Chapter 27B

MAIN SHAFT ASSEMBLY, DETAIL INSPECTION

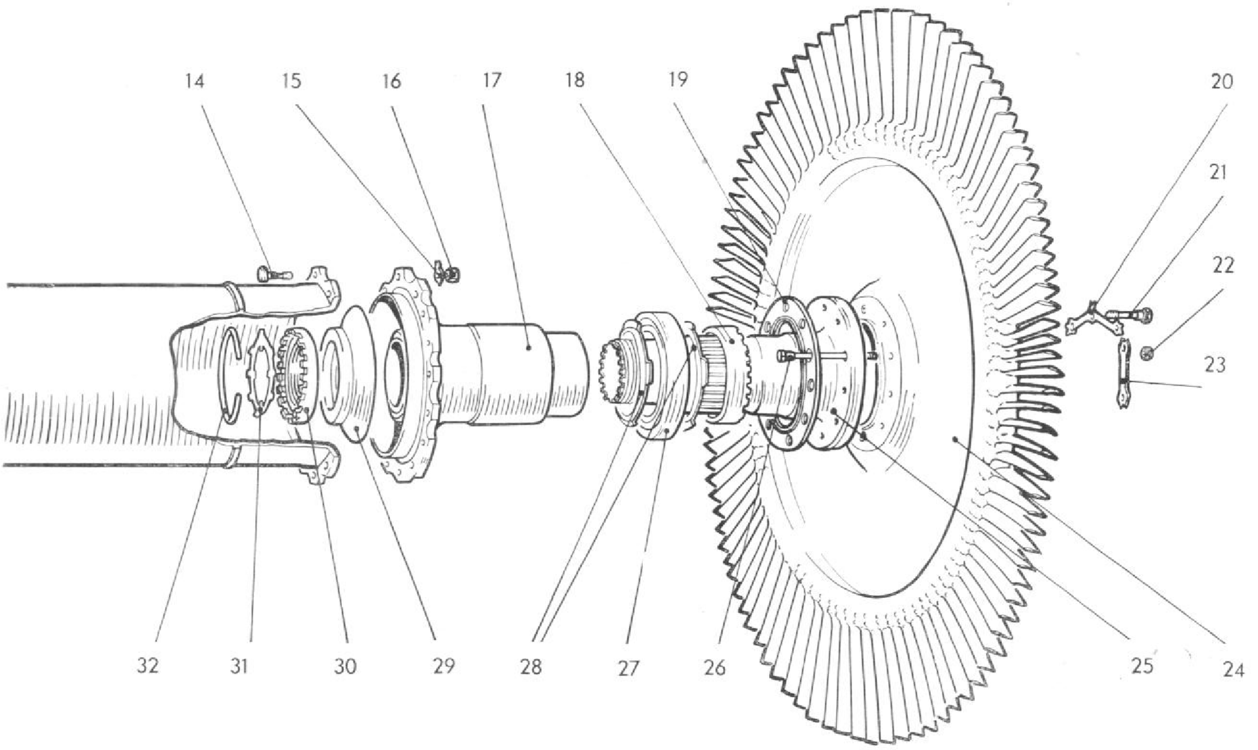


Fig. 1. Exploded view of main shaft assembly as fitted to Ghost 48 Mk. 1, and 48 Mk. 2. (In a 53 Mk. 1, a balancing ring is fitted to the rear face of the extension shaft flange.)

Contents

Illustrations

THIS CHAPTER, which is applicable to the Ghost 48 Mk. 1, 48 Mk. 2, and 53 Mk. 1, describes the inspection requirements applicable to the component parts of the main shaft assembly, Fig. 1. Where, in the text, the term "inspect for condition" occurs, it implies that the appropriate general viewing requirements described in chapter 27A must be carried out as part of the inspection requirements applicable to a particular component. Similarly, reference to a repair scheme (T.R.) implies that the operator must refer to that scheme, contained in chapters 28A to 28C, for the relevant information. Dimensional checks required on components, and assemblies, are detailed in the Table of Fits and Clearances, and, except when instructions are necessary in the method of measuring a dimension, or in the use of special tools or equipment, the checks are not specified in this chapter. The term "within the limits" implies that reference must be made to the Table.

ACCESSORY DRIVE SHAFT

Inspect the external, and internal serrations of the accessory drive shaft for wear and damage, particular attention being given to the condition of the copper deposit on the external serrations. The purpose of the copper deposit is to reduce fretting, and if bare steel is visible, the remainder of the deposit must be removed, and the external serrations replated. To check that the wear on the forty-eight external serrations is within the limits, use a 2 in. micrometer, and measure across twelve adjacent serrations, Fig. 2. Wear on the twenty-four internal serrations may be checked by the use of standard slip gauges, and feelers, between six adjacent serrations, Fig. 3. To obtain the maximum worn position, each of these operations should be repeated at several positions along the serrations, and over several groups of serrations around the circumference. Check that the backlash between the external and internal serrations is within the limits, by comparing the dimensions of their maximum worn positions.

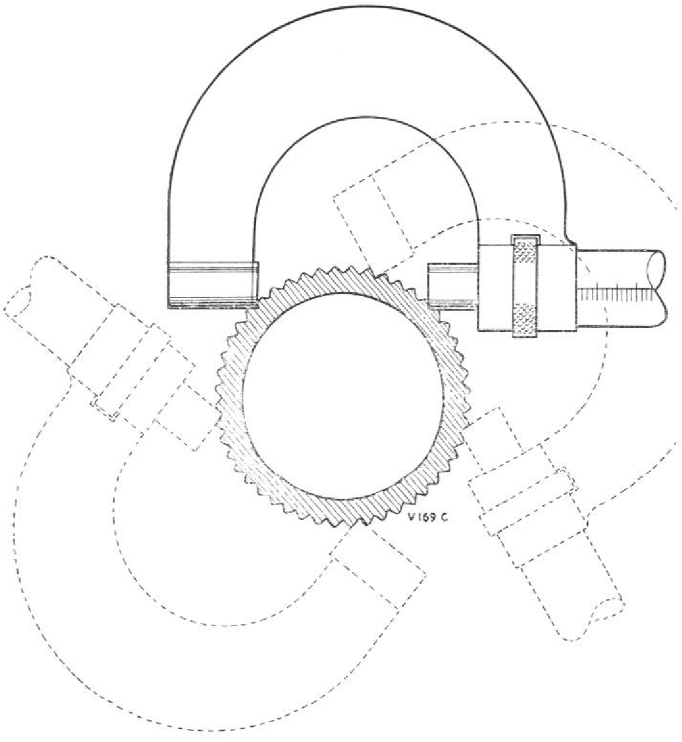


Fig. 2. Using a micrometer to check the external serrations of the accessory drive shaft.

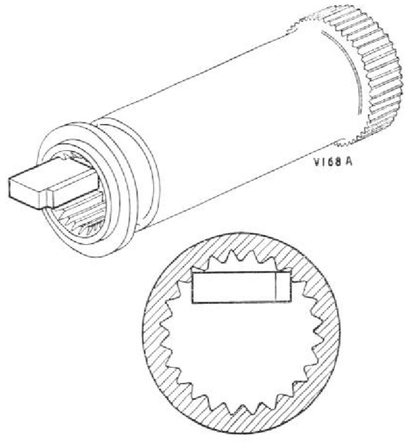


Fig. 3. Using slip gauges to check the internal serrations of the accessory drive shaft.

FRONT BEARING

Normally, the front bearing will be renewed at overhaul. If, however, the bearing is to be refitted, it must be cleaned, as described in chapter 25, and checked to ensure that its dimensions are within the limits. The end float should be checked on the ball-bearing end float checking fixture T.72851, as described in chapter 27A.

IMPELLER

At specified stages during reconditioning, it is essential that the impeller should be inspected carefully, to obviate further work being carried out on an impeller which may be damaged beyond the limits of acceptance. If cracks are found during any of these inspections, the impeller must be rejected. Similarly, any areas of corrosion, or damage, which cannot be blended within the limits specified in the relevant repair scheme (T.R.357), are not acceptable. The following paragraphs describe the stages at which these examinations should be applied, and give details of the relevant inspection requirements.

Following its separation from the main shaft, the impeller will have been kerosene washed, the pivot will have been removed, and it will have been subjected to the trichlorethylene vapour degreasing process. The impeller will then be mounted in cradle trolley T.76578, and will be received in the inspection bay. Use a magnifying glass to inspect the impeller for any obvious signs of cracks, or corrosion, and for impact marks, particularly at the leading edges, and the tips of the vanes. If the pivot studs, and the centre shaft studs have been removed, inspect the ten stud holes in the front (pivot) face, and the twelve stud and dowel holes in the rear (centre shaft) face of the impeller; the dowel holes must be free from scratches. Damage to any of these holes may be rectified as described in the relevant repair scheme (T.R.111, 133, 134, 253, or 254). Inspect the pivot bore for condition; damage may be rectified as described in the relevant repair scheme (T.R.222). Check the front face of the impeller for flatness, using blueing gauge T.74993, or, if an oversize pivot has been fitted, use the appropriate blueing gauge for the amount of oversize; high spots may be removed by hand scraping.

Provided that the impeller has passed the inspection requirements described in the previous paragraph, it will have been vapour blasted to remove the Rockhard lacquer, and will have been subjected to the Ardrox dye penetrant crack detection process, or a similar approved method. At this stage, further inspection should be carried out. Examine the impeller for cracks and flaws, which, as the result of the application of the Ardrox process, will be shown up as irregular red lines, or as a series of red dots, on a white background; if another method has been used, reference should be made to the appropriate instructions. Following this examination, thoroughly clean the impeller to remove all traces of the Ardrox developer, and, using the magnifying glass, inspect for any signs of corrosion which may have been revealed by the removal of the Rockhard lacquer. Look particularly for evidence of intercrystalline corrosion, which usually appears as microscopic pit marks, and the metal at these points is dull in colour, and tends to be of a loose, flaky nature. Defects of this type will necessitate the impeller being submitted to a laboratory for metallographic inspection.

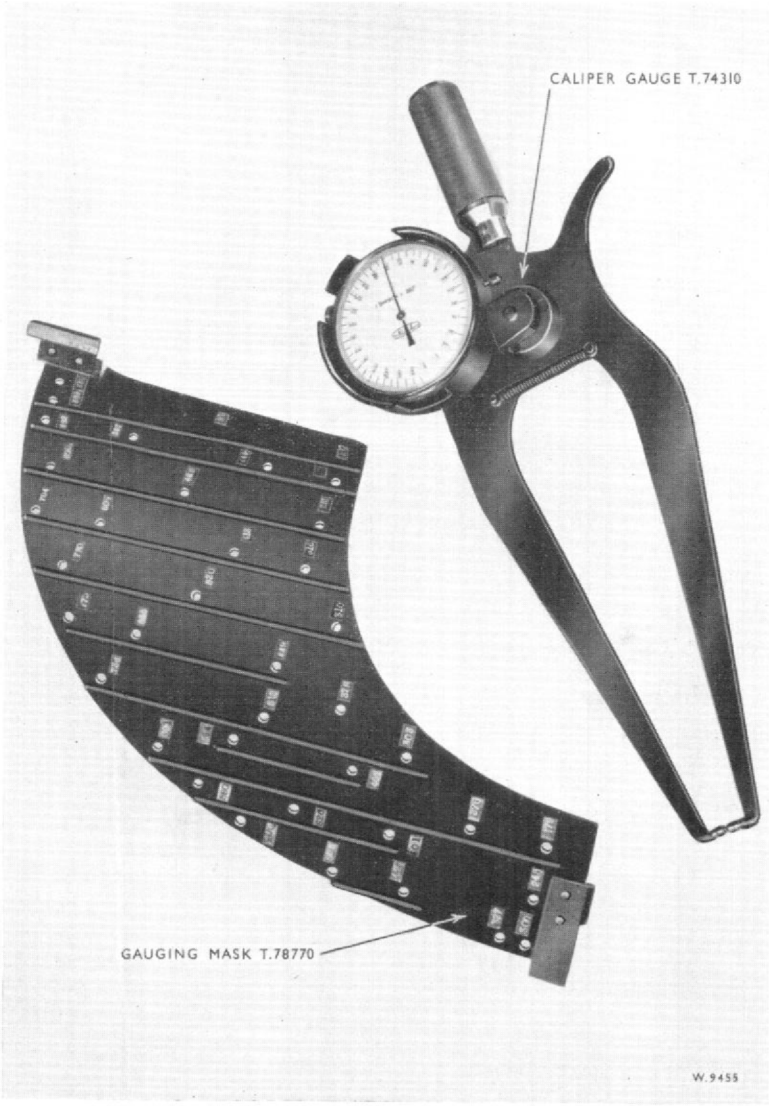


Fig. 4. Gauging mask T.78770, and caliper gauge T.74310 for checking thickness of impeller vanes.

If the impeller has passed the inspection requirements described in the previous paragraph, the trichlorethylene vapour degreasing process will have been applied again, scurfing and blending within the limits of the repair scheme (T.R.357) will have been carried out, and the impeller will have been coarse vapour blasted to remove the anodic film. At this stage, it is necessary to carry out a further inspection. This examination should be similar to that described in the previous paragraph, and, here again, particular attention should be given to any signs of corrosion which may have been exposed by the removal of the anodic film. Such corrosion, provided that it is not of an intercrystalline nature, may be removed by additional scurfing. At the conclusion of this inspection, or after additional scurfing, if this has been necessary, the impeller must be submitted to a dimensional check, and to a frequency check, as described in the following paragraphs.

Dimensional check of impeller vanes

The tools required for the dimensional check of the impeller vanes are the gauging mask, and the caliper gauge illustrated above (Fig. 4).

If, to remove corrosion or damage, it has been necessary to scurf a large area of a vane, so that its thickness in this area has been reduced below the bottom manufacturing limit, the general thickness of the vane must be thinned by a similar amount. Therefore, when all the necessary repair and reconditioning of the impeller has been completed, a dimensional check must be applied to each vane, to ensure that its thickness has not been reduced below the minimum permissible dimension. It is important to note that alterations made to the general thickness of a vane may influence its natural frequency, and a vane which has been thinned at all stations by a constant amount below the bottom limit, will result in that vane being of good proportions. Furthermore, in any radial section, vane thickness tapers from a maximum at the root to a minimum at the tip, and, here again, the principle of an equal amount of thinning results in a vane which will have the highest possible frequency. The inspector, therefore, should look for general thinning of the vanes, rather than for isolated areas of local thinning due to the blending of damage.

To carry out this check, proceed as follows:—

1. Use three-point lifting sling T.76768 to set the impeller, pivot face uppermost, on to a suitable bench.

2. Mark one vane, with chalk, as a datum, and place gauging mask T.78770 on this vane, so that the locating stops, one of which is fixed to each end of the mask, abut with the impeller hub, and with the root of the vane at the outer periphery of the impeller. Should the mask have a tendency to move, it may be held in position by wooden spring clothes pegs.

3. Using caliper gauge T.74310, as shown in Fig. 5, measure the thickness of the vane through each of the thirty-nine checking holes in the mask, and check each of these measurements against the limits for that particular location; ignoring any low readings which coincide with small areas of local blending within the limits given in T.R.357. The dimension marked adjacent to each of the checking holes is the nominal thickness, and, during overhaul, the impeller is acceptable provided that no reading is more than 0·040 inch below the marked nominal thickness.

4. Remove the mask, and, working in a clockwise direction, position it on the adjacent vane. Repeat the check described in operation 3.

5. Repeat operation 4 until each of the nineteen vanes has been checked.

In addition to the check described above, it will be necessary to carry out a dimensional check of the vane tips, except in instances where mod. 449 has been embodied. To carry out this check, proceed as follows:—

1. Commencing with the vane which was marked as a datum for the previous check, place gauging mask T.78771 on this vane, so that the two locating stops which are fixed to one edge of the mask abut with the delivery tip of the vane, and the third locating stop abuts with the leading edge of the vane.

2. Refer to the information contained in operation 3 of the previous paragraph, and using caliper gauge T.74310, measure the thickness of the vane tip

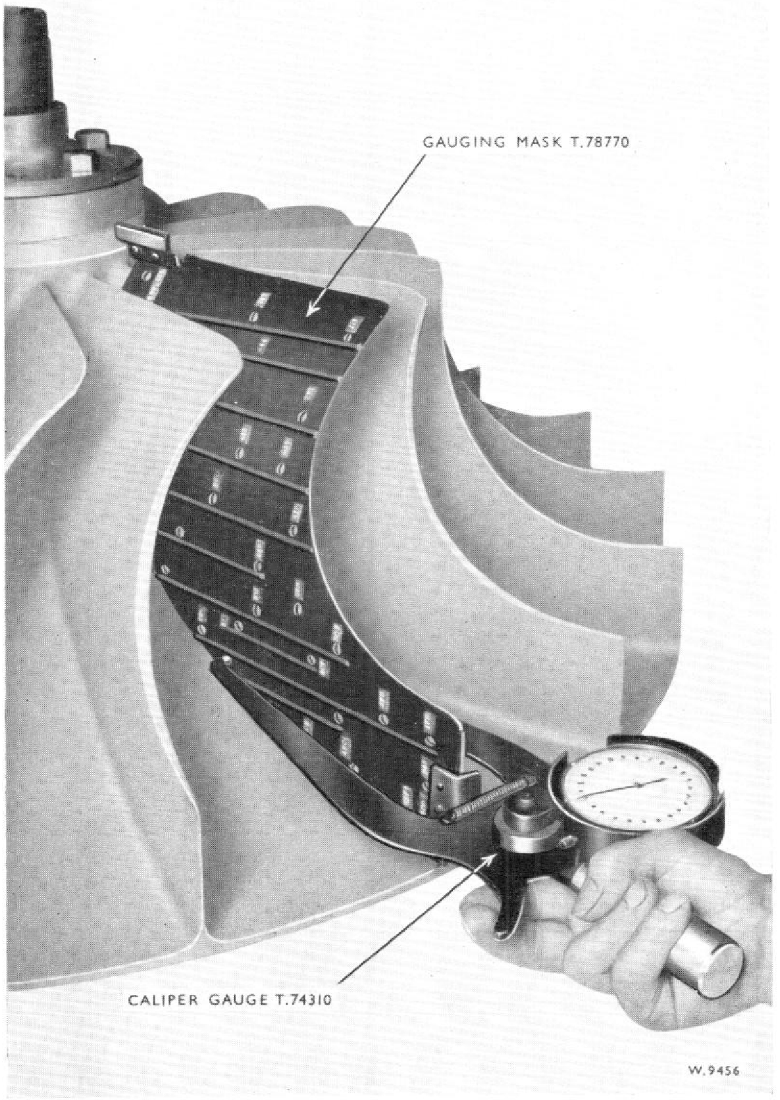


Fig. 5. Using caliper gauge T.74310 to measure the thickness of an impeller vane.

through each of the twelve checking holes in the mask.

3. Remove the mask, and, working in a clockwise direction, position it on the adjacent vane. Repeat the check described in operation 2.

4. Repeat operation 3 until each of the nineteen vane tips has been checked.

FREQUENCY CHECK OF IMPELLER VANES

The removal of metal from an impeller vane may alter the fundamental frequency of that vane, and, therefore, each of the vanes must be checked to ensure that its frequency has not been reduced below the permissible limit. The following table shows the various engine Marks together with the relevant minimum frequency which is acceptable.

Engine Mark	*Minimum frequency cycles per second*
48 Mk. 1, and 48 Mk. 2 (Pre-mod. 1272)	855
48 Mk. 1, and 48 Mk. 2 (Mod. 1272)	863
53 Mk. 1	863

Checking the fundamental frequency of impeller vanes requires considerable skill and experience, and should be carried out only by specially trained personnel. For the application of this check, two persons are necessary, one to operate the bow, and the other to manipulate the frequency checking apparatus. Briefly, the sequence of the check is as follows. A cello, or bass, bow is used to excite in turn each of the impeller vanes ; the vibrations set up, pass to a crystal pick-up ; the output from the pick-up is transmitted to the vertical plates of a cathode ray oscilloscope ; by reference to the display on the oscilloscope screen, an oscillator, which is connected to the horizontal plates of the oscilloscope, is tuned to the frequency of the impeller vane ; the frequency in cycles per second (c.p.s.) is shown on a counter. To facilitate excitation, the bow should be prepared by rubbing the hair on a block of resin, and this should be done before each impeller is checked ; the operator will find by experience if, and when, it will be necessary to repeat this operation during the check. The action of bowing a vane imposes a mass load on that vane, as long as the bow is in contact, and this tends to alter the frequency characteristics. Therefore, the setting of the oscillator should be adjusted during the "die-away" period of vane vibration, immediately after the bow has been removed ; this will eliminate any discrepancies which might appear in successive checks, due to different operators using varying bow pressures. It is important to ensure that there are no machines, or instruments, in the vicinity which could give out vibrations capable of upsetting the tests.

Equipment

The equipment necessary to enable frequency checks to be carried out is listed below.

1. A combined oscilloscope and oscillator unit such as the engine manufacturer's Type 1113. This consists of a single beam oscilloscope which has controls enabling focus, brilliance, X-axis shift, Y-axis shift, and attenuation of the image, to be adjusted ; an oscillator ; and a form of frequency counter.

2. A vibration pick-up, such as the G.E.C. SP.1000 Barium Titanate Accelerometer Type E Vibration Pick-up.

3. A cello, or bass, bow.

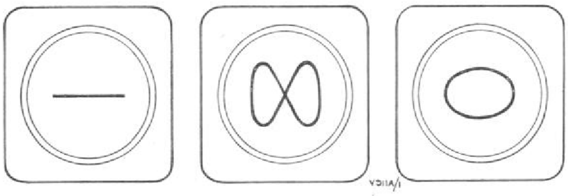
Checking the frequency

To carry out a frequency check of the impeller, proceed as follows:—

1. The impeller, with its rear face downwards, and mounted on four wooden blocks interspaced with rubber to prevent the transmission of vibrations, should be placed on a suitable rigid bench, or table. Ensure that the impeller is centrally supported, as this can affect the frequencies obtained, and if the centre shaft studs are in position, they must be kept clear of the table, so that the impeller does not rest on them.

2. Remove any burrs from the tips of the leading edges of the vanes, and number the vanes, with chalk, in numerical sequence ; the hub of the impeller is stamped, normally, to indicate the position of vanes 1, and 2. This will enable mistakes to be avoided when entering the frequency figures on the appropriate chart, or in instances when it may be necessary to re-check a particular vane.

3. Place the pick-up on the backplate of the impeller between two vanes. A film of plasticine smeared on the back of the pick-up will secure it in position, and will prevent chattering.



A IMAGE ON CATHODE RAY SCREEN BEFORE BOWING

B TYPICAL EXAMPLE OF PATTERN WHILST VANE IS VIBRATING

C IMAGE OBTAINED AFTER FINAL ADJUSTMENT (i.e. LISSAJOUS FIGURE)

Fig. 6. Patterns on cathode ray screen during frequency check.

4. Connect the pick-up leads to the apparatus, in accordance with the wiring diagram supplied.

5. By means of the controls, adjust the image on the cathode ray screen so that it forms a horizontal line about $1\frac{1}{2}$ in. in length, view A in Fig. 6.

6. Commencing with the vane numbered 1, and

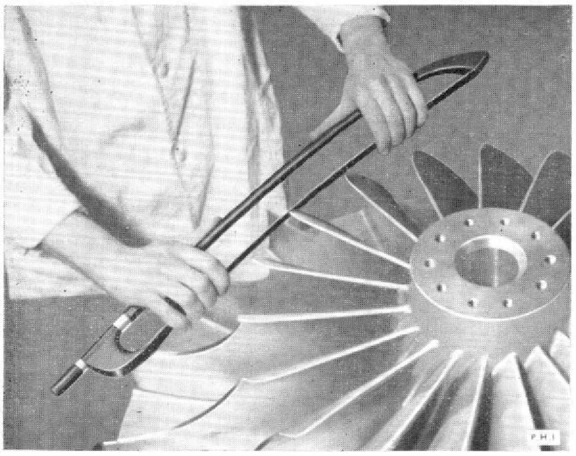


Fig. 7. Method of holding the bow.

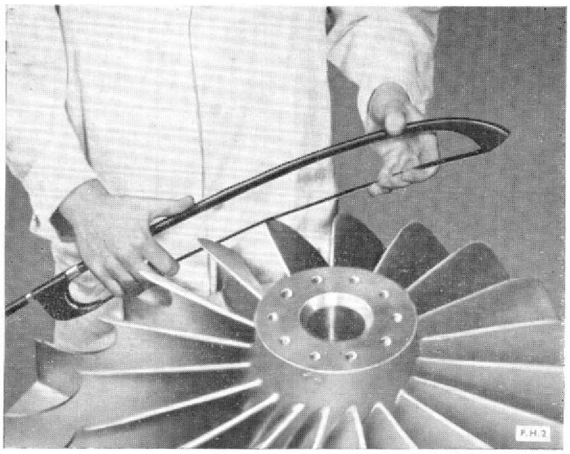


Fig. 8. Alternative method of holding the bow.

holding the bow at each end, draw the bow across the tip of the leading edge of the vane, as illustrated in Fig. 7, or 8. Either of these positions will produce a vibration in the fundamental mode. Remove the bow.

7. Whilst the vane is vibrating, a space pattern will appear on the screen, view B in Fig. 6. Should more than one frequency have been excited, a double, or complex pattern will appear on the screen, and, if this occurs, the excitation should be stopped, and the bowing operation repeated. Adjust the oscillator frequency until the pattern assumes the shape of a stationary ellipse, view C in Fig. 6; this pattern is known as a Lissajous figure, and its exact shape will depend on the relative output and phasing of the two vibrations. When this figure is obtained, the frequency of the oscillator output will be the same as that from the pick-up, i.e., the fundamental frequency of the vane, and an accurate measure of this frequency will be shown on the counter.

In this instance, the Lissajous figure is the stationary pattern obtained on the screen of the cathode ray tube. This pattern results when two alternating voltages, whose frequencies are related to each other by a simple integral ratio, are applied to the two pairs of deflector plates on the oscilloscope.

8. The reading shown on the counter will vary, normally, between 870 and 890 c.p.s., but, if a reading is obtained which is below the limit shown in the table, a further check of the vane must be made.

9. Select the remaining vanes in the numerical sequence in which they were marked, and apply operations 5 to 8 to each vane in turn.

10. An impeller, in which any vane has a fundamental frequency below the specified minimum, is not acceptable for further service, and must be returned to the engine manufacturer for investigation.

INSPECTION FOR CRACKS AFTER RE-ANODISING

The removal of the anodic film from the impeller creates a condition which is conducive to

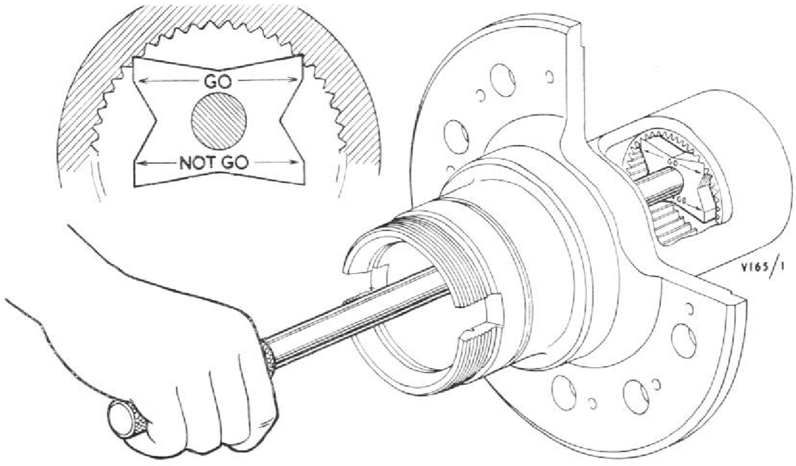


Fig. 9. Using GO and NOT GO gauge to check the internal serrations of the pivot.

intercrystalline corrosion. Therefore, immediately at the conclusion of the frequency check, the impeller must be cleaned by vapour blasting, using a fine grit, and re-anodised, as described in chapter 28A. After re-anodising, but before applying the protective Rockhard treatment, allow the impeller to stand for a period of not less than 24 hours, and then inspect for evidence of cracks. This inspection should be carried out in full daylight, or in artificial light of a bluish nature, and any cracks which may exist, will be revealed by the brown staining effect produced by chromic acid being trapped in those cracks. Immediately after this inspection, the impeller must be subjected to Rockhard treatment.

PIVOT

The pivot should be inspected for condition, and particular attention given to the serrations, and to the threads. It is important that the seal bearing diameter on the pivot should be protected from damage at all times, as blending of damage marks on the seal contact area is not permissible. Mod. 956 introduced hard chrome plating to this portion of the pivot, to improve resistance to wear. Check the impeller mating surfaces for flatness, using blueing ring T.74988, or, if the pivot is oversize, use the appropriate blueing ring ; high spots should be removed by hand scraping. Using a suitable GO and NOT GO gauge, check the serrations for wear, setting the gauge across twelve serrations, as shown in Fig. 9 ; check at several points along the serrations, and repeat the check over several groups of serrations, to locate the position of maximum wear. Where mod. 705 has been embodied, the front bearing location will be copper plated to obviate fretting, and this plating should be examined carefully.

CENTRE SHAFT

Examine the twelve dowel holes, and the threads of the three extractor holes in the front flange, and the sixteen bolt holes in the rear flange of the centre shaft. Any of the latter which are damaged may be repaired in accordance with the relevant repair scheme (T.R.221, 48 Mk. 1, and 48 Mk. 2 ; T.R.403, 53 Mk. 1). Examine the surface of the spigot bore in the front end of the shaft, and if any slight damage exists, this may be blended and polished. Use a 12 in. internal vernier gauge to check the spigot bore diameter, and ensure that it is within the limits. Slight damage marks on the exterior of the shaft may be blended out. Mount the shaft, front flange downwards, on fixture T.70438, and using indicator standard T.74448 in conjunction with a dial test indicator, as illustrated in Fig. 10, check the shaft for parallelism.

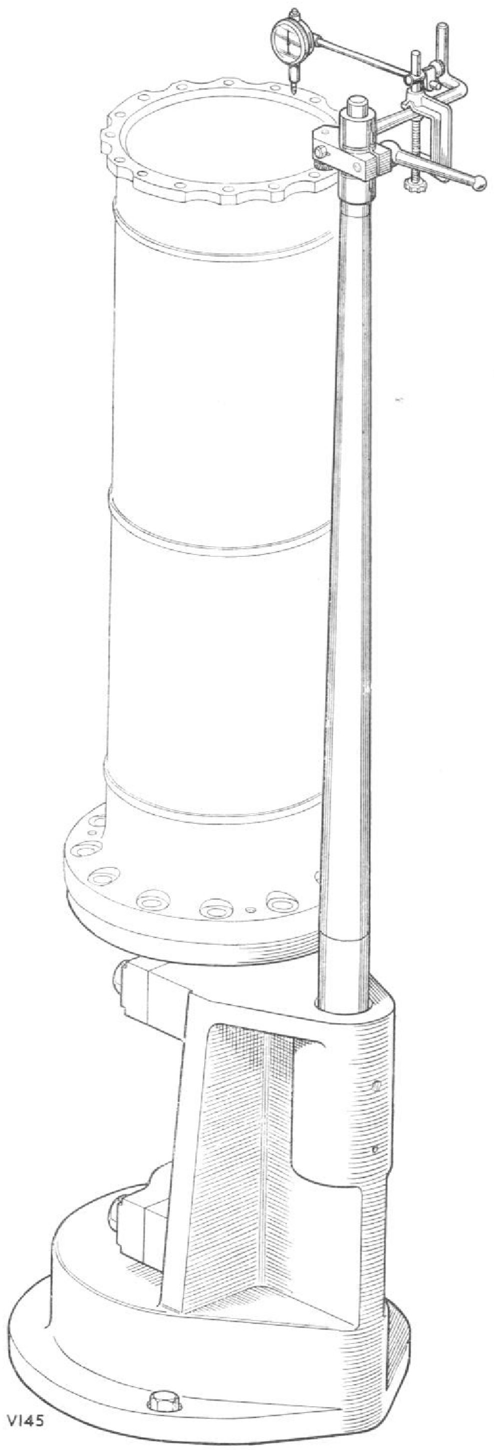


Fig. 10. Using fixture T.70438 to check the centre shaft for parallelism.

EXTENSION SHAFT

Examine the spigot, the internal serrations, the locating bush, and the roller bearing journal of the extension shaft for damage and corrosion. Ensure that the plug which secures the locating bush is secure, and that the twelve cooling air holes are free from corrosion and foreign matter. Inspect the sixteen bolt holes in the flange, and any that are damaged may be repaired as described in the repair scheme referred to in the previous paragraph.

HUB SHAFT

Examine the serrations, and the external threads of the hub shaft for condition. Inspect the turbine disc mounting face, and the eight bolt

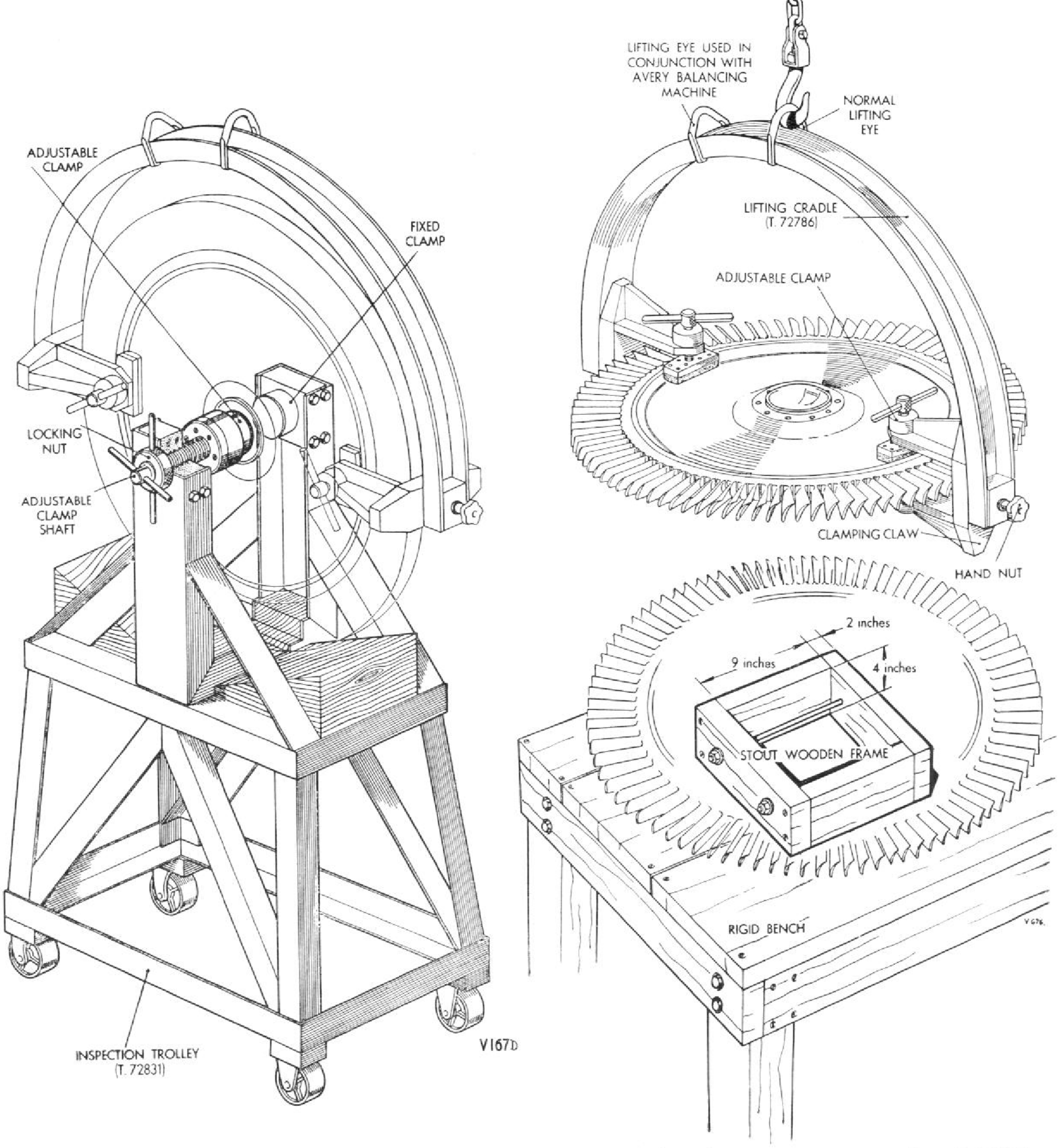


Fig. 11. Using lifting cradle T.72786 to transfer the turbine disc from inspection trolley T.72831 to a horizontal stand.

holes for corrosion, and scratches; small defects may be lightly stoned and blended. Inspect the two threaded holes in the disc mounting face, and the sixteen slots in the end of the shaft, for condition.

REAR BEARING

Normally, the rear bearing will be renewed at overhaul. If, however, the bearing is to be refitted, it must be cleaned as described in chapter 25, and its dimensions checked to ensure that they are within the limits.

TURBINE DISC AND BLADES

The turbine disc assembly should be received from the crack detection bay installed in inspection trolley T.72831, Fig. 11. If, however, the disc is received in a transport box, use lifting cradle T.72786 to remove the disc from the box. Rotate the disc, in the cradle, until it is in a vertical position, and install the disc in the trolley.

Inspect the turbine disc for condition, particular attention being given to the eight bolt holes, and the two eccentric nut holes; the finish in all holes must be free from scratches and damage. Damaged holes may be rectified in accordance with the instructions given in the relevant repair scheme (T.R.225, 252 or 266).

Inspect the turbine blades in accordance with the requirements of the relevant repair scheme (T.R.151). The instructions for the application of this repair contain a series of photographs showing examples of damaged turbine blades which can be rectified successfully, and those which are damaged beyond repair. By reference to these photographs, and to the limits specified in the instructions, it is possible to identify blades which can be repaired, or which must be removed and replaced by new blades. Use the magnifying glass to inspect each blade for notching, impact marks, and for any signs of cracks, particular attention being given to the trailing edge, and, in the case of a 48 Mk. 1 or 48 Mk. 2 engine, the peening of the fir-tree roots. Any blade which is cracked, or which is damaged within the area of the root fillet is not acceptable. Similarly, any blade which is damaged on the trailing edge must be rejected. In a 48 Mk. 1 or 48 Mk. 2 engine, loose blades which are to mod. 522 standard, but which are pre-mod. 731, can be accepted without rectification provided that the axial movement is less than 0·035 in.; where the axial movement is greater than this, those blades must be replaced by blades to mod. 731, or a later modification, standard. The axial movement of blades to mod. 731, or subsequent modification, standard must not exceed 0·015 in., but, if the axial movement is not greater than 0·020 in., hand peening, as described in chapter 28C, may be employed to reduce it to within the limits. Blades which are looser than the foregoing, or which are defective beyond the limits specified in the repair scheme, must be removed from the disc, and replaced by new blades.

Under no circumstances may a turbine blade be removed from the disc of a 48 Mk. 1 or 48 Mk. 2 engine in order to rectify damage; the removal of a blade automatically renders that blade unserviceable, since re-peening is not permissible. In the case of a 53 Mk. 1 engine, however, each blade is secured in position by a locking pin, and, therefore, any blade may be removed, repaired, and then refitted. To ensure that its interchangeability is unaffected, a 53 Mk. 1 bladed turbine disc to which any repair has been applied, must be balanced separately. It is important to note that the fitting of a new blade makes it necessary to dynamically balance the main shaft assembly. During overhaul, however, dynamic balancing of the main shaft assembly must be carried out as part of the reassembly procedure, and this operation is described in chapter 33A.

In addition to the examination described in the previous paragraphs, a check must be carried out to ascertain whether any growth has taken place in the radius of the bladed disc. Before this check can be made, it is necessary to know the radius of the bladed disc as recorded at initial manufacture, or at the previous reconditioning. Without this information, an assembly, which was accepted previously at the lower 'Dimension New' limit, could increase in radius by almost 0·004 in. and still be accepted, as it would be within the higher 'Dimension New' limit. If the engine was manufactured, or reconditioned, after August, 1953, the last measured radius will be recorded in the engine log book. In all other cases, the last measured radius must be obtained, through the inspection authority, by reference to the previous reconditioning, or to the manufacturer's build records. For a 48 Mk. 1, or 48 Mk. 2 engine, a dimension will be recorded for each of two specified blade positions, one of which will be the maximum, and the other the minimum, radius. In the case of a 53 Mk. 1 engine, the measured radius will be recorded for each blade position.

The interchangeability of 53 Mk. 1 bladed turbine discs makes it necessary to ensure that the serial number marked on the disc corresponds with that shown on the documents.

The equipment required for the application of this check consists of setting gauge T.72829, and checking gauge T.79527, Fig. 12. To check the radius of the bladed disc, proceed as follows:—

1. Use the lifting cradle to raise the disc out of the inspection trolley, rotate the disc into a horizontal position so that its front face is uppermost, and lower it on to a suitable stand, refer to Fig. 11.

2. The three support legs, which are situated at

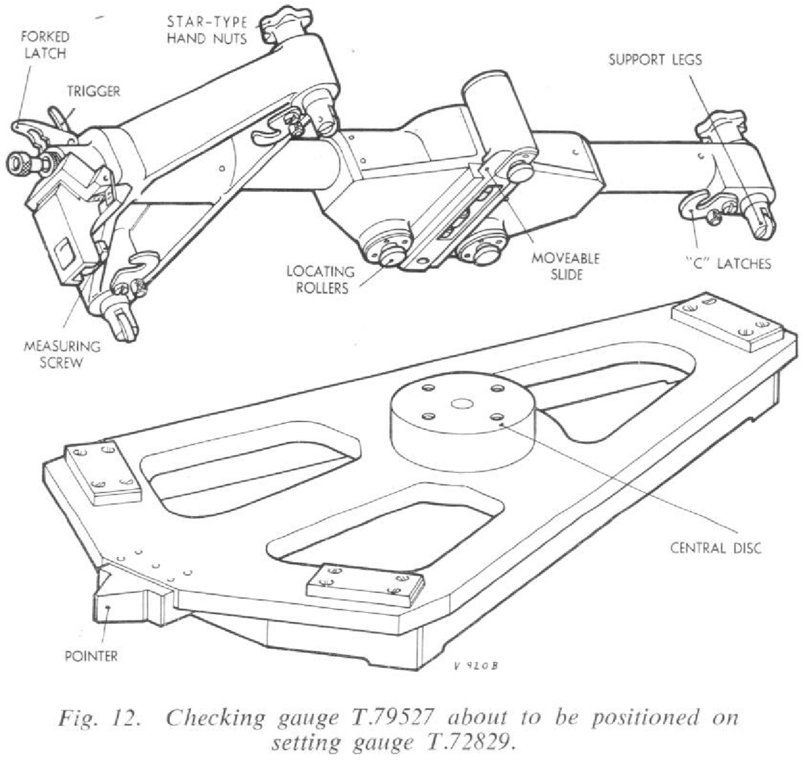


Fig. 12. Checking gauge T.79527 about to be positioned on setting gauge T.72829.

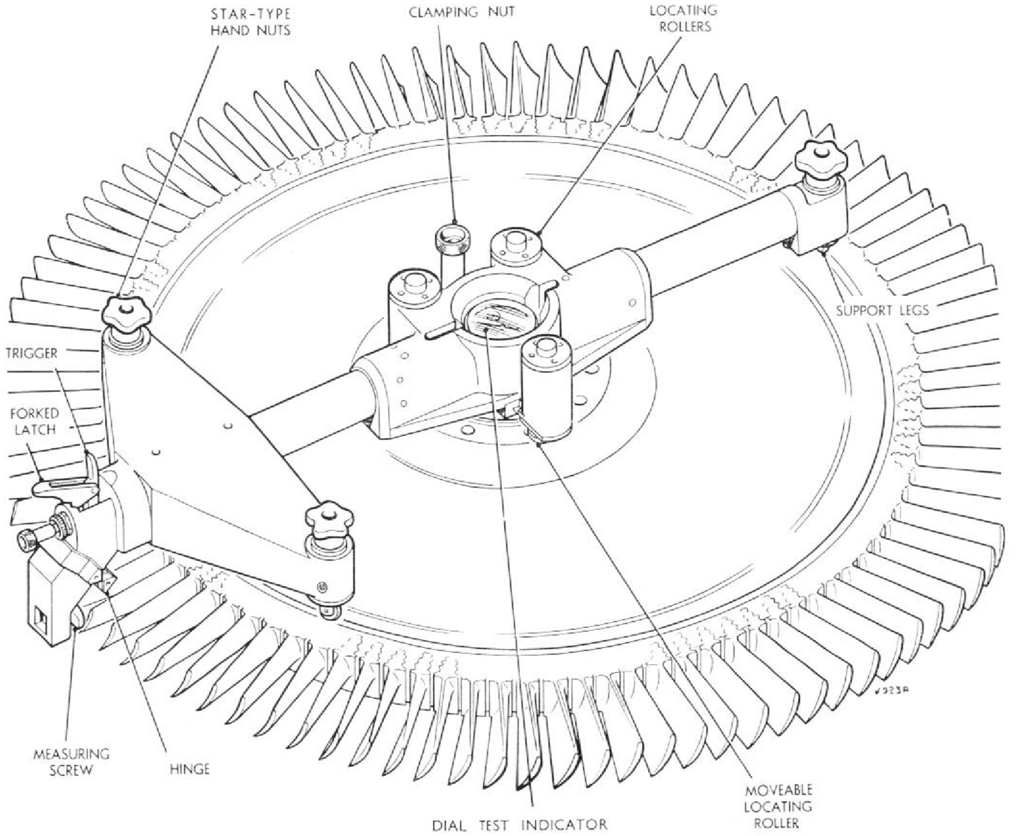


Fig. 13. Checking gauge T.79527 in position on the turbine disc.

the extremities of the checking gauge, should be raised to their shortest position by screwing the star-type hand nuts in a clockwise direction. Move the 'C' latches, one of which is fitted adjacent to each support leg, so that they are clear of the legs, and retain them in this position by tightening the knurled screws.

3. Press the upper end of the trigger towards the centre of the gauge, until the forked latch engages with the adjacent block. This engagement will hold the trigger in the inward position, so that, when the gauge is positioned, the measuring screw at the lower end of the trigger will be clear of the setting gauge pointer (or at a later stage, the turbine blades).

4. Release the clamping nut on the slide which carries the moveable locating roller. Move the slide and the roller outwards, against the spring loading, so that the three locating rollers are free to be passed over the central disc on the setting gauge (or at a later stage, the spigot of the turbine disc).

5. Position the checking gauge on the setting gauge, refer to Fig. 12.

6. Allow the slide carrying the moveable locating roller to move inwards until the three locating rollers locate on the central disc. Lightly tighten the clamping nut.

7. Gently raise the forked latch, and allow the trigger to move outwards until the measuring screw contacts the setting gauge pointer.

8. Set the dial test indicator, which is positioned at the centre of the checking gauge, to read zero.

9. Repeat operations 3, and 4, remove the checking gauge from the setting gauge, and transfer it to the turbine disc, Fig. 13.

10. Repeat operation 6, but locate on the turbine disc spigot.

11. Repeat operation 7, but position the gauge so that the measuring screw contacts No. 1 turbine blade. (The method of identifying No. 1 blade is described in chapter 17). Reference should be made to the Table of Fits and Clearances for the exact point of contact on the blade tip, and any necessary adjustment of the gauge can be made by regulating the height of the three support legs. The difference between the radius of the bladed turbine disc at this

position, and that of the setting gauge, will be indicated on the D.T.I. Record the D.T.I. reading.

12. Operate the trigger to bring the measuring screw clear of the blade, rotate the gauge until the trigger is opposite No. 2 blade, gently release the trigger, and record the D.T.I. reading.

13. Taking each blade in numerical sequence, repeat operation 12, until all the blades have been checked.

14. From the observed D.T.I. readings, and the setting radius, which is marked on the setting gauge, calculate the radius of the bladed disc at each position. Compare these dimensions with those recorded at initial manufacture, or at the preceding reconditioning. Provided that the difference between the measured radius and the previously recorded radius does not exceed 0·005 in. at any position, the component can be accepted for further service. If, however, the growth is greater than this dimension, the affected blade must be removed, and a new blade fitted.