CHAPTER XIV.

PRACTICAL INFORMATION FOR RIGGERS.

Accuracy of measurements.

434. Strictly speaking, it is not possible to determine the exact measurement of an object. A measurement by visual comparison can be made by means of a steel rule or tape to within, say, $\frac{1}{100}$ part of an inch. Greater accuracy than this cannot usually be relied upon, because of practical difficulties, and also because rules and tapes are themselves not made absolutely accurate. A vernier or micrometer caliper will measure to within 1/1,000 part of an inch (·001 in.), as explained in paras. 48 to 52, and micrometers can sometimes be read to an even finer degree, but dead accuracy is impossible, because even if the true length of the part could be measured, the length of both the part and the measuring instrument vary with every change of temperature. But a dimension or part can be measured to any reasonable degree of accuracy, and where it is of importance the accuracy required is usually stated, generally in the form of a "limit" or "tolerance," such as plus or minus two thousandths of an inch (written $\pm$ ·002 in.), which permits the part to be a little larger or a little smaller than the nominal size.

435. This means, that if, say, 20 parts go to make up a component, each of which have a limit of $\pm$ ·002 in., it is possible that the overall size of the completed article could be larger or smaller than the nominal size by ·04 in., or a little more than 1/32 in.

This principle applies to some extent to all aeroplane parts, but the individual limits are so arranged that the resulting accumulative error is not harmful.

436. The accuracy required generally varies with the length measured and the nature of the service required of the part. As an instance, engine parts are often measured to $\pm$ ·0005 in., whereas the span of a twin-engined bombing aeroplane is sufficiently accurate if it is correct to within the nearest $\frac{1}{2}$ in. The important point is that the rigger must be extremely careful in his measurements, realising that error—admittedly unavoidable—must be confined to a certain definite maximum. For this reason it is occasionally necessary to take the average of three independent measurements.

Plumb lines.

437. An improvised plumbline can satisfactorily be made from a length of fine cord and a piece of metal a few ounces in weight, say a short bolt or a nut. So long as one edge of the cord is used as the reference line, the absence of a point on the plumb-bob directly under the plumbline is immaterial.

Methods of determining right angles.

438. One of the necessities of rigging is some test of perpendicularity. It should be understood that in its geometrical sense (as used in this manual) the term "perpendicular" means "at right angles," and that one straight line which is perpendicular to another straight line may point in any direction so long as the angles at the point of intersection of the two lines are right angles (90°). The largest square usually available is about 10 in. long in the blade. This tool is indispensable for the rigger, but it is of little use when dealing with large dimensions. There are, however, several simple methods of ascertaining whether two lines or parts are at right angles.

439. One method is to mark off three units of length as large as convenient along one of the parts, and four of the same units along a second part. If the lines are at 90°, a line drawn between the outer marks (thus forming a triangle) will be equal to five of the units in length, as shown at B fig. 100.

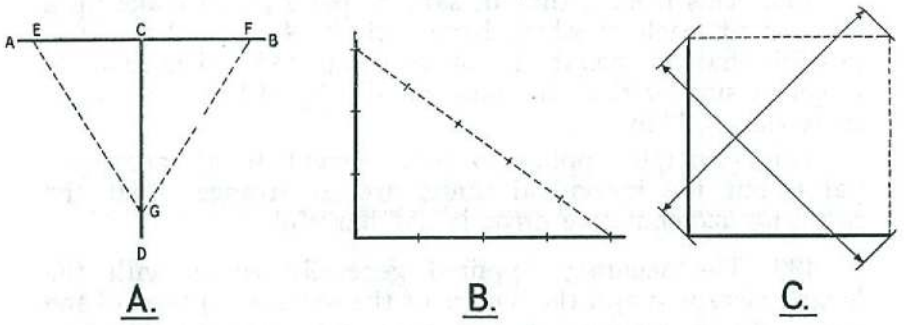

FIG. 100.—Methods of determining right angles.

440. Another method is shown at A, fig. 100. In this example it is desired to test whether AB and CD are at right angles. It is necessary to take two points on the line AB, which are equi-distant from C, say E and F. Then take a point G along the line CD and compare the distance GE, GF.

If the measurements correspond, the angles ACD and BCD are equal and if the lines AB and CD are straight, the angles will be right angles.

441. A third method of testing whether two lines are at right angles is as follows. Measure equal distances along each line, and using the same dimension, complete with square by marking the fourth corner, thus making a parallelogram with all four sides equal in length. Then measure the diagonals. When all four sides are equal and the diagonals are equal, adjacent lines will be at right angles to one another as shown at C, fig. 100.

Testing straightedges.

442. Straightedges can be roughly checked by sighting along the edges or placing two straightedges edge to edge and ascertaining by holding up to the light if there are any gaps. If greater accuracy is required, the straightedge should be placed on a surface plate and the truth checked by using feelers and a dial gauge.

Testing spirit levels.

443. Place the spirit level on any flat surface, such as a surface plate or a straightedge. Note, or mark, the position of the bubble and the position of the ends of the level. Now turn the level so that its ends are reversed, but the level occupies the same position as before. If the surface on which the spirit level is placed is truly horizontal and the level is accurate, the bubble will be central in both positions. If the surface is slightly inclined, the bubble should be in the same relative position in each case.

Testing a square.

444. To test a square obtain a piece of board which has a true edge. Then, placing the square in the normal manner against the true edge, draw a pencil line on the board using the blade of the square to obtain a line at right angles to the board. Then turn the square over and bring the edge of the blade up to the pencil line, the opposite face of the blade then being in contact with the board. If the square is true, the edge of the blade will be parallel to the pencil line.

Tie-rod holders and spanners.

445. When adjusting or locking the bracing wires of an aeroplane, care must be taken not to employ too much force, as by so doing a wire or the nuts may be damaged. With

these objects in view, the rigger is supplied with a fixed spanner in the form of a disc, $1\frac{5}{8}$ in. in diameter, as shown at C, fig. 101. This spanner has three slots round its periphery which are suitable for the smaller sizes of nuts. At A and D, fig. 101, are shown types of spanners which some riggers make up for themselves, but if spanners of this type are used, the tightening must be effected with discretion, as the leverage obtainable is sufficient to strip the threads.

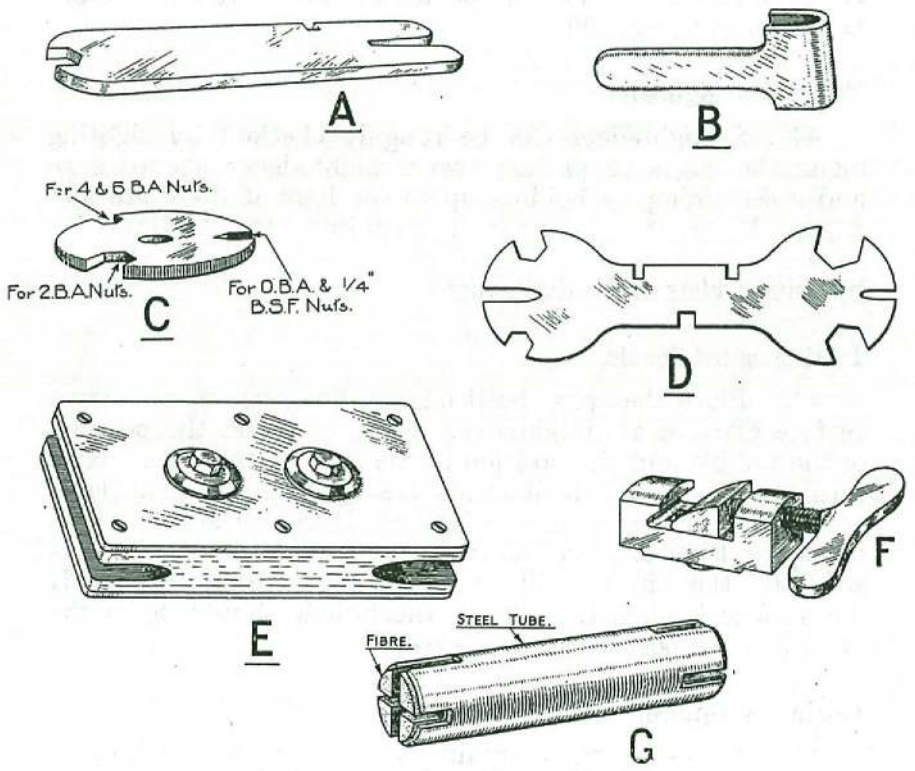

FIG. 101.—Spanners and wire holders.

446. During adjustment and locking, a streamline wire must be held as close as possible to the threaded portion and the whole wire turned bodily, without twisting it, if possible. The tool shown at F, fig. 101, is useful for this purpose, but does not form a part of the riggers standard tool kit. The tools shown at B and E, fig. 101, are additional types of wire holders which can be made up if desired. The ordinary adjustable spanner can, of course, also be used for the same purpose. Pliers of any sort should not be used to hold wires or to tighten nuts.

Telescopic Trammels.

447. A form of trammel which is especially useful in measuring or checking the distance between two points which are so placed as to make the use of one of the ordinary beam type difficult, may be easily made from materials to be found in any workshop. A length of tube of about $\frac{1}{4}$ or $\frac{3}{8}$ in. inside diameter has a pointed piece of rod inserted at one end, where it is brazed or soldered into the tube. A length of rod, of a diameter which allows it to slide freely within the tube, is then inserted at the open end and pushed home until

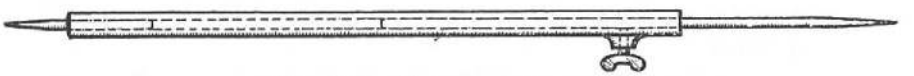

FIG. 102.—Telescopic trammel.

it meets the end of the fixed piece. The long piece is then cut to length with about 1 in. projecting beyond the end of the tube, this end being ground to a point similar to that of the fixed end. A pinching screw passing through the wall of the tube is used to secure the adjustable portion of the trammel when the points are at the required distance apart. The screwed hole to take this may be tapped directly into the wall of the tube, if this is thick enough, or it may be necessary to braze on a small boss to take the screw. Fig. 102 shows a typical trammel of this type.

Loop splicing of steel cables.

448. It is occasionally necessary to splice flexible steel cables, and the usual method adopted is shown in fig. 103. As will be seen by reference to the illustration, the cable is first served with waxed thread in two positions to prevent unnecessary unwinding of the cable. The cable is then bent in the form of a loop, and if a thimble is to be used it is then placed in position. Strands of the cable are next loosened by twisting and using a marline spike, and the separated strands at the end are tucked under and over the loosened strands of the cable in the order and manner shown. When sufficient tucks have been made, the splice is pulled strongly and lightly beaten with a wooden mallet into a regular formation. The ends of the separate strands are then cut off flush with the cable and the cable in this neighbourhood is whipped with waxed thread.

449. When a splice is made round a thimble, care must be taken to see that the loop grips the thimble tightly. This is achieved mainly by pulling strongly on the first tucks; a temporary whipping is sometimes of assistance.

Knots.

450. Fig. 104 gives a selection of useful knots. The purpose for which each is used is mentioned below :—

(i) *Thumb and figure of eight.*—To make a stop on a rope, to prevent the end from fraying, or to prevent the rope slipping through a block.

(ii) *Reef.*—To join two ropes of the same size together.

(iii) *Single sheet bend.*—To join two ropes of different sizes together.

(iv) *Bowline.*—To form a non-slipping loop at the end of a rope, or to secure the end of a rope to the hook on a block.

(v) *Bowline on a bight.*—To form a non-slipping loop in the middle of a rope, using a double of the rope.

(vi) *Hawser bend.*—To join two large cables together, of similar or different sizes.

(vii) *Clove hitch, timber hitch, and two half-hitches.*—To secure the end of a rope to a spar.

(viii) *Running bowline.*—To form a running noose at the end of a rope.

(ix) *Man harness hitch.*—To form a loop on a drag rope. The loop should be large enough to pass over a man's shoulder.

(x) *Catspaw.*—To secure the middle of a rope to the hook on a block.

Cleaning of metal fittings.

451. Great care must be taken when cleaning metal fittings, as in many instances the material has been specially prepared to prevent corrosion (*see* Air Ministry Technical Order 301 of 1929). As already described in paras. 419 and 420, steels are protected by zinc and cadmium, and light alloys by the anodic or the chromate immersion treatments. Whichever treatment is adopted, the adherent film is exceedingly thin and can consequently easily be destroyed by mishandling. It is sometimes difficult to identify these treatments, especially that of the anodic process, since in many cases there is little difference in appearance before and after treatment.

452. When metal fittings require cleaning, all forms of scraping, such as rubbing with emery cloth or a wire brush, should be avoided. A paraffin bath and a soft brush or rag soaked in paraffin should be all that is required.

453. When removing paint or varnish, no abrasive methods should be employed, but the covering material

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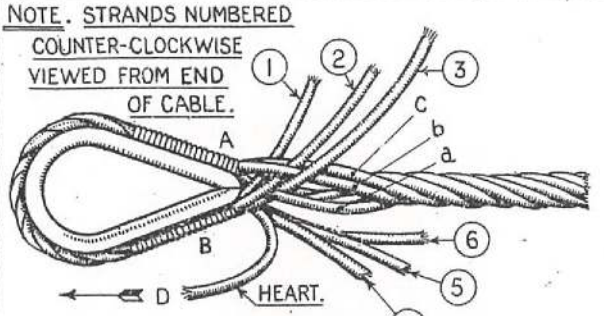
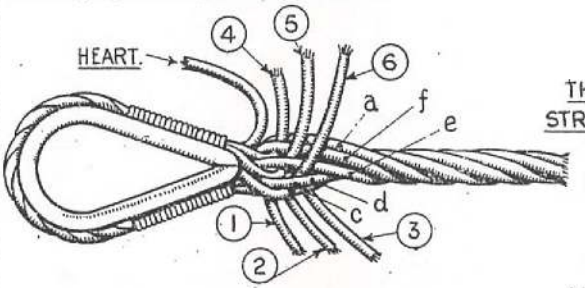
NOTE. STRANDS NUMBERED COUNTER-CLOCKWISE VIEWED FROM END OF CABLE.



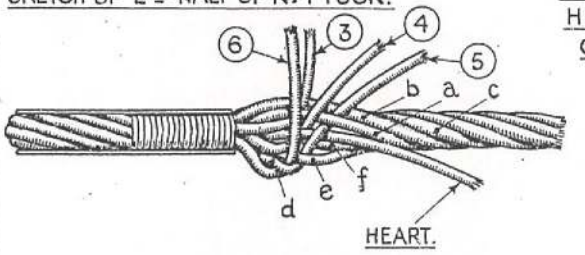
SKETCH OF 1ST HALF OF Nº1 TUCK.

CABLE SERVED AT A AND B WITH WAXED THREAD. CABLE BENT ROUND THIMBLE HEART TURNED BACK IN DIRECTION OF ARROW "D" Nº 3 STRAND THREADED UNDER "a". Nº 1 STRAND THREADED UNDER "b" AND "C". Nº 2 STRAND THREADED UNDER "b".



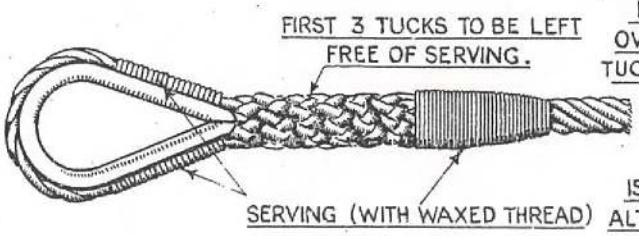
SKETCH OF 2ND HALF OF Nº 1 TUCK.

Nº 4 STRAND THREADED UNDER "f". Nº 5 STRAND THREADED UNDER "e". Nº 6 STRAND THREADED UNDER "d". ONE TUCK IS COMPLETED WHEN EACH STRAND HAS BEEN THREADED ONCE.



SKETCH OF COMMENCEMENT OF 2ND TUCK SHOWING HEART TUCKED IN.

IN THE 2ND, 3RD, 4TH AND THE HALF TUCKS, THE HEART IS LAID ALONG THE CABLE AND TAKEN UNDER A SUITABLE STRAND (IN ILLUSTRATION, Nº 5 STRAND) THUS FORCING THE HEART INTO THE CENTRE OF THE SPLICE. IN THE 2ND, 3RD AND 4TH TUCKS THE STRANDS 1, 2, 3 4, 5 AND 6 ARE TAKEN UNDER AND OVER ONE STRAND (a, b, c, d, e, f) e.g. Nº 3 STRAND IS TAKEN OVER "b" UNDER "C" IN 2ND TUCK. OVER "d" UNDER "e" IN 3RD TUCK. OVER "f" UNDER "a" IN 4TH TUCK. HALF A TUCK IS MADE BY THREADING ALTERNATE STRANDS ONCE. A COMPLETE SPLICE CONSISTS OF 4½ TUCKS. ON COMPLETION OF SPLICING LOOSE ENDS CUT OFF FLUSH AND SERVED.



SKETCH SHOWING COMPLETE SPLICE.

FIG. 103. METHOD OF LOOP SPLICING FLEXIBLE STEEL CABLES.

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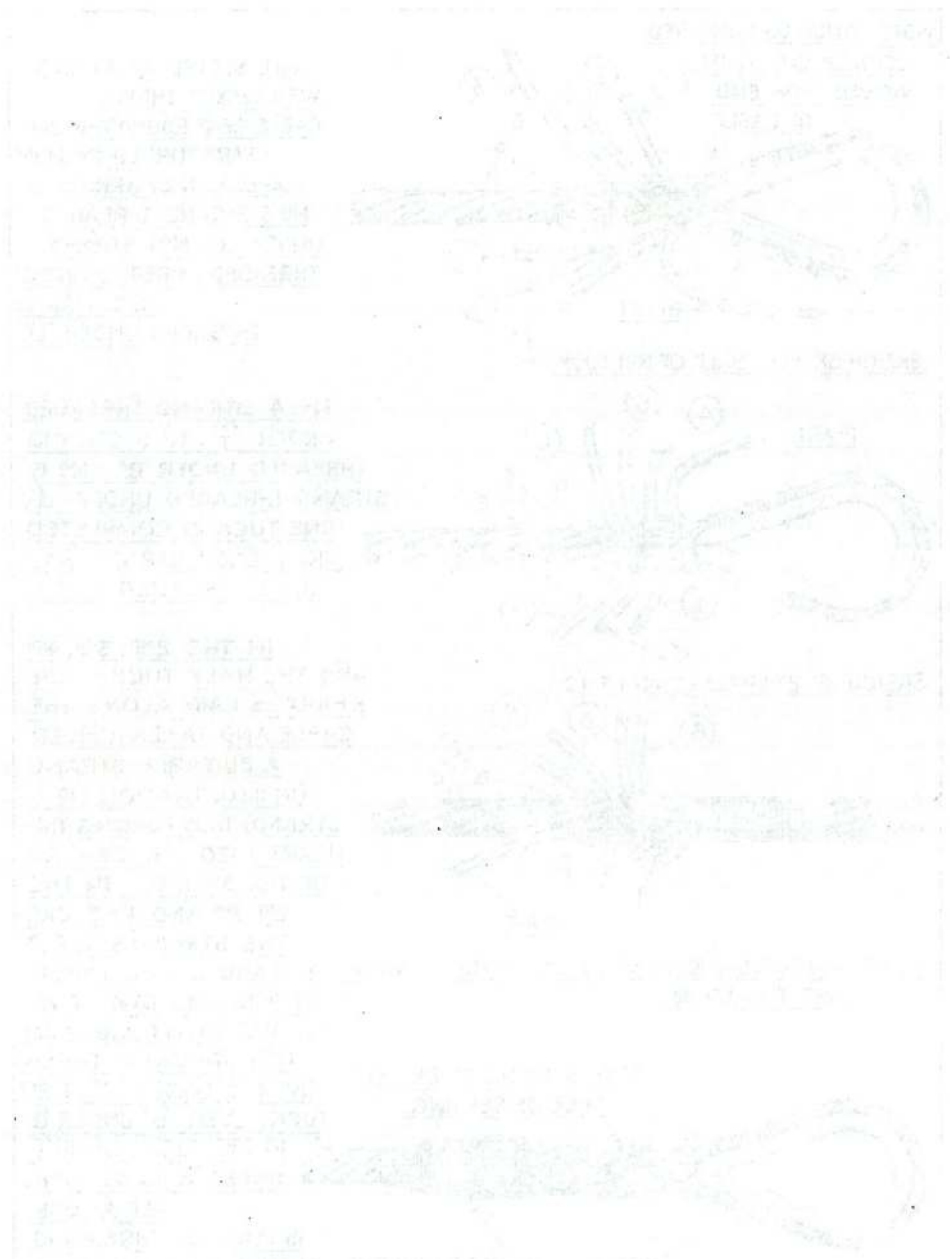


THUMB.

FIGURE OF 8.

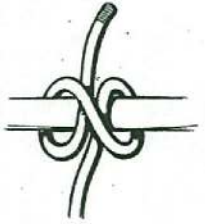
REEF.

SINGLE SHEET BEND.

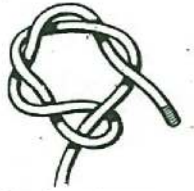
BOWLINE.

BOWLINE ON A BIGHT.

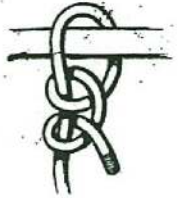
HAWSER BEND.



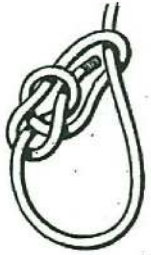
CLOVE HITCH.



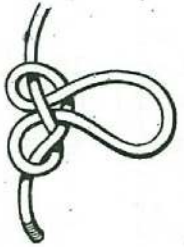
TIMBER HITCH.



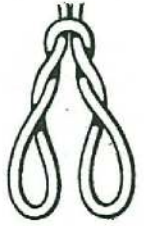
TWO HALF HITCHES.



RUNNING BOWLINE.



MAN HARNESS HITCH.



CATSPAW.

FIG. 104. KNOTS.

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should be softened with the varnish remover (N.S.40) Stores Ref. 11/40, and rubbed with a rag soaked in this solvent. Stove-enamelled fittings are not usually treated with zinc or cadmium, and therefore the normal methods of removing stove enamel may be employed. After removal of the defective paint or varnish, all fittings should be re-coated with the appropriate protective covering, with the exception of the side and bottom fuselage cowlings and the metal parts of undercarriages and radiators. These parts, if desired, need not be re-painted, but may be kept clean and bright by using metal polish or an oil-soaked rag.

Inspection doors in planes.

454. Metal inspection doors in main planes should be very closely watched, especially if situated in the slipstream region, as fastenings which would normally be regarded as quite secure may possibly become detached through vibration and the effects of the slipstream. Should this occur the inspection door may fly back with considerable force, involving a possible injury to the pilot or the fouling of control cables.

Rip-off patches on planes.

455. Inspection doors are usually provided only at those positions where frequent inspection or lubrication of the internal fittings is required. Where only occasional inspection or adjustment is required for internal fittings, such as bracing wires, a special form of patch is used which is capable of being torn off and renewed as necessity demands. There are several types and shapes of patches, but in all cases a light frame is secured to the fabric covering of the wing and the fabric enclosed by the frame cut away, thus providing a hole with a non-frayable edge. A covering patch of frayed fabric large enough to envelop the frame is then doped on to the plane over the hole as indicated at C, fig. 105. When it is necessary to place a rip-off patch on a plane, the frames should preferably be of the circular type with an internal diameter of 4½ in. to 5 in., but other shapes can be adopted to suit special conditions. Fig. 105 shows two types of frames, the type employing the aluminium frame being perhaps the better one.

456. Aluminium frames should not be made from less than 24 S.W.G. material, and celluloid frames should have the edges slightly chamfered, and should not be thinner than 1·5 mm. As indicated at A, fig. 105, the aluminium frames are first mounted on a sheet of frayed fabric, and attached thereto by means of the fabric tongues formed by radial cuts from the centre of the patch. The tongues are folded outwards

over the frame and doped down. The frayed fabric and the frame are then doped on to the plane. Celluloid frames are doped directly to the plane covering, as indicated at B, fig. 105, the dope being applied to both the frame and the fabric. Care must be taken to ensure that all air is excluded from between the doped surfaces. After the frames have been fixed in position, the fabric within the frame should be cut away with a sharp knife.

457. To remove a patch, knife-cuts are made across the opening as shown at C, fig. 105, and the patch ripped off in sections from the centre outwards.

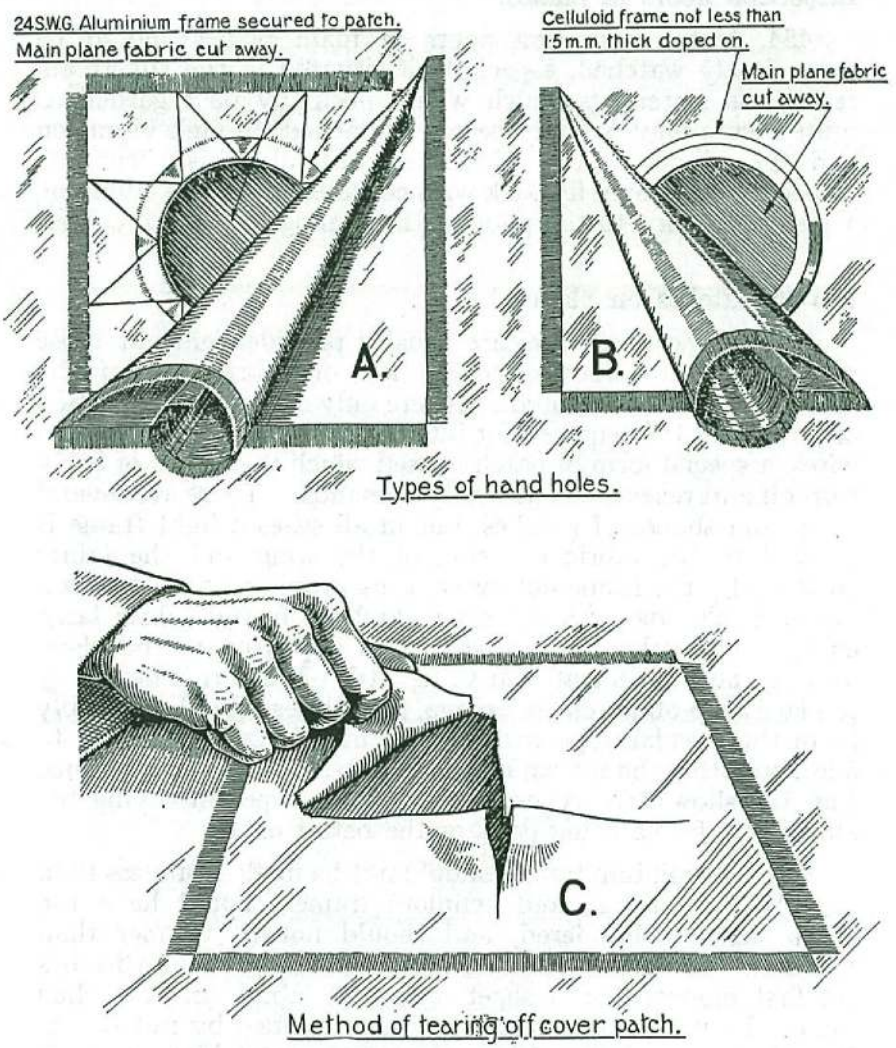

FIG. 105.—Rip-off patches on planes.

Detachable fairings.

458. When the flush-fitting type of cowling clip is used, special precautions must be taken to ensure that the clips are actually securing the fairing to the structure, as the fairing is in a dangerous condition if one of the clips does not catch as it should. It is usual to arrange for the screwdriver slots or other operating mechanism to be all in one direction so that the position of the catch can be ascertained at a glance. If this has not been arranged, suitable marks should be made on the clip, the marks being all in one direction when they are attached.

Renewing control cables.

459. Special arrangements are usually made for the renewal of all cables, but where this is not so, it is a good plan to tie a cord to the end of the cable to be withdrawn, and pull the cord over the pulleys and through the fairleads, etc., as the old cable is removed. Before the old cable is taken away, tie the two ends of the cord to any convenient fitting. The cord enables the new wire to be drawn into position without the difficulty of threading it through fairleads or over pulleys.

Lubrication.

460. The lubrication system of an aircraft should receive careful study by the rigger and the special instructions which are issued with the maintenance notes must be closely followed, but some general guidance on the matter is given below.

461. As a rule, manufacturers provide adequate means for lubrication, usually by the provision wherever necessary, of grease gun nipples. Every care must be taken to ensure that the lubricant used is actually reaching the surfaces in contact, even if this involves a small amount of dismantling and re-assembling. Normally, all flying controls are lubricated with anti-freeezing oil, Stores Ref. 34A/46 and 43, and all other parts with heavy steam cylinder oil, Stores Ref. 34A/47 and 18. Grease is not supplied to R.A.F. units as a lubricant for any aircraft part, because it tends to solidify when subject to very low temperatures such as those encountered at high altitudes. A mixture of grease and steam cylinder oil is, however, a suitable lubricant for the hubs of aircraft landing wheels. " Little and often " is a good general maxim in all questions of lubrication.

Care of shock-absorbers.

462. The shock-absorber legs on the undercarriage of any aeroplane should be of equal length under any given load, and, where this is not the case, an examination should be made to

ascertain the cause of the unequal extension. Gauge marks are normally provided to indicate the approximate safe minimum length.

463. As described in paras. 201 to 204, modern shock-absorbers consist of rubber in compression, oil or air dashpot oleos or a combination of both. Steel springs are also used at times, but they are not a common type of fitting.

464. Rubber shock-absorbers should be kept scrupulously free from oil or grease, because in the first place rubber rapidly deteriorates with any contact with oil, and, secondly, the correct shock-absorption is not obtained if the rubber is so lubricated. The only form of lubricants which can be successfully used in conjunction with rubber are powdered french chalk or graphite. All shock-absorber rubbers should be totally enclosed so as to exclude the light, especially in tropical countries, and if a covering has not been provided it is advisable to fit some form of stocking for this purpose.

465. Compression rubbers should not be screwed up to such an extent as to give excessive initial compression, as this increases the shock loads on the aircraft and also because the rubber will in time have a permanent set if placed under a steady heavy load (see Air Ministry Technical Order 49 of 1929). For this reason, aeroplanes with rubber shock-absorbers which are being stored for any length of time should be jacked up to take the weight off the rubbers.

466. Oil or air oleos should be frequently examined and re-filled with oil or air, as directed in the maintenance notes of the type.

Inflation of tyres.

467. Aircraft tyres should be inflated to a pressure of 60 lb. to 75 lb. a sq. in., depending on the size. The inflation pressure, which is sometimes marked on the outside of the cover, is tested by using a standard tyre-pressure gauge.

468. In tropical climates, care must be taken not to inflate to an excessive pressure, as the sun temperature will expand the air in the tyres and may burst the cover.

469. The standard two-stroke gas starter for aero engines can be very effectively employed for inflating tyres of aircraft. A gas starter, mounted on a four-wheel truck for aerodrome use, has been used, and the only change found necessary is the fitting of an adaptor nozzle for the tyre valve, and a cock to turn off the petrol supply to the auxiliary carburettor. The adaptor is fitted directly to the end of the mixture supply pipe used for starting, and no modification to the latter is involved. The adaptor should be provided with a calibrated release valve to prevent over-inflation of tyres.

Aileron stop, temporary.

470. When erecting the planes or adjusting aileron controls, some means must be provided to hold the ailerons in line with the main planes. The device illustrated in fig. 106 is designed to hold the ailerons normal while the cables are being adjusted,

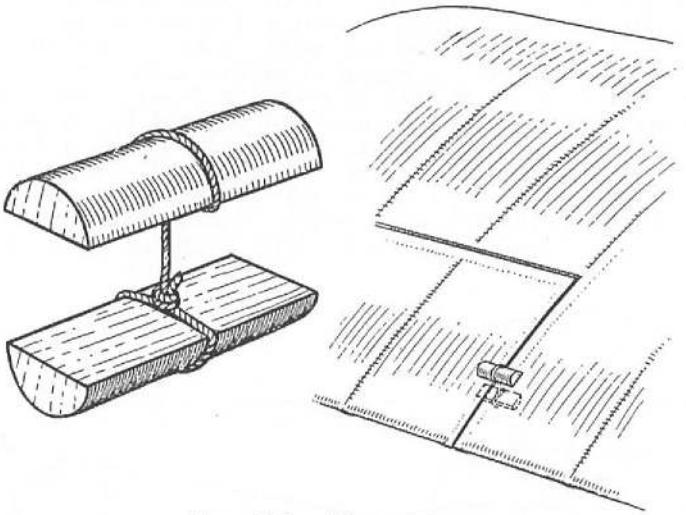

FIG. 106.—Aileron stop.

and is used by pushing the connecting cord in the crevice between aileron and plane, so that the two pieces of wood hold aileron and main plane in the same straight line. Similar devices for this purpose can be made up by the rigger as required.

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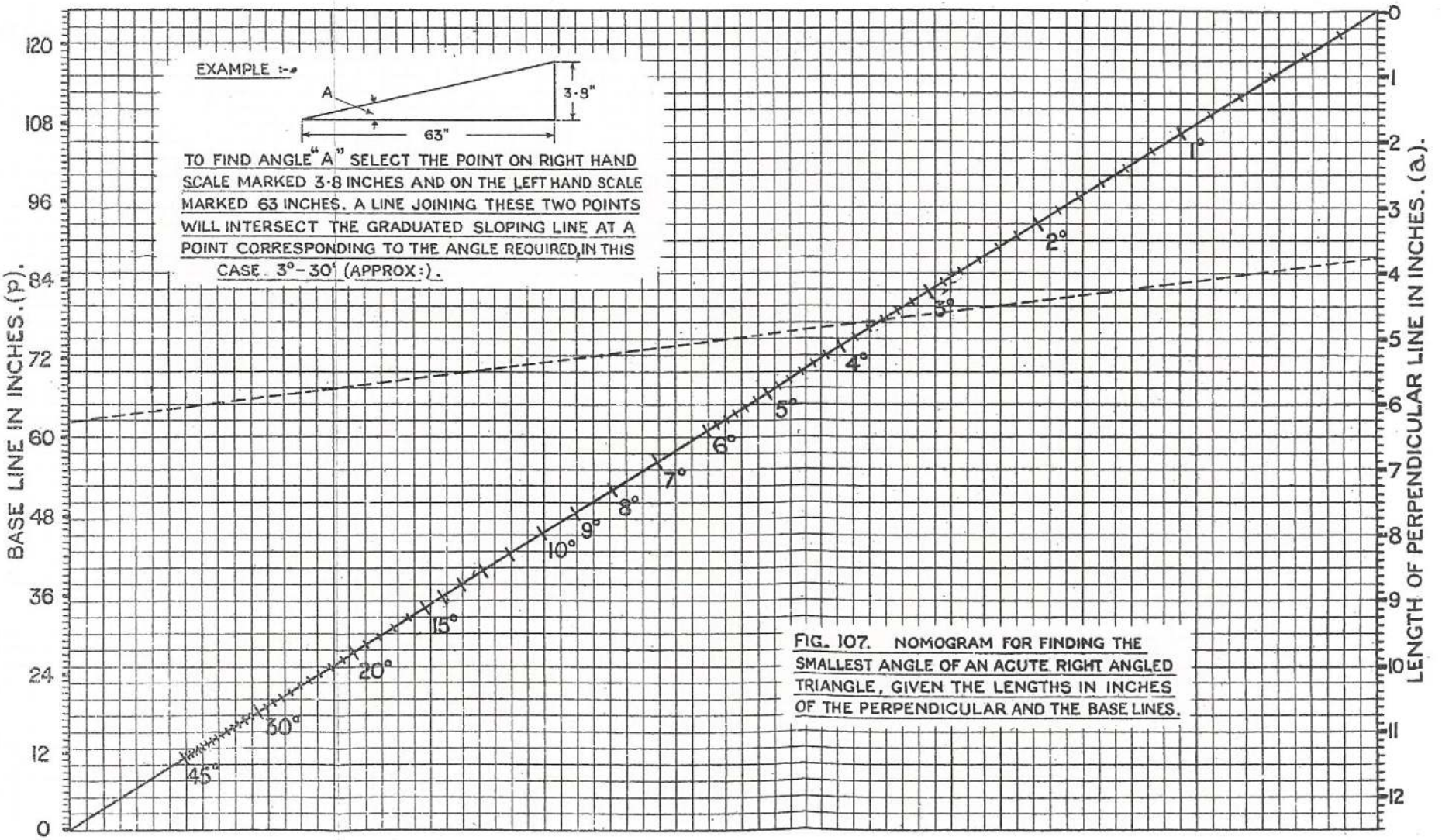

FIG. 107. NOMOGRAM FOR FINDING THE SMALLEST ANGLE OF AN ACUTE RIGHT ANGLED TRIANGLE, GIVEN THE LENGTHS IN INCHES OF THE PERPENDICULAR AND THE BASE LINES.

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