames must not be cut back to accommodate the spruce reinforcing blocks and in such cases you will have to make two vertical splices, probably in separate bays—Method "A".

Formers and intermediate frames can be cut back if necessary, in which case you should use Method "B" with horizontal splices.

GO AHEAD AS FOLLOWS:—

(i) Obtain access to the damage, cutting back the adjacent plywood skin as required.

(ii) Cut the longeron on each side of the damage, carefully breaking any glued joints and removing the damaged portion together with any packing wedges.

(iii) Scarf the ends of the remaining portion of the longeron to a ratio of 15 : 1 for either a horizontal or vertical splice as applicable.

(iv) Prepare the insertion piece:—
- (a) From the same grade material (solid or laminated, to match the piece removed).
- (b) With the same grain direction and cross section as the existing longeron, and
- (c) With scarfed ends to mate with those prepared in operation (iii).

(v) Cut spruce reinforcing member(s) as required:—
- (a) To the dimensions shown in the sketch,
- (b) With the same grain direction and
- (c) From similar grade material to the existing longeron.

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

(vi) (Method "B" only). Cut $\frac{1}{8}$ in. 3-ply reinforcements:—
- (a) To the dimensions shown in the sketch,
- (b) With the same grain direction as the former or intermediate frame being strengthened, and
- (c) With a $\frac{5}{8}$ in. chamfer at each end.

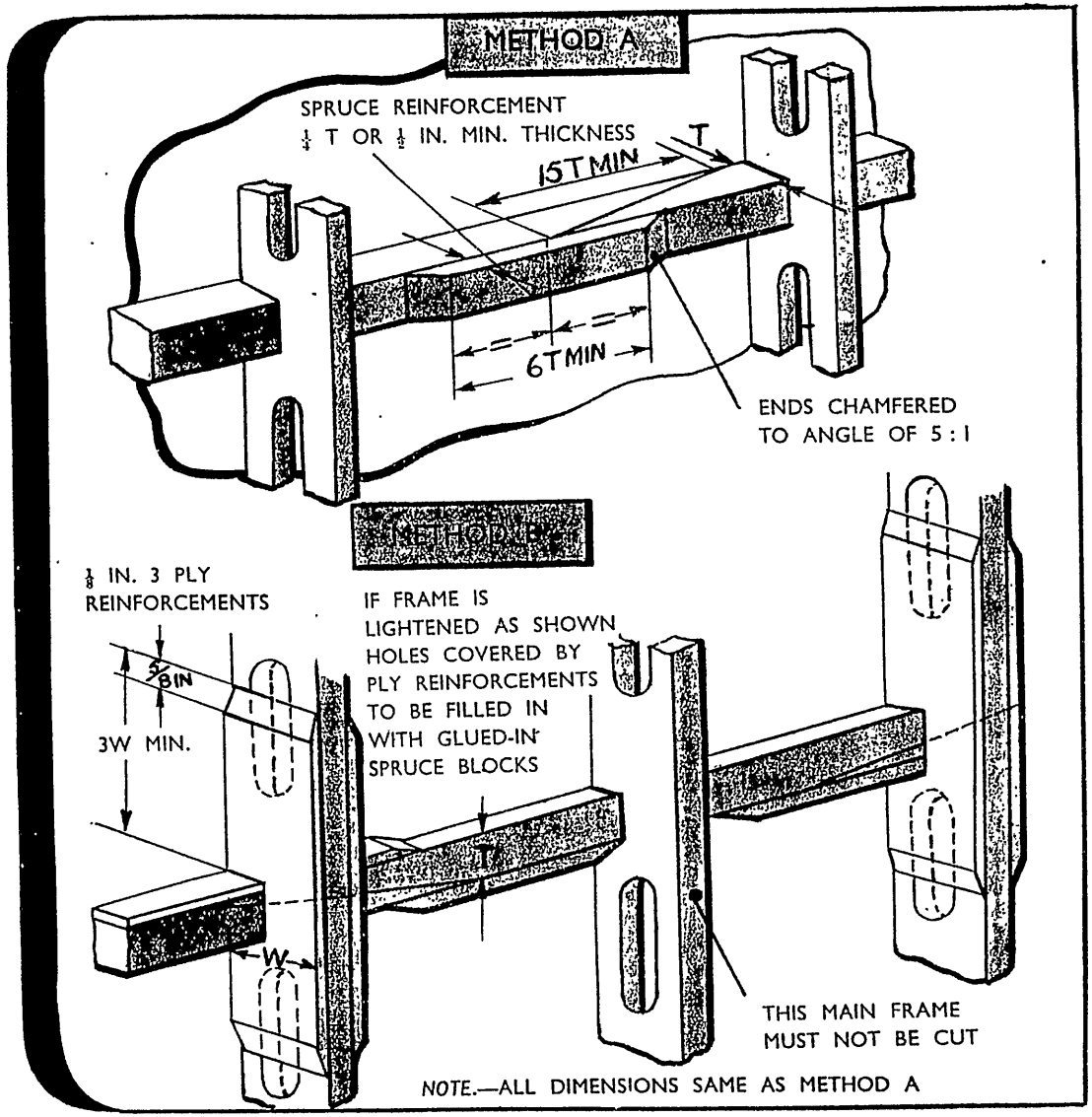
(vii) (Method "B" only). Prepare any formers or intermediate frames which have to be cut back to accommodate the spruce reinforcements.

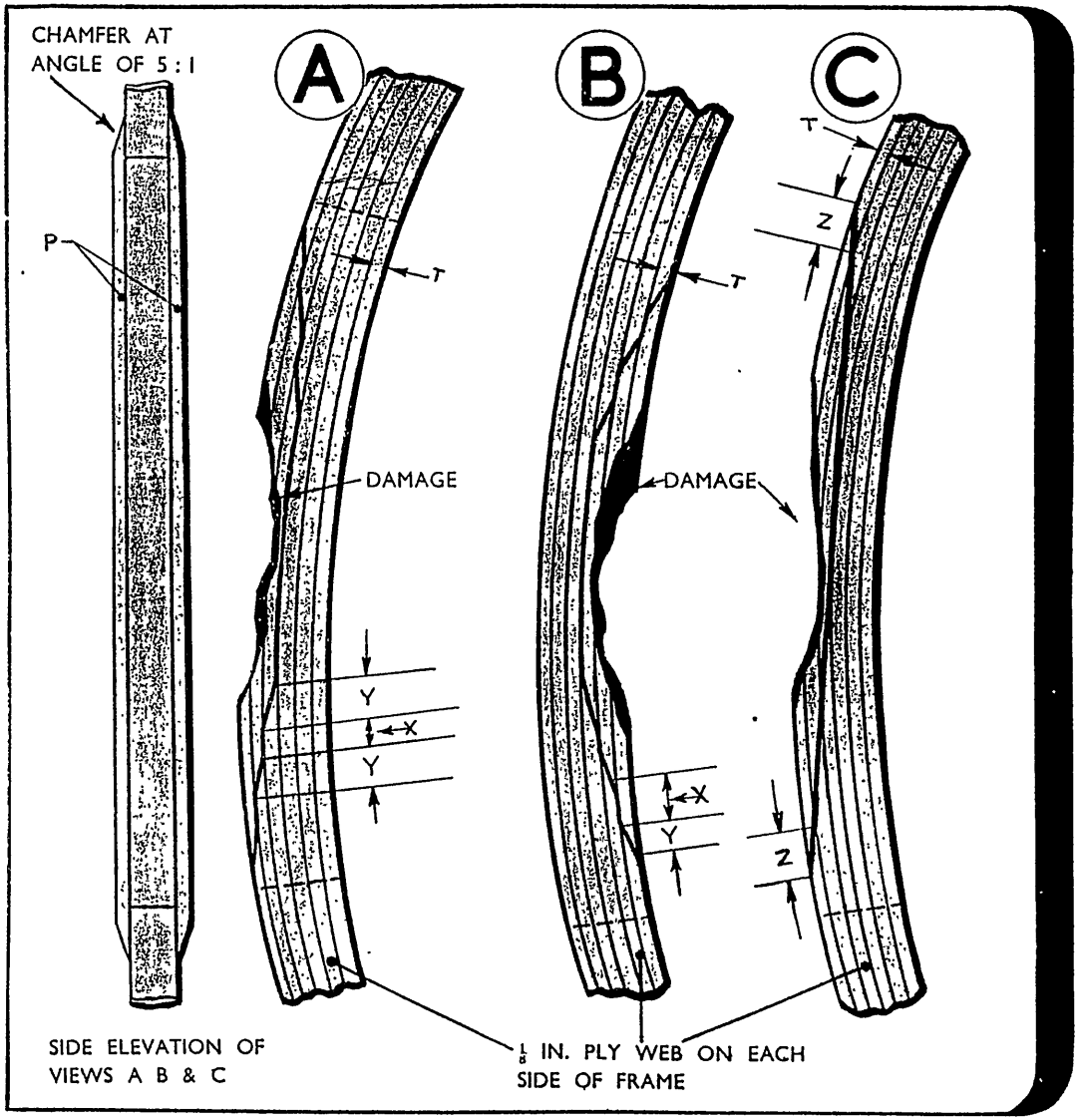
(viii) (Method "B" only). Pack lightening holes in the formers or frames as required (see sketch) with spruce blocks glued in position.

(ix) Glue and screw the insertion piece and the reinforcing members in position.

(x) Replace any packing wedges you removed in operation (ii).

(xi) Make good adjacent plywood if necessary as given in Chapter 32.





3304—REPAIR OF MINOR DAMAGE TO LAMINATED FORMERS

USE THIS METHOD where the damage is not greater than half the depth of the Former. For more extensive damage see Scheme 3305.

FOR DAMAGE ON THE OUTER FACE of the Former put a straight edge behind the damage, measure the distance "Z" (see sketch "C") and if the ratio Z : T (where "T" is the thickness of a lamination) is greater than 15 : 1 on the outer laminations you should follow sketch "C"; if less scarf in separate laminations as shown in sketch "A".

FOR DAMAGE TO THE INNER FACE of the Former, use sketch "B". If the curvature of the former is such that it is impossible to obtain the dimensions "X" equal to "T" and "Y" equal to or greater than 15T, you will have to splice a new length of Former into position (see Scheme 3305) or renew it entirely.

GO AHEAD AS FOLLOWS:—

(i) Obtain access to the damage, cutting back adjacent plywood skinning if required.

(ii) Cut away the damage as shown in the appropriate sketch, making sure that the scarf dimensions "Y" or "Z" are adequate and that the dimension "X" (sketches "A" and "B" only) is at least equal to "T".

(iii) Cut the insertion pieces:—
- (a) From similar grade of material,
- (b) With the same grain direction, and
- (c) With thickness "T" and the same width as the removed portion of the Former.

(iv) Shape the necessary laminations 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 (sketch "C").

(v) Glue and cramp the insertion pieces in position, building it up from the separate laminations.

(vi) Cut the reinforcing pieces "P" (see sketch):—
- (a) From $\frac{1}{8}$ in. plywood,
- (b) Shaped to the contour of the Former,
- (c) With the same grain direction as the Former, and
- (d) With their ends chamfered to an angle of 5 : 1.

(vii) Glue and cramp the reinforcing pieces centrally over the insertion piece on each side of the Former.

(viii) Make good any plywood removed in operation (i) as given in Chapter 32.

3305—REPAIR OF MAJOR DAMAGE TO LAMINATED FORMERS

USE THIS METHOD where scheme 3304 cannot be applied, i.e. where the curvature of the Former is too great or where the depth of the damage is greater than half the depth of the Former.

Note.—See Scheme 3306 for solid Formers.

GO AHEAD AS FOLLOWS :—

(i) Obtain access to the damage, cutting back adjacent skinning as required.

(ii) Cut out the damaged length of the Former and remove it, breaking any glue joints very carefully. Prepare the cut ends of the Former with 15 : 1 scarfs.

(iii) From the same grade wood and with the same grain direction as the damaged Former, build up an insertion piece with laminations equal in thickness to those in the original member.

Note.—It will be necessary to make up a jig to produce the required curvature during the building up operation.

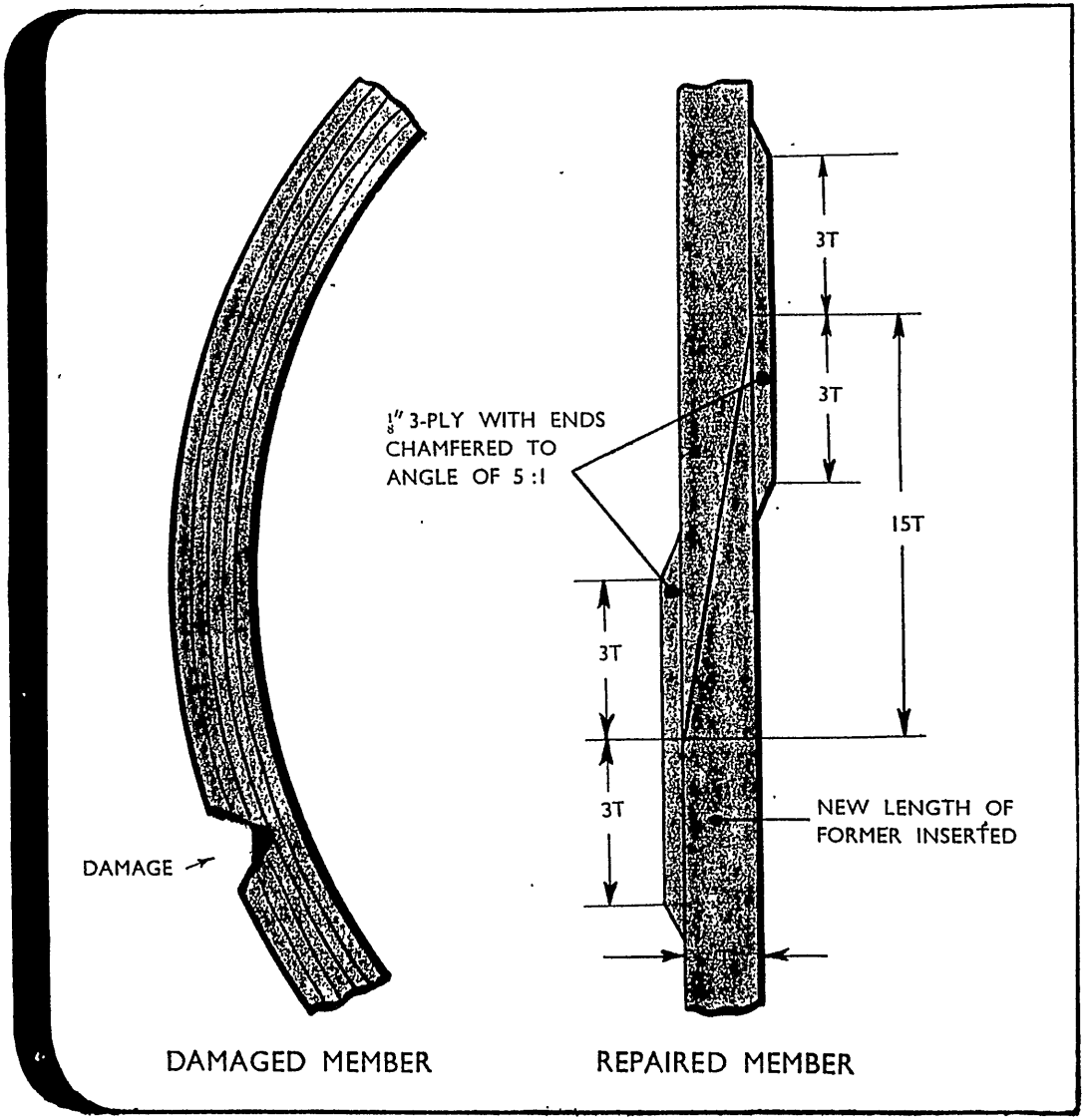
(iv) After the glue has been applied, leave the member in the cramps for twice the normal time and then scarf the ends to mate with those prepared in operation (ii).

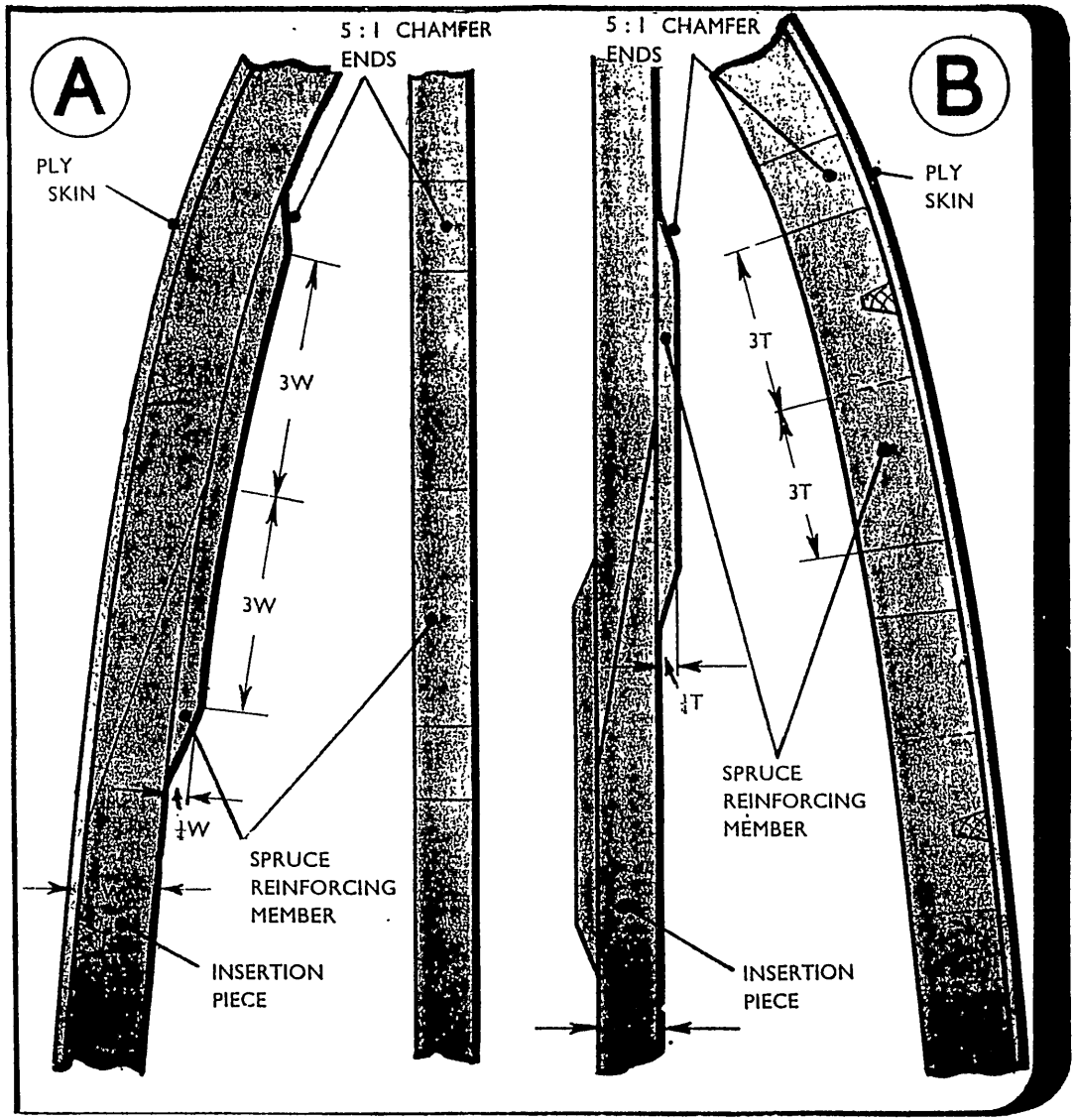
(v) Glue and cramp the insertion piece in position.

(vi) Prepare reinforcing members, as required, from $\frac{1}{8}$ in. 3-ply to the dimensions shown in the sketch (not forgetting to chamfer the ends).

(vii) Glue and screw the reinforcing members over the feather edges of the splice joints.

(viii) Make good any plywood removed in operation (i) as given in Chapter 32.





3306—REPAIR OF MAJOR DAMAGE TO SOLID FORMERS

METHOD "A" should be used wherever possible but if the damaged portion of the former is of small radius it will be impossible to obtain the required scarf ratio of 15 : 1. In such cases **METHOD "B"** should be used.

GO AHEAD AS FOLLOWS:—

(i) Obtain access to the damage, cutting back adjacent plywood skinning if required.

(ii) Cut away the damaged portion of the Former and scarf the cut ends to a ratio of 15 : 1.

(iii) Cut the insertion piece from solid wood from:—

- (a) Similar grade of material,
- (b) With the same grain direction, and
- (c) With the same dimensions as the portion of the former removed.

(iv) Scarf the ends of the insertion piece to a ratio 15 : 1 to mate with the remaining ends of the Former.

(v) Cut reinforcing member(s), for all feather edges of splice joints not backed by plywood :—

- (a) From spruce,
- (b) With grain direction matching the original member,
- (c) To the dimension shown (ends with 5 : 1 chamfer).

(vi) Glue and cramp the insertion piece in position.

(vii) Glue and cramp the reinforcing member(s) in position.

(viii) Make good any plywood removed in operation (i) as given in Chapter 32.

3307—INSERTION REPAIR TO STRINGERS

USE THIS METHOD where the damage is worse than negligible, as defined in the aircraft Vol. II, Part 3.

GO AHEAD AS FOLLOWS:—

(i) Obtain access to the damage, cutting back adjacent plywood skinning if required.

(ii) Cut away the damaged portion of the stringer and scarf the cut ends to a ratio of 15 : 1.

(iii) Cut the insertion piece:—

(a) With the same grain direction,

(b) From the same grade material, and

(c) With the same cross-section as the original stringer.

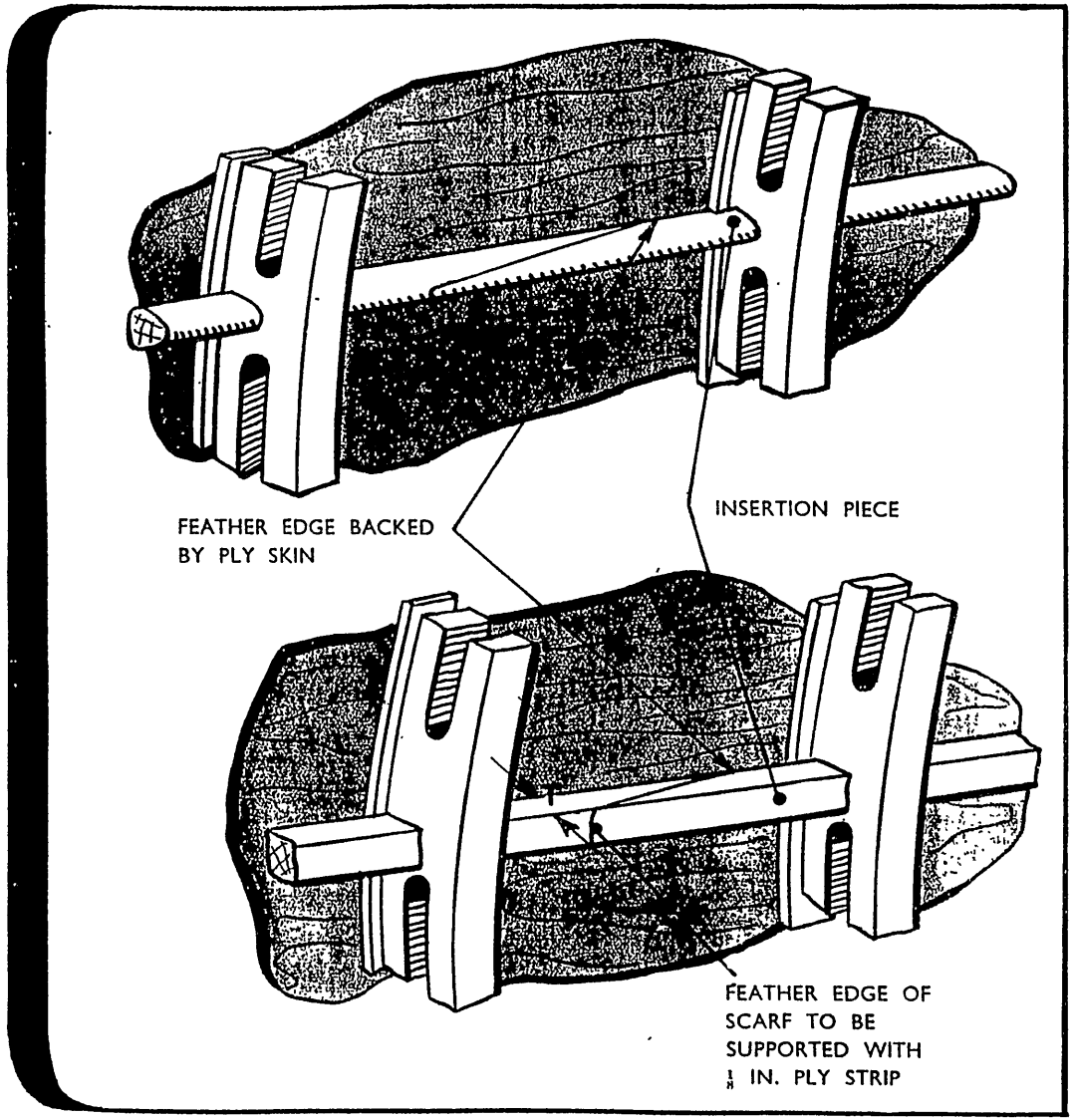
(iv) Scarf the ends of the insertion piece to a ratio of 15 : 1.

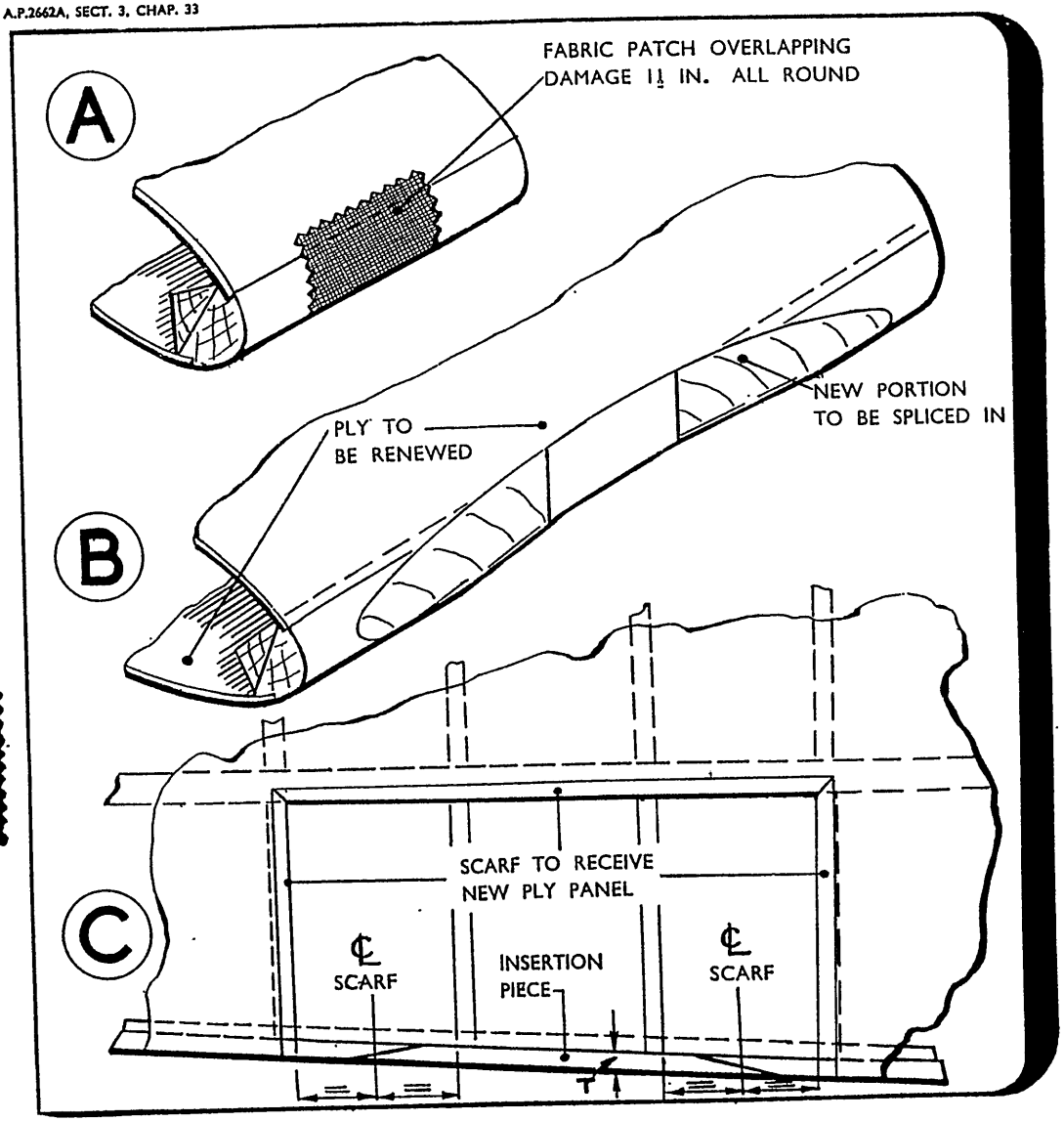
(v) Glue and cramp the insertion piece in position.

(vi) When repairing a stringer of square or rectangular section, protect the feather edge of the scarf with a reinforcing member cut from $\frac{1}{8}$ in. 3-ply 6 T long (see sketch) with ends chamfered to an angle of 5 : 1. This should be glued and screwed centrally over the feather edge.

(vii) Make good any plywood removed in operation (i) as given in Chapter 32.

Note.—Don't worry if the scarfed portion of the stringer passes through a former. This is permissible—but ***don't*** cut the former whilst preparing the scarf.





3308 — REPAIR TO LEADING EDGE OR TRAILING EDGE MEMBER

USE METHOD "A" for damage which does not exceed $\frac{1}{8}$ in. deep, $\frac{1}{4}$ in. wide, 2 in. long and provided that the fibres remain unbroken.

GO AHEAD AS FOLLOWS:—

(i) Fill the damage with plastic wood or any other approved filler.

(ii) Cover the damage with a serrated edged fabric patch which overlaps it by 1½ in. in all directions.

USE METHOD "B" and "C" for damage worse than that covered by sketch "A".

GO AHEAD AS FOLLOWS:—

(i) Cut back, to structural members if possible, the top and bottom surface skinning adjacent to the damage.

(ii) Cut out the damaged portion of the member and scarf the cut ends to a ratio of 15 : 1.

(iii) Cut an insertion piece:—
- (a) With the same dimensions,
- (b) From the same grade material, and
- (c) With the same grain direction as the original member.

(iv) Scarf the ends of the insertion piece to mate with those made in operation (ii) and glue and cramp it in position.

(v) If there are any feather edges of the scarf not backed by another member, glue and screw a reinforcing member centrally over them. This reinforcing member should be of $\frac{1}{8}$ in. ply, 6 T long and should have its ends chamfered to an angle of 5 : 1.

(vi) Make good the plywood removed in operation (i) by scarfing in new panels as given in Chapter 32.

3309—TYPICAL INSERTION REPAIR TO RIB BOOMS

GO AHEAD AS FOLLOWS:—

(i) Remove any plywood necessary to get at the damage.

(ii) Cut back to the nearest stiffeners, both the boom plywood webs adjacent to the damage and splice the cut ends to a ratio of 9 : 1.

(iii) Cut away the damaged portion of the boom and scarf the ends, as shown in the sketch, to a ratio of 15 : 1.

(iv) Where stiffener(s) would prevent the required length of reinforcing member from being fitted, cut them short as shown.

(v) Cut a boom insertion piece:—
- (a) With the same dimensions,
- (b) Of the same grade material and grain direction as the piece removed.

(vi) Scarf the ends of the insertion piece to mate with those prepared in (iii) and glue and cramp it in position.

(vii) Cut the boom reinforcing member:—
- (a) From the same grade material,
- (b) Having the same cross section and grain direction as the rib boom, and
- (c) Having the required overlap of 3 T (excluding the 5 : 1 chamfer at each end).

(viii) Glue and cramp the reinforcing member in position.

(ix) Where necessary, build up the width of the stiffeners with spruce blocks so that the splices in the ply webs are backed for $\frac{3}{4}$ of their width. (This arrangement is shown as a section through a completed repair in sketch "B").

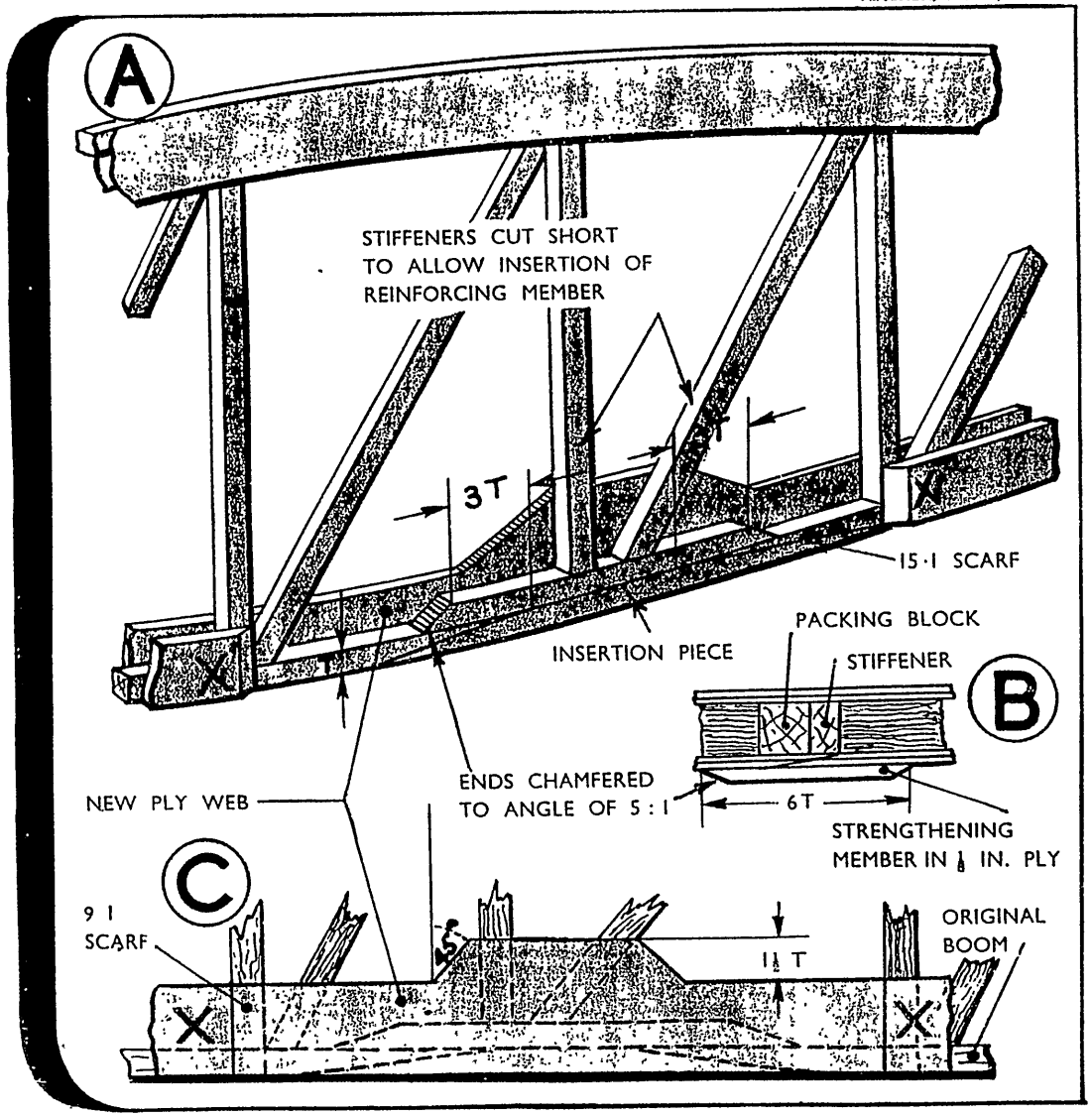
(x) (*a*) If the stiffeners have not been shortened, cut ply webs:—
- (a) To the same dimensions,
- (b) Of the same grade material, thickness and grain direction as the original webs,
- (c) With scarfed ends to mate with those prepared in operation (ii).

(x) (*b*) If the stiffeners have been shortened, go ahead as in operation (x) (*a*) but cut the webs to the dimensions given in sketch "C".

(xi) Glue and cramp the ply webs in position.

(xii) Prepare $\frac{1}{8}$ in. plywood strenthening members 6 T long and with ends chamfered to an angle of 5 : 1, and glue and cramp centrally over the splice as shown in sketch "B".

(xiii) Make good any plywood removed in operation (i) as given in Chapter 32.



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STANDARD REPAIRS FOR AIRFRAMES

A·P 2662A

Section 3

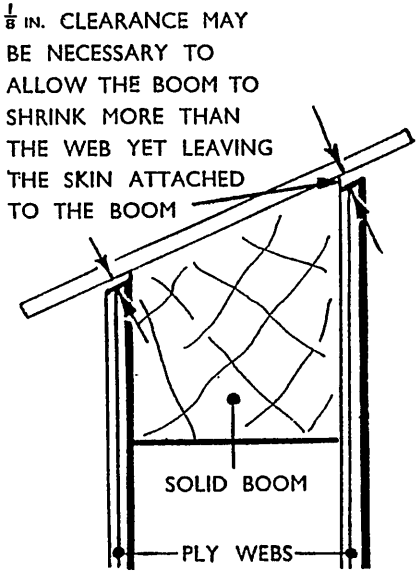
CHAPTER 34 BOX MEMBERS

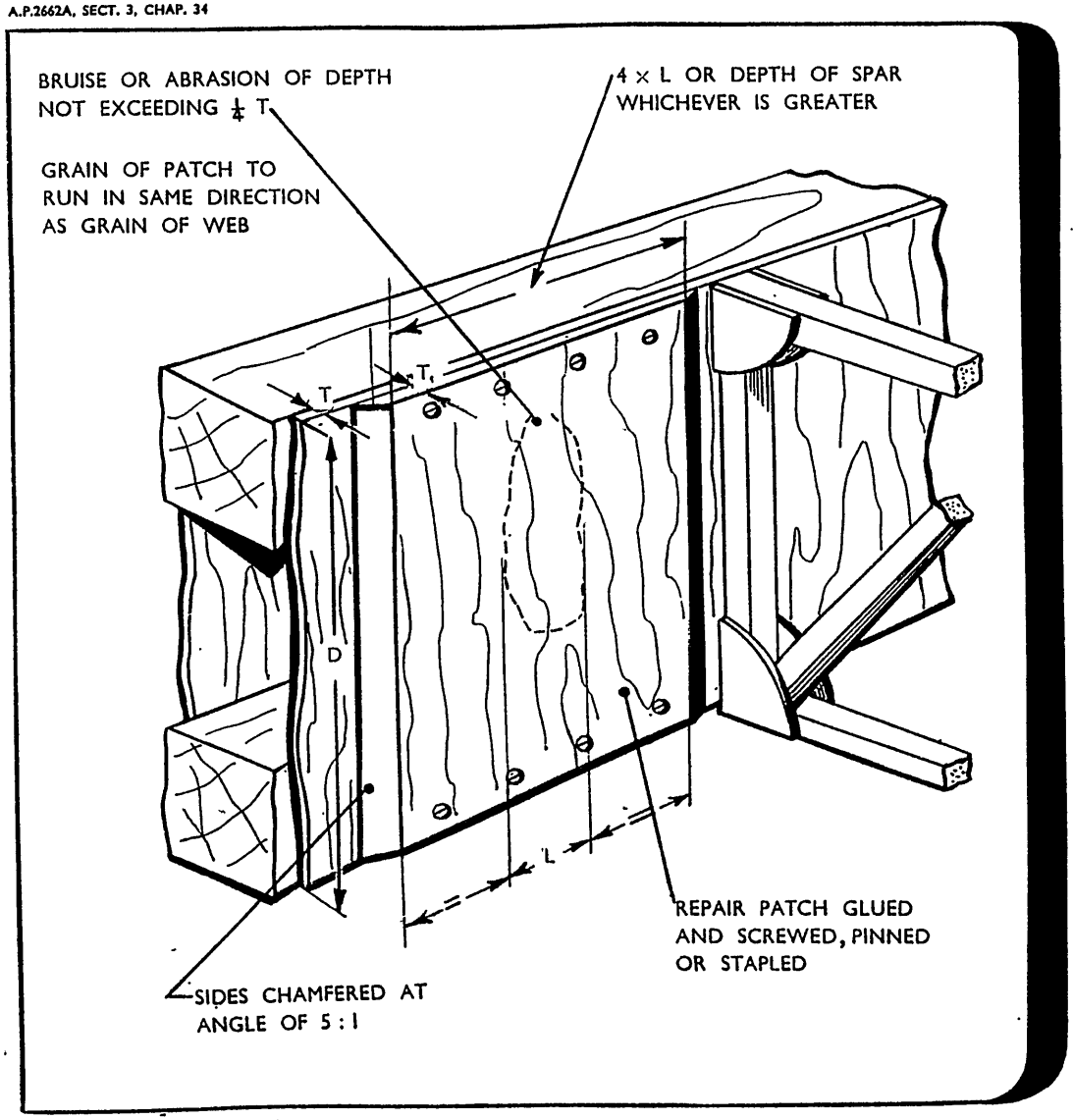
GENERAL NOTES ON BOX MEMBERS

BOX MEMBERS are widely used in aircraft construction owing to their superior resistance to bending, compared with solid members of the same material cross-sectional area. Thus for a given strength, a great saving in weight is obtained by using such members. The usual form of box member is a combination of solid or laminated spruce and plywood. This chapter deals with the repair of such members.

REFER TO SCHEME 3301—General Notes on Solid Members. The remarks on the selection of timber and the defects which occur in spruce are, of course, also applicable to the material used for repairs in this chapter.

SOME BOX MEMBERS have about $\frac{1}{8}$ in. clearance between the longitudinal edges of their plywood webs and the adjacent skinning. This practice is not universal but is adopted in some cases to prevent failure of the joint between the skinning and the spar boom, following unequal shrinkage of the solid boom and the ply webs of the spar. When repairing box members with this construction, always see whether such clearance was provided in the original structure and if so the clearance must be reproduced in the repair. If, however, no clearance was provided, the longitudinal edges of the ply web must be finished "dead" flush with the outer surfaces of the boom in order to maintain the glue area between the member, i.e. boom and webs, and the skinning. The final strength of a repair will depend largely on your following out the above instructions correctly.





3402—REPAIR TO SLIGHTLY DAMAGED PLY SPAR WEB

USE THIS METHOD for bruises or abrasions less than ¼ T deep (where "T" is the thickness of the web) and provided that the spar boom is not damaged.

GO AHEAD AS FOLLOWS:—

(i) Remove any plywood necessary to gain access to the damage.

(ii) Cut the patch :—
- (a) To the dimensions shown,
- (b) Of the same grade and thickness material, and
- (c) With the same grain direction as the damaged web.
- (d) Chamfer the vertical edges of the patch to an angle of 5 : 1.

(iii) Glue and screw the patch centrally over the damage.

(iv) Make good any plywood removed in operation (i) as given in Chapter 32.

3403—INSERTION REPAIR TO PLY SPAR WEB

USE THIS METHOD for damage which is more than $\frac{1}{4}$ T deep (where "T" is the thickness of the spar web) and where the spar boom is not more than negligibly damaged as defined in the relevant aircraft Vol. II, Part 3. You may use this repair on both webs at any point in the spar span, provided the splice joints in opposite webs of the spar are staggered at least 12 in. apart.

GO AHEAD AS FOLLOWS:—

(i) Remove any plywood necessary to gain access to the damage.

(ii) Cut away the damaged area of the web to the full spar depth.

(iii) Check the width of the vertical stiffeners and if this is inadequate to support a 9 : 1 splice, cut reinforcing blocks (see sketch) from spruce and glue in position against the stiffeners. You may find it advisable to prepare and glue in position new vertical members to save cutting out too much of the spar web (see operation (iv)).

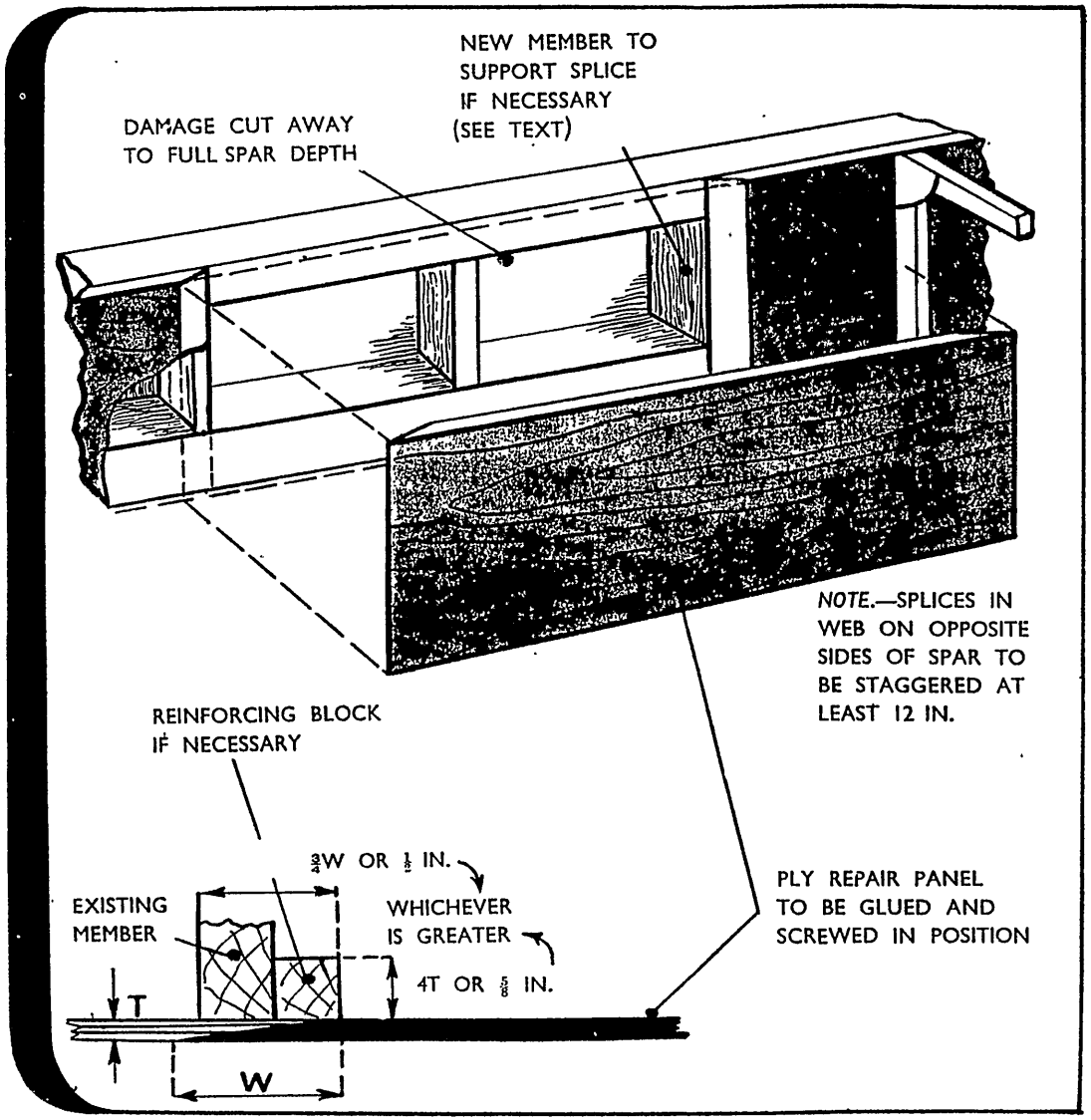
(iv) Vertical members (if required) should be :—
- (a) Of the same grade material,
- (b) With the same grain direction,
- (c) With similar lightening holes (if any) to the existing members, and
- (d) With a width of $\frac{3}{4}$ W (where "W" is the length of the splice to be supported).

(v) Cut back the ply web to the stiffeners or to the position of new members you have decided to use to support the web splices and prepare the splices to a ratio of 9 : 1.

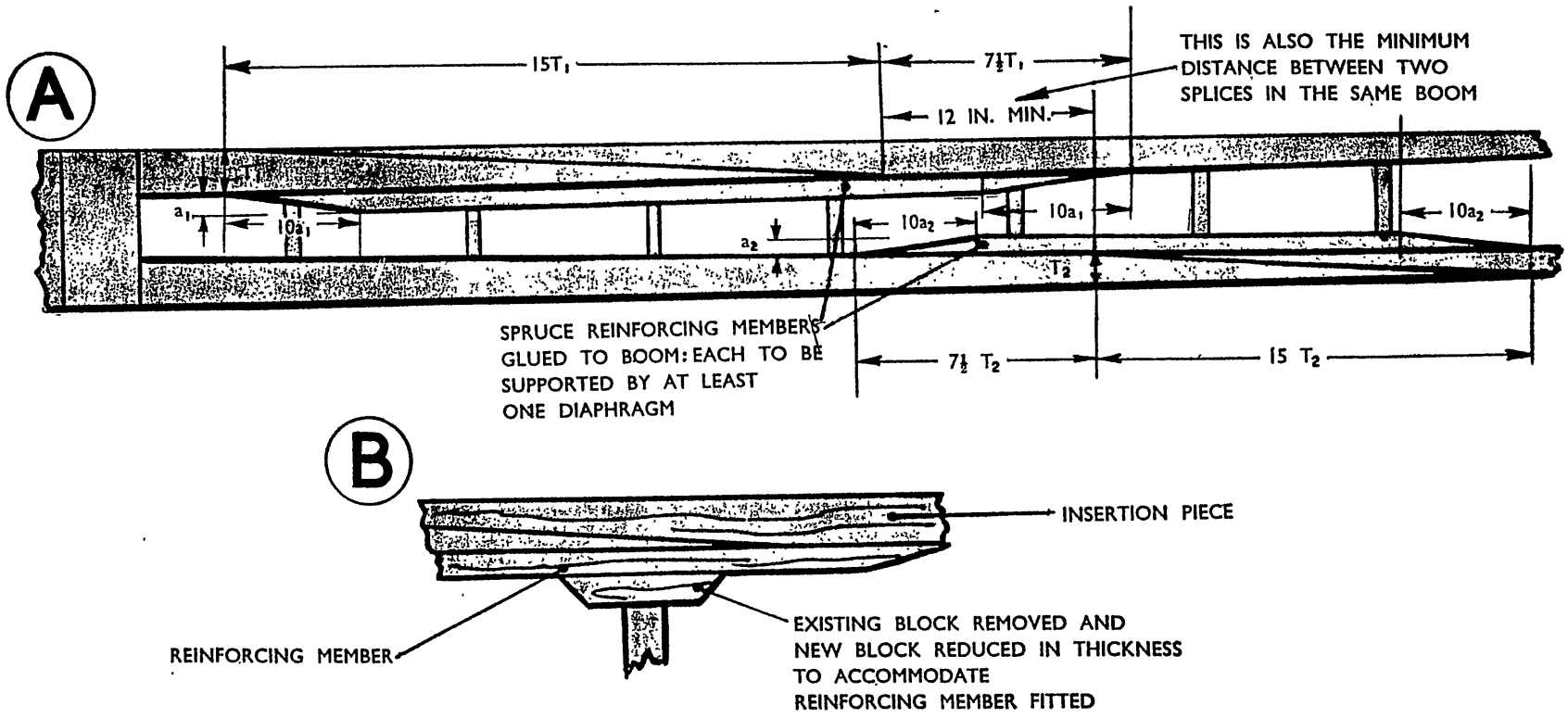
(vi) Cut the plywood insertion panel :—
- (a) Of the same depth and thickness as the spar web,
- (b) From the same grade material, and
- (c) With the same grain direction.
- (d) With scarfed ends to mate with those prepared in operation (v).

(vii) Glue and screw the insertion panel in position. The screws should be left permanently inserted.

(viii) Make good any plywood removed in operation (i) as given in Chapter 32.

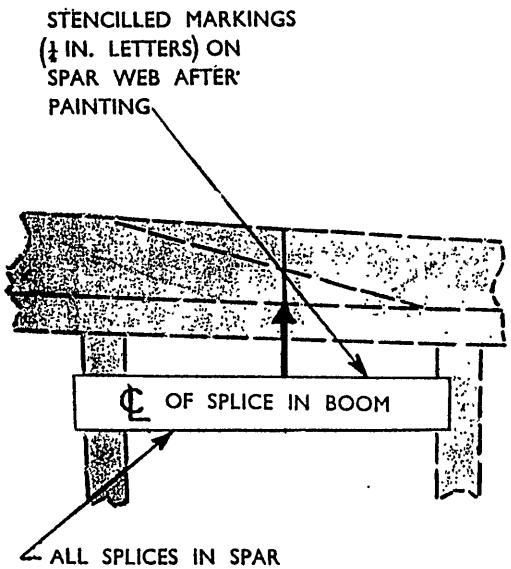


3404 - INSERTION REPAIR TO SPAR BOOM



3404 - INSERTION REPAIR TO SPAR BOOM

THE MARKING OF SPLICE CENTRE-LINES



Warning.—This repair is not universal in application. ***Therefore you must always refer to the aircraft Vol. II, Part*** *to ensure that it is approved for the aircraft in question.*

USE THIS METHOD where a spar boom is damaged beyond that covered by the following Scheme 3405.

GO AHEAD AS FOLLOWS:—

(i) Remove any plywood, including part of the spar webs, necessary to gain access to the damage.

(ii) Cut the boom on both sides of the damage, break any glued joints carefully and remove the damaged portion. Scarf the cut ends to a ratio of 15 : 1.

Note.—ANY SCARF JOINT MUST BE AT LEAST 12 IN. FROM ANOTHER SCARFED JOINT EITHER IN THE SAME OR THE OPPOSITE BOOM—plan your scarfs accordingly.

(iii) Cut insertion pieces:—
- (a) From the same grade material,
- (b) With the same dimensions and grain direction, and
- (c) Laminated or solid, to match the damaged portion of the boom.
- (d) Scarfed to mate with those prepared in operation (ii).

(iv) Glue and cramp the insertion piece in position.

(v) Cut reinforcing members:—
- (a) To the dimensions shown ($a_1 = \frac{1}{3} T_1$ and $a_2 = \frac{1}{3} T_2$).
- (b) From the same grade material,
- (c) With the same grain direction as the spar boom, and
- (d) With chamfered ends as shown.

Note.—Where splices in the same boom are less than a splice length apart, you should use one continuous reinforcing member.

(vi) Cut back inter-boom stiffeners or reduce the size of the blocks (sketch "B") to accommodate the reinforcing members. If the stiffeners are constructed with lightening holes, they should be replaced by solid but otherwise similar members.

(vii) Glue and screw the reinforcing members centrally over the feather edges of the scarf joints.

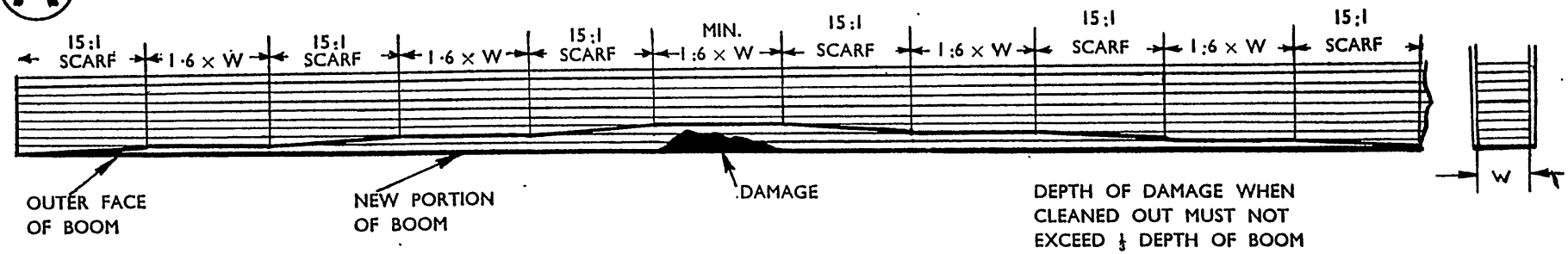
(viii) Splice in new lengths of plywood spar web as required (for instructions see Scheme 3403).

(ix) Make good any plywood removed in operation (i) as given in Chapter 32.

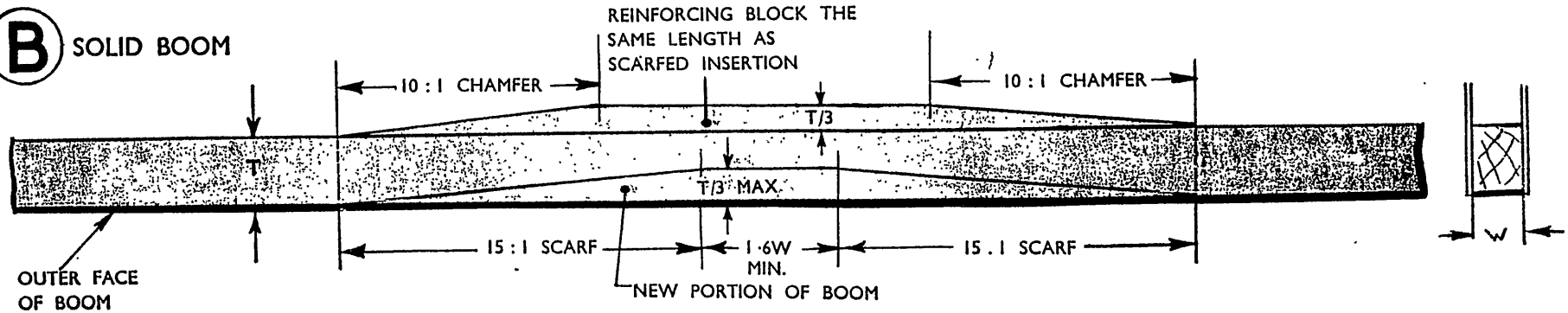
DON'T FORGET to mark the centre line of each scarf on the ply web as illustrated in the sketch opposite. This will assist if repairs at the same part of the spar become necessary at a later date.

3405—PARTIAL INSERTION REPAIR TO SPAR BOOM

A LAMINATED BOOM



B SOLID BOOM



3405

Warning.—*This repair is not universal in application.* ***Therefore you must always refer to the aircraft Vol. II, Part 3*** *to ensure that the repair is approved for the aircraft in question.*

USE THIS METHOD for damage to a spar boom, less than one third of its depth.
METHOD "A" is applicable to booms of laminated construction.
METHOD "B" is applicable to booms of solid construction.
GO AHEAD AS FOLLOWS:—

(i) Remove plywood, including parts of the spar webs, to gain access to damage.
(ii) Cut out the damaged portion of the boom parallel to its longitudinal axis, but not exceeding one third of the depth of the spar.
(iii) Prepare the scarfs to an angle of 15 : 1 ready to receive the insertion piece or laminations as shown in the appropriate sketch.
(iv) Cut the insertion piece or laminations:—(a) From the same grade material,
(b) With the same grain direction, and
(c) To same dimensions (including scarfed ends), as removed portion of boom.
Note.—For Method "A" only, the insertion piece will be built up from laminations equal in thickness to those in the original member.
(v) Glue and cramp the insertion piece in position.
(vi) (Method "B" only). Cut the reinforcing block:—
(a) To the dimensions shown in the sketch,
(b) From the same material, and
(c) With the same grain direction as the spar boom.
(vii) (Method "B" only). Glue and screw the reinforcing block in position.
(viii) Make good any plywood removed in operation (i) as given in chapter 32.

Standard Repairs for Airframes

APPENDIX

A·P 2662A

DETAILS OF REPAIR EQUIPMENT AND ORGANISATION OF CERTAIN REPAIR TECHNIQUE

This leaf issued with A.L. No. 3, July, 1945

STANDARD REPAIRS FOR AIRFRAMES

APPENDIX

A.P 2662A

INTRODUCTION

THE LAST SECTION OF THIS BOOK has been arranged as an Appendix which is to contain all information not needed for coping with individual repairs. Generally speaking, however, the information given will be supplementary to Schemes found earlier in this book.

THE SCOPE OF THE APPENDIX is fairly wide but the information given will deal, mainly, with the construction of equipment needed for certain airframe repairs or with the organisation of certain aspects of repair procedure.

THE MAKE-UP OF THE APPENDIX is similar to the body of this book in that it consists of separate Schemes. Each Scheme is given a number starting at "1" and is preceded by the letter "A" to distinguish it from the Schemes given in the first three Sections of the book.

"A" SCHEMES will be added to the Appendix as required and consequently, although in numerical order, they will not be in any particular order of subject. As, however, the number of Schemes in this Section will never amount to very many, a quick glance through the List of Contents will give you any Scheme number you require. Furthermore, you will usually be referred directly to an "A" Scheme from the "parent" Scheme with which you happen to be concerned.

BACK REFERENCE to the "parent" Scheme is made directly under the title of each "A" Scheme.

CONTENTS

A.1 Aerolite 306—Aids to efficiency

A.2 Aerolite 306—Glue room

A.3 Steel foil resistance

A.4 Adapter box

A.5 Radiant heat reflector

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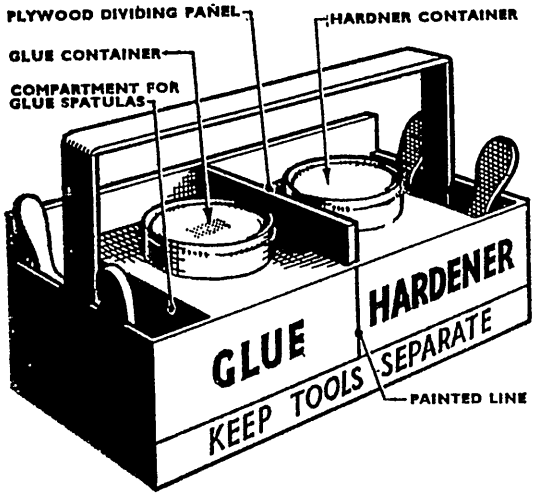
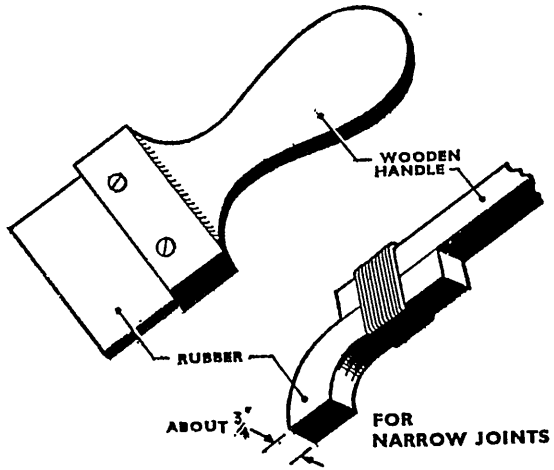
A1 - AEROLITE 306 - AIDS TO EFFICIENCY

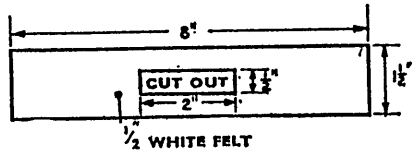
The following ideas are given to assist you in the use of Aerolite 306 (the synthetic resin glue introduced by Scheme 3104). Although the appliances described are not essential for synthetic resin glue work, they will probably save you a lot of time and energy.

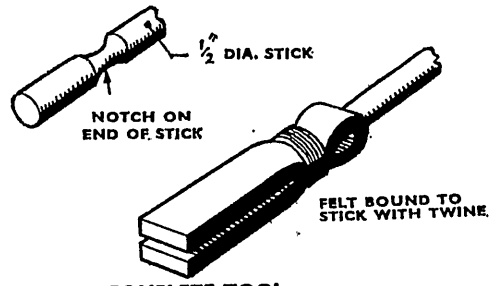


It is very important to keep mixed Aerolite 306 and its hardener separate. A portable rack, for carrying the glue, hardener and brushes to the repair site, will help you to do this. Be careful, of course, not to put the hardener brush in the glue brush compartment or vice versa. A suitable warning notice should be added, as shown in the illustration, or the "hardener" half of the rack and the hardener tools should be painted red to avoid confusion.



Good tools for spreading the glue can be made by screwing or binding a piece of scrap rubber to a suitably-shaped wooden handle. To cope with joints of various widths it is best to make up spreaders of different sizes. The rubber should either be $\frac{3}{16}$ in. thick sheet or solid cut to the dimensions and shape shown in the sketch.





COMPLETE TOOL

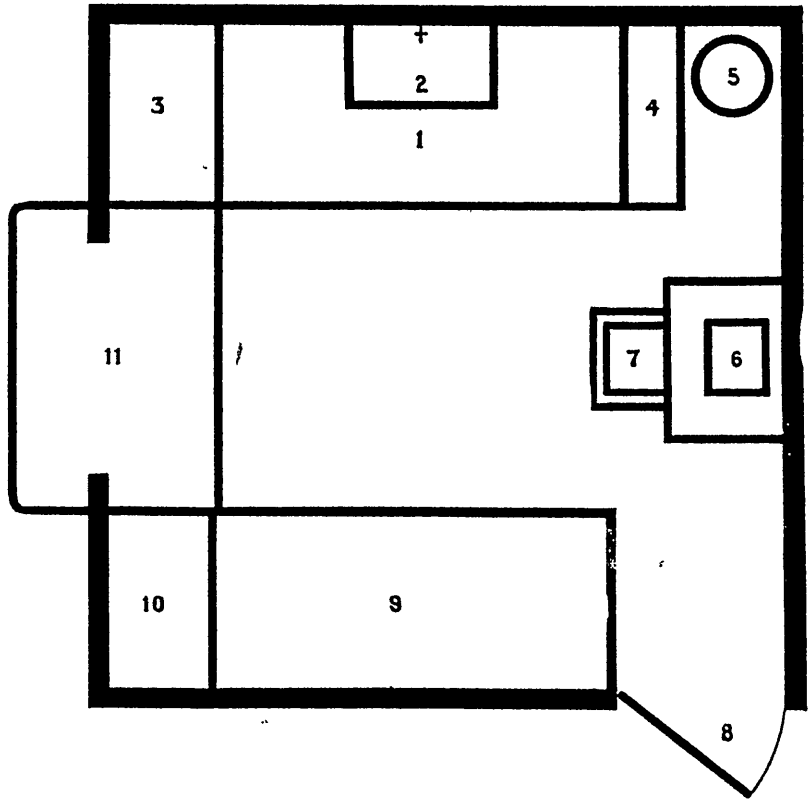
Hardener can be applied to a joint very satisfactorily by means of a piece of white felt bound with twine to a wooden handle. Suitable dimensions for normal work are given in the sketch. This tool will produce the desired thin, even layer of hardener and minimise the risk of splashing excess fluid round the joint. The felt can be renewed very easily so that an even contact surface can always be ensured without the wasteful scrapping of brushes.

A2 - AEROLITE 306 GLUE ROOM

As mentioned in Scheme 3104, it is desirable to set aside a small room or portion of a hangar for the mixing and issue of S.R. glue. A suggested layout for such a room is given in the plan alongside.

KEY TO DIAGRAM

1. Glue mixing bench (Aerolite 306 powder and clean waxed paper containers stored underneath).
2. Water supply and sink.
3. Rack for glue spatulas, stirrers, etc.
4. Rack for measuring vessels, etc.
5. Methylated spirits.
6. Desk for mixing and issue records.
7. Chair.
8. Door to room.
9. Hardener bench (Hardener and clean waxed paper containers stored underneath).
10. Rack for hardener spreaders, etc.
11. Issue counter and hatch.



A4 - ADAPTOR BOX

AN ADAPTER BOX is required to connect the heating circuit used in the Steel Foil and Electric Blanket methods of accelerated gluing and the ground starter trolley supplying the necessary electric current. These boxes will be made up, as required, by Units themselves and the necessary instructions for doing this are given below. The method of using this adapter box will be found described in the relevant Schemes dealing with accelerated gluing.

MATERIALS REQUIRED

Stores Ref.	*Material*	*Size*	*No. Reqd.*
	Plywood	13¼ × 8 × ½ in.	1
	Plywood	7¾ × 1½ × ½ in.	2
	Plywood	13¼ × 1½ × ½ in.	2
	Plywood	13¼ × 8 × ⅛ in.	1
	Woodscrews	Various	As reqd.
5G/1632	Ammeter	0–50 amps.	1
5C/2225	Socket, B.T.H. Type E.2 ...		1
5A/2194	Socket, 3-pole, No. 1 ...	25 amp.	1
5C/543	Switch		1
5C/1722	Magnetic relay		1
5C/445	Fuse box		1
5C/1666	Fuse, type "L"		1
5K/470	Terminals, instrument ...	0 B.A.	4
5E/1360	Cable, electric, L.T., Unicel 19		As reqd.

TO CONSTRUCT THE ADAPTER BOX, go ahead as follows:—

(i) Round off the 8 in. edges of the piece of ½ in. plywood 13¼ × 8 in. which is to serve as the base board of the adapter.

(ii) Set out the construction lines TT', UU', VV', WW', XX', YY', and ZZ', as shown in the plan view on the opposite page.

(iii) With centre A, the intersection of the lines XX' and WW', cut a hole to accommodate the circular body of the ammeter, Stores Ref. 5G/1632. Mount the ammeter in position.

(iv) Mount the 2-pole socket (Stores Ref. 5C/2225) centrally over the point B where the lines WW' and YY' intersect. Holes will have to be drilled in the base board to accommodate the two terminals of the socket.

(v) With centre C, the intersection of the lines XX' and ZZ', cut a hole 1¼ in. dia. and mount the 3-pole socket (Stores Ref. 5A/2194) centrally over this hole.

(vi) At D, the intersection of the lines YY' and ZZ', cut a hole 1¼ in. square to accommodate the body of the switch, Stores Ref. 5C/543. Mount the switch in position.

(vii) At the points E and F on the line VV' and at G and H on the line UU', drill the board with 0 B.A. holes and fit the terminals (Stores Ref. 5K/470).

(viii) Mount the magnetic relay (Stores Ref. 5C/1722) centrally over the construction line TT' as shown in the sketch. Drill the four holes at the corners of the relay as shown.

(ix) Mount the fuse box (Stores Ref. 5C/445) centrally over the construction line TT' as shown. Drill the ¼ in. dia. holes at two corners of the component.

(x) Make and solder the connections shown in the circuit diagram, using Unicel 19 cable.

(xi) Glue and screw the side pieces of plywood (two measuring 7¾ × 1½ × ½ in. and two 13¼ × 1½ × ⅛ in.) in position and complete the box by attaching the bottom (13¼ × 8 × ⅛ in. plywood).

Note. At the discretion of Unit's Engineer Officers, a hinged lid may be fitted to the box to protect the components from accidental damage.

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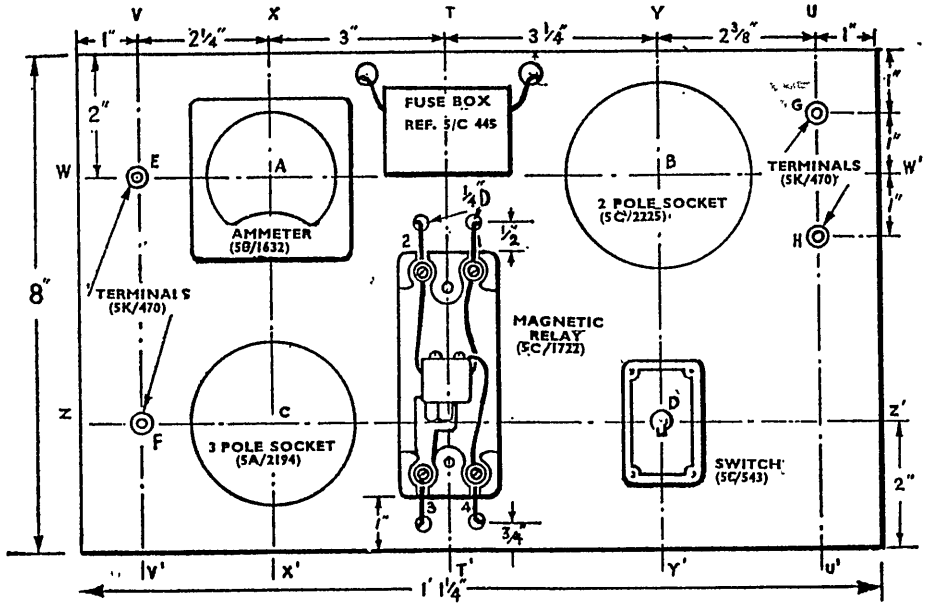
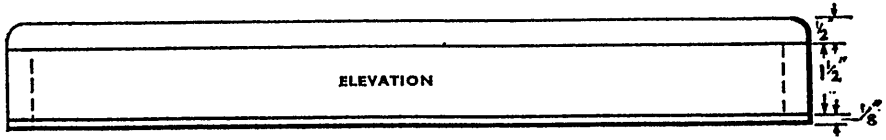
A4 - ADAPTOR BOX cont.

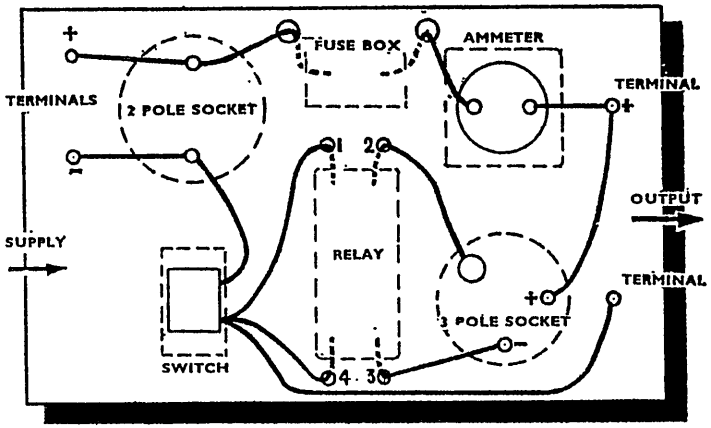


PLAN

NOT TO SCALE



ELEVATION



CIRCUIT DIAGRAM

(BOTTOM SURFACE OF BASE BOARD)

A4