CHAPTER 10 - COMPRESSOR AND FRONT BEARING HOUSING

Contents

Illustration

1. Introduction

A. If inspection through the air intake, as detailed in Vol.1, Part 2, Sect.3, Chap.1, reveals signs of damage to the compressor, the cause and extent of the damage must be ascertained to determine whether the engine is fit for further service or suitable for repair as described later in this chapter.

NOTE: The repairs described can only be effected where damage is the result of the passage of a foreign body and where the damage is confined to the front bearing housing assembly and the compressor blades. Engines exhibiting damage to other parts are not to be considered suitable for repair in accordance with these instructions.

B. If ingestion of foreign matter is suspected, it is essential that the compressor is inspected for damage and the ingested matter, e.g. ice, slush, water or bird, removed as soon as possible to prevent any debris being carried further back into the compressor.

C. Although it is possible to inspect rotor blades as far back as stage 4, it is only possible to completely assess damage to rotor blades up to stage 2 without removing the compressor top-half casing.

D. Removal of the top-half casing allows inspection and repair of the rotor blades and compressor top-half stator blades, an assessment of the damage to the stator blades in the lower-half casing may be made from the condition of the visible stages.

E. A list of special tools and equipment is given in Sect.1 Refer to the appropriate aircraft Air Publication for instructions on removing the e.c.u. from the aircraft.

2. Types of damage

A. Compressor damage varies according to the type of foreign matter ingested; the effects of three main types of foreign matter are considered in the following paragraphs.

B. Metallic damage

(1) Metallic objects which enter the compressor usually cause numerous tears and indentations on the rotor and stator blades; a careful examination for damaged blades should be made as far rearward as possible. Damage by metallic objects, e.g. nuts, setscrews or washers, is evidenced by thread impressions (fig.1) or regularly shaped marks or indentations. If such damage is observed, examine the air intake and front bearing housing for missing setscrews or similar items.

(2) Scoring on the walls of the front bearing housing and compressor casing may indicate ingestion of a heavy metallic body. Examine the turbine and exhaust unit for traces of aluminium which may indicate break-up of compressor blades.

C. Stone damage

(1) Stone damage is characterized by the marked difference between the damage on stage 1 rotor blades and that on subsequent stages. Usually, if stones are ingested by the compressor, they are shattered on the leading edges of the stage 1 rotor blades, and damage beyond this stage is not sufficient to cause concern. In addition to the obvious damage difference between the blade stages, the ingestion of shattered stone and grit causes erosion of the concave surface of the blades.

(2) If damage was caused by stones alone, engine serviceability should be assessed on the extent of damage to the stage 1 rotor blades.

D. Ice, slush, water or bird damage

(1) Ingestion of ice, slush, water or birds may result in damage to the trailing edges of the intake guide vanes and the leading tips of the Stage 1 rotor blades. On entering the compressor, foreign matter of this type may bend stage 1 rotor blades backwards against the direction of rotation and axially forward, contacting the trailing edges of the intake guide vanes. This action will turn over the edges of the intake guide vanes and leave a damage mark on the leading edge of the affected rotor blade.

(2) In severe cases, a blade may be bent backwards until it fouls the tip of the following blade, and will inevitably foul the intake guide vanes when they are in the minimum incidence position.

3. Inspection

A. If it is suspected that an engine has sustained compressor damage, or where incidents which could cause compressor damage are reported, inspect the engine as follows:

(1) Examine the intake guide vanes for damage.

(2) Using a strong spotlight, examine the rotor and stator blades for distortion, damage and cracks, looking as far back into the compressor as possible.

(3) Examine the inner walls of the front bearing housing and compressor casing for damage.

(4) Check the exhaust unit and turbine blades for traces of aluminium which may indicate compressor blade failure.

(5) Examine the compressor air bleed valves for evidence of foreign matter.

(6) Check that the engine run-down time after the last flight or ground run was comparable with that after previous flights or ground runs.

(7) Rotate the compressor rotor slowly, by hand, and check that fouling does not occur between the rotor and stator blade assemblies.

B. Functional check after ice, slush, or water ingestion

(1) If it is known that ice, slush or water has been ingested, but inspection (sub para.A) reveals no damage proceed as follows:

CAUTION: IT IS ESSENTIAL THAT THE INSPECTION DETAILED IN SUB PARA.A IS COMPLETED AND REVEALS NO DAMAGE BEFORE COMMENCING THE FUNCTIONAL CHECK.

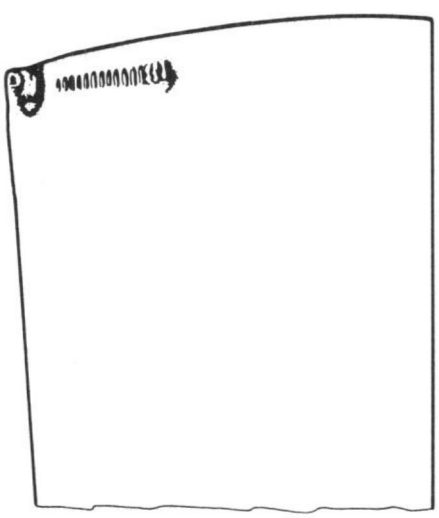
(2) Motor the engine as described in Vol.1, Part 2, Sect.2, Chap.2, and, during the run-down, listen for any abnormal noise which may indicate engine internal damage. When the engine has stopped rotating, turn the compressor rotor by hand not less than two complete revolutions and check for freedom of rotation and any indication of internal damage.

(3) Manually operate the intake guide vanes and examine the compressor for damage and evidence of foreign matter, whilst slowly rotating the compressor by hand. If damage is not evident, start the engine (Vol.1, Part 2, Sect.1, Chap.2) and allow the engine to stabilize at the ground idling condition; stop the engine and check that the run-down time is comparable with that after previous flights or ground runs.

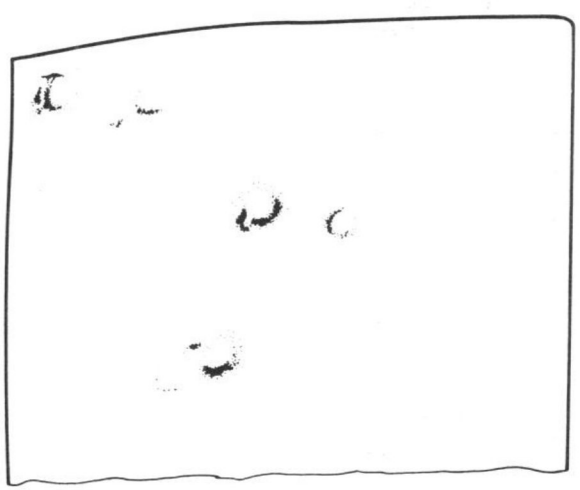
(4) If the run-down time is satisfactory, restart the engine and make the following checks:

CAUTION: IF ANY MALFUNCTION IS APPARENT DURING GROUND RUNNING, SHUT DOWN THE ENGINE IMMEDIATELY AND INVESTIGATE AND RECTIFY THE DEFECT BEFORE CONTINUING WITH THE GROUND RUNNING CHECKS.

(a) Open the throttle slowly until the engine reaches 7500 rev/min, carefully observing the engine instruments for any abnormal indications allow the engine to stabilize, then close the throttle.



Typical damage caused by a 2 BA setscrew



Damage caused by pop rivet mandrel heads. This view shows the back of the blade indicating that the mandrel head has deeply cratered the reverse side

SRT 614

Typical foreign object impression-unacceptable
Fig.1

(b) With the engine stabilized at ground idling rev/min, move the throttle lever rapidly from ground idling to the maximum rev/min position and check that the time taken to reach governed rev/min is within the specified limits (Vol.1, Part 2, Sect.2, Chap.2). Check for any abnormal noise and/or vibration and tendency to surge.

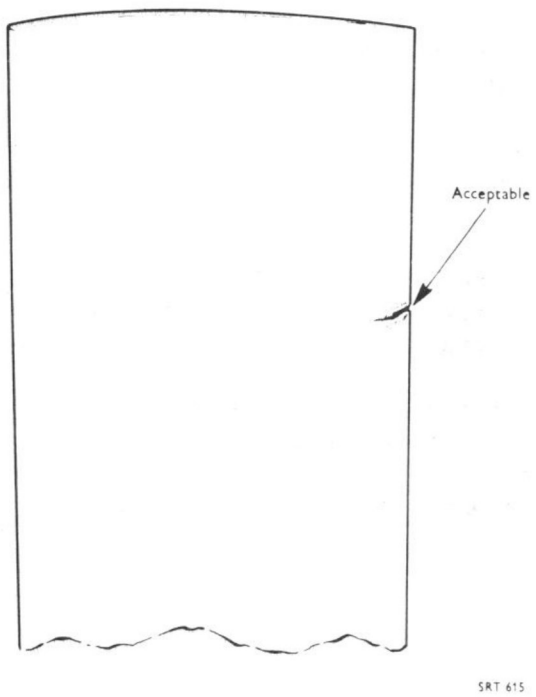
(c) At governed rev/min, check the engine instruments for indication of abnormal rev/min or jet pipe temperature.

(d) Move the throttle rapidly from governed rev/min to ground idling rev/min and check for abnormal noise and/or vibration and tendency to surge.

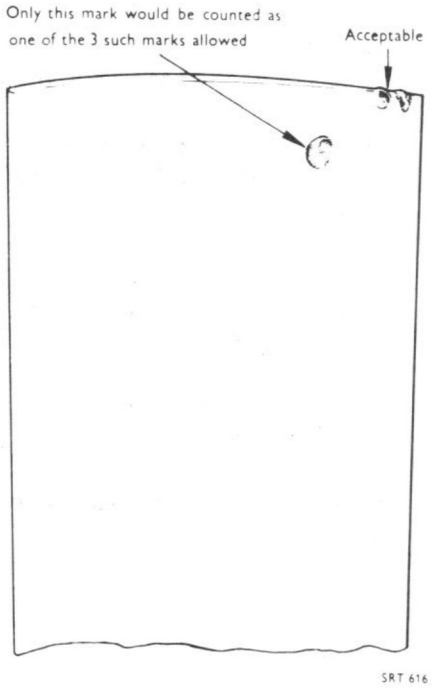
(5) If suspected ingestion occurred during the take-off, but performance was satisfactory during flight, inspect the compressor (sub para.A.). If damage is not evident, carry out the functional checks (sub. para.B.).

C. If, after frontal inspection and functional checks, the serviceability of the compressor is in doubt, the engine must be removed from the aircraft for further investigation. If doubt still exists, the compressor top-half casing may be removed to permit closer examination of the compressor blades.

Continued on next page



Acceptable bruise
Fig.2



Acceptable indentations
Fig.3

4. Acceptance standards - frontal inspection

A. Specific standards are difficult to establish. The number of tears or indentations should be considered in conjunction with the type of damage (para.2); there is a greater chance of severe damage being caused by the entry of, for example, a 2 B.A. setscrew than by pop rivet mandrel heads. It is necessary, therfore, not only to inspect the first stages of blades for the extent of damage but also, if possible, to determine the cause by carefull examination of the damage marks. The decision to accept, repair or reject a damaged engine must be based on the broad standards detailed in the following paragraphs and the table of acceptance limits given in fig.7.

B. The following standards should be applied in assessing damage to the visible compressor stages by frontal inspection of the engine. The maximum number of 'acceptable' damage marks must not exceed three on any inlet guide vane, rotor blade or stator blade. Small bruises or shallow indentations (fig.2 or 3) may be ignored.

C. Intake guide vanes

(1) The following damage to intake guide vanes is acceptable:

(a) Smooth indentations not exceeding 0.120in. in diameter or length in the area within 0.250in. of any edge.

(b) Smooth indentations not exceeding 0.630in. in diameter or length outside the zone covered in (a).

(2) The following damage to intake guide vanes is unacceptable:

(a) Sharp indentations or clearly defined foreign object impressions (fig.1)

(b) Penetration or tearing of the skin.

(c) Two or more indentations which merge together.

(d) Any indentation on one side of the aerofoil which causes deformation of the opposite side.

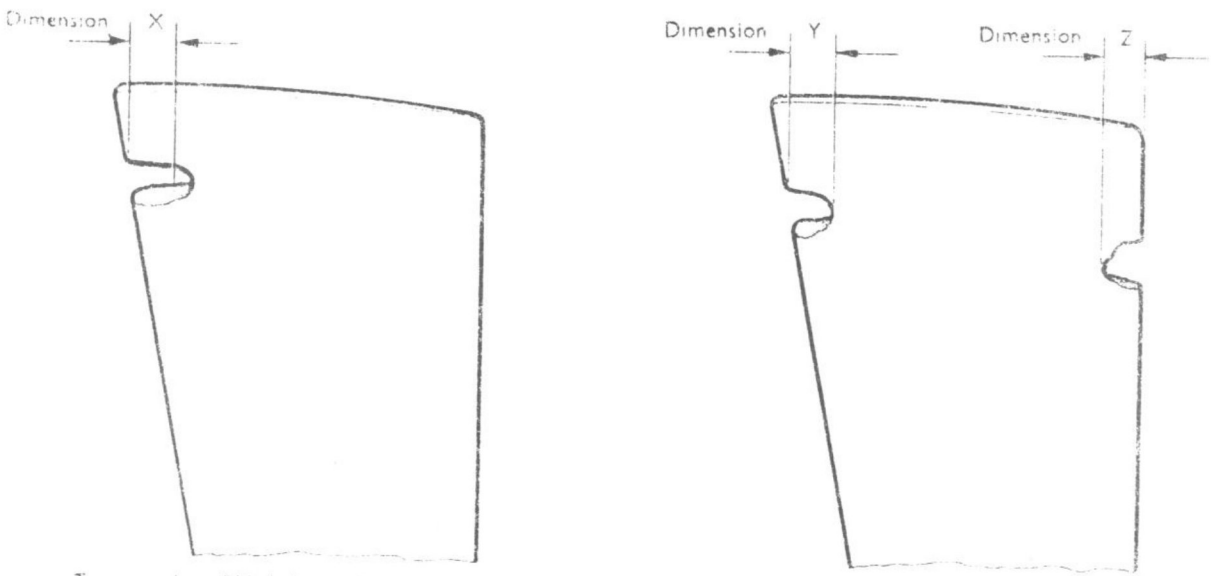
(e) Rippling or corrugation of the vane surface.

(f) Obvious abnormal twisting or bending of the aerofoil.

(3) Repair of intake guide vanes is not permitted. If unacceptable damage is confined to the intake guide vanes the front bearing housing may be removed and either the complete assembly replaced by a new assembly (para.7.A.) or individual inlet guide vanes renewed (para.7.B.)

D. Rotor blades and stator blades

(1) Damage to either leading or trailing edges or a combination of both, exceeding a chordal depth equivalent to dimension 'X' of fig.7 is unacceptable fig.4.



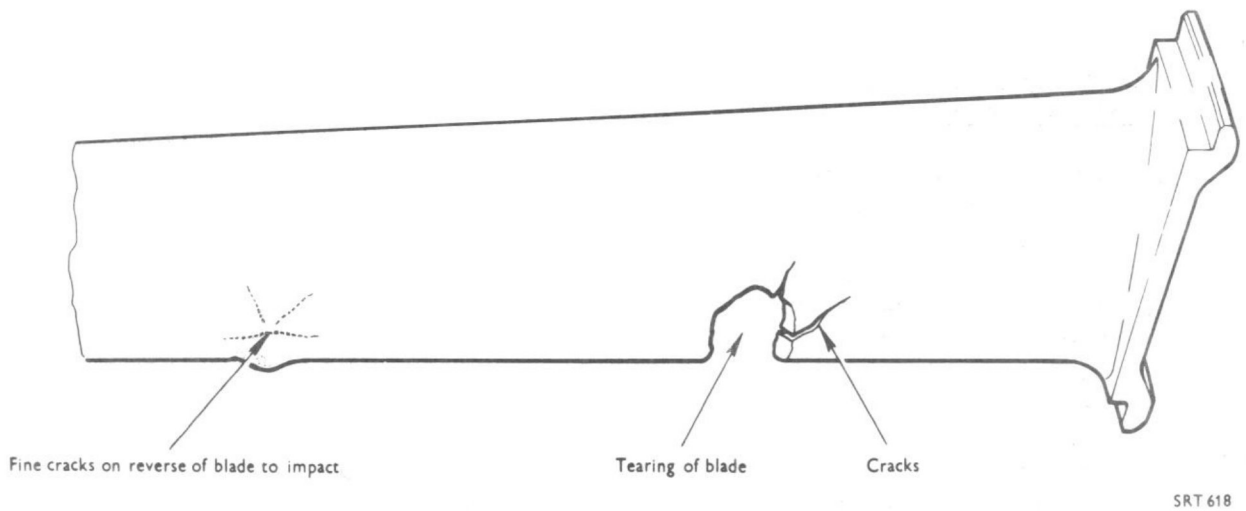
Tear on edge of blade beyond acceptable limit (Dimension X of fig 7)

Tears on leading and trailing edges (Dimensions Y + Z greater than X of fig 7

SRT 617

Unacceptable tear
Fig.4

(2) Cracks originating from leading or trailing edge damage marks (fig.5.), irrespective of the length of crack or the size of damage mark are unacceptable.

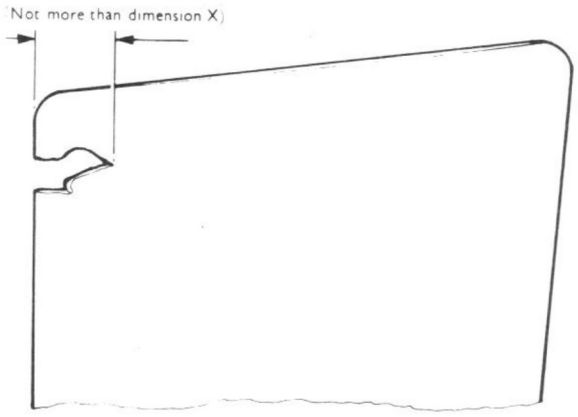


Unacceptable indentations and cracks
Fig.5

Continued on next page

(3) Damage marks within 0.500 in. of the root fillet radius of rotor blades, other than small bruises and pit marks, are not acceptable.

(4) Damage which leaves a piece of blade which might subsequently become detached (fig.6) is unacceptable irrespective of the chordal depth of the damage.



Piece of blade likely to become detached
Fig.6

5. Acceptance standard - top-half casing removed

A. Instructions for the removal of the top-half casing are contained in para.6.

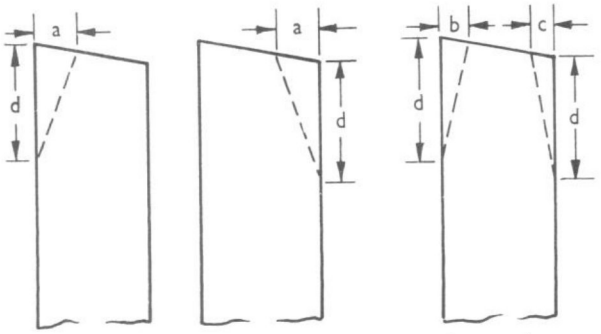
B. With the top-half casing removed, the rotor assembly and the stator blades in the top-half and bottom-half casings should be carefully examined and the damaged assessed to establish whether damage marks can be blended (para.6.B.) by dressing the blades to bring them within the acceptance limits of fig.7.

C. Although stator blades in the bottom-half casing cannot be fully inspected in situ, experience has shown that their condition is generally similar to those in the top-half casing.

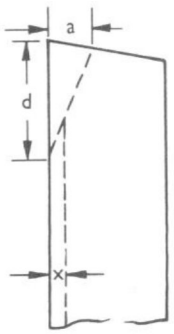
D. Damage marks within 0.500 in. of the root fillet on unshrouded stator blades, other than small bruises and pit marks, are not acceptable.

E. There is no limit to the number of stator blades which may be repaired, and the number of rotor blades in any one stage and the number of stages which may be repaired by blending is limited only by the effect on engine performance.

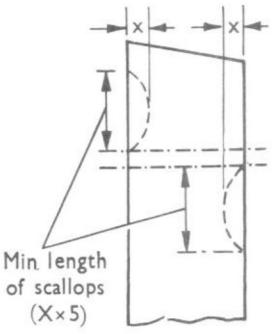
Continued on next page



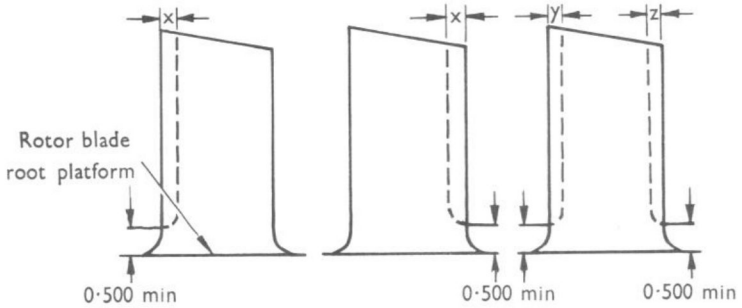
'b + c' must not be more than 'a'. This rule must be adhered to where damage is within 'd' of blade tip



Combination of edge and tip limits



Scallops must not overlap



'y + z ' must not be more than 'x'

ROTOR BLADES							STATOR BLADES	
Stage	Minimum chordal width of new production Rotors			x (or y+z)	a (or b+c)	d	Minimum chordal width of new production Stators	x (or y+z)
	Root	Centre	Tip					
1	1·780	1·780	1·918	0·150	0·500	1·500	1·660	0·200
2	1·440	1·440	1·530	0·150	0·375	1·500	1·460	0·200
3	1·250	1·250	1·320	0·150	0·375	1·250	1·230	0·100
4	1·040	1·050	1·090	0·150	0·375	1·090	0·990	0·100
* 5		0·920		0·100	0·250	1·000	0·940	0·100
6		0·920		0·100	0·250	0·875	0·940	0·100
7		0·920		0·100	0·250	0·875	0·940	0·100
8		0·920		0·100	0·250	0·750	0·880	0·100
9		0·820		0·100	0·250	0·750	0·890	0·100
10		0·820		0·100	0·250	0·625	0·890	0·100
11		0·820		0·100	0·250	0·625	0·890	0·100
12		0·820		0·100	0·250	0·500		

* After stage 4, average minimum chordal width is given, since nominal rotor blade width does not vary appreciably from root to tip

ALL DIMENSIONS IN INCHES.

SRT 620A

Limits of acceptance for blending stator and rotor blades
Fig.7

6. Compressor

A. Top-half casing - removing

(1) Remove the engine from the aircraft as described in the appropriate aircraft Air Publication and install the engine in its transportation stand.

(2) Disconnect the low tension (l.t.) harness lead from the anti-icing hot air valve actuator and remove the hot air valve and actuator. Remove the setscrews which secure the air inlet elbow, to the hot air manifold and remove the elbow and pipe.

(3) Remove the pipes from the compressor air bleed valves (Chap.2.).

(4) Remove the acceleration control unit and associated pipes and remove the fuel pumps and metering block (Chap.6.).

(5) Remove the pipe connecting seventh stage air to the bleed valve control unit (Chap.2.).

(6) Disconnect the electrical connections and clips from the air dipping unit (Mk.122) and remove the pipes (Chap.2.).

(7) Remove the setscrews which secure the top-half casing to the compressor outlet casing and, using the extractor, withdraw the dowels sufficiently to clear the compressor (approximately 0.625in.). Note the relative locations of the setscrews.

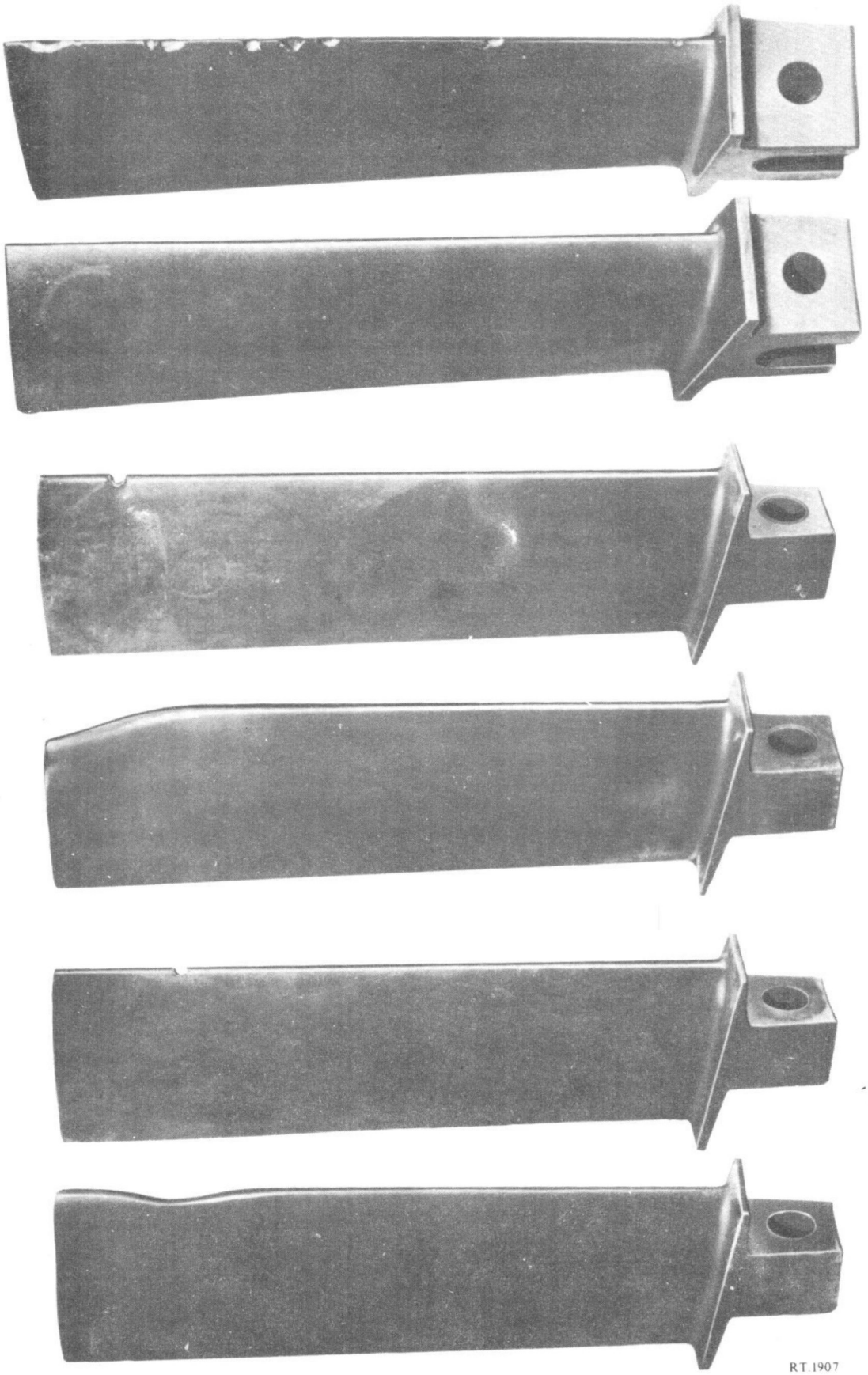
(8) Remove the blanking plug from the lifting eye insert in the top-half casing and fit the lifting eye and washer.

(9) Extract the split pins from the four fitting bolts (2 front and 2 rear) which locate the compressor halves and remove the nuts and bolts. Remove the remaining split line nuts and bolts.

(10) Remove the setscrew which secure the top-half casing to the front bearing housing and, using the extractor, withdraw the dowels. Note the relative locations of the setscrews.

(11) Slacken the setscrews which secure the bottom-half casing to the front bearing housing sufficiently to prevent the top-half casing binding between the front bearing housing and the compressor outlet casing.

(12) Attach a lifting sling to the lifting eye then, using a suitable hoist, raise the top-half casing clear of the engine.



Typical examples of damaged rotor blades
before and after blending
Fig.8

(13) Lower the top-half casing into the vertical position onto a low wooden bench at a convenient working height to permit inspection of the stator blades.

(14) Tighten the setscrews which secure the bottom-half casing to the front bearing housing.

B. Blade dressing

(1) When blending damage to rotor and stator blades, observe the following conditions:

(a) Only the minimum of dressing should be done to bring the blades within acceptable limits.

(b) Prevent filings or metal dust from lodging in the compressor by using a piece of oil soaked rag, slit to accommodate any rotor bladed being dressed. It may be found more practicable to remove stator blades that require dressing, from the top half and bottom-half casing.

(c) Blades which have small pieces liable to become detached should be dressed and adjacent damage marks on any one blade can be merged by blending to bring them to an acceptable form.

(d) When a combination of tip and edge scalloping is necessary, it is preferable that the full length of the blade is dressed to dimension 'X', 'Y' or 'Z' rather than a local edge scalloping.

(e) If damage is scalloped and blended on both the leading and trailing edge of a blade, the run out of the blends must not overlap (fig.7.).

(f) Care must be taken not to leave any sharp edges, the blade profile must, as near as possible, be maintained, and all scalloping must blend smoothly into the aerofoil.

(g) Scalloping is not permissible within 0.500 in. of the root radius.

(2) Blending should be effected with small, suitably shaped fine files, or a small power tool with suitable attachments, taking care to avoid making deep file or grinding marks. After blending, polish the affected area with progressively finer grades of fine emery tape.

CAUTION: TAKE CARE NOT TO BREAK OFF PIECES OF BLADES OR FILES WHICH MAY LODGE IN THE BOTTOM-HALF COMPRESSOR CASING AND CAUSE FURTHER DAMAGE.

(3) After dressing, aluminium blades must be treated with an approved air-drying varnish; using the minimum amount of varnish required to re-protect the dress area only.

(4) After blending damaged blades there must not be any sharp corners. Typically damaged blades, before and after treatment, are shown in fig.8.

(5) Unless the dressed rotor blades are fairly evenly distributed amongst the blades in any stage, counterbalancing should be effected by dressing, to a similar degree, the diametrically opposite blades.

C. Top-half casing - replacing

(1) Slacken the setscrews which secure the bottom-half casing to the front bearing housing sufficiently to give clearance to the top-half casing whilst lowering it into position.

(2) Carefully lower the top-half casing into position, ensuring that the rotor and stator blades do not foul.

(3) Tighten the setscrews which secure the bottom-half casing to the front bearing housing.

(4) Enter all the setscrews and dowels which secure the top-half casing to their appropriate locations (noted in sub. para.A.(7) and (10) in the front bearing housing and the compressor outlet casing.

(5) Enter the four fitting bolts in their appropriate positions which locate the compressor halves then enter the remaining split-line bolts.

(6) In the following order and using clean engine oil as a lubricant, tighten the nuts and setscrews to the torque load specified in Chap.1.

(a) Using the templates (Sect.1), compressor top and bottom-half casings.

(b) Compressor top-half casing to front bearing housing.

(c) Compressor top-half casing to compressor outlet casing.

(7) Fit new split pins to the castellated nuts of the fitting bolts at the compressor split-line.

(8) Replacement of all units, pipes, clips and harness connections is the reverse of removal; renew all sealing rings and jointings.

D. Serviceability check

(1) Hand turn the engine and check for freedom of movement.

(2) Bleed the fuel system as described in Chapter 6. Install the engine in the aircraft and ground run in accordance with Vol.1, Part 2, Sect.2, Chapt.2; check for oil, fuel and gas leaks.

(3) On completion of the ground run, check that the engine run-down time is comparable with the run-down times experienced prior to the compressor repair.

7. Front bearing housing

A. Removing

(1) Remove the starter fairing and starter (Chap.8).

(2) Remove the socket connection from the compressor end of the starter electrical supply cable, and remove the cable casing.

(3) Remove the nuts securing the starter drive housing to the front bearing housing and, using the extractor, withdraw the starter drive housing.

(4) Unlock the cupwasher locking the inner shaft retaining nut and, using the special spanner, remove the nut and cupwasher. Withdraw the pawl carrier assembly.

(5) Unlock the lockring locking the outer shaft nut and, using the special spanner, remove the nut.

(6) Using the withdrawal tool, remove the drive shaft assembly and the adjusting washer fitted between the drive shaft shoulder in the compressor shaft.

(7) Disconnect the intake guide vane ram spring coupling from the intake guide vane operating lever by removing the two nuts and disengaging the coupling from the lever.

(8) Remove the setscrews from the keep plates securing the oil pipes at their entry into the front bearing housing.

(9) Remove the setscrews from the keep plate securing the starter electrical cable socket to the front bearing housing and withdraw the socket connection from the front bearing housing. It may be necessary to remove the adjacent clip securing the branch cable to the compressor before the socket can be withdrawn.

(10) Screw the threaded sleeve of the support bar firmly into the compressor shaft and secure the adapter of the tool to the ring of starter attachment studs, using the original attachment nuts. The starter electrical cable is to pass through the recess in the rim of the adapter plate.

(11) Unless previously removed for lifting the top-half casing, remove all but four (distributed in the upper sector of the joint) of the setscrews from the front bearing housing to compressor casing joint and, using the extractor, withdraw the ten flanged dowels from the joint.

(12) Attach lifting tackle to the link of the support bar and lift until the cable is just taut.

CAUTION: ENSURE THAT THE COMPRESSOR SUPPORT BAR IS NOT SUBJECTED TO A LIFTING LOAD WHICH WILL TILT AND LOCK THE FRONT BEARING HOUSING, PREVENTING REMOVAL OF THE ASSEMBLY.

(13) Unscrew and remove the remaining setscrews from the housing to compressor casing joint.

(14) Place a tray beneath the joint to catch waste oil and detach the housing from the compressor casing; slide the assembly forward along the support bar.

(15) Remove the nuts from the five special studs in the bottom-half of the dummy front bearing housing and offer up the bottom-half to the compressor casing (with its straight edge horizontal) to support the compressor shaft. Engage the five dummy housing special studs with their corresponding housing attachment holes and fit the five special nuts; tighten the stud thumbscrews.

(16) Fit the top half dummy housing in the same way as the bottom-half.

(17) Check that the dummy housing is in continuous contact with the compressor casing and that the attachment studs are fully tightened.

(18) Remove the lifting tackle from the link and remove the engine front bearing housing, manually, from the support bar. The housing is a heavy unit, two men will be required.

(19) Remove the support bar and adapter from the engine front bearing housing.

B. Intake guide vanes - renewing

(1) With the front bearing housing removed from the engine (sub. para.A.), it is permissible to renew individual blades which are damaged beyond acceptable limits (para.4.C.)

(2) Unlock and remove the four nuts securing each master guide vane control lever housing to the hot air manifold and withdraw the housing and control lever assemblies.

(3) Using the extractor in conjunction with the reacting plate, remove the hot air manifold from the front bearing housing.

(4) Support the front bearing housing on a stand (or suitable wooden blocks to protect the studs) rear face uppermost.

(5) Unlock and remove the nuts and tabwashers which secure the actuating levers to the guide vanes. Withdraw the levers from the guide vanes and trunnions, then withdraw the trunnions from the actuator ring.

(6) Unlock and remove the tabwashered setscrews, then ease the surge stops from under the actuating ring.

(7) Rotate the actuating ring to bring the rollers in line with the cut-away portions of the support ring, then lift out the actuating ring and remove the rollers.

(8) Unlock and remove the nuts and setscrews which secure the support rings and fixed stops then, withdraw the stops and the rear support ring.

(9) Remove the circlip retaining the vane pivot bush from the intake guide vanes which are to be replaced. Remove the bush and lift out the guide vane.

(10) Replacement of the new guide vanes in the front bearing housing is the reverse of removal, but it should be noted that anti-freeze grease XG-273, DTD.900/4408 (Ref.34B/9423141) should be smeared in the guide vane pivot bush and support ring scallop prior to fitting the vane and any circlips removed (sub. para.(9)) replaced by new circlips.

C. Front bearing housing - replacing

NOTE: Before fitting a new replacement front bearing housing check the assembly for completeness and transfer all relevant serviceable parts from the original assembly. The gland sealing assembly and the oil seal housing and outer track assembly are to be transferred as a unit because the outer track is mated to the front bearing and is not interchangeable.

(1) Ensure that all mating faces are clean; apply engine oil to the internal bearing surfaces.

(2) Fit the adapter of the support bar to the starter securing studs in the new housing, tighten the nuts.

(3) Replacing the front bearing housing is the reverse of removing; note the following sub-pragraphs.

(4) Renew all sealing rings and jointings.

(5) Ensure that the lifting tackle is applied to the support bar link and is giving adequate support, without imparting a lifting load, before the dummy front bearing housing is removed.

(6) Clean the front mating face of the compressor casing before sliding the front bearing housing into contact with it.

(7) Take care that the oil pipes, protruding from the compressor, enter the housing without damage; close the joint carefully moving the housing radially, slightly, to enter the pipes into their sockets in the housing.

(8) When fitting the starter drive, obtain the correct clearance between the pawl carrier and the compressor shaft, as follows:

(a) With the original adjusting washer fitted, tighten the outer shaft nut to the correct torque load; do not lock the nut.

(b) Fit the pawl carrier and a new or reclaimed cupwasher and tighten the inner shaft nut to the correct torque load; do not lock the nut.

(c) Take up the pawl carrier end-float (0.008 to 0.024in.) rearward and, using feeler gauges, measure the clearnace between the front face of the compressor shaft and the opposing face of the pawl carrier; if the clearance is not 0.050 ± 0.010in., the adjusting washer is to be substituted for one selected to give the correct clearance. Adjusting washers are supplied in a range between 0.225in. thickness to 0.325in. in increments of 0.010in.

(d) When the correct clearance has been obtained, tighten both the outer and inner shaft nuts with the correct torque load and lock, respectively, the lockring and cupwasher.

(9) Before fitting the starter drive housing lightly coat the mating flange of the front bearing housing with jointing compound SQ.32L (Ref. No. 34B/1417), applied as instructed in Sect.2, Chap.1.

D. Serviceability check

CAUTION: BEFORE THE ENGINE IS RUN, CHECK THAT ALL LOOSE ARTICLES AND DEBRIS HAVE BEEN REMOVED FROM THE ENGINE AND ITS VICINITY. CHECK THAT THE OIL SUMP CONTAINS SUFFICIENT OIL.

(1) Turn the compressor rotor, by hand, to check that it turns freely, without rubbing or abnormal sound.

(2) Instal and ground run the engine, making the full set of post-installation checks given in Vol.1, Sect.2, Chap.2. During the ground run, check for leaks from the disturbed connections. As the engine is shut down from ground idling rev/min, note the run-down time and compare it with previously recorded times. Replenish the engine oil system.