# Chapter 8.1 GENERAL INFORMATION

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# GENERAL NOTES ON FABRIC REPAIRS



**Applicability**

**1.** The information in Section 8 of this publication applies only to fabric covering which forms the load-carrying surface and maintains the contours of an aircraft or component. The fabric or madapollam covering on a wood or metal surface forms part of the protective treatment of the basic surface and repairs for this type of covering are included in Section 9 of this publication or in A.P.2656A.

**Cuts for small openings**

**2.** When small openings are required, for example for inspection of control-cable turnbuckles, L- or X-shaped cuts should be made, but no part of the cuts should be within 2 in. of an existing seam. Cuts in main planes, tail planes, ailerons and elevators should be made in the undersurface whenever possible. The cuts should be parallel to the warp and weft of the fabric which, in turn, will be parallel to the main members if fitted straight and at 45 degrees if fitted on the bias. The cuts should be repaired to Scheme 8.2.1 unless a reinforcing frame is required (*para.* 4).

**Large opening for inspection or repair**

**3.** When a large opening is required for extensive inspection or for repair of internal structure, the cuts should be always made parallel to the main members, even when the fabric is fitted on the bias. On a main-plane the chordwise cut should be made along the centre-line of a rib and the spanwise cut either along the stitching of the trailing-edge seam or at a more convenient position at right-angles to the rib. A cut must never be made along a lap or balloon seam. New cuts should be repaired to Scheme 8.2.1 and trailing edge seams renewed to Scheme 8.2.4. The stringing on a rib should be renewed before the covering strip is doped on. The stringing strengthens the repair but a check must be made to ensure that the ends of both original and new stringing are effectively locked.

**Note . . .**

*Cuts in fabric must be made carefully to avoid damage to internal structure.*

**Permanent inspection openings**

**4.** A permanent opening, consisting of a cut-out within a doped-on cellulose acetate or metal frame and covered with a rip-off patch, is initially provided at each station where frequent inspection of internal components is considered necessary. If further openings are required, frames should be fitted to Scheme 8.2.2 and this scheme may also be used for the repair of holes, provided that surface finish is not important.

**Covering of seams**

**5.** With the exception of balloon seams, all joins in fabric must be covered by doped on, serrated-edge fabric patches or strip. This also applies to standard stringing and to other methods of attachment, whether the fabric is joined or not. All single-thickness edges must be serrated with pinking shears or frayed to a distance of $\frac{1}{4}$ in. from the edges to assist adhesion and to prevent uncontrolled fraying.

**Alternatives to stringing**

**6.** On some aircraft, the standard stringing method (*Scheme* 8.3.1.) for attachment of fabric to ribs and other members is replaced by other methods, usually involving the use of rigid or semi-rigid wires or strips. A typical method using wire is given in Scheme 8.3.2. The alternative methods often give greater strength than standard stringing, usually allow the fabric to be pulled more taut and almost invariably result in a flush surface except for the thickness of the covering strip.

**Drainage holes**

**7.** A drainage hole is formed by cutting the fabric from the inside of a doped-on plastic eyelet. The fabric must be cut cleanly to the edge of the eyelet as ragged edges will collect dirt and accelerate blockage of the hole. The holes must be kept clear at all times as accumulation of moisture and, in some cases, restriction of ventilation will result in rotting of the fabric and rapid deterioration of internal structure. When material containing drainage holes is removed or covered, new eyelets must be fitted in the appropriate positions.

**Protection of wood and metal surfaces**

**8.** Wood and metal surfaces must be protected by a dope-resistant paint such as a universal primer if there is any possibility of contact between the surfaces and the covering fabric when dope is applied to the fabric.

**Doping technique**

**9.** The technique and materials used during repairs when doping the fabric surround, insert patches and cover patches must conform to the original doping schemes (*Scheme* 8.1.3) unless specifically stated otherwise in the appropriate aircraft repair publication. Fabric patches must not be doped direct on to synthetic camouflage finish because satisfactory adhesion would not be obtained. The finish must be removed down to the basic coat of dope, from an area larger than that of the patch.

**Surface finish of fabric repairs.**

**10.** The aerodynamic cleanliness of the surface being repaired should conform to the basic design standards for the particular aircraft. This will determine the tautness required (*Scheme* 8.1.3) and the type of repair to be used for attachment to structure where normal stringing would result in a bumpy surface. On all repairs, however, the finished surface must be free from trapped dust or loose strands and the fabric fibres must be laid as described in A.P.2656A, Sect. 11.

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# MATERIALS AND TOOLS FOR FABRIC REPAIRS

**Construction of fabric**

**1.** The fabrics quoted in Table 2 are woven from yarns, the lengthwise yarns forming the warp and the crosswise yarns forming the weft. The fabric is supplied in bolts or lengths of 75 to 125 yards. On one lengthwise edge, the weft is woven back into itself to form a non-fraying selvedge.

**Storage of fabric**

**2.** Fabric and tape should be stored on wooden racks in a dry building at an even temperature of approximately 70 deg. F. Exposure to strong sunlight, moisture, acid fumes, etc. and prolonged contact with rusty nail or screw heads causes deterioration of the fabric and must be avoided. Absorption of oils or greases might not cause deterioration but would prevent satisfactory application of dope.

**Inspection of fabric prior to use**

**3.** Each length of fabric, strip or tape must be inspected for acid or oil stains, iron-mould or other signs of deterioration, before use. The lengthwise positions of major weaving defects discovered on inspection at the factory are marked by red cotton stitches in the selvedge. If possible, any lengths containing such defects should be used for making patches, the defective areas being cut away and discarded. When it is necessary for a length containing a defect to be used for a large repair or re-covering operation, the defective area must be cut out, the cuts being made parallel to warp and weft. A patch must be stitched in position (*Chap.* 8.2) before the length of fabric is pulled taut in its final location on the airframe.

**Table 1**
**Tools**

| Items | Ref. No. | Size | Description and remarks |
|---|---|---|---|
| Needles:— | | | |
| Straight | 1B/1614 to 1620 | | For hand stitching. |
| Circular | 1B/1602 and 1604, 2929 to 2931 | Various | For hand stitching enclosed flat surfaces. |
| Upholsterers | 1B/1634 to 1638 | | For stringing. |
| Shears:— | | | |
| Tailors' | 1C/2586 | 8 in. cut | 15½ in. overall length, for normal trimming and cutting out. |
| Serrating | 1C/5501 | 4 in. cut | 11 in. overall length, for serrating edges of patches or strips to prevent fraying and to assist adhesion. |
| Tailors' square | 1C/2587 | | For marking out and cutting of fabric. |

## MATERIALS AND TOOLS FOR FABRIC REPAIRS (*Continued*)



**Table 2**
**Materials**

| Item | Ref. No. | Specification | Size | Description and remarks |
|---|---|---|---|---|
| Linen fabric | 32B/147 and 614 | D.T.D. 540 | 38 and 48 in. wide | Unbleached Irish linen, for covering load-carrying surfaces. |
| Fabric strip | 32B/751 to 758 | D.T.D. 540 | $2\frac{1}{4}$ to 12 in. wide | Serrated-edge linen fabric, for covering seams, repaired cuts, etc., on load-carrying surfaces. |
| Madapollam fabric | 32B/556 and 569 | D.T.D. 343 | 38 and 48 in. wide | Bleached cotton material, lighter than linen, used mainly for direct covering on plywood surfaces (*Sect.* 9). |
| Egyptian tape | 32B/686 | D.T.D. 407 | 1 in. wide | Cotton tape for binding ribs and for reinforcing fabric prior to stringing. (*Scheme* 8.3.1). |
| Linen fabric tape | 32B/759 | — | 1 in. wide | Alternative to Egyptian tape. |
| Linen thread | 32B/654 | — | No. 40 | Used single and unwaxed for machine stitching, double and well waxed for hand stitching. |
| Beeswax | 33C/10 | — | | For waxing thread prior to hand stitching. |
| Braided stringing cord | 32A/94 | B.S. F.35 | 50 lb. break load | For stringing fabric to airframe structures. (*Scheme* 8.3.1). |
| Kite cord | 32A/4 to 10 | B.S. F.32 | Various weights | For lacing fabric where repeated access is required. |
| Drainage eyelets:— Plain type | 28N/473 | A.G.S. 840 | — | Small cellulose acetate frames, to provide outlets for moisture and fumes on land-based aircraft. |
| Shielded type | 28N/5409 | A.G.S. 889 | — | For use on sea-going aircraft. |
| Inspection frames | 27H/1193 | A.G.S. 583 | 2 in. opening | Woods type, 4 × 4 in. overall, for inspection openings or repair of small holes. (*Scheme* 8.2.2). |
| | 27H/1194 | A.G.S. 582 | $4\frac{5}{8}$ in. opening | Woods type, $6\frac{5}{8} \times 6\frac{5}{8}$ in. overall. |

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# DOPING AND FINISHING SCHEMES

**Functions**

**1.** The functions of the doping schemes applied to load-carrying fabric covering are as follows:—

(1) To tauten and strengthen the fabric so that it will maintain the required contour.
(2) To make the covering airtight and thus prevent loss of lift.
(3) To provide a waterproof and oilproof surface.
(4) To protect the fabric from deterioration due to exposure to sunlight and
(5) To present a smooth surface to the airflow.

**Standard doping schemes**

**2.** The three standard schemes for load-carrying fabric are quoted in Table 1. The first scheme, to D.T.D. 751, is used on light structures on which the tautening effect provided by the other schemes would result in distortion of the structures. D.T.D. 752 is used on more robust wooden structures and on light metal structures. The third scheme, D.T.D. 753, is used to provide maximum aerodynamic cleanliness on relatively high speed aircraft, on which the need for higher strength ensures that the structure, usually of light alloy, is sufficiently rigid to resist distortion. ◀ Additional information on these schemes is given in A.P.2656A, Vol. 1.▶

**Cellulose materials**

**3.** All tautening dopes for use on load-carrying fabric covering have a nitro-cellulose base to D.T.D. 591. In the three standard schemes, the finishing materials are also cellulose. Each component should be marked, after application of a standard doping scheme, with the appropriate specification number and with the letter 'C' to indicate that the materials used are of cellulose base.

**Synthetic finishes**

**4.** In some instances, a non-standard doping scheme is used, pigmented or aluminium synthetic finish being applied over cellulose tautening dopes. This finish should be marked with the letter 'S' instead of 'C'.

**Identification of finish**

**5.** If there are no identification markings and there is reason for doubt on the nature of the existing finish, a small area of the surface should be wiped initially with a dry cloth to remove dirt and then with a clean cloth moistened with cellulose thinners. If the finish is cellulose the cloth will be stained immediately but vigorous rubbing will be required to produce stains from a synthetic finished surface.

**Removal of existing finish**

**6.** Removal of existing cellulose finish is not necessary for small repairs (*Schemes* 8.2.1 *and* 8.2.2) but the surrounding surface should be wiped with a cloth, moistened with thinners, to remove all dirt and grease before the cover patch is doped on. On larger repairs to cellulose-finished surfaces, the finish must be removed before the edges of the cut-out are folded back (*e.g.*, *Scheme* 8.2.3). Synthetic finishes must always be removed and the cover patch doped to the original tautening cellulose to ensure that good adhesion is obtained.

**Table 1**

**Standard doping schemes**

| Scheme of low tautness to Spec. D.T.D. 751 | | | Scheme of medium tautness to Spec. D.T.D. 752 | | | Scheme of high tautness to Spec. D.T.D. 753 | | |
|---|---|---|---|---|---|---|---|---|
| Material | Total weight in oz./ sq. yd. | No. of coats | Material | Total weight in oz./ sq. yd. | No. of coats | Material | Total 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 | $\frac{3}{4}$ | 1 |
| Aluminium non-tautening finish | 1 | 2 | Aluminium tautening dope | 1 | 2 | Clear tautening dope | $4\frac{3}{4}$ | 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 | $\frac{3}{4}$ | 1 |
| | | | Aluminium non-tautening finish | 1 | 2 | Clear tautening dope | $5\frac{3}{4}$ | 8 |
| | | | | | | Aluminium non-tautening finish | 1 | 2 |

**Note.**—*Where a glossy finish is required, add* 1 *or* 2 *coats of transparent, non-tautening finish to give about* 1 *oz./sq. yd.* (*A.P.2656A, Vol.* 1 *refers*).

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# Chapter 8.2 FABRIC REPAIRS

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# REPAIR OF CUTS AND TEARS (HERRINGBONE STITCH)

# 8.2.1

**Applicability**

**1.** This repair should be used when a clean cut or tear affects less than one-third of the smallest dimension of the enclosing fabric panel, provided that no part of the cut or tear is within 2 in. of an existing seam or stringing. The repair should only be applied if each part of the cut or tear is parallel to either warp or weft, to ensure that the stitches do not pull through to the edges of the cut when the thread is drawn taut or, later, in flight. The 'damage' may be therefore straight, L or X-shaped.

**2.** This scheme must not be used for the repair of a straight tear if the tear is not parallel to warp or weft, or if the fibres of the surrounding fabric have been overstretched, opened up, frayed back from the edges, or damaged in any other way. Similarly, the scheme must not be used for a jagged tear. For these cases Scheme 8.2.2, 8.2.3 or 8.2.4 should be used, as appropriate.

**Preparation for repair**

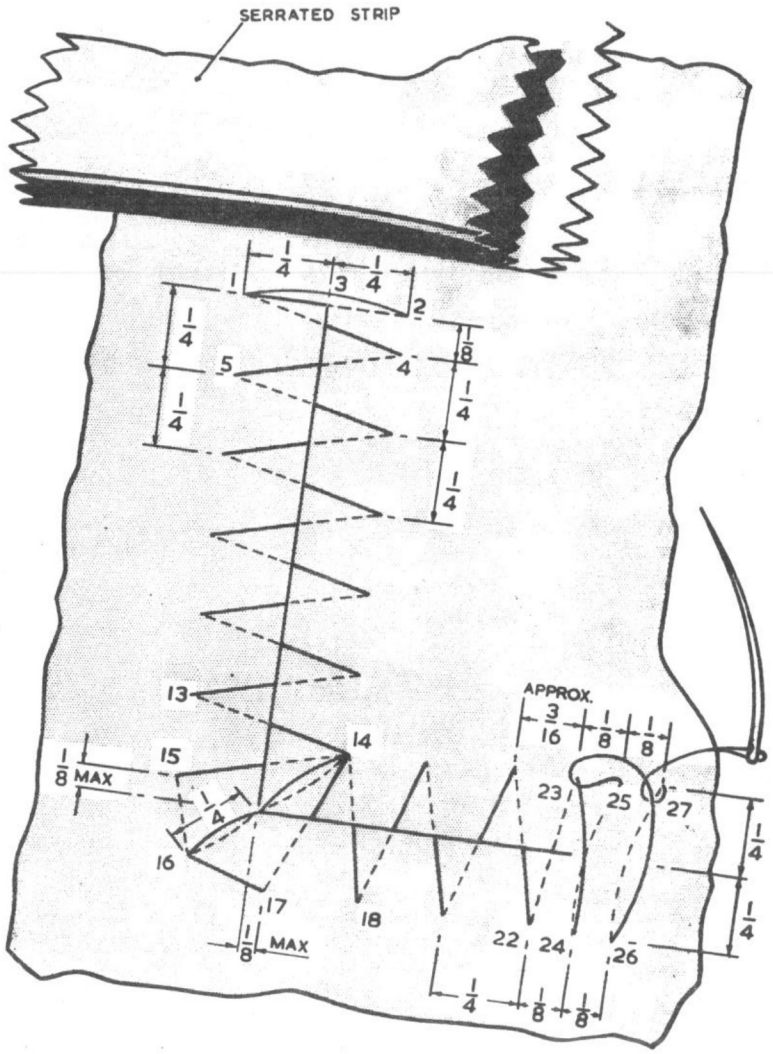
**3.** Unless the existing cellulose at the edges of the cut or tear is cracked to such an extent that it would interfere with the stitching, it should not be removed, but should be wiped clean with a rag moistened with dope thinners. If the cellulose is badly cracked or if its removal is considered necessary to allow for inspection of the fabric underneath, it should be cleaned off with dope thinners until the fabric is pliable. If possible, support should be provided on the undersurface to prevent stretching of the fabric during removal of the cellulose.

**Procedure for repair**

**4.** Refer to fig. 1 for dimensions and sequence numbers and, using a circular needle and No. 40 linen thread, doubled, waxed and knotted, proceed as follows:—

(1) Make an overstitch. Pass the needle up through the fabric at 1, but leave the knotted end of the thread protruding from the cut or tear at 3. Pass the needle down at 2 and up through the cut at 3 again. Thread the needle through the loop formed by the knotted end, pull taut and lock back by a single knot round the thread from 2. Ensure that the knot is at 3 and pass the needle over the fabric and down at 1.

(2) Commence the herringbone stitch. Bring the needle up through the cut and down at 4, up through the cut again and




NOTE:- THE ABOVE DIMENSIONS ARE FOR GENERAL GUIDANCE, BUT SHOULD NOT BE EXCEEDED. ALL DIMENSIONS ARE IN INCHES

**Fig. 1. Repair of L-shaped tear.**

down at 5. After each stitch pull the thread just taut enough to bring the cut edges together without puckering, at the same time taking care not to open the fabric at the needle holes. Keep the thread taut by placing a finger over the last stitch in each case.

(3) Continue the herringbone stitch to the equivalent of point 13 at a corner or of point 22 if the cut is straight.

(4) At a corner, equivalent to 13, continue the herringbone stitch to 14, then 15, but this time bring the needle up at 16. Form a double loop, passing the needle down through the cut at the corner, up at 14, down through the corner of the cut again and up again at 16. Pass the needle down at 17 and continue with the herringbone stitch to 14, then 18 *et seq.*, finishing down at 22.

(5) Complete the repair with an overstitch and two half-hitches. Bring the needle up at 23, thus taking the thread right across the cut on the undersurface. Pass the needle down at 24 and up at 25, the thread being pulled taut each time. Pass the needle under the loop 23 to 24, pull back towards 25 and complete the first half-hitch (completion not shown in fig. 1). Continue down at 26, leaving a little slack to allow for the second half-hitch, up at 27, under the loop 25-23-26, pull taut and complete the second half-hitch (completion not shown). Cut off the surplus thread, leaving approximately $\frac{1}{4}$ in. free.

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(6) Brush a coat of red dope over the repair area and pad down the free ends of the thread.

(7) Prepare a fabric patch or strip, with serrated edges, of sufficient size to ensure a minimum overlap of 1 in. from any part of the cut.

(8) Place the patch or strip in position and brush red dope thoroughly into the fabric. Using a pad of scrap fabric, lay the fibres and smooth the patch or strip edges down to the surrounding surface.

(9) Apply a further coat of red dope over the patch and surrounding surface.

(10) Restore the appropriate finish, avoiding local build-up of thickness.

# REPAIR OF SMALL HOLES BY DARNING OR WOODS' FRAMES

# 8.2.2

### Repair of 2 in. square holes

**1.** Holes up to a maximum of 2 in. square may be repaired either by darning or by the use of reinforcing frames (*para.* 3). In some cases a hole up to 1 in. square in fuselage fabric may be repaired without stitching, by the use of serrated edge fabric patches, with 1 in. overlap all round, doped on each face of the fabric with a second patch, 1 in. larger all round than the first, doped on the outer surface only.

### Repair by darning

**2.** For repair by darning, No. 40 linen thread is used, waxed and doubled. The stitches must be interwoven and must follow the lines of the warp and weft, being set $\frac{1}{4}$ in. apart and at least $\frac{1}{4}$ in. from the edge of the hole. Excessive tension must not be used. A serrated fabric patch, overlapping by $1\frac{1}{2}$ in. all round, should be doped over the repair.

## REPAIR USING WOODS' FRAMES

**3.** This type of repair is quicker and more convenient than darning or stitching, and is used for holes up to $4\frac{1}{2}$ in. square, provided that the effect of the inherent surface irregularity on aerodynamic performance can be considered to be negligible. (If the aerodynamic effect would not be acceptable, Scheme 8.2.3 should be used.) A cellulose acetate or metal frame is doped to the fabric, enclosing the damaged area. The damaged fabric is then trimmed back to the inner edge of the frame and a cover patch is doped over the frame. This type of repair is particularly useful where frequent inspection of internal components is required.

### Removal of the cover patch

**4.** When removal of the frame cover patch is necessary, an X-shaped cut should be made, from corner to corner in each case, in the fabric within the frame. The resulting four triangular pieces of fabric should then be ripped off outwards. Attempts to remove the cover patch by initially lifting the outer corners or edges may cause damage to the main surface fabric surrounding the frame.

### Cellulose acetate frames

**5.** The provisioned reinforcing frames (*Table* 1) are made from cellulose acetate sheet not less than 0·030 in. thick and are square in shape. The sides of the frames are 1 in. wide and the outer edges are chamfered to assist adhesion and reduce disturbance of the airflow. Frames may be made up locally, from cellulose acetate sheet, to either a square or circular shape. In each case, the thickness and width of side should be as quoted for the provisioned frames and the outer edges should be chamfered (*fig.* 1).

### Metal frames

**6.** If cellulose acetate is not available, reinforcing frames may be made from aluminium or aluminium alloy sheet not thinner than 24 s.w.g. The frame sides should be 1 in. wide, the outer edges should be chamfered and smoothed, and the inner edges rounded to prevent damage to the fabric. Fabric mounting strips, as in fig. 2, must be used with all metal frames. Both free edges of a strip must extend at least $\frac{3}{8}$ in. beyond the outer edge of the frame to ensure that good adhesion will be obtained when the covered frame is doped to the surface.

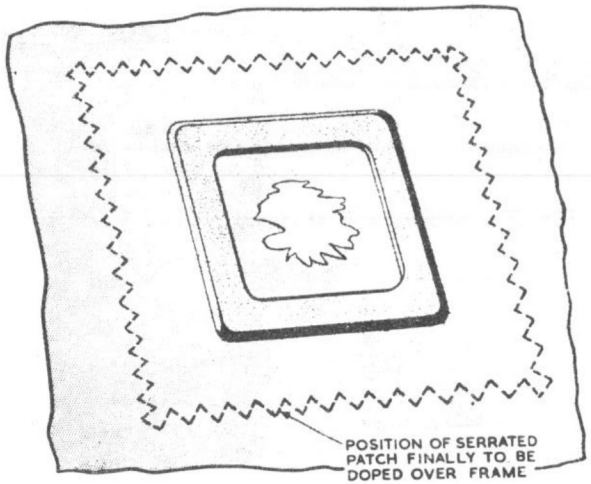


**Fig. 1. Attachment of cellulose acetate frame.**

**Table 1**
**Details of provisioned frames**

| Ref. No. | 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 |

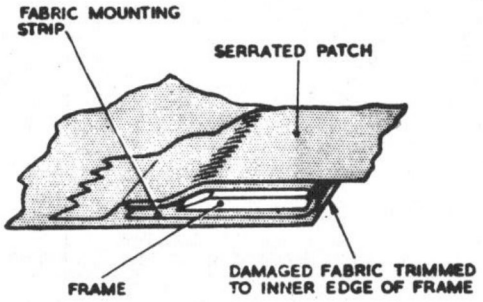


**Fig. 2. Attachment of metal frame.**

**Repair procedure**

**7.** The procedure for repair is as follows:—

(1) Clean off the camouflage and dope down to a clean surface of red dope, over an area slightly larger than that required for the cover patch.

(2) Apply red dope to the fabric surface and to the undersurface of the reinforcing frame and place the frame in position, if possible supporting the undersurface of the fabric.

**Note . . .**

*Square frames should be mounted parallel to the warp and weft of the fabric. When a metal frame is used, the dope must be brushed thoroughly into the fabric mounting strip.*

(3) When the dope has dried, trim out the damaged fabric neatly to the inner edges of the frame.

(4) Dope on the serrated-edge fabric cover patch, to overlap the frame by at least 1½ in. all round.

(5) Restore the appropriate finish.

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# REPAIR OF HOLES BY PATCHING

# 8.2.3

**Applicability**

**1.** This type of repair is used for damage up to 4½ in. square when the surface irregularity caused by a Woods' frame is unacceptable, and for damage from 4½ in. square up to that necessitating renewal of a complete panel width. The repair consists of an insertion patch, trimmed and stitched to fit accurately into the trimmed damage, covered by a doped-on, serrated-edge patch.

**Repair procedure**

**2.** Refer to fig. 1 and proceed as follows:—

(1) Cut out the damage to the minimum possible size of rectangle, making the cuts parallel to the warp and weft of the fabric.

(2) Clean off all old dope until the fabric is moderately flexible; if necessary support the fabric to prevent stretching of the fibres.

(3) Mark a line ½ in. back from each edge and cut diagonally from each corner of the cut-out to the junction of the marked lines.

(4) Fold each edge under to the marked line in each case, crease the fabric accurately along the line and tack or hem the fold in position, as appropriate.

(5) Mark out and cut a patch (*parallel to warp and weft*) to fit the hole, allowing ½ in. on each edge for the fold. Fold back and tack the folds loosely in position.

(6) Tack the patch in position in the hole, firstly at a corner and then at 4 in. intervals along each side, pulling the patch taut before making each tack.

(7) Sew all round, using the herringbone stitch (*Scheme* 8.2.1) at ¼ in. pitch and ¼ in. from each edge. Draw the thread (*No.* 40 *linen, doubled and waxed*) just taut enough to close the gap without puckering. Remove tacking stitches and adjust the folds on the patch as necessary to take up slack, to render the patch reasonably taut and free from ridges.

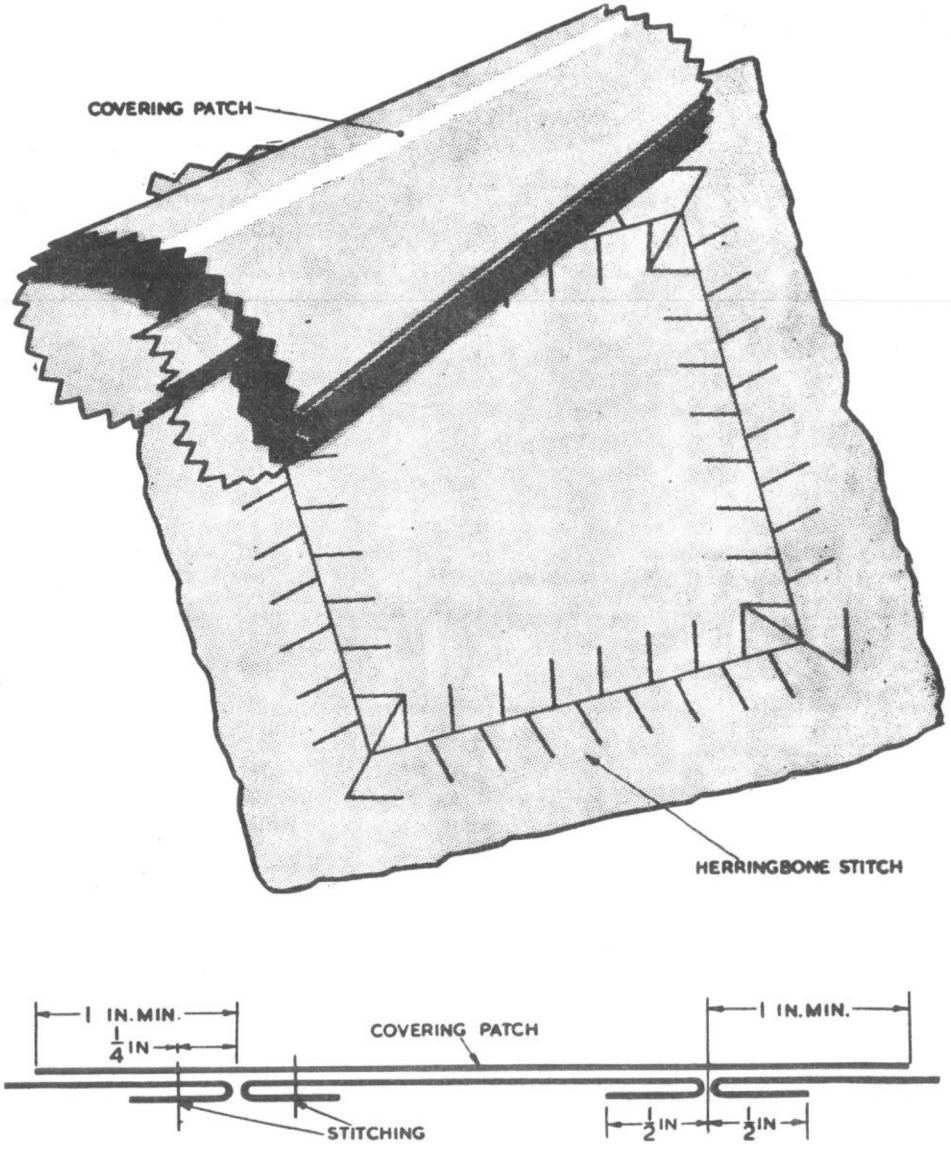


**Fig. 1. Fabric insertion patch.**

(8) Brush red dope thoroughly into the insertion patch. When dry, apply a further coat of dope over the patch and the surrounding surface.

(9) Dope on a serrated fabric covering patch to overlap the join by 1 in. all round. If a covering patch would be more than 8 in. square, use 2 in. wide serrated strips instead. The strips should be centred over the joins and should be mitred at 45 deg. at each corner, not overlapped.

(10) Restore the appropriate finish.

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# SEAMS FOR LARGE REPAIRS

# 8.2.4

## POSITIONING STITCHES

**1.** Hemming and tacking or basting stitches are used as a temporary measure to maintain folds or to retain seam laps or insertion patches in position to facilitate permanent stitching. The hemming stitch is normally used for long folds and the tacking stitch for insertion repairs and for machined seams.

### Hemming stitch

**2.** This stitch is used to produce a smooth, straight, non-fraying edge. The stitches are made straight up and down to the dimensions given in fig. 1 and No. 40 linen thread is used doubled. If the stitching is to remain *in situ* after repair, the thread should be waxed and an occasional back stitch should be made to prevent the thread from pulling out if broken.

### Tacking stitch

**3.** For a fold, an unwaxed single thread is taken through the material as in hemming, but at $\frac{1}{4}$ in. to 1 in. intervals. The tacking is pulled out after completion of the permanent seam.

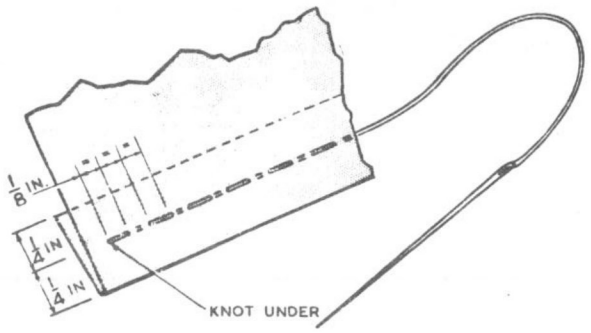


**Fig. 1. Hemming stitch.**

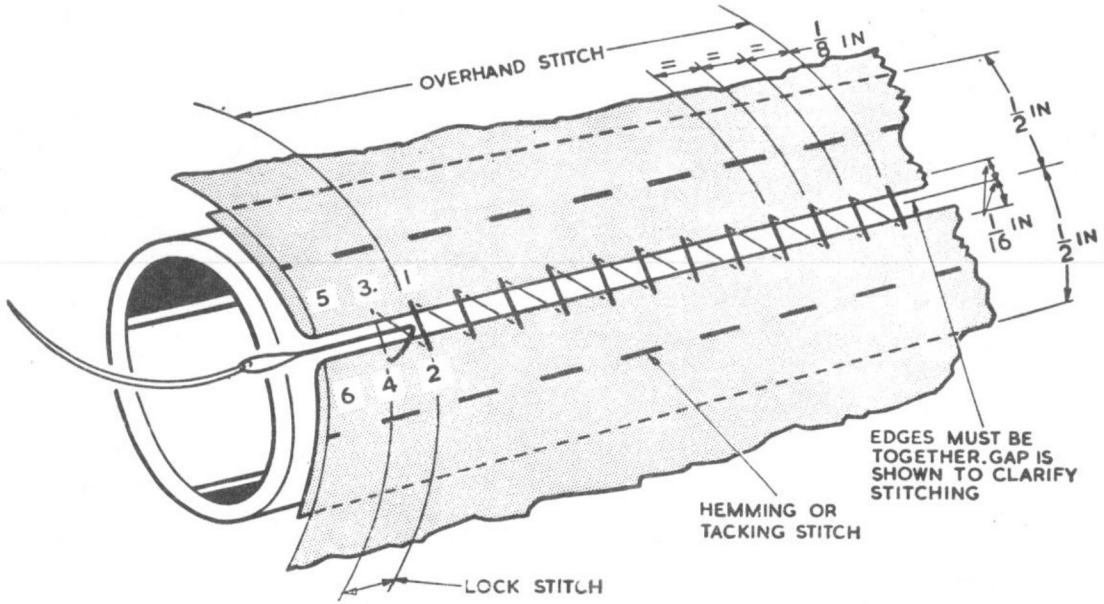


**Fig. 2. Typical trailing edge seam.**

## PERMANENT STITCHES AND SEAMS

**4.** Two types of hand stitching are used, the overhand stitch, which is used in conjunction with the lock stitch for making seams on the edges of components, and the herringbone stitch (*Scheme* 8.2.1) which is used for insertion patch seams. Machined lap and balloon seams are used for joining full widths of material, off the aircraft, when a major component is to be completely or partially recovered. On large repairs, combinations of the different types of stitching are almost always required.

### Overhand stitch

**5.** The dimensions for this type of stitching are given in fig. 2. The edges of the fabric are trimmed as required to produce a neat joint with the folded fabric taut but unpuckered. Each fold is then hemmed or tacked in position. If necessary, the folded edges are tacked together at 4 in. intervals. For the overhand stitch, double, waxed No. 40 linen thread is used with a circular needle and taken up through the top fold $\frac{1}{16}$ in. from the edge, across over the gap and down $\frac{1}{16}$ in. from the edge of the lower fold. The edges are drawn together and the first stitch is locked by any convenient, safe knot. The needle is brought up $\frac{1}{8}$ in. from the first stitch and straight across again. The advance of $\frac{1}{8}$ in. is made on the undersurface in each case and thus the finished repair shows only vertical overhand stitches. Each stitch is

drawn just taut enough to close the gap without overlapping or puckering and the thread is trapped with thumb or finger to prevent loosening. A lock stitch (*para.* 6) is made at approximately 2 in. intervals to limit opening up of the seam if the thread breaks.

**Lock stitch**

**6.** Using the numerical sequence shown on fig. 2, the lock stitch is made as follows:—

(1) Make a normal overhand stitch from 1, passing down at 2.

(2) Bring the needle up through the gap, *down* at 3, straight across on the undersurface and *up* at 4.

(3) Take the needle down in the gap between 1-2 and 2-3 and *under* the two threads 2-3 and 3-4.

(4) Draw the thread taut enough to pull the edges together and continue the overstitch up at 5, down at 6 and so on.

**Machined lap seam**

**7.** The machined lap seam (*fig.* 3) is generally preferred to the balloon seam, although the two are of equal strength, due to its relative simplicity and smoother finish. The procedure for making a lap seam is as follows:—

(1) Ensure that the edges to be joined are selvedged or serrated.

(2) Make an overlap of $1\frac{1}{4}$ in. and secure with two lines of tacking. The tacking may be made with coloured thread and set on, or slightly to one side of, the machined seam lines to provide a guide during machining.

(3) Set the sewing machine to give 8 threads per inch and use No. 40 linen thread.

(4) Machine the two seams at the positions shown in fig. 3.

(5) When the covering is doped after being fitted on the aircraft, lift the $\frac{3}{8}$ in. free edge of the seam on the outer surface and brush dope thoroughly into the fabric beneath it and on the undersurface of the free edge itself.

(6) Apply dope over the seam and press the free edge firmly down, using a pad of scrap fabric.

(7) Dope a strip of serrated fabric over the seam as shown in fig. 3. The strip must be at least 3 in. wide.

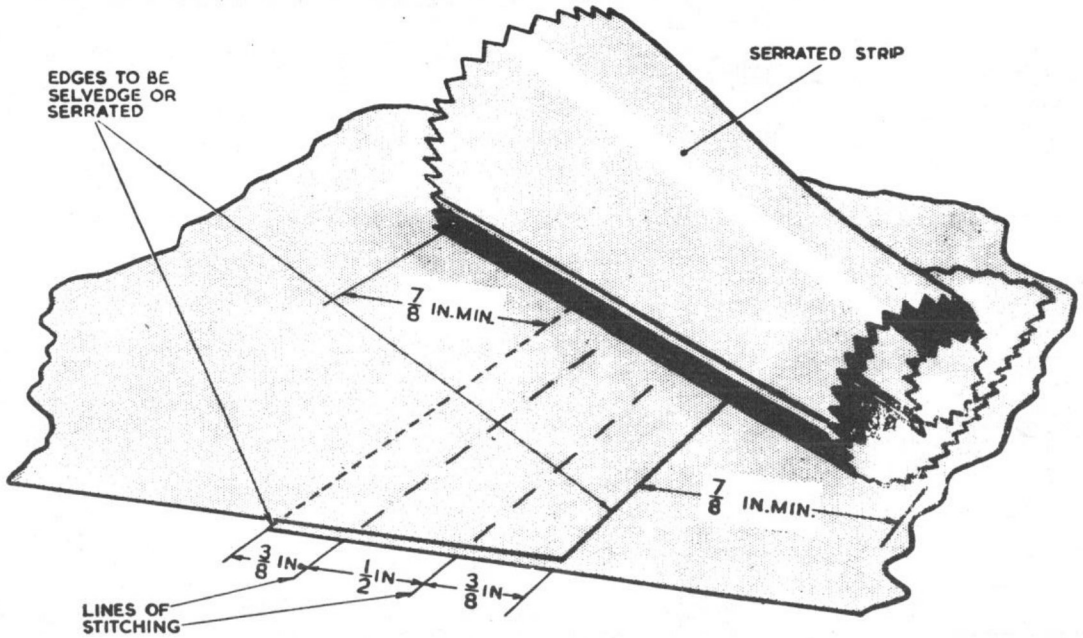


**Fig. 3. Machined lap seam.**

**Balloon seam**

**8.** The balloon seam (*fig.* 4) may be used instead of the machined lap seam, if required, for chordwise seams only. If placed spanwise or diagonal it would cause considerable disturbance of the airflow. It has the advantage that a covering strip is not required but is more bulky, consisting of four thicknesses bunched together, compared with the three 'tapered' thicknesses of the lap seam and cover patch. Consequently it is difficult to handle at cross seams on trailing edges and other positions. The seam should be made to the dimensions given in fig. 4. Considerable care is needed to ensure that the raw edges are completely stitched in throughout the length of each seam.

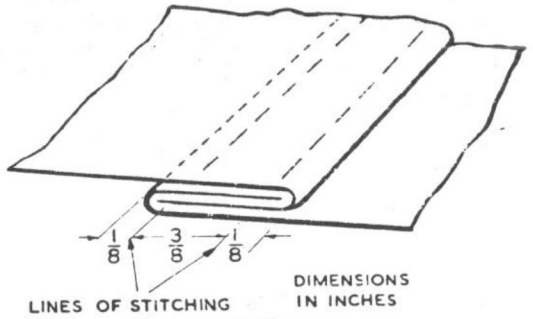


**Fig. 4. Balloon seam.**

# Chapter 8.3 STRINGING

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*Scheme*

# STANDARD METHODS OF STRINGING



**General**

**1.** Stringing is the basic method used for attaching fabric to aircraft structures. Braided stringing cord is used to tie the fabric to the internal structure, the cord being knotted at frequent intervals to ensure tautness of cord and fabric, and to localise any loosening of the fabric if the cord is subsequently severed accidentally.

**Preparation of stringing cord**

**2.** The cord is No. 1 braided stringing cord, of 50 lb. breaking load, to specification B.S. F.35 (*Ref. No.* 32*A*/94), and this must be thoroughly beeswaxed before use. The beeswax renders the cord waterproof and prevents rotting, prevents the brittleness that would result from penetration by dope, minimises fraying and reduces the tendency to ravel during the stringing operation. The cord should be waxed just before use, to ensure that the wax is still soft (due to frictional heat) during stringing. If the wax has been allowed to harden, it will tend to flake when the cord is pulled through the fabric, and fraying of the cord may occur.

**Reinforcement of fabric**

**3.** To reinforce the main fabric cover on lines of stringing, a strip of Egyptian tape is placed over the fabric (*fig.* 2), overlapping the rib or other component by $\frac{3}{8}$ in. on each side. Linen tape may be used as an alternative and, in emergency, fabric strip may be used, provided that the edges are selvedged or serrated and the $\frac{3}{8}$ in. is measured to the inner points of the serrations. A similar strip of tape or fabric (*fig.* 2) is used to cover the internal member under the main fabric, to prevent chafing between the member and the cord. This strip may be tack-sewn or fixed in position with a suitable adhesive. Finally, an overlapping serrated strip is doped over the stringing and external reinforcing tape. This protects the stringing from moisture and chafing, and improves the aerodynamic characteristics of the surface.

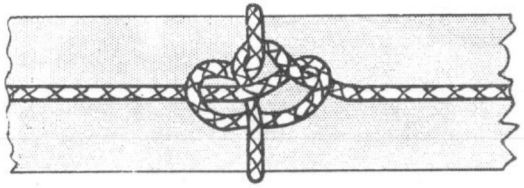


**Fig. 1. Stringing knot.**

**Stringing knots**

**4.** The form of knot used for standard stringing is shown in fig. 1. Double knots are used at intervals to provide greater security. In the type of stringing shown in fig. 3, the knots may be made at the upper or lower surface as convenient, but the surface irregularities caused by the knots will have less effect on lift if on the underside of the aerofoil. The knots may be located in the centre or on the side of the component (*fig.* 2). The side position will give a smoother finish, but care is needed when the knots are made in this position to avoid extension of the holes in the fabric and local over-tensioning and distortion of the fabric. Whenever possible, the position of the knots and frequency of double knots should be copied from the existing stringing.

**Stringing loops**

**5.** Different types of loop are used on different depths of section, as indicated in fig. 3, 4 and 5. In each case, however, the upholsterer's needle used for stringing must be inserted as close as possible to the edges of the internal components to ensure that the stringing will fit snugly against the sides of the rib when pulled taut, without increasing the size of the holes and damaging the fabric. The cord must not be pulled so taut that the internal component is distorted.

*Aerofoils up to 6 in. deep*

**6.** On thin aerofoils and on deeper sections in which the ribs have full diaphragm webs, the stringing loop at each knot is passed round the full depth of the rib, as in fig. 3.

*Medium depth aerofoils*

**7.** On aerofoils between 6 and 14 in. deep (*fig.* 4) two cords are used. The first cord is used to make loops at double pitch, round one boom only. On the other boom, the second cord is used to make alternate loops round the boom and round the full depth of the rib respectively. The full depth loops are made at staggered pitch to lie midway between the existing boom loops on the first

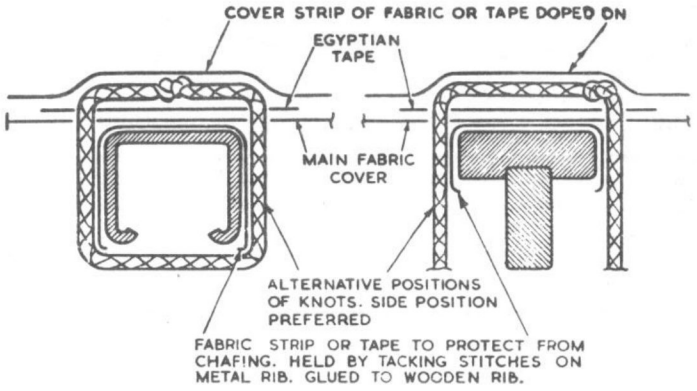
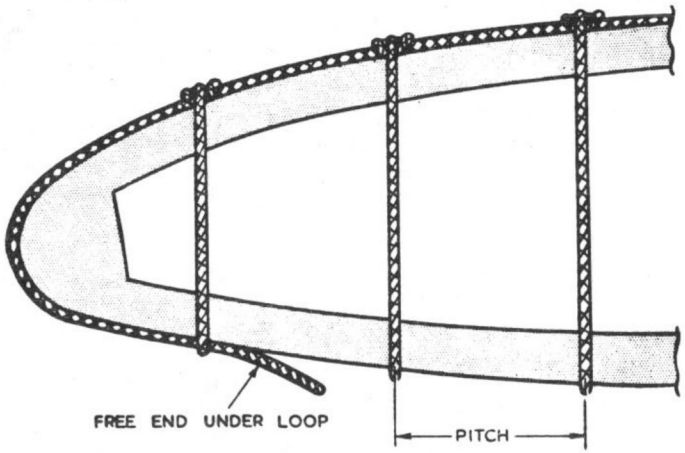



**Fig. 2. Typical sections.**




STRINGING FULL DEPTH OF RIB.

**Fig. 3. Aerofoils up to 6 in. deep.**

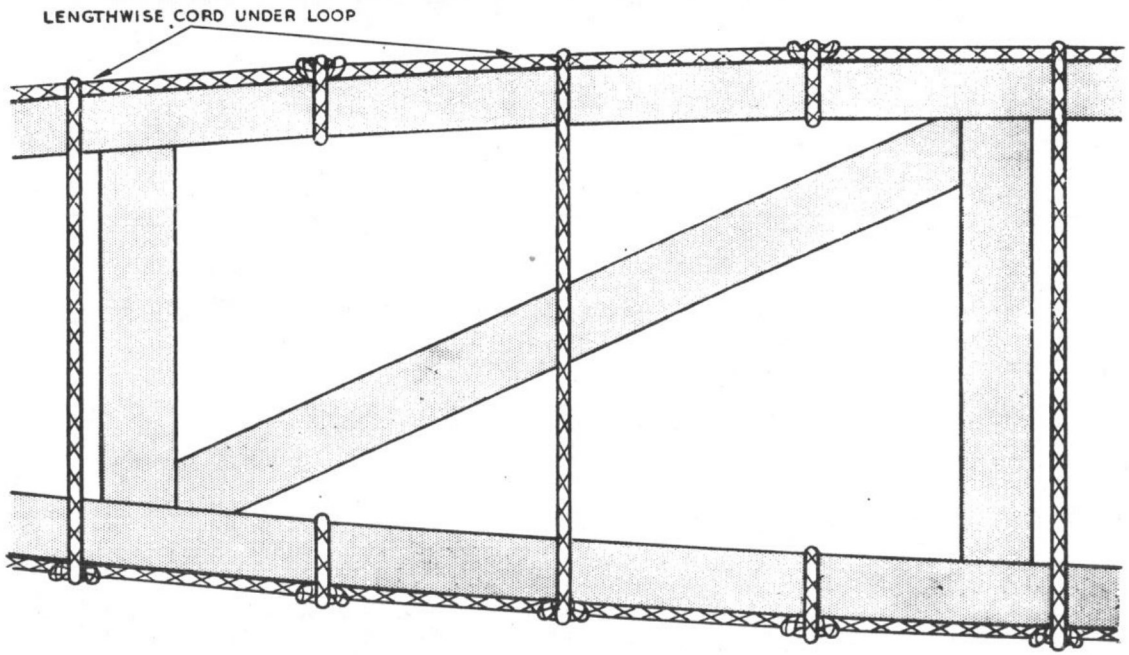
boom in each case. The boom loops on top and bottom booms are therefore in vertical alignment.

*Aerofoils of deep section*

**8.** When a rib is more than 14 in. deep, loops are made round the boom only, at each single-pitch knot, unless the rib has a diaphragm-type web.

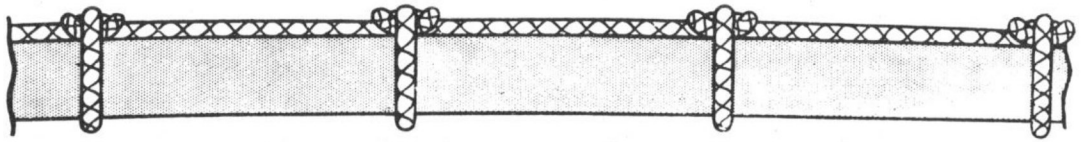
**Stringing pitch**

**9.** The existing pitch used on the same or a similar component on the aircraft should be copied whenever possible. On low speed, lightly-loaded aircraft generally, and on fuselages on higher speed aircraft, the pitch (*fig.* 3) is normally 3 in. On higher speed aircraft aerofoils and in slip-stream areas on low speed aircraft, a pitch of 1½ in. is used.




STRINGING ALTERNATELY ROUND BOOM AND FULL DEPTH. TWO CORDS ARE NEEDED.

**Fig. 4. Aerofoils 6 in. to 14 in. deep.**



STRINGING ROUND BOOM ONLY. BOTTOM BOOM SIMILAR TO TOP.

**Fig. 5. Aerofoils more than 14 in. deep.**

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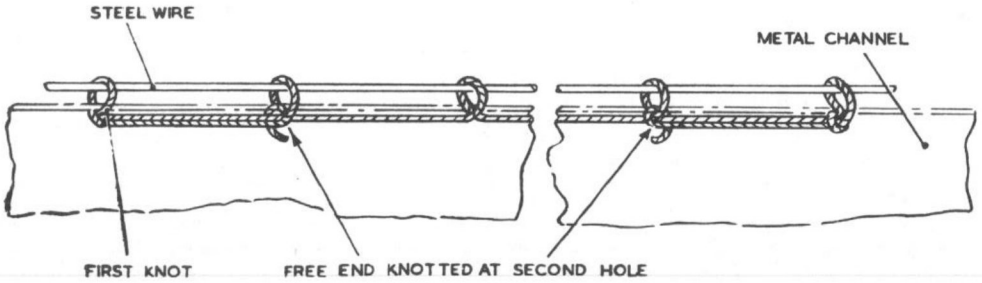
# FLUSH STRINGING

# 8.3.2



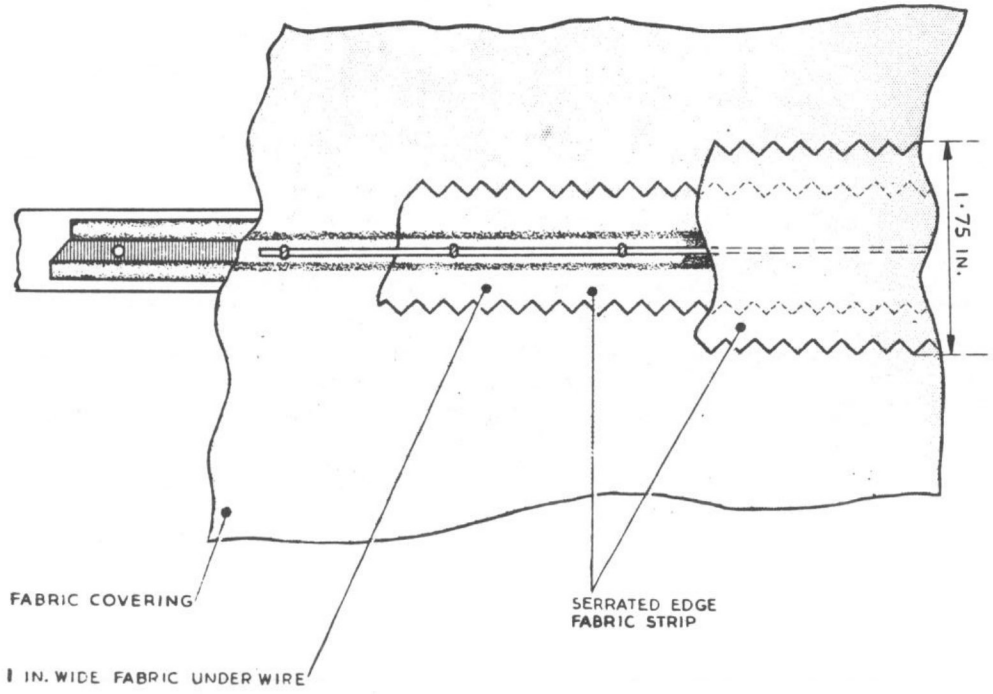
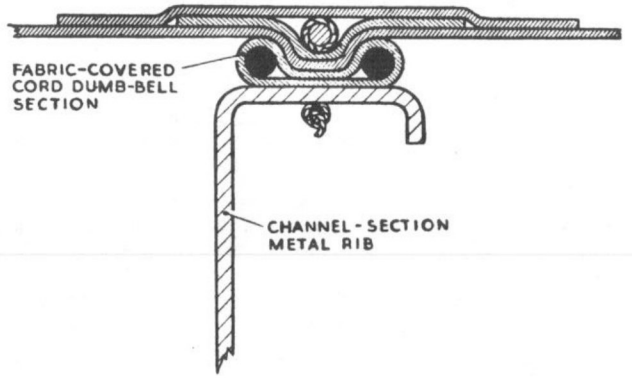




**Fig. 1. Typical flush stringing method.**




**Typical procedure**

**1.** Several methods are used for flush stringing. In the example given in fig. 1 the fabric is trapped in a well-section by a length of steel wire. The procedure for the method shown is as follows:—

(1) Pass the braided stringing cord up through the first hole, round the wire and down through the hole again. Pull taut and knot, leaving sufficient cord at the free end to knot at the second hole.

(2) Pass the main cord up through the second hole, round the wire, down through the hole and then on to the next hole and so on.

(3) At the last hole in the section, make a loop over the wire, pass the cord down through the hole, ensure that the cord is taut throughout and knot the cord. Take the free end back to the previous hole and knot again.

(4) Take the free end left at the first hole and knot at the second hole.

(5) Dope on the cover strip.

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