ADVANCE INFORMATION

ADVANCE INFORMATION LEAFLETS

This Marker Card is to be inserted immediately in front of the Amendment Record Sheet at the beginning of the book; Advance Information Leaflets are to be inserted, as received, in numerical sequence following this Card.

The information contained in Advance Information Leaflets will be incorporated by normal amendment list action in due course. In the meantime appropriate action is to be taken in accordance with any instructions contained therein.

ATP/6982/1100/12/51

AMENDMENT RECORD SHEET

Incorporation of an Amendment List in this publication is to be recorded by signing in the appropriate column and inserting the date of making the amendments.

A.L.No.	AMENDED BY	DATE
1 to 40	Incorporated in this Reprint	Oct. 1952
41	D. D. Bennett	9/7/54
42		"
43		"
44		"
45		"
46		"
47	D. D. Bennett	9/7/54
48		"
49		"
50		"
51		"
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54	D. D. Bennett	9/7/54
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58	D. D. Bennett	9/7/54
59	D. D. Bennett	9/7/54
60	D. D. Bennett	9/7/54
61	D. D. Bennett	9/7/54
62	D. D. Bennett	9/7/54
63	D. D. Bennett	9.9.54
64	D. D. Bennett	9.9.54
65	D. D. Bennett	1.10.54

A.L.No.	AMENDED BY	DATE
66	L. Black	14.3.55
67	L. Black	14.3.55
68	L. Black	14.3.55
69	L. Black	14.3.55
70	A. Black	28/1/55
71	L. Black	15/4/55
72	[illegible]	15-7-55
73	[illegible]	16-7-55
74		
75	J. Doolley	18-8-56
76	J. Doolley	18-8-56
77	[illegible]	5/3/57
78		
79	E. Hobbs	10.12.57
80	[illegible]	23/8/57
81	E. Hobbs	28.1.58
82	E. Hobbs	3/1/58
83	E. Hobbs	4.1.58
84	B. E. Campbell.	25/2/59
85	B. E. Campbell.	31/12/58
86	B. E. Campbell.	28/5/59
87		
88	B. E. Campbell.	17/5/60
89	B. E. Campbell	1/9/62
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(Continued overleaf)

A. T. P./8933/180/10/52

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★An Amendment Record Continuation Sheet (R.A.F. Form 2096B.) will be required when this page is full. Order it now.

LETHAL WARNING

EJECTION SEATS AND CANOPY JETTISON MECHANISMS

1. Ejection seats and canopy jettison mechanisms are sources of potential danger to personnel and of damage to the aircraft. Serious injury (possibly fatal) may result if any firing mechanisms are inadvertently operated whilst the aircraft is on the ground.

2. The following instructions are to be obeyed:—

R.N. **Safety Precautions contained in A.P.(N.)140—Naval Aircraft Maintenance Manual.**

R.A.F. **ALL PERSONNEL before entering the cockpit or cabin of an aircraft fitted with an ejection seat are to report to the N.C.O. immediately in charge of air-frame servicing who is to ensure that all safety pins (or other safety devices) are correctly positioned to render the seat and canopy jettison firing mechanisms safe. On completion of servicing, tradesmen are to report to the N.C.O.**

3. Full instructions for rendering the firing mechanisms safe are contained in the A.P.4288 and A.P.(N.) 1023 series, in Aircraft Servicing Schedules and in the A.D.5037 series.

LETHAL WARNING

ADMIRALTY
AIR MINISTRY

GOBLIN Mk. 2 & 3 AERO-ENGINES

This is Amendment List No. 43 to Air Publication, 4121B & C, Volume 2, Parts 3 and 4

Remove and dispose of the existing leaf bearing Note to Readers and substitute this revised leaf. Record the incorporation of this A.L. in the Amendment Record Sheet.

ENGINEER

NOTE TO READERS

The subject of this publication may be affected by Admiralty Fleet Orders, Air Ministry Orders, or by "General Orders and Modifications" leaflets in this A.P., in the associated publications listed below, or even in some others. If possible Amendment Lists are issued to correct this publication accordingly, but it is not always practicable to do so. When an Order or leaflet contradicts any portion of this publication, the Order or leaflet is to be taken as the overriding authority.

Each leaf bears the date of issue and, when applicable, the number of the Amendment List with which it was issued. New or amended technical information on new leaves which are inserted when this publication is amended will be indicated by a vertical line in the margin. This line merely denotes a change and is not a mark of emphasis. When a Section or Chapter is issued in a completely revised form the line will not appear.

* * *

LIST OF ASSOCIATED PUBLICATIONS AND AIR DIAGRAMS

	A.P.
Aero-engine ignition equipment ...	*1374 Series*
Aircraft hydraulic equipment—Lockheed ...	*1803B*
Aircraft pneumatic equipment—Hymatic ...	*4303C*
Electrical equipment manual—general (airborne) ...	*1095A*
Fuel system components (general) for gas turbine aero-engines ...	*4282*
Fuel system components (Lucas) for gas turbine aero-engines ...	*4282A*
Instrument manual—general instruments ...	*1275A*
R.A.F. engineering and relevant aircraft Air Publications and Pilot's Notes ...	*1464 Series*
	A.D.
Goblin 2 Aero-engine ...	*4614*
Goblin 2 Servicing information ...	*4481*
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Goblin Mk. 2 Combustion chamber and burner ...	*ON682*
Goblin Mk. 2 Fuel system (Sheet A) ...	*ON680A*
Goblin Mk. 2 Fuel system (Sheet B) ...	*ON680B*
Goblin Mk. 2 Rotor shaft assembly ...	*ON675*

LAYOUT OF
A.P.4121B & C GOBLIN Mk. 2 and 3 AERO-ENGINES

VOL. 1

VOL. 1	**SECT. 1** Operation	**SECT. 2** Description
VOL. 2	**PART 1** **(Leaflets)** **General orders and modifications**	**PART 2** **Servicing schedule** **(See relevant Aircraft A.P. Vol. 2, Part 2)**
	PART 3 **Servicing**	**PART 4** **Minor Repairs**
	PART 5 **Depot repair**	**PART 6** **Schedule of Fits and Clearances**
VOL. 3 **Schedule of spare parts**		
VOL. 6		**PART 2** **Major Repairs**

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LIST OF PARTS AND SECTIONS

PART 3
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GOBLIN Mk. 2 AND 3 AERO-ENGINES

LIST OF SECTIONS

Note.—*A list of Chapters appears on the marker card for each section*

SECTION I

INSTALLING AND REMOVING

SECTION 1

INSTALLING AND REMOVING

LIST OF CHAPTERS

***Note.**—A list of contents appears at the beginning of each chapter*

Chapter I

UNPACKING AND INSTALLING

Note.—*This chapter applies to Goblin Mk. 2 and 3 aero-engines*

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

General

1. This chapter describes the installation of an engine as received by a unit. As personnel will normally be concerned with effecting a replacement, this chapter and Chapter 2 have been written to facilitate easy cross reference between the procedures either for installing or removing an engine. Reference must also be made to the relevant aircraft Air Publication for information regarding the fitting of engine-driven aircraft accessories.

2. Due to possible variations between aircraft and between the equipment installed in individual aircraft of the same type, the sequence given in the following paragraphs may require adjustment to suit the exigencies of local conditions, and the equipment and facilities available. The connections differing between the two marks of engines have been identified accordingly, and it will be quite easy to choose the connections applicable to a particular installation.

3. Where reference is specifically made to engines in Vampire aircraft, the instructions do not necessarily apply to other installations.

Slinging

4. A mobile crane capable of hoisting a weight of at least 25 cwt., the combined weight of the engine and the cylindrical metal container, is necessary. When installing in Vampire type aircraft, the crane boom must be capable of lifting the engine above the aircraft and of being extended over the engine bay at the rear of the fuselage. The approved lifting slings must always be used for hoisting the engine, and it must be ensured that the shackles are attached securely to the front and rear lifting eyes and that the sling eye is adjusted so that the engine balances correctly.

Unpacking

5. The engine will be received in a metal packing and transit container (*fig.* 1), or in a wooden case (*fig.* 2), whilst the tail-pipe will be received separately in a wooden transit case. The cases are fitted with four slinging

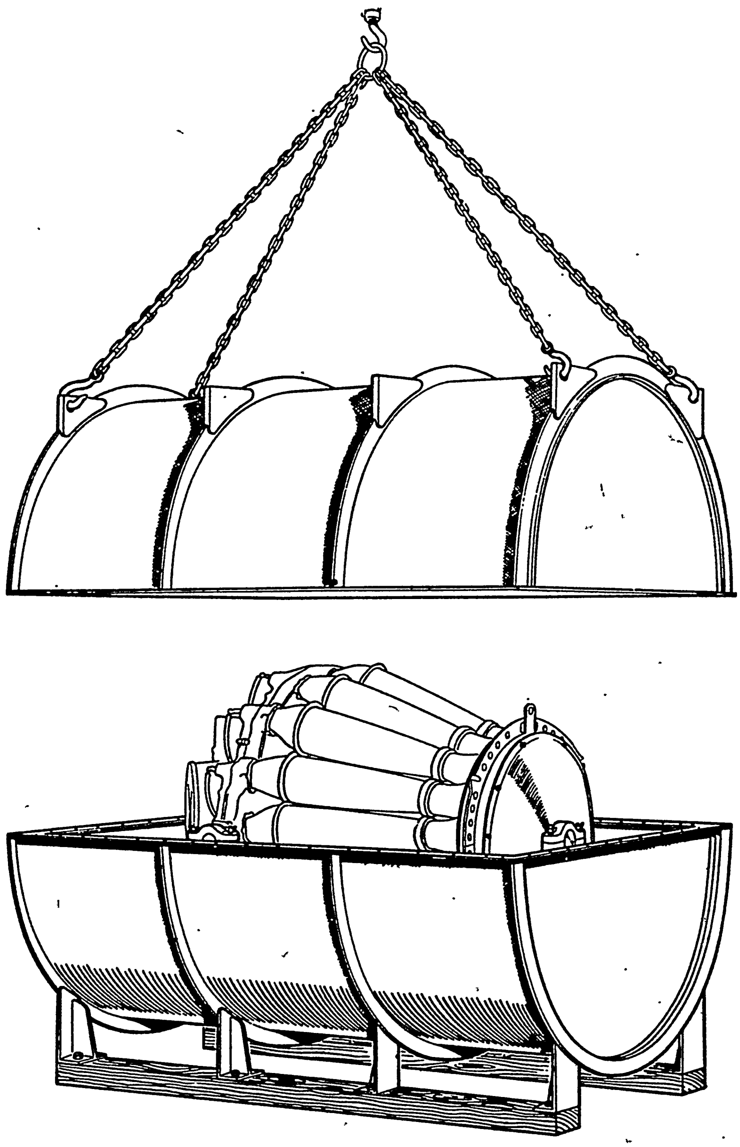

Fig. 1. Engine in cylindrical metal container

rings for lifting and the drum has four lifting eyes, two being attached to each end flange. Remove the bolts from the base of the wooden engine case or the fifty-two nuts and bolts from the central longitudinal flange of the drum. Attach the four-piece chain sling to the top of the container and lift off the top half of the drum or the shell of the wooden case. The engine will remain attached to the inside of the lower half of the drum or to the stand mounted on the base of the wooden case. The operation of removing the upper half of the drum or the shell of the wooden case should be carried out carefully to avoid damaging the engine. The engine log book, appropriate copies of the relevant issue or receipt vouchers and Forms 640 will be with the engine.

6. Attach the sling (*Stores Ref.* 4G/2872) to the eye on the top accessory box and by the special adapter plates to the eye on the turbine shroud. Adjust the eye on the beam so that the load will be evenly distributed

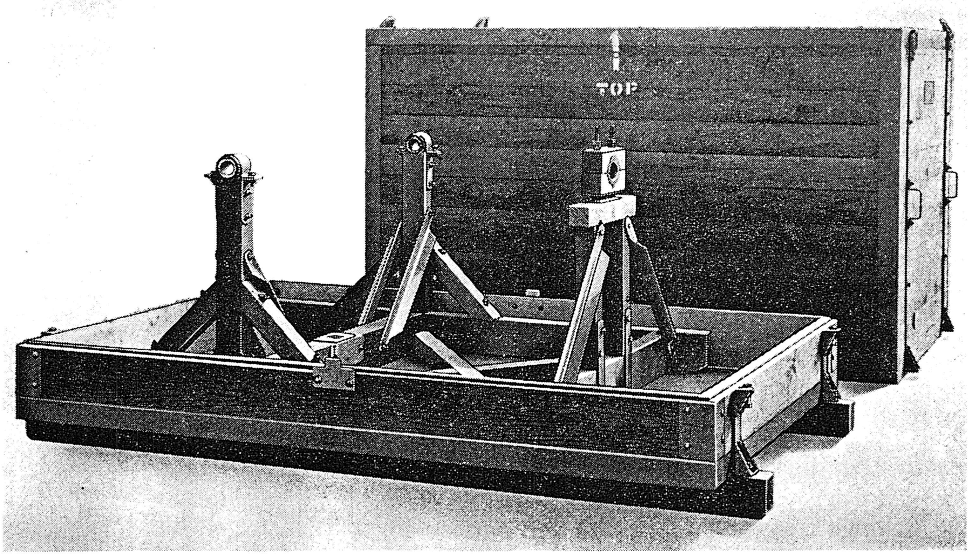

Fig. 2. Engine transit stand and packing case

(*fig.* 3) and take up the slack in the sling. Remove the trunnion bush caps from each side and the rear of the engine. Lift the engine clear of the drum or case. Remove the two transverse rubber bushes and assemble the brass bushes of the transport stand. Gently lower the engine into the transport stand and secure the trunnion caps.

7. Examine the engine externally for any damage that may have occurred in transit or during unpacking. Such damage is likely to be confined to the projecting parts. Any damage or evidence of corrosion must be reported to the inspection authority. Carefully check the engine and all loose components (which will be tied to the engine or to the container) against the Checking List at the beginning of Volume 3, Part 1, of this Air Publication. A shortage of any components should be recorded in the log book, and the relevant issue or receipt vouchers and Forms 640 suitably endorsed.

Blanks and transport spares

8. It is advisable to leave blanks and aperture covers in position until immediately before the component is to be mounted on the engine, or the connection is to be made. This will reduce the likelihood of dust or other foreign matter entering the engine, particularly when operating in sandy localities. The following is a list of the blanks, etc. that will require removal at the appropriate stages.

Description	Part No. Goblin Mk. 2	Part No. Goblin Mk. 3	Qty.
Blanking cover, supercharger or alternator facing ...	17087	17087	1
Blanking cover, generator facing	17087	17087	1
Blanking cover, vacuum pump facing	17133	17133	1
Blanking cover, hydraulic pump facing	17133	17133	1
Blanking cover, air compressor facing	17135	17135	1
Blanking cover, tachometer generator facing	19138	19138	1
Protection tube, fireguard drain	71234	71234	1
Flanged trunnion mounting	22860	22860	3
Bolt, for trunnion	N.118	N.118	18
Spring washer, for trunnion bolt	AGS.162E	AGS.162E	18
Blanking cover, turbine disc	70554	70554	1
Blanking tube, accumulator drain	22126	—	1

Description	Part No. Goblin Mk. 2	Part No. Goblin Mk. 3	Qty.
Blanking cap, accumulator drain	—	AGS.597B	1
Blanking cover, air-intake	20620	20620	2
Blanking plug, igniter plug boss	20638	20638	2
Blanking cap, overspeed governor fuel drain	AGS.597A	—	1
Blanking cap, overspeed governor oil drain	AGS.597B	—	1
Blanking cap, dump valve drain	AGS.597B	—	1
Blanking cap, combustion chamber drain	AGS.597B	AGS.597B	1
Blanking cap, rear bearing drain	AGS.597A	AGS.597A	1
Blanking nut } oil thermometer pocket sleeve	810–3D	810–3D/3	1
Rivet ... } oil thermometer pocket sleeve	AS.155–1008	AS.155–1008	1
Blanking cover, starter mounting face	21372	21372	1
Blanking cap-nut, starter coupling union	N.663	N.663	1
Blanking plug, fuel pump inlet connection	AGS.597H	—	1
Blanking cap, port fuel pump inlet connection	—	AGS.597F	1
Blanking cap, starboard fuel pump inlet connection ...	—	AGS.595F	1
Blanking nipple } oil pressure gauge vacuum pump and compressor oil connections ...	N.2102	N.2102	3
Union nut } oil pressure gauge vacuum pump and compressor oil connections	2510–15	2510–15	3
Blanking plug, vacuum pump oil pipe	AGS.595B	AGS.595B	2
Blanking plug } air compressor oil feed pipe ...	AGS.595B	AGS.595B	1
Blanking banjo bolt } air compressor oil feed pipe	6A1–3L	6A1–3L	1
Blanking nut } air compressor oil feed pipe	A16Y–LP	A16Y–LP	1
Washer } air compressor oil feed pipe	AGS.160G	AGS.160G	2
Blanking cap, barostat drain	AGS.597A	—	1
Blanking cap, burner pressure gauge connection ...	AGS.597A	AGS.597A	1
Blanking plug } cabin demisting air pipe	AGS.1140H	—	1
Outer sleeve } cabin demisting air pipe	AGS.904H	—	1
Split pin } cabin demisting air pipe	SP.9–C5	—	1
Blanking cap, fuel tank pressurization connection ...	AGS.597B	—	1
Protection cap, cabin air pipe connection	—	AGS.596F	1
Blanking cover } turbine disc cooling air pipes and elbows	72614	72614	4
Blanking cover } turbine disc cooling air pipes and elbows	72613	72613	4
Protection plug } turbine disc cooling air pipes and elbows	AGS.595F	AGS.595F	4
Protection cap } turbine disc cooling air pipes and elbows	AGS.596F	AGS.596F	4
Bolt ... ... } turbine disc cooling air pipes and elbows	6A1–8E	6A1–8E	8
Nut ... ... } turbine disc cooling air pipes and elbows	A16Y–EP	A16Y–EP	8
Spring washer } turbine disc cooling air pipes and elbows	AGS.162D	AGS.162D	8
Blanking cap, for barostat spill connection	Z7070–175 or GTS.55–6	—	1
Blanking cap, barostat drain	Z7067–45 or GTS.55–5	—	1
Blanking nut, tail-pipe thermocouple	N.688	N.688	4
Blanking nut, tail-pipe thermocouple	16001A	16001A	3
Blanking cap, barostat head connection	X7067–46 or GTS.55–2	—	1
Blanking cap, B.P.C. total head connection	—	X7067–46 or GTS.55–2	1
Blanking cap, P.L.V. drain	AGS.597B	AGS.597B	1
Blank, Lucas fuel pump seal drains	—	Z7067–46 or GTS.55–2	2
Blanking cap, starting valve	AGS.597B	AGS.597B	1

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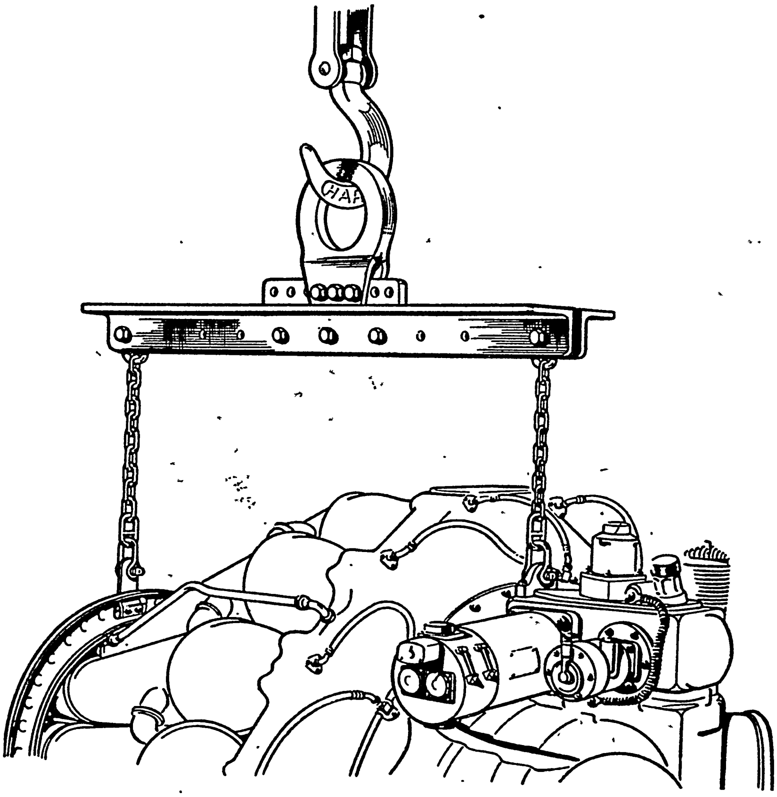


Datum points

Centre line of front chain attachment is datum point from which the position of the eye on the bar is measured. Position of centre of gravity from datum point without tail-pipe and fireguard:—with accessories 14·93 in., without accessories 16·93 in. Position of centre of gravity from datum point with tail-pipe and fireguard:—with accessories 18·93 in., without accessories 20·43 in.

Fig. 3. Slinging the engine

Preparation of engine

9. It is advisable to carry out as much work as possible whilst the engine is on the transport stand, because at this stage all parts of the engine are accessible. Work must not be carried out with the engine suspended from the crane. If the transport stand is unsuitable for certain operations, the engine must be transferred to a dismantling and assembly stand.

10. Remove the blanking plates and fit the appropriate engine-driven accessories in accordance with the instructions given in Part 4, Sect. 2, Chap. 9.

11. Remove the blanking plugs from No. 2 and 14 combustion chamber and screw the igniter plug into each combustion chamber. File the copper seating washer for each igniter plug until the hexagon flat marked with an arrow is facing squarely upstream.

12. Check that the engine accessories are of the correct Mark number, and that the appropriate aircraft accessories have been fitted.

13. Make a note of the starter terminals; if it is an old installation with the starter terminals forward it will be more convenient to connect up the starter after the engine is partly installed in the aircraft.

14. Fit any aircraft components which are convenient and practicable at this stage. For example, on Vampire aircraft with the appropriate accessories, the bracket for the generator-to-air-compressor cooling pipe can be attached to the two rear port studs of the top accessory box cover; the cooling pipe with its integral cooling cowl for the air compressor can be fitted in place between the generator and air compressor and the pipe can be secured to the bracket. In addition, if a Mk. 2 engine is being installed, the barostat end of the total head pipe complete with filter can be attached to the barostat using a worm-drive clip, and the pipe can be secured to two burner studs with the clips provided. With either mark of engine remove the H.P. cock lever and re-position it so that when the cock is closed the lever is horizontally forwards and when the cock is open the lever is vertically downwards. Another item which may be fitted at this stage is the upper cowl rail, which is attached by means of stirrups and long bolts to the diffuser casing hollow bolts. On Mk. 3 engines the hot-and-cold air valve may be secured to the front casing studs above the alternator.

Preparation of aircraft

15. The following instructions apply specifically when the engine is being installed in Vampire aircraft.

16. Ensure that all work in the engine bay has been completed as most components, particularly the flying control cables, will be less accessible after the engine is in.

17. Check that the "floating" air-intake duct on each side is in place, lined-up with the wing intake and secured with a rubber sealing ring and two worm-drive clips in the fuselage tank bay; it is advisable to arrange the worm-drive clip screws at the bottom where they will be more accessible for future adjustments if necessary.

18. Fit the rubber sealing rings around the rear ends of the "floating" ducts and secure with one worm-drive clip each. Roll back the rear edge of each sealing ring over the worm-drive clip and out of the way of the engine intake when installed.

19. If the engine is being installed in a new aircraft, in an aircraft which has been extensively repaired or in one which the bearer arms are suspected of faulty alignment, check the alignment of the bearer arm bolt holes and their relationship to the axis of the engine. Also check the relationship between the ends of the "floating" ducts and the bearer arm pick-up points. If a large number of engines are being installed, it will be advantageous to make up a dummy front casing for the latter check; this should consist of an unserviceable front casing fitted with four diffuser eye-bolts so adjusted that the perpendicular distance between the air-intake to the eye-bolts is on the lower limit. With this front casing a check of the alignment of the complete air-intake system can be made (*para.* 39 *to* 42).

20. After removing the dummy front casing, check that the rudder balance cable is clear of the "floating" intake ducts.

21. See that the cowling hooks are fitted with springs, and tie back the hooks to ensure that neither they nor their springs are damaged when the engine is being installed.

22. The cabin supercharger control rod must be tied up vertically to the cables above it, otherwise it will be trapped by the engine if it is allowed to hang down. For the same reason it is advisable to place the pilot's throttle lever in the OPEN position and to wedge the lower end of the short control rod behind the electric cables beneath it.

23. Fit the elbows which connect the cabin supercharger and the gun-heater muff to their appropriate leading-edge air-intake ducts; the port elbow is fitted with the cabin supercharger inlet filter.

24. Check that the inboard edge of the asbestos plate on the starter resistance is cut back at an angle. If not, rectify with a rasp sufficiently to allow the dipstick to be removed when the engine is installed.

25. Either remove the low pressure fuel filter bracket struts and swing the filter outwards, or remove the filter completely from the lower port bearer strut, otherwise the starter will foul it as the engine is being lowered into position.

26. Check that all connections on the fire-wall are blanked off. To prevent damage to the fire-switches it is recommended that the bracket on each side of the engine bay containing four fire switches should be removed. Remove also the pipe running along the bottom of each No. 1 rib, which connects the front and rear of the wing tanks.

27. Remove all loose nuts, bolts, washers, pieces of locking wire, etc., from the ledge formed on each side of the engine bay by the lower flange of No. 1 rib. Clean out the engine bay and ledges with compressed air.

28 A check must be made of the turbine tip clearance as described in Sect. 3, Chap. 1, to ensure that no distortion has occurred as the result of rough handling during transit. This check may be made at this stage or after the engine has been installed. If checked at this stage, however, it must be checked again after installation if rough handling occurs during installation, particularly if such handling heavily shock-loads the turbine shroud, for example, by the slipping of the lifting tackle. As rough handling during transit is more likely to occur than during installation it is usually only necessary to make this check before installation.

29. The tail-pipe clearance check which is also described in Sect. 3, Chap. 1, should be combined with the turbine tip clearance check. Assuming the result of the turbine tip and tail pipe clearance checks to be satisfactory, assemble the tail-pipe, with its drain at the lowest point, and secure it with the forty-five nuts and bolts after smearing the threads with Whitmore's compound No. 5 or anti-seize grease D.T.D. 392.

30. If it is decided to leave the checks until after the engine is installed do not set it on a strip-and-assembly stand but proceed as follows. Remove the turbine cover and apply four pieces of plasticine to the turbine disc in order to commence the tail-pipe clearance check described in Sect. 3, Chap. 1. Assemble the tail-pipe, with its drain at the lowest point, and secure with four nuts and bolts evenly spaced near to the pieces of plasticine. This check will be concluded when the tail-pipe is removed to conduct the turbine tip clearance check after installation of the engine.

Removing engine from transport stand

31. Wheel the transport stand to a convenient position near the aircraft. Attach the lifting sling (*Stores Ref.* 4G/2872) by its shackles to the front and rear lifting eyes; adjust the eye on top of the sling to a position suitable for lifting level an engine complete with tail-pipe. Just take the weight of the engine, remove the three trunnion bearer caps, raise the engine and wheel away the transport stand. Take care that the engine does not swing, as this might cause damage through contact with the stand. Remove the two brass trunnion bearings and the three trunnions; one beneath the engine and one each side.

Installing engine in airframe

32. The following instructions are applicable to Vampire aircraft but can be adapted to other installations. It is advisable to have five men, apart from the crane driver, available for the actual installation of the engine, although, of course, a crew of this size will not be necessary for the subsequent operations. These men should be stationed as follows:—one each side of the engine beneath the fuselage, one each side of the engine on the wings and one man at the rear of the engine to grasp the tail-pipe and guide the engine into the engine bay. Each man should be provided with an engine bearer bolt to the end of which has been screwed a locally-made bullet-shaped cap of the same diameter as the plain portion of the bolt (introduced by Vampire Mod. 808). These caps will enable the mounting eyes on the front of the engine to be aligned with the bearer arm pick-up points as the bolts are tapped home. Where Vampire Mod. 808 is not embodied, that is, where the bolts are not stepped, a bullet-shaped drift will be needed to align the bolt-holes.

33. Immediately before installing the engine, remove the air-intake covers. To mount the engine raise it above the fuselage and lower it very gently so that the diffuser casing passes through the cut out portion of the flange of No. 1 rib on each side of the engine bay. The clearance is very small and the engine must be lowered very slowly, whilst a constant watch must be kept to ensure that it does not foul anything in the engine bay. Care must also be taken to ensure that the engine is not dropped below the level of the bearer pick-up points, otherwise the engine air-intakes will damage the lower bearer struts, necessitating the removal of the engine. This damage can occur even after the top bolts are in position if the engine is allowed to "hinge" too low. These points must be watched carefully by the two lower men and there must be a rapid system of communication between them and the crane driver, for damage can be done if the engine is allowed to drop as little as half-an-inch. The lower man on the port side must also watch particularly that the starter does not foul the bearer arm struts.

34. Engage the top pick-up points first and insert the "bullets" or prepared bolts. Lower the engine slightly so that it hinges about the top pick-up points, when the bottom eye-bolts should slide easily between the lugs of the bottom pick-up points; insert the two lower "bullets" or prepared bolts. Thoroughly inspect the engine and engine bay to ensure that nothing has been trapped or damaged during the above operations.

35. Unscrew the "bullets" from the end of the bolts or if old-type bolts are used tap out the "bullets" one at a time using the bolts so that they follow the "bullets" into the bolt-holes. Assemble the special washers and the castellated nuts to the bolts. Split-pin the nuts and wire-lock the heads of the bolts to the pick-up lugs with 18 s.w.g. mild steel wire.

36. After the engine is secured to its mounting in any type of aircraft, the tail-pipe to turbine disc clearance check must be completed and the turbine tip clearance checked, if these operations have not previously been carried out. The latter check must be repeated if the engine has received any rough treatment during installing, particularly if the sling has slipped and shock-loaded the turbine shroud to which the rear lifting eye is attached. Remove the four nuts and bolts and take off the tail-pipe. Measure the thickness of the four pieces of plasticine, and complete the tail-pipe to turbine disc clearance check described in Sect. 3, Chap. 1. In addition check the turbine tip clearance also described in Sect. 3, Chap. 1. If these checks show that the engine is satisfactory, assemble the tail-pipe and secure it with the forty-five nuts and bolts after smearing the threads with Whitmore's compound No. 5, or anti-seize grease D.T.D. 392. Fit a propelling nozzle blanking cover.

37. Remove the blanking caps from the rear end of the front half of the four turbine disc cooling pipes (supplied with the engine), and the blanks from each end of the loose rear halves. Also take off the blanking plates from the ends of the tail-pipe support tubes, leaving the joint washer in place. Assemble the four loose pipes to the engine, attaching each by the union nut at the front end and by the two bolts and spring washers at the rear. Wire-lock the union nuts.

Tail-pipe thermocouple

38. Instructions for fitting the thermocouple to the tail-pipe are given in Sect. 3, Chap. 1. Before fitting it remove the blanking plug, and after fitting wire-lock the thermocouple to the blanking plug, adjacent to the thermocouple, with 22 s.w.g. stainless steel wire.

Air-intakes

39. Remove the air-intake blanking covers and, using a torch or inspection lamp, see that there is no forward-facing step at any point on the periphery of the joint at each end of the floating duct. It is not necessary to investigate rearward-facing steps at these points; such steps are permissible on Vampire aircraft for the tolerances are so arranged that the maximum specified cannot be exceeded, and in addition they are difficult to see from the front of the aircraft. With an inspection lamp placed below the aircraft examine, from above the engine, the gap between the floating duct and the engine air-intake. If the gap appears to be outside the limits:—0·080 in., and 0·200 in., check with AL 83
feeler gauges around the outside of the air-intake. Alternatively the gap may be inspected by using a mirror securely attached to the end of a long rod and checked, if necessary, with a feeler gauge made up of a piece of metal of suitable thickness securely attached to a rod. ***On no account place in the air-intake any material from which burrs or splinters can fall, and when checking the above gaps ensure that mirrors and feeler gauges are attached firmly to their rods.***

40. If the above requirements are not met it may be possible to rectify by slackening off the worm-drive clips securing the floating duct and adjusting the position of the duct in its sealing rings.

41. Roll back the rubber sealing rings over the engine air-intakes and feed the long worm-drive clips around the intakes. Join up the two ends of each clip and adjust the clip so that it is situated between the beading on the edge of the rubber and that on the edge of the air-intake. Tighten the clip.

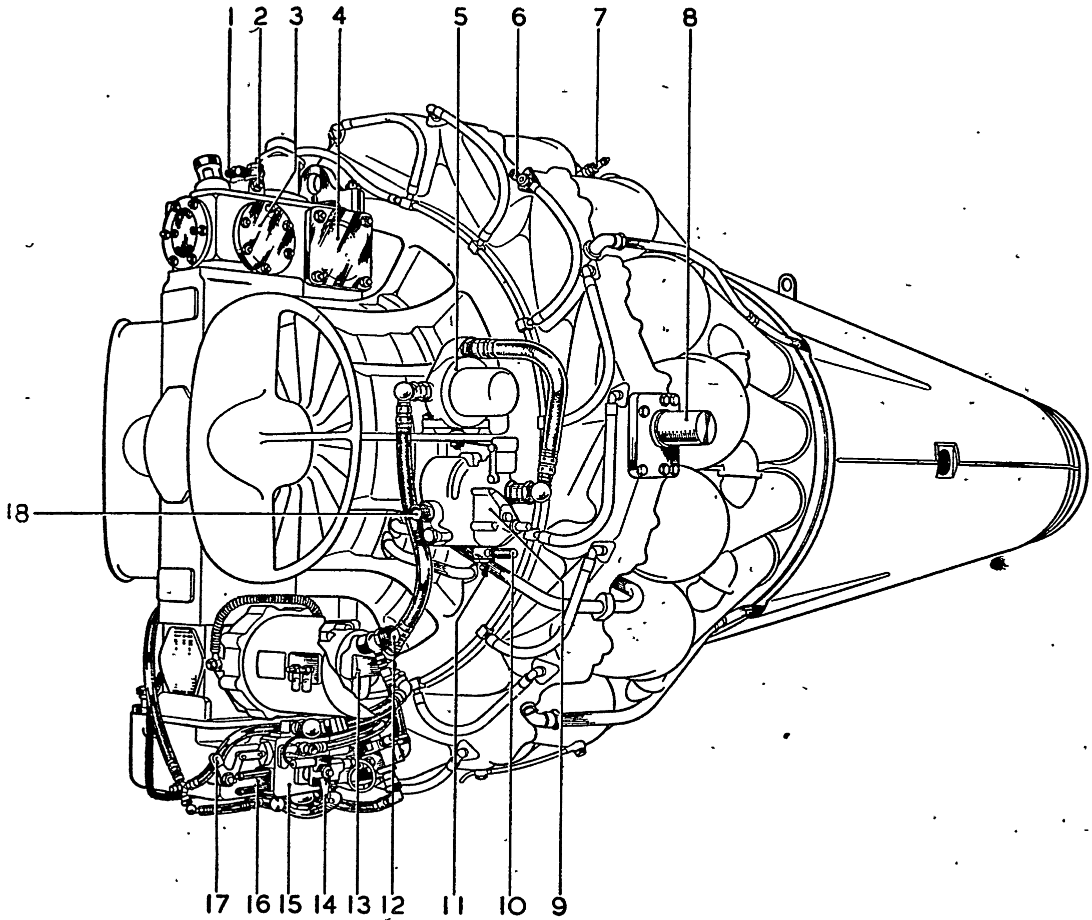
42. After all work has been completed see that nothing has been left in the air-intakes and replace the blanking covers immediately.

Tail-pipe fireguard

43. The instructions for assembling the fireguard are contained in Sect. 3, Chap. 1. It should be noted that the turbine disc cooling pipes (*para.* 37), the tail-pipe thermocouple (*para.* 38) and the tail-pipe drain (*para.* 61) must be assembled before the fireguard; and during the assembly of the fireguard the gun-heater muff pipes must be attached (*para.* 69).

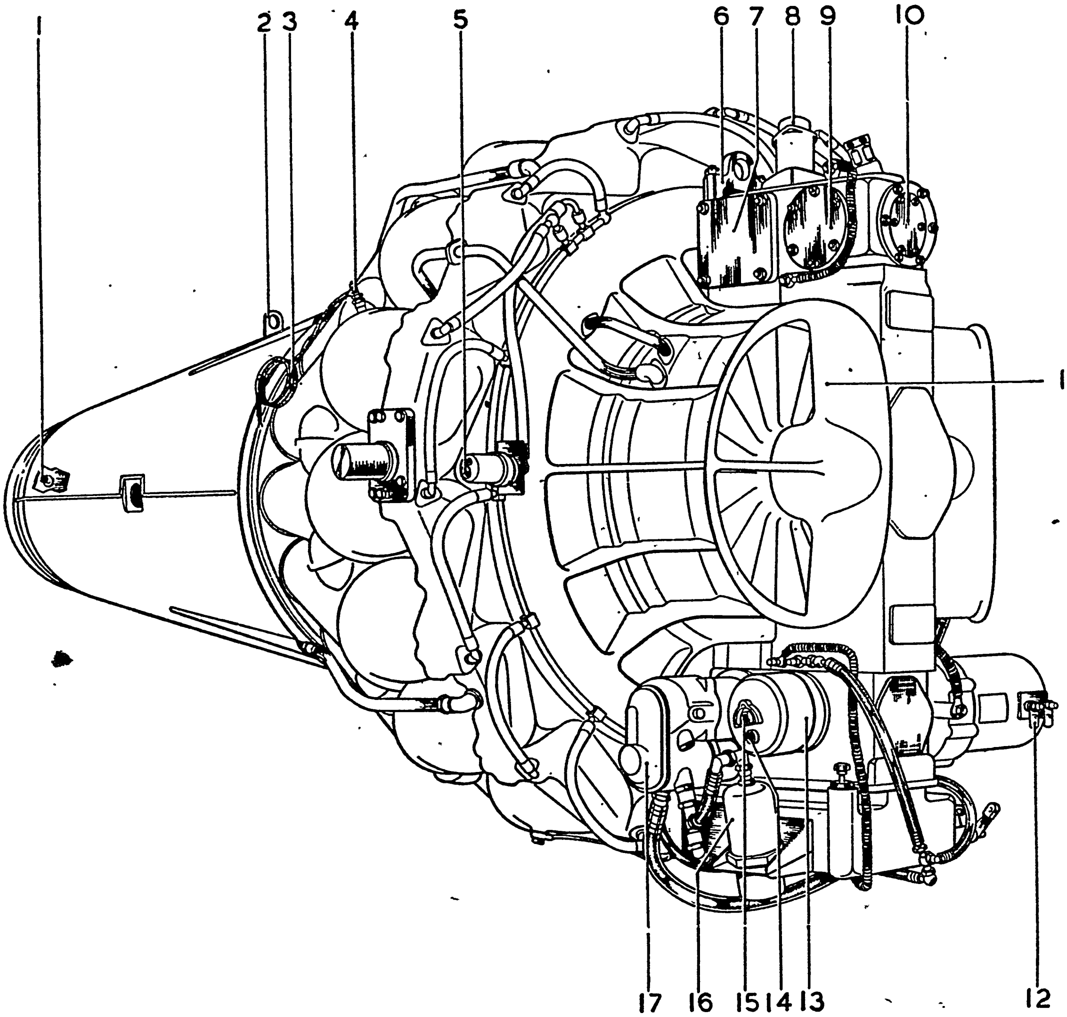
Cowl rails

44. The upper and lower rails for the engine cowls, in Vampire aircraft, are secured to the engine by stirrups attached by long bolts to the hollow diffuser casing bolts. If not already fitted, these should be attached at this stage, for various pipes and the common drain box are built into the assemblies. For instructions for fitting and adjustment of the rails and cowls see the relevant aircraft Air Publication.



1 OIL PRESSURE GAUGE CONNECTION
2 OIL TEMPERATURE GAUGE THERMOMETER POCKET
3 AIR COMPRESSOR MOUNTING (TRANSPARENT BLANK)
4 CABIN SUPERCHARGER MOUNTING (TRANSPARENT BLANK)
5 HIGH-PRESSURE FUEL FILTER
6 BURNER PRESSURE GAUGE CONNECTION
7 IGNITER PLUG
8 MOUNTING TRUNNION (3 SPACED AT 90 DEG.)
9 BAROSTAT
10 VENT TO ATMOSPHERE
11 BAROSTAT DRAIN
12 FUEL INLET
13 FUEL PUMP
14 HIGH-PRESSURE FUEL CUT-OFF CONTROL
15 CONTROL BOX
16 MINIMUM PRESSURE VALVE MOUNTING (BLANKED OFF)
17 THROTTLE CONTROL
18 BAROSTAT SPILL OR FUEL RETURN CONNECTION

Fig. 4. Goblin Mk. 2 installation connections (port)



1 JET PIPE TEMPERATURE THERMOCOUPLE (4 OFF)
2 REAR LIFTING EYE
3 REAR BEARING TEMPERATURE GAUGE THERMOCOUPLE LEAD
4 IGNITER PLUG
5 FUEL PRESSURE CUT-OUT SWITCH (IF FITTED)
6 FRONT LIFTING EYE
7 GENERATOR MOUNTING (STANDARD BLANK)
8 TACHOMETER GENERATOR (TERMINALS)
9 VACUUM PUMP MOUNTING (STANDARD BLANK)
10 HORIZONTAL DRIVE SHAFT HOUSING COVER
11 AIR-INTAKES
12 STARTER MOTOR TERMINALS
13 HYDRAULIC PUMP
14 HYDRAULIC PUMP OUTLET
15 HYDRAULIC PUMP INLET
16 FUEL ACCUMULATOR
17 OVERSPEED GOVERNOR

Fig. 5. Goblin Mk. 2 installation connections (starboard)

Oil connections

45. These engines have self-contained oil systems with the oil contained in the sump and not in an aircraft tank. With the exception of the drains, which are described in para. 53 to 62, there are therefore only two oil connections.

46. Remove the $\frac{1}{4}$ in. B.S.P. blanking nipple from the forward-facing leg of the double banjo on the front of the top accessory box cover, and, with a flexible pipe, connect it to the oil pressure transmitter. Wire-lock the union nut.

47. Remove the $\frac{3}{8}$ in. B.S.P. blanking nut from the oil thermometer pocket on the port side of the top accessory box cover. Insert the thermometer bulb and tighten and wire-lock the union nut.

Fuel system connections

48. Remove the one-inch B.S.P. blanking cap from the inlet of the Dowty fuel pump on Mk. 2 engines and connect up to the low pressure fuel filter. Wire-lock the union nuts. The L.P. filter will need to be fitted to the aircraft as it was removed before installing the engine. For detailed instructions, reference must be made to the aircraft Air Publication.

49. Mk. 3 engines have an inlet to each fuel pump, that for the starboard pump being accommodated on the port side at the end of a long flexible pipe. Remove the blanking cap from the port pump inlet and the blanking plug from the starboard pump inlet and connect them to the L.P. filter. Wire-lock the union nuts.

50. The barostat spill return on Mk. 2 engines is a $\frac{5}{8}$ in. B.S.P. union situated on the front of the barostat. Remove the blanking cap, connect up the flexible pipe and wire-lock the union nut.

51. The total head pressure hose-pipe must be connected to the banjo union beneath the barostat on Mk. 2 engines and a similar banjo on top of the B.P.C. in the case of the Mk. 3. As this connection has already been made on Mk. 2 engines during preparation of the engine, the aircraft pipe must be connected to the filter by means of a rubber hose and two worm-drive clips, and the end of the pipe must be attached by a clip to one of No. 3 burner studs. On Vampire aircraft fitted with Mk. 2 engines the total head pipe is part of the top cowl rail assembly. The total head pressure line is not complete until the other end is connected to a plain hose connection in the air supply pipe from the leading edge of the starboard wing to the gun-heater muff around the tail-pipe. On Mk. 3 engines, however, the total head union is connected to the filter at the bottom of the fire-wall and this is, in turn, connected to a small pipe welded to the cabin supercharger or cold-air radiator inlet on the port side.

52. Remove the blanking cap from the $\frac{1}{8}$ in. B.S.P. banjo connection on No. 3 burner, and connect up the fuel pressure gauge pipe. If no fuel pressure gauge is fitted ensure that the union is correctly sealed with a blanking nipple. Wire-lock the union nut.

Drains

53. On Vampire aircraft all drains at the front of the engine are connected by means of flexible pipes, to a common drain box built into the bottom cowl rail.

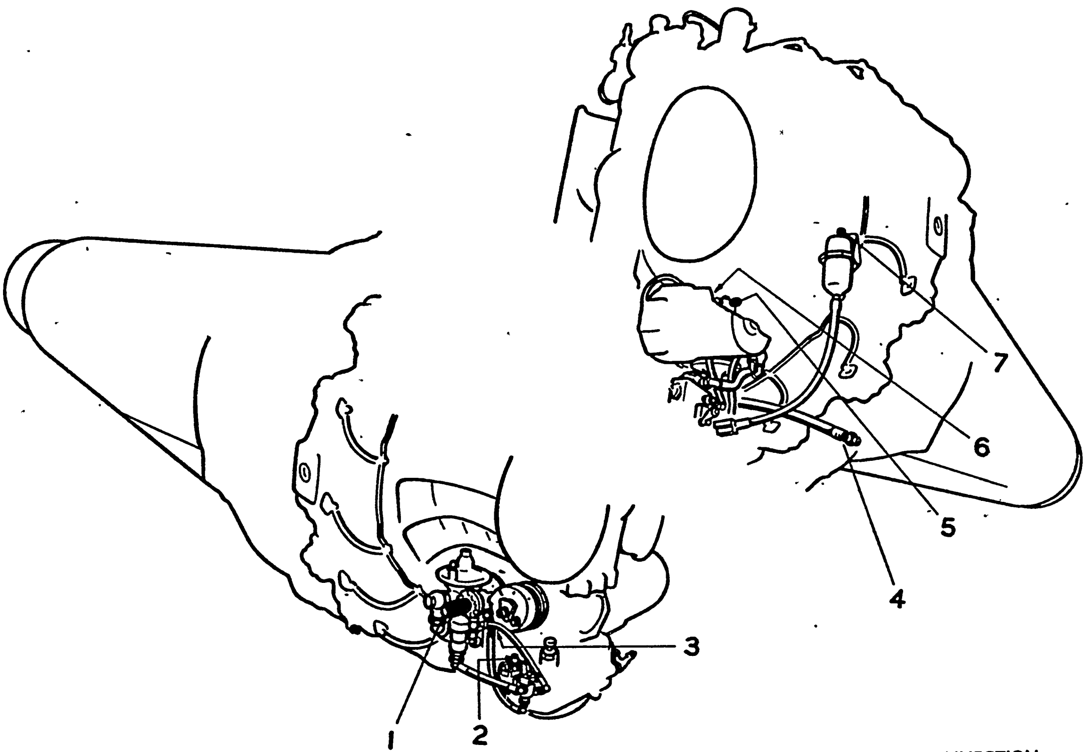
54. Remove the $\frac{1}{8}$ in. B.S.P. blanking cap from the rear bearing drain, situated on a bracket beneath the diffuser casing. Fit the pipe and wire-lock the union nut.

55. Remove the $\frac{1}{4}$ in. B.S.P. blanking caps from the unions beneath the pressure limiting valve and the dump valve. Connect up the drain pipes and wire-lock the union nuts.

56. Remove the blanking caps from the Mk. 2 overspeed governor fuel and oil drains. Connect the oil drain pipe to the $\frac{1}{4}$ in. B.S.P. union beneath the governor cover and the fuel drain pipe to the $\frac{1}{8}$ in. B.S.P. banjo on the rear side of the governor. Wire-lock the union nuts.

57. Remove the blanking caps from the $\frac{1}{4}$ in. B.S.P. fuel drain unions on the flanges of the Lucas fuel pumps on the Mk. 3. Connect up the flexible pipes and wire-lock the unions.

58. Unscrew the banjo bolt beneath the Mk. 2 fuel accumulator, and remove the blanking sleeve. Connect up with a banjo and two sealing washers, and re-insert the banjo bolt. On Mk. 3 engines the connection is a plain $\frac{1}{8}$ in. B.S.P. union situated on top of



1 FUEL PUMP ISOLATING SOLENOID
2 BAROMETRIC PRESSURE CONTROL TOTAL HEAD CONNECTION
3 STARBOARD FUEL PUMP SEAL DRAIN
4 STARBOARD FUEL PUMP INLET CONNECTION.
5 PORT FUEL PUMP INLET CONNECTION
6 PORT FUEL PUMP SEAL DRAIN
7 FUEL ACCUMULATOR DRAIN OR VENT

Fig. 6. Goblin Mk. 3 installation connections which differ from those shown in fig. 4 and 5

the accumulator to which the drain should be attached.

59. Attach the air compressor drain pipe to the $\frac{1}{8}$ in. B.S.P. union after removing the blanking cap. Tighten and wire-lock the union nut.

60. Remove the $\frac{1}{4}$ in. B.S.P. blanking cap from the connection on the drain valve beneath the combustion chamber. Attach the flexible drain pipe and wire-lock the union nut.

61. The tail-pipe drain stub-pipe must be attached to the union beneath the front end of the tail-pipe and the nut wire-locked. This union is inaccessible after the fireguard has been fitted.

62. Remove the rubber protection tube from the $\frac{3}{4}$ in. plain drain union beneath the front end of the fireguard, lower half. Push on the split stub-pipe and secure with a worm-drive clip.

Controls

63. After connecting up the following controls, they should be adjusted so that their travel is limited by the stops in the engine and not by the aircraft stops. To achieve this the aircraft cables, rods and stops only must be adjusted so that the control levers in the cockpit "spring" at each end of their travel, due to slight stretching of the aircraft cables as the control levers reach their stops. The engine stops must on no account be tampered with.

64. The fork-end of the throttle control bell-crank lever is attached to the lower end of the tie-rod in the Vampire by a 2 B.A. bolt and castellated nut. The nut must be securely split-pinned.

65. The H.P. cock lever is fitted with a ball-type connection. To connect up the control rod unscrew the plug in the end of the socket, press down the spring-loaded cap and push the socket on to the ball on the H.P. cock lever. Screw in the plug until it nips the ball and then unscrew it sufficiently to line up one of the split pin holes with a slot in the plug. Split pin the plug securely.

66. The cabin supercharger clutch control lever is similar to the H.P. cock control and is connected in the same manner. On Vampire aircraft ensure that the forward end of the control rod does not foul the cables on the firewall so limiting the travel of the cock. On aircraft not fitted with a cabin supercharger the control used to operate the hot-and-cold air valve must be connected and adjusted for correct operation.

67. The sump heating control cock fitted to Mk. 3 engines is fitted with a ball-type coupling and is connected in the same manner as the high pressure cock.

Air connections

68. Not all of the following air tappings may be required in every installation. The transport blank must therefore be removed from the unused connections and correct flight blanks fitted, otherwise leakage of air from the diffuser will occur.

69. The gun-heater pipes are connected to flanges each side of the muff on the tail-pipe, the inlet from the starboard wing leading-edge intake to the starboard flange and the outlet to gun-bay to the port flange. A gasket is placed between each pipe elbow flange and the heater muff flanges and the elbow is held by four H.T. bolts and shakeproof washers. The pipes between the elbows and the gun bay and the intake cannot be installed until after the engine is in place.

70. The fuel tank pressurization pipe must be connected to the ¼ in. B.S.P. connections on the end of the pipe which protrudes between No. 11 and 12 combustion chambers. Wire-lock the union

71. The windscreen de-mister pipe also protrudes between No. 11 and 12 combustion chambers; in this instance it is a ⅜ in. B.S.P. connection. Remove the blanking cap and attach the de-mister pipe. Wire-lock the union.

72. The canopy seal air supply pipe is situated between No. 1 and 16 combustion chambers. It has a ¼ in. B.S.P. connection and can be connected up after removal of the blanking cap. Wire-lock the union.

73. The cabin supercharger connection is a 1¼ in. B.S.P. connection between No. 2 and 3 combustion chambers and on Mk. 3 engines must be connected to the hot-and-cold air valve mounted above the alternator. The valve is connected to the inlet to the cabin and to the cold-air radiator mounted on top of the port bearer arm, the radiator being in turn connected to the cabin air-inlet. When this type of cabin supercharging is employed the tappings mentioned in para. 70 to 72 inclusive will not be fitted to the engine. Instead there are three unions welded to the pipe between the engine air tapping and the hot-and-cold air valve, two of these being used for fuel tank pressurizing and the third for canopy sealing.

Electrical connections

74. The tail-pipe thermocouple leads emerge from the fireguard at the top of the engine. There are no terminals on these leads, and in Vampire aircraft they should be connected to the rear terminal block on No. 1 starboard rib.

75. All engines are fitted with rear bearing thermocouples although not every type of Vampire is fitted with the related instrument in the cockpit. Even where the thermocouple is not needed for flight the terminal block is still fitted, and the thermocouple leads should be attached. The terminal block is just forward of the jet-pipe thermocouple terminal block on No. 1 starboard rib, and the rear bearing thermocouple leads are fitted with Chater-Lea type of terminals.

76. The high tension connection on each igniter plug in No. 2 and 14 combustion chambers has a 3 B.A. thread, the terminal being secured with two 3 B.A. nuts, one serving as a lock-nut. On Vampire aircraft the two H.T. leads pass through two rigid pipe conduits attached to the upper cowl rail. The other ends of the leads are connected to the booster coils which are strapped one above and the other below the top strut of the starboard engine bearer arm.

77. The pressure switch (Mk. 2) has a two-pin socket into which may be screwed a suitable plug with external thread (*Stores Ref.* 5X/6004). The switch is situated on the front casing just to starboard of the top accessory box.

78. Access is gained to the tachometer generator terminals by removing the terminal cover and the blanking cap from the union. Insert the cable, tighten the union nut and attach the leads to the appropriate terminal screws (red lead to terminal No. 1, green to No. 2, and blue to No. 3); replace the cover.

79. The oil temperature gauge is connected by inserting the plug into the end of the bulk socket. Tighten and wire-lock the bakelite union nut.

80. The isolating solenoid on the Lucas pump Mk. 3 is connected by removing the circular end cover, connecting up the leads and replacing the cover.

81. The starter terminals are protected by rubber shrouds, and these should be first pushed along their cables to expose the spade terminals. Connect up the cables to the appropriate leads; main series terminals on the side of the starter and shunt terminal on the back and secure the terminals with the spring washers and nuts. Pull back the terminal shrouds so that the terminals, nuts and washers are completely enclosed.

82. The electrical bonding of all non-metallic pipes, etc., must be carried out as instructed in the relevant aircraft Air Publication.

Aircraft accessories

83. The engine-driven aircraft accessories are connected up to their services as described in the aircraft Air Publication.

Checking the installation

84. Having completed all installation work carefully check all connections for tightness and ensure that all lockings are securely made. Ensure that the transport blanks have been removed from all drains and the connections made. Examine all unused connections to ensure that they are correctly blanked. See that all flexible pipes, or rigid pipes having long runs between supports, are lashed with waxed twine or Empire tape at the points where they cross other rigid pipes, bearer arm members, etc., to prevent chafing.

Prevention of corrosion

85. When the complete installation has been passed as satisfactory, a close scrutiny must be made for any damage done to the anti-corrosive protective coating. Any such damage must be rectified by applying lanolin resin protective D.T.D.663 with a suitable brush. At the same time all nuts, bolts, or other parts fitted during installation must be coated with lanolin resin protective whenever the surface is exposed.

Chapter 2

REMOVING

***Note.**—This chapter applies to Goblin Mk. 2 and 3 aero-engines*

LIST OF CONTENTS

General

1. The sequence of operations detailed in Chap. 1 when making the installation connections can be applied equally well to removal, by reversing the sequence and reading the word "connect" as "disconnect". Similarly the list, given in Chap. 1, para. 8, of blanks and transport spares to be removed during installation is the same as those that will require fitting when an engine is removed.

2. In some instances the engine will be removed temporarily in order that some work may be carried out, or an engine may be transferred from an unserviceable aircraft. In these circumstances not as much work will be involved as there would be if the engine was being removed for overhaul. In para. 8 to 11 some of the differences are enumerated, when an engine is being temporarily removed from a Vampire aircraft.

Prevention of corrosion

3. If the engine is not being re-installed immediately the engine and its fuel system must be inhibited as described in Sect. 4, before any connections are broken.

Preparing to remove the engine from airframe

4. In order to remove the engine from the airframe a portable crane and lifting sling as specified in Chapter 1 will be required. A transport stand must be available to receive the engine and a complete set of blanks and transport spares as listed in Chap. 1, para. 8, should be available.

Disconnections

5. Reference should be made to para. 42 to 83 of Chapter 1, each paragraph being read in reverse order; i.e., read the words "connect up" as "disconnect" and "remove the blanking cap" as "fit the blanking cap", and reverse the sequence of operations.

6. When disconnecting the fuel pump inlet pipes from the L.P. filter remove the filter completely as it will obstruct the removal of the engine.

7. As soon as the throttle is disconnected the throttle needle should be closed and wired in this position, because it is then less exposed and less likely to become damaged.

8. If the engine is to be placed on a transport stand after removal it will be necessary to remove the tail-pipe. However, it is inadvisable to carry out any work on an engine which is swinging on a crane therefore it will be necessary to remove the four turbine disc cooling pipes from the tail-pipe and forty-five nuts and bolts securing the tail-pipe. The tail-pipe is left secured to the engine by four equidistant nuts and bolts so that it will be easier for the man grasping the rear of the engine to guide it out of the airframe.

Disconnections—Temporary removal of engine

9. As explained previously the paragraphs under this heading show how certain operations may be omitted when an engine is being removed temporarily, but the instructions contained in para. 5 to 7 inclusive will still be applicable.

10. If it is more convenient flexible pipes can be disconnected at the aircraft end instead of at the engine connections. Rigid pipes between the engine and aircraft, which are connected by a short hose at each end, should be disconnected at both ends because the short hose is not sufficiently flexible to keep the pipe clear of obstructions. An example of this is the cabin supercharger pipes and silencer.

11. The top cowl support rail need not be removed from the engine, but it should be disconnected, at each end, from No. 1 ribs. The fire extinguisher pipes will have to be disconnected but the H.T. leads need be disconnected only from the booster coil. The complete total head pipe can be left in position after being disconnected from the heater muff inlet pipe.

12. The bottom cowl rail must be removed completely otherwise it will prevent the engine being lifted out of the bay. Disconnect the fire extinguisher pipes and drains; the other ends of these should be left connected to their components.

Withdrawing the engine

13. Ensure that all connections have been disconnected. Check also that all pipes, wires, control rods, etc., are securely stowed out of the way so that they will not foul as the engine is withdrawn; the instructions regarding these points contained in para. 16 to 26 inclusive of Chap. 1 are also applicable to removal of the engine.

14. Attach the engine lifting sling to the lifting eyes and just take the weight of the engine. Station four men around the engine and one on the tail-pipe as for installation. Remove the engine bearer bolts, the lower bolts first.

15. Make a final check that all connections have been broken and that nothing is liable to hinder the withdrawal of the engine. Carefully move the engine backwards to the cut-out portion of the engine bay, and slowly raise the engine clear of airframe. Avoid letting the engine swing, otherwise damage will be caused through contact with the airframe parts.

16. Lower the engine to within working height of the floor so that the engine can be prepared for the transport stand. All the following operations will not be necessary for engines which have been temporarily removed; it will depend on the type of work to be done on the engine. If work other than that prescribed here is to be carried out and the transport stand is unsuitable for this work, on no account must anything be done whilst the engine is swinging on the crane. Under these circumstances the engine must be lowered into a strip-and-assembly stand.

Setting on transport stand

17. Before the engine can be transferred to the transport stand the tail-pipe must be removed. Remove the four remaining bolts and nuts securing the tail-pipe; remove the latter and fit the turbine blanking cover, Part No. 70554.

18. Secure with six bolts each the three flanged support trunnions to the recessed faces on each side and below the engine. Assemble a brass bearing bush to each of the two side trunnions and lower the engine on to the transport stand. Secure the three bearing caps.

Removal of accessories

19. Remove the accessories and reverse the sequence of operations given under "Preparation of engine" in Chap. 1, para. 9 to 14.

Blanks and transport spares

20. It is advisable to fit blanks and aperture covers immediately the relevant component is removed from the engine or a connection is broken, and the airframe portion of the connection should be blanked off at the same time. If this policy is followed, the majority of blanks and transport spares will have been fitted, at this stage, but a careful check must be made to ensure that all items listed in Chap. 1, para. 8, have been correctly dealt with.

Completion of anti-corrosion treatment

21. Carry out the remainder of the anti-corrosion treatment as specified in Sect. 4, If the engine is faulty and the impeller cannot be rotated inhibit the engine internally as far as possible.

Packing the engine

22. When the engine is to be transported overseas it must be installed in the cylindrical metal type of container illustrated in Chap. 1. For home transport the engine can be installed in the wooden transit case, also illustrated in Chap. 1. The tail-pipe and fire-guard should be packed in the wooden tail-pipe transit case both for home and for overseas transport.

Installing the engine in the cylindrical metal container

23. Assemble the lifting tackle and hoist the engine clear of the transport stand. Attach the rubber bushes to the two transverse flanged support trunnions then lower the engine into the bottom half of the metal drum ensuring that the bottom flanged support trunnion is entered in its bushed socket. Remove the lifting tackle. Suspend six linen bags each containing 1 lb. of silica-gel from approximately evenly spaced locations on the engine and container. If the rubber sealing gasket is not securely affixed to the flange of the container lower half, clean the face and evenly coat it with a sealing compound approved for this purpose, such as Bostik cement, then position it on the flange. Evenly coat the top face of the gasket with mineral jelly. Check that the four loose air feed pipes are blanked off with adhesive tape (*Stores Ref.* 32B/793) then securely tie the pipes to a convenient part of the engine. Ensure that the igniter plugs and other loose equipment specified in the engine checking list are packed in linen bags and tied to the engine. Insert a humidity indicator card into the window in the container. Assemble the four-piece lifting chain, hoist the container top half and lower it over the bottom half until the flanges abut. Secure the container halves with fifty-two nuts and bolts. Insert the log book and any other relevant engine documents into their tube and seal with the screw cap.

Installing the engine in the wooden transit case

24. Hoist the engine from the transport stand, ensure that the three flanged support trunnions are secure, assemble rubber bushes to the transverse trunnions, then lower the engine on to the base stand of the case. Remove the lifting tackle. Secure the caps to the transverse trunnion bushes. Ensure that the air pipes, igniter plugs and other loose equipment specified in the engine checking list together with the log book and any other relevant engine documents are securely tied to a convenient part of the base stand. Hoist the lid of the transit case, lower it into position in the guides of the base and secure it with the nuts and bolts.

Installing the tail-pipe and fireguard in their wooden transit case

25. Prepare the wooden tail-pipe and fire-guard transit case by removing the lid and the straps of the two tail-pipe support diaphragms. Check that the felt is secure in the diaphragm grooves and lower the tail-pipe into the cradle formed by the diaphragms. Assemble the straps over the tail-pipe and secure them with nuts to the diaphragm. Cover the tail-pipe with a layer of grease-resisting paper (*Stores Ref.* 32B/820 *or* 799), then a layer of felt and another layer of grease-resisting paper. Place one-half of the fireguard over the tail-pipe then cover it with another layer of grease-resisting paper and felt followed by the other half of the fire-guard. Secure the components by tying the webbing attached to the case. Screw the lid to the case.

SECTION 2
STARTING AND

SECTION 2

STARTING AND GROUND CHECKING

SECTION 2

STARTING AND GROUND CHECKING

LIST OF CHAPTERS

***Note**—A list of contents appears at the beginning of each chapter*

R E S T R I C T E D

Chapter 1

PREPARING FOR SERVICE

***Note**—This chapter applies to Goblin Mk. 2 and 3 aero-engines*

LIST OF CONTENTS

General

1. The instructions contained in this chapter describe operations which must be carried out before an engine which is newly installed or which has been stored, is started for the first time. General precautions to be taken before starting and the procedure for starting an engine, are detailed in Chapter 2.

2. When more than one motoring cycle is necessary, time must be allowed for the starter motor to cool. It is permissible to carry out three cycles with a two-minute interval between each, followed by a twenty-minute interval after the third cycle. The engine must have ceased rotation before a fresh motoring cycle is attempted.

3. Scrupulous cleanliness, and the proper use of the correct tools are important. The engine-driven fuel pumps are fuel lubricated and to avoid damage the engine must not be rotated without fuel in the pumps. The L.P. fuel cock must therefore be OPEN and the aircraft tank must contain fuel whenever the engine is motored over.

4. Except when their removal is essential in order to perform some particular operations, dust covers must be kept on the air-intakes and on the propelling nozzle; they must be refitted immediately such operations have been completed.

5. To obviate risk of the engine being started unintentionally, whilst work is in progress, ensure that the L.P. fuel cock lever, the H.P. fuel cut-off lever, and the starter (linked master) switches are in the OFF position except where they are required to be ON for specific checks.

6. At the completion of preparation, ensure that no loose parts, tools, or rags are left lying about the engine or cowling; particularly examine the air-intakes and ducts leading to the impeller. The subsequent ground run must be made with the cowling open so that a thorough examination may be made for fuel leaks.

Preliminary checks

7. Make a thorough visual examination of all external fittings and accessories to ensure that the engine is complete and has not been damaged whilst in transit or being installed. Ensure that the appropriate oil feeds are correctly connected to the relevant accessories.

8. Examine the connections of each engine instrument both at the engine attachment and in the cockpit. Ensure that all thermocouple leads are properly supported and clear of the engine. Check the electric wiring to the starter motor, and to the fuel pump isolating valve on the Mk. 3. Check the low tension wiring to the high energy ignition units on the engine.

9. Examine the welding of all sheet metal work as thoroughly as possible without undertaking any dismantling.

10. Check that all external bolts, nuts, screws, unions, etc., on the engine and its mounting structure are tight and properly locked. Check the airframe fittings and components in the engine bay in accordance with any instructions given in the relevant aircraft Air Publication.

11. Ensure that all pipes are correctly connected and that all unions are tight and securely locked, with the exception (Mk. 2 only) of the fuel return (spill) pipe connection on the forward face of the barostat which should be left disconnected and blanked until the fuel system is primed and de-inhibited. Do not wire-lock the fuel supply pipe union nut at the pump inlet connection. Check that each burner is securely tightened, and ensure that the flexible pipe unions and adapters are separately locked by wire to the existing lockwire tabs.

Note . . .
Ensure that the blanking cap has been removed from the starting valve adjusting plug, and that the air vent in the end of the plug is free from obstruction.

12. Examine all drain connections to ensure that they are clear and that all drain pipes have an uninterrupted fall from the engine to the exit point.

13. Check the level of the oil in the sump with the dip-stick and if necessary replenish to the correct level as described in Chapter 2.

14. The H.P. fuel cut-off and the throttle must be checked to ensure that the direction of movement of the cockpit levers agrees with that of the relevant controls on the engine. It must also be ensured that the travel of the control valve plunger is limited by the slow-running stop in the control box on the engine and not by any stops in the airframe portion of the control system, and (except where the throttle switch has been deleted by Vampire Mod. No. 921) that the pilot's throttle lever operates the throttle switch when the plunger is in the slow-running position. Also check that the control valve plunger can reach the MAXIMUM R.P.M. position (there is a positive stop in the control box on the engine) before the pilot's lever reaches the end of its travel. If any corrections are necessary, adjustment must be made to the airframe control system and not to the stops on the engine control box.

15. *Mk. 2 only.* It is of particular importance, that whenever the H.P. cut-off valve control has been disconnected from the engine, or has been re-adjusted, the check specified in para. 40, Op. 3 must be carried out.

Priming the front and rear bearings

16. Prior to installation, the engine may have been standing in a vertical position which would cause the oil to drain away from the front and rear bearings. The engine must not be started after installation until the bearings have been primed with oil; in the case of the rear bearing, priming must be continued until a flow of oil is observed from the rear bearing drain pipe. Similarly, if the front or rear bearing oil supply has been disconnected since the previous engine run the bearing(s) must be primed before the engine is next started. Priming can be carried out using a syringe such as T.72894 or test trolley T.78458. In either case the priming pipe must be fitted with an adapter simulating the pipe which has been disconnected or removed. It can be a long and tiresome process to prime the rear bearing with the aid of a syringe, especially when the weather is cold, even though the oil is thoroughly preheated. In such cases where test trolley T.78458, which embodies a heater, is not available, if a pump such as a Ki-gass priming pump is mounted vertically in a box, or a suitable stand, and a length of pipe used to connect the priming pump outlet to the rear bearing feed pipe, a 50 lb. weight may be placed on the plunger of the priming pump and the oil automatically forced into the bearing whilst other servicing operations are performed. If a spring-loaded hand-operated pump, such as those used to spray de-icing fluid on to aircraft windscreens, is used, even a 50 lb. weight will be unnecessary.

17. To prime the front bearing proceed as follows.

(1) *Pre-mod.* 1101 (*Goblin Mk.* 2) *and pre-mod.* 1109 (*Goblin Mk.* 3). Cut the locking wire and unscrew the banjo bolt from the front bearing metering pump. Cut the locking wire and unscrew the cap nut from the upper end of the front bearing metered oil pipe. Remove the oil pipe and the banjo washers.

Mod. 1101 (*Goblin Mk.* 2) *and Mod.* 1109 (*Goblin Mk.* 3). Cut the locking wire and remove the cap nut from the connector at the upper end of the front bearing metered oil pipe. Screw adapter, Part No. T77097 ($\frac{1}{8}$ in. B.S.P. female to $\frac{1}{4}$ in. B.S.P. male), onto the connector.

(2) Connect a syringe, or one of the alternatives suggested in para. 16, to the oil inlet connection on the front casing (*pre-mod.* 1101 *or* 1109), or to the adapter (*mod.* 1101 *or* 1109).

(3) Gently force about $\frac{1}{8}$ pint of clean filtered oil of the correct specification into the front bearing.

(4) *Pre-mod.* 1101 (*Goblin Mk.* 2) *and pre-mod.* 1109 (*Goblin Mk.* 3). Fill the disconnected oil pipe with oil, and, with as little delay as possible, to mimimize the loss of oil from the duct in the front casing, disconnect the syringe and refit the pipe. Wire-lock the banjo bolt and the cap nut.

Mod. 1101 (*Goblin Mk.* 2 *and Mod.* 1109 (*Goblin Mk.* 3). Disconnect the syringe and the adapter, and, with as little delay as possible, to minimize the loss of oil, refit the cap nut. Tighten and wire-lock the cap nut.

18. To prime the rear bearing proceed as follows.

Note . . .
Mod. 1101 (*Goblin Mk.* 2) *and Mod.* 1051 (*Goblin Mk.* 3) *introduce a two-way banjo on the metering pump, and where either of these modifications is embodied, the removal of the union nut and nipple plug from the banjo renders operation* (1) *unnecessary.*

(1) *Goblin Mk. 2.* Cut the locking wire. Unscrew the union nut which couples the rear bearing metered oil pipe to the banjo on the metering pump. Unscrew the banjo bolt from the metering pump. Remove the banjo and the two washers. Connect a length of flexible hose to the open end of the rigid pipe.

Goblin Mk. 3. Cut the locking wire. Unscrew the union nut which couples the front half of the metering pump to rear bearing pipe to the forward side of the bracket on the diffuser casing. Unscrew the banjo bolt from the metering pump and remove the pipe and the two banjo washers.

Note . . .
In the case of the Goblin Mk. 2 it is permitted to connect a flexible hose to the end of the rigid pipe because the connection at the bracket on the diffuser casing is very inaccessible when the engine is installed in an aircraft.

In both cases it is recommended that the banjo should be detached from the metering pump, instead of simply disconnecting the pipe from the banjo, as, where Bundy piping is fitted (Mod. 765), the pipe enters the union and the banjo for an appreciable distance and, therefore, if an attempt were made to withdraw the pipe from the banjo, whilst the latter remained attached to the metering pump, the pipe might be distorted seriously.

(2) Cut the locking wire and disconnect the rear bearing drain pipe from the forward side of the bracket which is bolted to the lower portion of the diffuser casing.

(3) Connect a syringe, or one of the alternatives suggested in para. 16, fitted with a suitable adapter, to the oil feed connection (*pre-mod.* 1101 *or* 1051), or to the banjo (*mod.* 1101 *or* 1051).

(4) Gently force clean filtered oil of the correct specification, through the oil feed pipe into the rear bearing, until a flow is observed from the drain union. 50 to 100 c.c. of oil should be sufficient. Over-priming, or priming at too rapid a rate, should be avoided, as the absence of oil seals in the rear bearing and the liberal clearances between the emergency bearing surfaces will permit oil to flow into the centre casing and down the face of the turbine disc, rather than through the drain pipe.

(5) *Goblin Mk.* 3, *pre-mod.* 1051. Fill with oil the front half of the metering pump to rear bearing pipe.

(6) With as little delay as possible, to minimise the loss of oil from the metering pump to rear bearing oil pipes, disconnect the syringe and reconnect the normal oil pipe (*pre-mod.* 1101 *or* 1051) or refit the union nut and nipple plug (*mod.* 1101 or 1051).

(7) Reconnect the drainpipe.

Note . . .
If these pipes (*Op.* 7 *and* 8) *are of the Bundy type* (*Mod. 765 pre-mod. 1051*) *the instructions given in Sect. 3, Chap. 1, para. 5A to 5D must be adhered to strictly.*

(8) Correctly tighten and wire-lock the union nuts and the banjo bolt.

Priming the starter gearbox

19. Prior to assembly to the engine, ensure that the starter gearbox is primed with oil. A metering orifice is incorporated in the connection and priming will be facilitated if the oil is warmed. A ¼-pint of oil will be required if the gearbox has been drained. Unscrew the cap-nut which secures the flexible pipe to the banjo pillar in the gearbox casing and force the required quantity of oil to the correct specification into the gearbox with a suitable syringe.

Priming the fuel system

20. The fuel system should be primed as far as the pump (or pumps) and on Mk. 3 engine the air bled out of the pump (or pumps) on each occasion that the low pressure fuel filter, which is an airframe component, is removed for cleaning or when the system has been disconnected for a servicing operation or when the L.P. fuel cock has been switched OFF in an emergency whilst the engine was still running.

21. With a newly installed engine or one that has been inhibited, complete priming of the fuel system will be carried out as part of the de-inhibiting procedure described in para. 23 to 32. Slacken the fuel supply pipe union nut sufficient to allow the pipe to be eased back from the connection on the engine-driven fuel pump (or pumps) which are mounted on the bottom accessory box. Ensure that the H.P. fuel cut-off lever is in the CLOSED position; move the L.P. fuel cock lever to the ON position and switch ON the tank booster pump until fuel leaks continuously from the connection (or connections); then tighten and wire-lock the union nut (or nuts). The remainder of the system will be primed automatically as the engine starts.

22. Should the engine fail to start due to insufficient fuel in the system, it will usually start satisfactorily at the second attempt, but this must not be made until the rotating parts of the engine have come to rest and any unburnt fuel drained from the engine. With Mk. 3 engines it is necessary to bleed all the air out of the pump (or pumps) before the system is fully primed. This must be done to ensure the satisfactory operation of the overspeed governor mechanism incorporated in the fuel pumps. The bleed valve of the starboard pump (dual pump installations) consists of a small piston, situated on the overspeed diaphragm cover. With the tank booster pump switched ON, use a thin rod or screwdriver to depress the valve; the valve must be depressed fully to ensure bleeding both sides of the diaphragm. The fuel flow will cease after a few seconds but bleeding must be continued until all the air has escaped. The port pump (single and dual pump installations) is bled through a remote valve fitted to the end of a pipe which is situated near the fuel accumulator. Depress the valve until fuel commences to flow.

De-inhibiting the fuel system

23. With a newly installed engine the checks required in para. 7 to 15 must be carried out, and the front and rear bearings and the starter gearbox must be primed before the fuel system is de-inhibited. The interior of the engine will be automatically de-inhibited during the first normal start. Opportunity may be taken during the simulated starts which the de-inhibiting process necessitates to check the operation of the igniter plugs and the starting cycle as described in para. 33 to 38.

24. Slacken the fuel supply pipe union nuts and ease the pipes back from the fuel pump inlet connections, then prime the fuel system as far as the fuel pumps as described in para. 20 to 22.

Mk. 2

25. Disconnect the anti-hammer pipe between the control box and the fuel pump at the pump inlet connection and fit blanks to both unions. Disconnect or remove the blank from the fuel return (spill) pipe connection on the forward face of the barostat and place a half-gallon container underneath to collect the fluid which will be ejected.

26. Short-circuit the fuel pressure switch by breaking the locking-wire and moving the auxiliary starting switch to the ON position. If a fuel pressure switch is not fitted, simply move the auxiliary starting switch to the ON position.

27. Simulate a start in accordance with the starting drill detailed in Chapter 2, but with the throttle and the H.P. fuel cut-off levers in the CLOSED position. During the motoring over period, inhibiting fluid and fuel should be ejected from the barostat return connection. The operation of the igniter plugs and the starting cycle may be checked at the same time.

28. Remove the blank from the disconnected end of the anti-hammer pipe and place the open end of the pipe into a suitable container to receive the fuel that will be expelled from the pipe during the next operation.

29. Move the H.P. cut-off lever to the open position and simulate a second start in accordance with the recommended starting drill, but immediately the starting cycle has been initiated (starter button released) open the throttle fully. The operation of the igniter plugs and the starting cycle may be rechecked if desired. Immediately the engine has attained its maximum motoring speed (1600–1700 rev./min.), move the H.P. fuel cut-off lever to the CLOSED position, when fuel should be expelled from the disconnected anti-hammer pipe.

30. When the results of these checks are satisfactory, return the auxiliary starting switch to the OFF position. If a fuel pressure switch is fitted, wire-lock the auxiliary starting switch in the OFF position. Remove all blanks and connect the fuel pipes to their respective adapters; tighten and wire-lock the union nuts.

Mk. 3

31. The auxiliary starting switch is normally wire-locked in the ON position. Move the H.P. fuel cut-off lever to the OPEN position and close the throttle. Simulate a start in accordance with the starting drill detailed in Chapter 2, but as soon as the start is initiated OPEN the throttle. This will cause the inhibiting fluid to be expelled into the combustion chambers. The operation of the igniter plugs and the starting cycle may be checked at the same time.

32. Simulate a second start in accordance with the recommended starting drill, but with the throttle and the H.P. fuel cut-off levers in the CLOSED position to allow air to flow through the combustion chambers. The operation of the igniter plugs and the starting cycle may be rechecked if desired.

Starting system checks

33. The starting system is described in Volume 1, Section 1, and a knowledge of the information contained in that section will assist in assessing the results obtained when checking the starting system. The check detailed in the following paragraphs is intended to check the operation of the electrical equipment; since the fuel pressure switch will be short-circuited or, where this switch is not fitted, the auxiliary starting switch will be closed, the operation of the automatic time switch will also be proved. This check can conveniently be combined with the simulated starts required for de-inhibiting the fuel system.

34. *Mk. 2 pre-mod. 984 and Mk. 3 pre-mod. 830 only.* Remove the two igniter plugs and examine them to ensure that they are clean and serviceable. Connect the plugs to their respective H.T. leads and earth them firmly to the combustion chambers so that the electrodes can be seen. Ensure that the H.T. lead and terminal of the centre electrode are clear of any adjacent metal parts.

35. Move the H.P. fuel cut-off lever to the CLOSED position to prevent the combustion chambers being flooded; in the case of the Mk. 2, short circuit the fuel pressure switch or switch ON the auxiliary starting switch, as described in para. 26. Without touching either the H.P. fuel cut-off lever, or the auxiliary starting switch, simulate a start in accordance with the starting drill detailed in Chapter 2 and make the following observations of the times and rev./min. attained during the starting cycle.

(1) The time in seconds after release of the starter button to commencement of acceleration to "light-up" speed.

(2) The time in seconds after release of the starter button to automatic switch-off of the starter motor.

(3) The maximum rev/min attained during the motoring period.

(4) The operation of the igniter plugs.

36. If the starting system is functioning correctly the observed times and rev/min should be approximately:—

(1) 4 to 7 seconds.

(2) 32 to 42 seconds.

(3) 1,600 to 1,700 rev./min.

37. *Mk. 2 pre-mod. 984 and Mk. 3 pre-mod. 830 only.* When checking the igniter plugs the centre electrodes should glow for approximately ¼-inch of their length. Steady arcing should occur between the centre and earth electrodes. If the centre electrode does not glow, try the effect of changing over the primary leads to the relevant booster coil. In bright sunlight it may be necessary to shade the igniter plug before the glow can be seen. If it is considered that there is any risk of fire from the exposed arcing electrodes a suitably ventilated transparent shroud may be used to enclose the end of each igniter plug. If the performance of the starting system is satisfactory, refit the igniter plugs and connect the respective H.T. leads.

38. *Mk. 2 Mod. No. 984 and Mk. 3 Mod. No. 830 only.* To check the functioning of the high energy ignition equipment, do not remove any component but listen for the discharge at each igniter plug; the discharge should be clearly audible.

Ground running checks

39. After completion of the preparation and checks described in this chapter the engine is ready for ground tests.

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40. Start the engine as described in Chapter 2, and carry out the ground running checks detailed in that chapter, but with the following additional checks.

(1) Ensure that there are no leaks at any point in the lubrication or fuel systems.

(2) Ensure that there are no air or gas leaks from the engine.

(3) *Mk. 2 only*. Whenever the H.P. cut-off valve control has been disconnected from the engine, or has been readjusted, run the engine at 9,700 rev./min. with an observer watching the fuel drain on the control box, and move the H.P. cut-off valve control lever in the cockpit towards the rear. Absolutely no dumping of fuel is to take place until the cockpit lever has been moved at least ¼ in. past the spring gate towards the CLOSED position. Where this requirement cannot be met, the angular setting of the lever on the H.P. cut-off valve in the control box on the engine and the lever on the layshaft (airframe part) must be checked in accordance with the instructions in the relevant aircraft Air Publication, and reset if necessary.

41. Gas leaks will be indicated by smoke issuing from leaking joints or from under the tail pipe fireguard, but this should not be confused with the smoke which will inevitably issue from a newly installed or fully inhibited engine as the inhibitor is burnt off. If there is any doubt the check should be repeated after the engine has done some running.

42. Fit all cowling panels and inspection doors and ensure that they are securely attached, referring, if necessary to the relevant aircraft Air Publication for any special instructions. Ensure that there is an annular clearance between the engine cowling and the rear of the propelling nozzle.

Chapter 2

STARTING AND CHECKING

Note.—This Chapter applies to Goblin Mk. 2 and 3 aero-engines

LIST OF CONTENTS

Introduction

1. This chapter contains instructions for starting the engine, making the required ground checks and stopping the engine, while the aircraft is in service. Reference should be made to Volume 1, Section 2 of this Air Publication for detailed information of the starting cycle and equipment. The precautions given in the following paragraphs should be strictly observed during any period of ground running.

General

2. Before starting the engine ensure that:—

(1) No personnel are within five yards of the air-intakes.

(2) The ground immediately in front of the aircraft is free from scraps of paper, small stones and other light articles liable to be drawn into the air-intakes.

(3) The aircraft is positioned so that the jet is not directed towards any building, vehicle, or other aircraft within a distance of 50 yards; no inflammable material, however stored or contained, should be within 25 yards.

(4) The aircraft is headed as nearly as possible into wind.

(5) The aircraft is standing on concrete, or grass, not tarmac.

(6) Debris guards are fitted to the air-intakes.

3. Should personnel or motor transport vehicles pass close to the front of the aircraft whilst the engine is running at large throttle openings, the engine should be throttled back.

4. Dust covers must be kept on the air-intakes and propelling nozzle whenever the engine is not running, and they should not be removed until immediately before starting. If a take-off is not contemplated, the air-intake covers should be replaced by wire mesh debris guards.

Oil level

5. The correct lubricating oil is specified in the Operating Limitations in Vol. 1, and clean oil of the correct specification only may be used. The capacity of the lubrication system is 14½ pints, but when filling a completely dry engine the initial quantity required will be only 12½ pints. About 2½ pints of this will fill the pockets in the top and bottom accessory boxes, the remainder filling the oil sump to capacity. After a short engine run to prime the lubrication system, the remaining 2 pints may be added, after checking the sump level as described in para. 6. Filling should be carried out with the dipstick removed, so that any trapped air can escape. The oil sump has a capacity of 10 pints. The minimum quantity of oil required in the sump for satisfactory operation is 5 pints, and operating the engine with less than this quantity in the sump is likely to affect the working pressure of the lubrication system. Overfilling must be avoided, as the bottom accessory box gears will be submerged and cause leakage. Such leakage may be into the air-intake, with consequent cabin air pollution and fire hazard.

6. To check the oil level, release the knurled locking nut, which is immediately below the dipstick knob at the starboard front corner of the sump, and unscrew and withdraw the dipstick. Note the oil level registered on the graduated dipstick. Remove the oil filler cap from the top accessory box and, using clean oil of the correct specification, add only the required amount as determined from the dipstick. The added oil will take some time to percolate through to the oil sump and there is no need to recheck the sump level. Replace the filler cap and replace and tighten the dipstick.

STARTING THE ENGINE

7. Before starting an engine which is newly installed or which has been inhibited, or has had certain components removed for servicing operations, the appropriate procedure and checks described in Chapter 1 must be carried out. If the fuel system, or the front or rear bearing oil supply line has been disconnected since the previous engine run, ensure that they are primed as described in that chapter. Check the oil level and replenish if necessary. If the ambient temperature is below the minimum specified for the oil in use, the oil should be warmed to at least this temperature before filling, or the engine should be heated with a ground heater unit until the oil temperature reaches this value. Remove the air-intake and propelling nozzle covers, and, if an immediate take-off is not contemplated, replace the former by wire mesh debris guards. When ground running during times of low ambient temperature and high air moisture content, e.g. fog at low temperature, ice may form on the wire mesh debris guards which are fitted over the air-intakes. This can result in air starvation and partial collapsing of the air-intake ducting, particularly when the engine is running at large throttle openings. Under such atmospheric conditions a careful watch should be kept on the wire mesh debris guards during ground running, and if ice is seen to be forming on them, the engine should be stopped and the debris guards removed. Before proceeding, ensure that there are no indications of collapsing of the air-intake ducting. Ensure that no loose parts, tools, or rags are lying about the engine; particularly examine the air-intakes and ducts leading to the impeller.

Starting drill

8. The recommended starting procedure which should be closely adhered to is detailed in the following paragraphs.

Note . . .
It is most important that no attempt is made to re-start the engine until it has ceased rotating, otherwise shock engagement of the starter dogs will occur and serious internal damage may result.

(1) Plug in and switch on a 230 ampere-hour 24 volt ground starter battery.

(2) Check the oil temperature; no attempt must be made to start with an oil temperature below the minimum specified for the oil in use.

(3) If a cold air unit is fitted, ensure that the cabin air control is in the OFF position.

(4) Move the L.P. fuel cock lever to the ON position.

(5) Pull the throttle lever hard back against the slow-running stop, thus closing the throttle switch (if fitted) which completes the starting circuit when the starter switch is ON. With Mk. 3 engines also ensure that the fuel pump isolating switch is OFF.

Note
Mk. 2 only. In aircraft not fitted with a throttle switch, the throttle lever should be set approximately one inch from the slow-running position. This assists starting but the throttle must be returned to the slow-running position as soon as idling speed is attained.

(6) With Mk. 2 engines ensure that the auxiliary starting switch is OFF. In the case of Mk. 3 engines, the auxiliary starting switch (if fitted) is wire-locked in the ON position and must be ignored.

(7) Move the master switch to FLIGHT.

(8) Switch ON the tank booster pump.

(9) *Mk. 2* only. Open the H.P. fuel cut-off valve.

(10) *Mk. 3 only.* Ensure that the H.P. fuel cut-off valve is closed.

(11) Switch ON the starter switch.

(12) Press the starter button for two seconds and release.

Note . . .
To prevent overheating and possible burning-out of the slow engagement relay, the specified period of two seconds must not be exceeded.

(13) *Mk.* 3 *only.* Approximately 15 seconds after pressing the starter button open the H.P. fuel cut-off valve.

(14) *Mk. 2 only.* Open the throttle lever approximately one inch from the slow-running position.

(15) *Mk. 2 only.* Immediately 'light-up' is heard, or observed on the jet temperature gauge, switch ON the auxiliary starting switch.

(16) *Mk. 2 only.* Return the throttle lever to the slow-running position as soon as idling speed is attained.

(17) In cold weather, after the completion of a successful start, turn on any oil heater mechanism provided in the aircraft.

(18) Switch OFF the starter switch.

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(19) Switch OFF the auxiliary starting switch if it has been used.

9. During a normal start, 'light-up' occurs at approximately 700 to 900 r.p.m. about a quarter of a minute after pressing the starter button. During the next 20 seconds approximately, the starter motor assists the engine to accelerate to between 1,600 and 1,700 r.p.m. and self-sustained acceleration then brings the engine speed up to the normal idling speed of 3,000 r.p.m. It is important therefore, that the ground starter battery should not be disconnected until the engine has attained at least 2,000 r.p.m.

Note . . .

A possible risk of fire may also be introduced if the starter battery is disconnected before the engine has attained at least 2,000 r.p.m.

Subsequent attempts to start

10. Following failure to start at the first attempt, which may be indicated either by failure to 'light-up' or by failure to accelerate after 'light-up', proceed as follows:—

(1) Close the H.P. fuel cut-off valve fully to seal off the fuel entry port to the burner ring and to open the burner ring to drain through the dump valve (if fitted). This prevents the combustion chambers being flooded with fuel.

(2) Switch OFF the starter switch to prevent overheating of the slow-running resistance in the starting circuit.

(3) Switch OFF the auxiliary starting switch if it has been used.

Note 1 . . .

Do not attempt to re-start until the engine has ceased rotating, the burner ring and the combustion chambers have drained, and the resistances have cooled. In an emergency the drainage period may be shortened by depressing the tail of the aircraft, after which a further attempt may be made immediately the engine has drained and ceased rotating. After any failure to start, particularly after failure to light up, consideration must be given to the fire risk incurred by the fuel drained on to the ground beneath the aircraft. To minimize the risk of a fire, it is advisable to move the aircraft to a new location before attempting a further start.

Note 2 . . .

When more than one motoring cycle is necessary time must be allowed between cycles for the starter motor to cool. It is permissible to carry out these cycles with a two-minute interval between each, followed by a twenty minute interval after the third cycle.

(4) *Mk.* 2 *only.* Open the H.P. fuel cut-off valve.

(5) *Mk.* 3 *only,* Ensure that the H.P. fuel cut-off valve is closed.

(6) Switch ON the starter switch.

(7) Press the starter button for two seconds and release.

Note . . .

To prevent overheating and possible burning-out of the slow-engagement relay, the specified period of two seconds must not be exceeded.

(8) *Mk.* 3 *only.* Approximately 15 seconds after pressing the starter button, open the H.P. fuel cut-off valve.

(9) Continue as described in para. 8, sub-para. 13 to 18.

Cold weather starting (Mk. 2 only)

11. Difficulty may be experienced in starting at temperatures below minus 20 deg. C. When such conditions prevail, move the auxiliary starting switch to the ON position before commencing to start the engine.

Failure to start

12. Damage to the starter will occur from overheating if the maximum rest periods are not adhered to; a defect is probable if the engine fails to start after two attempts and the cause should be investigated in accordance with the table of defects given in Chapter 3. A knowledge of the starting cycle and equipment described in Vol. 1, Sect. 2, will assist in the elimination and rectification of starting troubles.

Ground running check

13. All ground running should be conducted with the cowlings open so that the leaks may be immediately detected and rectified. When ground running during times of low embient temperature and high air moisture content, e.g. fog at low temperature, ice may form on the wire mesh debris guards which are fitted over the air-intakes. This can result in air starvation and partial collapsing of the air-intake ducting, particularly when the engine is running at large throttle openings. Under

such atmospheric conditions, a careful watch should be kept on the wire mesh debris guards during ground running, and if ice is seen to be forming on them the engine should be stopped and the debris guards removed. Before proceeding, ensure there are no indications of collapsing of the air-intake ducting. When the ambient air temperature is below that specified for the oil in use, any oil heater mechanism provided in the aircraft should be turned ON during ground running; the oil temperature should be frequently observed to ensure that the maximum temperature appropriate to the specification of oil used is not exceeded and the heater adjusted accordingly. If excessive oil temperatures are obtained when the heating is OFF the engine should be stopped and the cause investigated.

(1) While running at 3,000 r.p.m., check that the oil temperature and pressure, and the jet pipe temperature are within the limits specified in the Operating Limitations. *Mk. 3 only.* Move the fuel pump isolating switch to the ON position; a slight increase in r.p.m. may be noticed. In the event of an r.p.m. loss occurring an investigation into the operation of the pressure limiting valve should be made. Return the pump isolating switch to the OFF position.

(2) *Mk. 3 only.* Increase the engine speed to 4,000 r.p.m. and move the fuel pump isolating switch to the ON position. A rise of at least 1,000 r.p.m. should be observed. This is caused by the engine-driven fuel pump (starboard pump in the case of dual pump installations) now being controlled by its relief valve setting instead of by the barometric pressure control. Return the switch to the OFF position.

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(3) Increase the engine speed to maximum continuous r.p.m. and check temperatures, note the oil pressure which should be normal at this speed.

(4) Steadily open to full throttle and check the maximum governed speed of the engine. Maintain this speed long enough for the jet pipe temperature to stabilize and repeat the observations made at the maximum continuous condition.

(5) Reduce the engine speed gradually to idling for about half a minute to allow the temperature conditions to stabilize then stop the engine.

(6) Make a careful visual examination of the engine, looking particularly for evidence of gas, fuel and oil leaks or blowing joints.

Note 1 . . .

It is not unusual, and quite permissible, for a small amount of oil to leak from the front bearing housing during ground running. This is due to a depression which exists in the area of the front bearing housing, whilst the aircraft is static. The liberal clearance which exists between the swirl on the impeller pivot, and the white metal safety bearing, thus allows a small amount of oil to be drawn through. The condition is completely reversed and oil leakage is prevented, when the aircraft has sufficient forward speed to pressurise the intake. Oil leakage of the nature described above, may be recognised either by a thin film of oil coating the impeller, or if closely examined after run down, a trickle of oil may be seen from the front bearing housing into the front casing. This must not be confused with the Rockhard lacquer coating on the impeller, as the resinous finish of the brownish lacquer (not the blue-finish lacquer) gives an impression, particularly when an engine is new or newly overhauled, of a thick film of oil.

Note 2 . . .

If lubricating oil is observed in the exhaust cone or on the turbine blades, it must not be assumed immediately that an oil leak has developed at the rear bearing. It is a feature of the Goblin engine that a quantity of oil supplied to the rear bearing is afterwards lost down the face of the turbine disc rather than escaping via the oil drain pipes. If oil leakage from the rear bearing appears to be excessive, however, the following should be checked —

(*1*) *Metered oil supply.*

(*2*) *Engine run down times.*

(*3*) *Extraneous noises during engine run or run down suggestive of bearing failure (not to be confused with fuel pump noises).*

Note 3 . . .

Where oil pressure, oil temperature, or rear bearing temperature gauges are not fitted in the cockpit, and it is required to check these figures, it will be necessary to connect suitable gauges to the appropriate points on the engine. If it is required to check the delivery of the metering pumps, proceed as described in Part 4, Sect. 2, Chap. 7.

Stopping the engine

14. Throttle down to idling speed for about 30 seconds to stabilize the temperature conditions, and stop the engine as follows:—

(1) Close the H.P. fuel cut-off valve, and commence to time the run-down of the impeller as described in para. 16.

(2) Whilst the engine is stopping, listen carefully for any unusual noises which, if detected, should be investigated immediately.

Note 1 . . .

Mk. 3 only. On engines embodying Mod. No. 700 or 731 a noise from the Lucas slipper-type fuel pump(s) may occur when the engine speed has dropped to approximately 300 r.p.m. The cause of the noise which is usually of a few seconds duration, is however, not detrimental to the functioning of the pump(s), and can be disregarded.

Note 2 . . .

If a tinkling noise is heard from the engine when the rotating assembly is turning slowly, it may be caused by movement of the turbine hub shaft lock-washer, which under this condition may be free to rock considerably. This rock is permissible, but the sound may be amplified by the shape of the centre casing and be mistaken for an internal foul. If it is considered necessary to confirm that the lock-washer is in fact responsible for the noise the engine must be removed from the aircraft, the tail pipe assembly removed, and the engine mounted in a stand with the air-intake uppermost. The impeller should then be rotated and if the noise no longer persists, it may be safely attributed to movement of the lock-washer and the engine accepted as serviceable.

(3) When the engine has come to rest, close the L.P. fuel cock.

(4) Switch OFF the booster pump.

(5) Move the master switch to GROUND.

Note . . .

The rotating assembly must come to rest before any attempt is made to restart the engine. During this time all residual fuel will drain from the burners and burner ring.

15. Ensure that no residual fuel is burning in the exhaust system; then refit the air-intake and propelling nozzle covers. Allow sufficient time for the oil to drain into the sump; check and if necessary replenish the oil level with the correct grade of oil.

Free running check

16. Check the free running of the engine by noting the time taken after closing the H.P. fuel cut-off valve for the main rotor to come to rest from idling speed. In still air, the rotor of the Mk. 2 should come to rest in approximately two minutes; with the Mk. 3 the time will be about $1\frac{1}{2}$ minutes. With a new engine and full complement of engine-driven acessories the time to run down may be less, but if it is less than one minute a further check should be made with the aircraft accessories removed.

Chapter 3

(This chapter supersedes that issued with A.L.28)

RUNNING DEFECTS

***Note.**—This chapter applies to Goblin Mk. 2 and 3 aero-engines*

1. This chapter describes how to investigate defects readily and for this purpose the information is presented in the form of a defect investigation chart, which is designed to lead from the known symptom, column by column, to the remedial action with the minimum of work.

2. If the engine is not functioning correctly the probable defect will be indicated by certain symptoms and these symptoms are the only point from which any investigation can commence. The first step, therefore, is to locate the observed symptom in the first (left-hand) column of the table.

3. In practice it is found that more than one defect can produce the same symptoms, and, therefore, each probable defect with the method of investigation is listed in the columns headed 'Primary cause' and 'Primary investigation'. The probable defects are listed so that either the most probable are investigated first or the first investigations lead on to the others in a logical sequence. Therefore, the primary causes should be investigated in the order given. Once the primary cause has been identified it is unnecessary to proceed with any further primary investigation and attention should be transferred to the next two columns and any secondary cause identified in a similar manner. In each instance, the immediate remedial action is suggested in column six of the table.

4. The actual method of rectifying defects is considered as coming within the category of servicing or minor repair and where a section and chapter reference is given the essential information will be found within the chapter. Supporting information may also be found elsewhere in the publication, in the Volume 1, or in the relevant Aircraft Air Publication to which reference must be made. Where the method of rectifying the defect is self-evident, no entry has been made in the Air Publication reference column of the chart.

5. An attempt has been made to list all known and possible defects which may affect the running of the engine. It is impossible to forecast the peculiar defects which may occur in individual engines, therefore this chapter is not intended to supersede the knowledge of an experienced operator, but to assist those who are unfamiliar with this particular type of engine. It must not be assumed that all the defects listed are likely to occur; many of them may never be encountered.

6. Leakages, insufficient or incorrect grades of fuel or oil, faulty aircraft components (e.g. booster pump) and instruments, closed cocks and incorrect operating sequences have not been considered.

7. A knowledge of the starting cycle and equipment as described in Vol. 1, Sect. 1, will assist in the elimination and rectification of starting troubles. The method of checking the operation of the electrical starting equipment, particularly the automatic time switch, is described in Chapter 1 of this Section. When investigating electrical system faults, the cause of a blown fuse must be investigated and rectified before any further action is taken.

8. In addition to the normal tools, the following equipment should be available when carrying out defect investigations:—

(1) 0–24v. voltmeter, H.T. tester and lamp and battery for insulation and continuity tests.

(2) T72803, pressure gauge and pipe for connection to burner ring at No. 3 burner.

(3) Tee-piece ⅜-in. B.S.P. by ⅜-in. B.S.P. by ⅛-in. B.S.P. to connect pressure gauge into fuel accumulator line.

(4) T71808, pressure gauge and pipes for connection to Mk. 2 fuel pump and control box.

(5) Adapter T79254, to connect pressure gauge of T71808 into B.P.C. pressure line.

(6) Isolating pipe T73445 for connection to Mk. 2 governor inlet and outlet pipes.

(7) Stroboscope adapter T73447 and equipment for accurate checking of engine speed.

(A.L.77, May 56)

Defect	Primary cause	Primary investigation	Secondary cause
1. NO LIGHT-UP AT STARTING	(1) Faulty or discharged aircraft batteries	Check the aircraft batteries and electric circuit	—
	(2) (*High energy ignition*) Faulty surface discharge igniter plug	Fit two igniter plugs which are known to be serviceable and attempt another start	—
	(3) (*High energy ignition*) Faulty igniter circuit	Check igniter cable for continuity, insulation, and good contact at each end	—
			(a) Fault in L.T. supply to high energy condenser unit
			(b) Faulty high energy condenser unit
	(4) Inadequate fuel supply	Fit 0-50 lb. per sq. in. gauge direct to No. 3 burner with short pipe. Conduct complete starting cycle. Momentary peak pressure of 19-24 lb. per sq. in. should be recorded	(a) Incorrect setting of throttle slow-running position. Cannot occur if throttle lever is opened one inch as specified in Mk. 2 starting drill
		Note.—Engine speed should not exceed 3,000 r.p.m. whilst gauges are fitted to burner, and in the accumulator line	(b) Faulty starting valve

RESTRICTED

Secondary investigation	Remedy	Refer to
—	Change the batteries for ones known to be fully charged and without fault, or correct the defect in the electric circuit	Aircraft A.P. and A.P. 1095C
—	—	Part 4, Sect. 2, Chap. 8
—	Renew defective ignition cable	Part 4, Sect. 2, Chap. 8
Check circuit for continuity and insulation	Rectify defect	Aircraft A.P.
Change condenser unit for one which is known to be serviceable	—	Part 4, Sect. 2, Chap. 8
This will affect idling speed and should have been noticed before previous shut-down. Check controls. Screw in slow-running screw two complete turns and start engine	When idling adjust idling speed to correct value. If no start, turn screw to original position and adjust when start is eventually made	Part 4, Sect. 2, Chap. 6
Fit pressure gauge in accumulator line. During start opening pressure of starting valve should be 40 to 45 lb. per sq. in. If nil or low pressure disconnect inlet and investigate sticking valve	Renew or adjust starting valve	Part 4, Sect. 2, Chap. 6

Defect	Primary cause	Primary investigation	Secondary cause
1. NO LIGHT-UP AT STARTING—(*contd.*)			(*c*) *Mk. 2 only* Faulty dump valve
			(*d*) Faulty accumulator
			(*e*) *Mk. 2 only* Faulty barostat or pump
			(*f*) *Mk. 3 only* Faulty B.P.C. or pump/s
			(*g*) Faulty burners

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Secondary investigation	Remedy	Refer to
This would be apparent during previous starts when fuel would issue from valve	Renew control box	Part 4, Sect. 2, Chap. 6
Remove drain union or plug from accumulator. Insert a graduated rod. Observe that piston charges and discharges and that travel is 40 ± 1 mm.	Renew accumulator	Sect. 3, Chap. 1 and Part 4, Sect. 2, Chap. 6
1st check. Fit pressure gauge T71808 between the pump and the control box. During starting cycle approx. 200 lb. per sq. in. should be recorded	If incorrect change the barostat. Otherwise the components are satisfactory	Part 4, Sect. 2, Chap. 6
2nd check. Repeat attempt to start. If still unsatisfactory pump is faulty	Clean carbon off burners. If this fails, renew the pump, and refit the original barostat	Part 4, Sect. 2, Chap. 6
1st check. Switch ON the isolating switch and attempt a further start	If the start is now successful one pump or the B.P.C. is faulty; proceed with 2nd check. If the start is unsuccessful these components are satisfactory. Proceed with 7	—
2nd check. Disconnect and blank off servo line to B.P.C. Start engine with isolating switch OFF	If start is now successful B.P.C. is faulty and should be changed. If unsuccessful one pump is faulty. Proceed with 3rd check	Part 4, Sect. 2, Chap. 6
3rd check. Conduct starts under conditions of single pump check when faulty pump can be determined	Change faulty pump	Part 4, Sect. 2, Chap. 6
If all other checks are satisfactory the burners are faulty	Renew all burners ensuring that correct ones are fitted to each combustion chamber	Sect. 3, Chap. 1
Note.—Mk. 3 only. In the above investigation it has been assumed that it is improbable that the two pumps, or one pump and the B.P.C., could fail together. If a light-up is still unobtainable this assumption is invalid and all three checks under (6) above should be carried out		

Defect	Primary cause	Primary investigation	Secondary cause
1. NO LIGHT-UP AT STARTING—(*contd.*)	(~~4~~ 3) High engine speed causes cooling of igniter plug	Fit burner pressure gauge (if not fitted) to No. 3 burner. Conduct normal start. Gauge should indicate an accumulator discharge at same time as engine commences to accelerate in final starting stage	(a) Faulty electrical equipment is indicated if engine accelerates too soon
2. FAILURE TO ACCELERATE AFTER LIGHT-UP	(1) Starter not receiving full voltage during final stage	Check voltage across starter terminals during cranking cycle with H.P. cock shut. Voltage during final stage should not be less than 15 volts	(a) Uncharged or faulty aircraft batteries
			(b) Long leads from battery truck
			(c) Faulty connections
			(d) Uncharged or faulty ground truck batteries
			(e) Faulty aircraft electrical starting equipment
	(2) Internal resistance in engine	This would probably have been revealed during the running-down check at previous shut-down	—
	(3) Faulty starter	If previous checks are satisfactory the starter may be defective	—

Secondary investigation	Remedy	Refer to
Check starter panel with stop watch against time base in fig. 2, Vol. 1, Sect. 2	Renew defective component	Aircraft A.P. also Sect. 3, Chap. 1 of this publication and Part 4 A.P. 1095C, AL
		Sect. 2, Chap. 2
		Aircraft A.P. and A.P. 1095C
This will prevent operation of relays which bring in third stage. Check that voltage at relay terminals on starter panel is not less than 15 volts. An alternative check is to plug in the ground batteries to the aircraft test point (port side on Vampire) and attempt a further start. If the start is successful then the aircraft batteries are faulty	Recharge or change batteries *Note*.—If the engine is started in the manner described in this check, the aircraft should not be flown until the faulty batteries have been remedied	—
These should not be more than 15 feet each way	Shorten cable	—
Examine condition and check continuity across terminals	Determine cause and rectify	—
Check by drop test or by fully charged batteries	Recharge or change batteries	—
If other checks are satisfactory the equipment is faulty	Change defective component	Aircraft A.P. and A.P. 1095C
—	—	Sect. 2, Chap. 2
—	Change starter and recheck	Part 4, Sect. 2, Chap. 9

Defect	Primary cause	Primary investigation	Secondary cause
2. FAILURE TO ACCELERATE AFTER LIGHT-UP —(*contd.*)	(4) Inadequate fuel supply 'Light-up' too late in cycle therefore engine receives too little starter assistance after light-up; low fuel pump delivery	—	—
3. FAULTY STARTING	(1) Faulty slow-engagement equipment	No slow engagement period and starter is heard to engage with a loud clank. This indicates that the slow-engagement equipment is burnt out	—
4. INCORRECT IDLING SPEED *Note.*—Idling speed varies slightly with atmospheric conditions	(1) *Mk. 2 only* Incorrect barostat relief valve pressure	Connect up pressure gauge as stated in 1 (3) (e) Pressure at idling should be between 1,030 and 1,090 lb. per sq. in.	—
	(2) *Mk. 3 only* Incorrect B.P.C. setting	Insert pressure gauge in pressure line to B.P.C. Pressure at idling should be between 1,115 and 1,200 lb. per sq. in.	—
	(3) Faulty pressure limiting valve	Remove P.L.V., blank off ports in control box with suitable blanking plate. Start engine	(a) If idling speed is now correct P.L.V. is faulty
	(4) Incorrect adjustment of throttle needle	—	—

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Secondary investigation	Remedy	Refer to
—	See 1 (3) in this table	—
—	Renew slow-engagement equipment	Aircraft A.P. and A.P. 1095C
—	Renew barostat	Part 4, Sect. 2, Chap. 6
—	Renew B.P.C.	Part 4, Sect. 2, Chap. 6
—	Fit new pressure limiting valve	Part 4, Sect. 2, Chap. 6
—	*Note.*—No adjustments must be made before checking the P.L.V.	Part 4, Sect. 2, Chap. 6

Defect	Primary cause	Primary investigation	Secondary cause
5. INCORRECT OIL PRESSURE	(1) Insufficient oil	Check level of oil in sump	—
	(2) High or low ambient temperature	This will cause either low or high oil pressure respectively	—
	(3) Faulty relief valve	Remove pressure relief valve and examine condition of valve and seat	—
	(4) Incorrectly set relief valve	If other checks are satisfactory setting of valve is faulty	—
6. INCORRECT JET PIPE TEMPERATURE	(1) Faulty thermo-couple leads and connections	This is usually evidenced by erratic tempera-ture readings. Remove leads and check for continuity and insulation	—
	(2) Faulty thermocouple	Fit new thermo-couple and recheck	—
	(3) Uneven burning	Can sometimes be checked by stand-ing well clear of the engine and inspecting the turbine blades from the rear. Hot and cold spots may be visible. *Note.*—This check must be made quickly and the engine shut down immediately after-wards	(a) Burners assembled in wrong combustion chambers (b) Choked burner filters (c) Faulty burners (d) Cracked or burned combustion chambers

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Secondary investigation	Remedy	Refer to
—	Refill as necessary. Check again after running when oil temperature has settled down at 35-40 deg. C.	Sect. 2, Chap. 2
—	Check again after running when oil temperature has settled down at 35-40 deg. C.	—
—	Renew faulty parts and re-adjust	Part 4, Sect. 2, Chap. 7
—	Readjust	Part 4, Sect. 2, Chap. 7
—	Fit new leads	Sect. 3, Chap. 1
—	—	Sect. 3, Chap. 1
Check combustion chamber numbers stamped on burners	Reassemble in correct chambers	Sect. 3, Chap. 1
Remove and check	Clean or renew as necessary	Sect. 3, Chap. 1
Burners are faulty if defect persists	Renew all burners	Sect. 3, Chap. 1
If condition is not cured, combustion chambers may have been damaged by the excessive temperatures. Remove and examine for cracks, burns, etc.	Renew combustion chambers as necessary	Sect. 3, Chap. 1

Defect	Primary cause	Primary investigation
7. ENGINE VIBRATION	(1) Unstable combustion at starting due to over-rich mixtures	This will die out as engine speed increases to idling
	(2) Contact between engine and airframe structure. This only occurs when the engine is running or when it is hot.	Carefully examine all likely points for evidence of rubbing or contact. Engines are frequently rejected, unnecessarily, because of vibration, subsequent examination revealing no engine defect. Contact between engine and air-frame components—indicated by rub marks—is most likely the real cause of vibration. In Vampire aircraft, the most common points of contact are:—Rear bearing Bundy pipe, front half on cowling stiffener; rear half on cowling rail. Rear bearing metering pump, banjo bolt on cowling hinge. Front bearing metering pump, Bundy pipe union nut on cowling hinge stiffener. Gun heater pipe on lower starboard cowling. Gun heater pipe on No. 15 combustion chamber. Gun heater pipe on screen box of igniter plug in No. 14 combustion chamber. Port and starboard gun heater pipes on former of rear engine-cowling cone. Cowling stirrup fastener on upper starboard gun heater pipe. Fire extinguisher pipe on diffuser casing—mainly on port side. Rear bearing cooling pipe, flange joint on lower port fuel line. Engine sump front starboard on B.P.C. total head connection. Cabin air-line from collector ring, on No. 2 combustion chamber. Fire extinguisher pipe, on generator. Diffuser casing on drain box in lower cowling rail.
	(3) Engine faulty	If vibration persists or is encountered at other speeds, engine is faulty
8. LOW GOVERNED SPEED	(1) Incorrect travel of throttle needle and H.P. cock	Check that the controls reach the stops on the engine

Secondary investigation	Remedy	Refer to
—	No action required	—
—	Obtain clearance at all points	Aircraft A.P.
—	Reject engine and remove from airframe	Sect. 1, Chap. 2
—	Adjust aircraft controls accordingly	Aircraft A.P.

Defect	Primary cause	Primary investigation	Secondary cause
8. LOW GOVERNED SPEED —(*contd.*)	(2) *Mk. 2 only* Incorrect governor setting	Adjust, noting each alteration made. If governor does not respond to adjustment this may be caused by faulty governor or faulty barostat	(a) Faulty governor
		Note . . . *If governor is faulty, it will, of course, be the max. permissible r.p.m., therefore, care governor isolated to avoid exceeding max.*	
			(b) Faulty barostat relief valve setting
	(3) *Mk. 2 only* Faulty pump	If maximum speed is still unobtainable the pump is faulty. Check as in 4 (1) but measure barostat spill flow at same time. This should be approximately 160 g.p.h.	
	(4) *Mk. 3 only* Faulty overspeed setting	—	—
	(5) *Mk. 3 only* Faulty pump	If maximum speed is still unobtainable a pump may be faulty. To determine which pump is faulty conduct a single pump check	—
	(6) *Mk. 3 only* Faulty B.P.C.	See 4 (1)	—

RESTRICTED

Secondary investigation	Remedy	Refer to
To check whether governor or barostat is faulty, disconnect the inlet and outlet fuel pipes from the governor. Connect pipes together by means of the isolating pipe (T73445). Run engine to check if max. permissible r.p.m. can be obtained with the governor isolated	If max. permissible r.p.m. is obtainable with governor isolated, change the governor	Part 4, Sect. 2, Chap. 6

possible to obtain a maximum r.p.m. exceeding must be taken whilst running engine with permissible r.p.m.

Check setting as under 4 (1)	Renew barostat	Part 4, Sect. 2, Chap. 6
—	Renew pump	Part 2, Sect. 4, Chap. 6
—	Re-adjust	Part 4, Sect. 2, Chap. 6
—	Change faulty pump	Part 4, Sect. 2, Chap. 6
—	Renew B.P.C.	Part 4, Sect. 2, Chap. 6

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SECTION 3

SERVICING

SECTION 3

SERVICING

LIST OF CHAPTERS

Note.—A list of contents appears at the beginning of each chapter

Chapter 1

ROUTINE SERVICING

Note.—*This chapter applies to Goblin Mk. 2 and Mk. 3 aero-engines*

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

(A.L.77, May 56)

GENERAL

1. This chapter describes the method of servicing the engine in accordance with the requirements of the Basic Servicing Schedule. Operations which are considered self-explanatory have not been included. Instructions are given in respect of the removal, the dismantling and cleaning and, wherever possible the acceptance standards of permissible wear or damage of components and their subsequent re-assembly. The Part No. of expendable items which must be fitted at each assembly is also given.

2. Running adjustments and the rectification of defects by the replacement of unit assemblies and, when applicable, the repair of defective components is described in Part 4. Reference should also be made to the relevant aircraft Air Publication for instructions regarding the removal of cowlings and airframe components.

3. Scrupulous cleanliness, the proper use of the correct tools, and attention to detail are essential. Anything loose left near the air-intake may damage the engine, and a particle of foreign matter may cause failure of the fuel system. Except when their removal is essential to perform certain operations, dust covers must be kept on the air-intakes and on the propelling nozzle; they must be refitted immediately such operations have been completed.

4. To obviate risk of the engine being started unintentionally whilst work is in progress, ensure that the L.P. fuel cock lever, the H.P. fuel cut-off lever, and the starter (linked master) switches are in the OFF position, except when they are required to be ON for specific checks.

5. To ensure correct assembly, components should be checked for assembly markings before removal, unless the design is such that incorrect fitment is precluded. This is particularly important with parts which can be turned through 90 or 180 deg. All small parts, e.g. shims, packing pieces etc., should be labelled and secured to their respective components. Copper and aluminium sealing washers should be rejected if unserviceable. To prevent tearing of the counterbored faces of light alloy components, Mod. No. 755 introduces plain washers to be fitted under spring washers in all applications. Longer studs are introduced when necessary to accommodate the extra thickness. During servicing and minor repair, the modification should be embodied in part by introducing a plain washer where one was not previously fitted, provided that full engagement of the nut is obtained, otherwise the plain washer should be omitted. TR 513 permits the spot-facing of light alloy components, during re-conditioning, to enable full engagement of the nut when Mod. No. 755 is embodied.

Bundy pipe	Thread	Tighten
$\frac{5}{16}$ in.	$\frac{1}{4}$ in. B.S.P.	Hand-tight plus one complete turn
$\frac{1}{4}$ in.	$\frac{1}{4}$ in. B.S.P. or $\frac{7}{16}$ in. by 26 T.P.I.	Hand-tight plus one complete turn plus one sixth (60 deg.) of a turn.

Bundy type pipes, tightening union nuts

5A. When tightening Bundy type union nuts, the nut must be tightened sufficiently to deform the olive so that slight but positive necking of the pipe is produced; Bundy pipes may be recognized by their characteristic bright silvery finish. Excessive tightening must, however, be avoided as each time a particular pipe is fitted the nut will require just a little extra movement to ensure a leak-free connection, and it is the sum of these extra movements, plus the initial distortion, which dictates the life of the pipe assembly. The slight necking of the pipe is necessary to ensure a mechanical lock; friction pressure of the olive on the pipe, although probably leak free, is not sufficient. For the foregoing reasons, whenever a pipe which is to be refitted is disturbed, it is most important that the olive remains in the same position on the pipe; any lateral movement of the olive on the pipe will destroy the initial seal.

5B. When fitting a new assembly, the union nuts should be tightened as shown in the above table.

5C. When refitting a used assembly, the union nuts should be tightened hand-tight plus one sixth (60 deg.) of a turn regardless of the pipe size. A radial pencil line should be marked on the nut end to provide a datum of the nut movement.

5D. It must be fully understood that no attempt must be made to continue tightening these nuts until appreciable resistance is felt. The check for sufficient tightening, having complied with the foregoing instructions, is freedom from leaks on ground run. If it is necessary to tighten a union nut further to correct slight leakage, this must be done to the least possible extent that will cure the leak, tightening the nut a few degrees at a time only. If excessive necking of the pipe or excessive distortion of the olive has occurred, a new pipe assembly should be fitted.

Flexible type pipes

5E. At the specified periods, all flexible pipes should be examined in accordance with the instructions contained in Part 4, Sect. 2, Chap. 10. Pipes that are removed, or replacement pipes, should be flushed through with clean kerosine, preferably under pressure, before refitment to the engine. In particular it should be ensured that no foreign matter is present around the end fittings. After flushing, oil pipes should be dried out with dry clean compressed air to avoid kerosine contamination of the lubricating oil. Flexible pipes must be pressure tested, before being fitted to an engine, as described in Part 4, Sect. 2, Chap. 10. Care must be taken when handling flexible pipes to avoid excessive bending, especially when one end only is disconnected.

Burner feed pipes

5F. Particular attention is drawn to the care necessary with burner feed pipes which tend to take up a permanent set after a short period of service. To avoid undue flexing each pipe should be refitted in its original position. Positional identification tags are attached to the pipes when Mod. No. 723 is embodied.

(This chapter continued on next leaf)

6. All consumable parts such as split pins, locking washers, joint washers, etc., must be disposed of without delay so that there is no risk of their becoming mixed with new items and used again. When components are difficult to remove or to separate due to the adhesion of jointing compound, or close fitting dowels or studs, tapping with a mallet around the periphery of the component should be sufficient to break the joint. In no circumstances should any form of wedge be inserted between mating faces in an endeavour to part them.

7. All apertures and unions which are exposed after the removal of an assembly or component, should be blanked off immediately to prevent the entry of foreign matter, loose nuts or small tools. Metal or wood should be improvised in the absence of approved blanking plates or plugs, and rubber caps may be used for unions and pipe ends if metal ones are not available. Fabric in the form of cotton waste or rag must not be used as small particles might enter the oil-ways or the fuel system.

8. Before assembly, joint faces must be cleaned and examined for burrs, nicks, or other damage which might prevent the faces seating properly or an oil-tight joint being obtained. Where applicable apply a thin even film of 'Wellseal' jointing compound to each joint face. To reduce risk of seizure, all screw threads which are subject to high temperatures, such as the bolts which secure the tail pipe to the turbine shroud, and the jet temperature thermocouple, should be coated with anti-seize grease (Stores Ref. 34B/88). Ragosine L.M. paste is recommended for the set-bolts which secure the turbine disc air-cooling pipes to the exhaust cone and for the turbine disc nuts and bolts.

9. At the completion of any servicing operation, ensure that loose parts, tools, or rags are not left lying about the engine or cowling; particularly examine the air-intakes and ducts leading to the impeller. Ground tests which are made subsequent to operations which have necessitated disturbing fuel or oil pipes, should be carried out with the cowling open so that a thorough examination may be made for leaks. Finally ensure that all cowling panels and inspection doors are correctly fitted and securely attached, referring, if necessary, to the relevant aircraft Air Publication.

AIR-INTAKES

10. Due to the fitment of the air-intake covers whenever the engine is not running, snow or ice seldom accumulates in or around the air-intakes. In very severe conditions further precautions can be taken by stretching a tarpaulin over the leading edge of the main plane to completely cover the air-intake apertures. If, however, snow or ice has accumulated in the air-intakes, it must be entirely removed before flight; rag, or wood which may leave splinters which can be drawn into the engine when it is started must not be used for this purpose.

LUBRICATION

Oil sump

11. The correct method of checking the oil level and filling the oil sump is described in Sect. 2, Chap. 2. When it is required to drain the oil sump, remove the filler cap from the top accessory box and the dip-stick from the sump to facilitate the entry of air and assist the escape of oil through the drain. Remove the drain plug from the suction filter cover or, if Mod. 486 has not been incorporated, the suction filter cover itself, as described in the next paragraph and, by means of the projecting stem, force up the drain valve against its spring load. The contents of the sump can then drain into a suitable container. If a drain plug is not embodied a tool to hold the drain valve open can be made as indicated in fig. 1, and secured to two of the suction filter cover studs. When drainage is complete, refit the drain plug and washer, Part No. A.G.S. 568–B which should be renewed if necessary, or the suction filter cover, refill the sump with the correct grade of oil and refit the dip-stick and the filler cap.

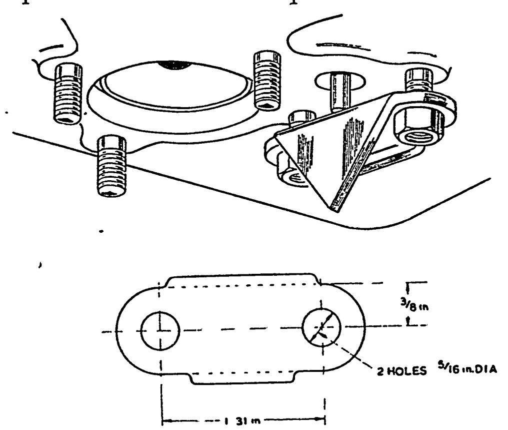

Fig. 1. Suggested tool for holding open the drain valve (pre-Mod. 486)

(A.L.66, June, 54)

Oil suction filter

12. When removing the suction filter cover, the nut on the extended portion of the cover which encloses the drain valve should be removed last. Remove four of the plain 2 B.A. nuts and the washers which secure the suction filter cover. Holding the cover in position so that the drain valve spring load does not cause the cover to tilt and jam on the studs, remove the fifth nut and washers. Remove the cover and the suction filter element.

13. Using a syringe thoroughly clean the suction filter element in clean kerosine. Move the syringe over the entire area inside the gauze so that the kerosine is forced through every part; brush any sediment off the exterior and dry off the element with a compressed air jet.

14. The element should be examined for damage which if slight may be repaired by soldering. Ensure that the mating faces of the filter cover and the sump are clean and undamaged. Examine the joint washer (Part No. 22343) and renew if necessary.

15. Insert the suction filter element into its housing in the sump, locating it in the recess at the inner end of the housing. Place the joint washer over the studs and refit the suction filter cover, ensuring that the end of the drain valve stem and the filter element locate correctly in their respective recesses in the cover. Hold the cover in position against the drain valve spring load and secure the cover with the five plain nuts and the washers.

Oil pressure filter

16. To remove the oil pressure filter, undo the six plain $\frac{1}{4}$ in. B.S.F. nuts securing the pressure filter cover, and remove the washers and the cover. Where Mod. No. 323 has been embodied, the pressure filter assembly will come away attached to the cover, otherwise the filter assembly is separate from the cover and, unless prevented, will tend to fall out immediately the cover is removed (*fig.* 2). To dismantle the pressure filter assembly if the filter assembly is attached to the cover; press the top of the assembly downwards and turn it anti-clockwise relative to the cover to release the bayonet fastening. Separate the filter assembly from the cover and dismantle it in the following order; bottom plate, first synthetic rubber washer, felt element, second synthetic rubber washer, top plate, and spring. Extract the circlip from the upper end of the gauze

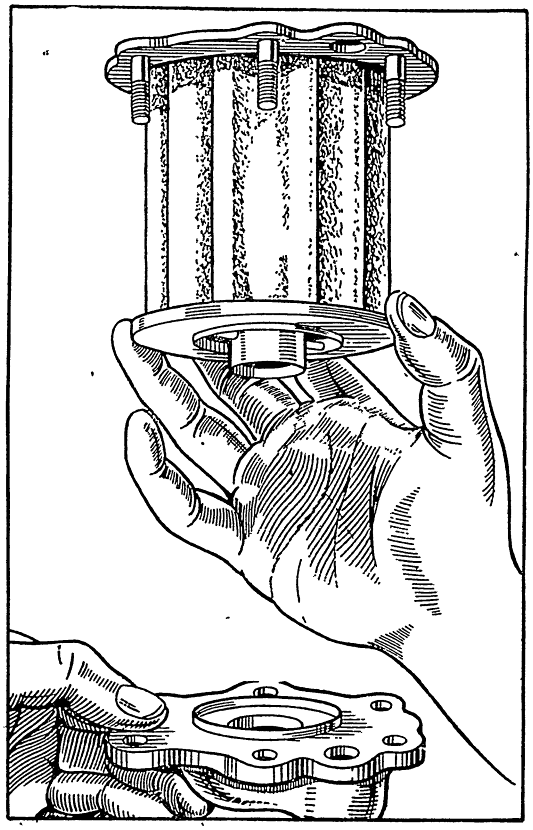

Fig. 2. Removal of oil pressure filter (pre-Mod. 323)

covered support tube and remove the seating washer, overload valve and spring. To dismantle the Pre-mod. 323 filter assembly, press in the bottom end plate against the action of the spring, extract the retaining pin, and remove the detail parts as described already.

17. Thoroughly wash the parts in clean kerosine; the gauze covered support tube should be cleaned as described for the suction filter element. A new Tecalemit filter element must be fitted every 300 hours; cleaning of the element is not permitted.

18. Examine the gauze surrounding the support tube for damage which if slight may be repaired by soldering. Ensure that the solder does not prevent the end plates passing freely over the support tube. Ensure that the joint faces of the filter cover and the sump are clean and undamaged. Examine the filter element Part No. 22772, the joint washer Part No. 22342 (Pre-mod. 323) or 23444 (Mod. No. 323), and the two synthetic rubber sealing washers Part No. 22562 (or 75061 when Mod. No. 867 is embodied) and renew if necessary.

19. Place the overload-valve spring, the overload valve, and the seating washer in the upper end of the gauze covered support tube. Secure with circlip Part No. 13587 (or 16864 when Mod. No. 384 is embodied) which should be renewed if necessary. Check the overload valve for freedom to operate and ensure that the seating faces are clean. Place the parts over the support tube in the following order; filter spring, top end plate, first synthetic rubber washer, felt element, second synthetic rubber washer, and bottom end plate. Secure the filter assembly to the cover by the bayonet fitting; Pre-mod. 323, depress the bottom end plate against the action of the filter spring until the retaining pin can be inserted into the holes in the support tube. Centralize the pin, release the bottom end plate, and ensure that the pin is correctly located in its recess in the end plate. Place the joint washer over the studs and refit the filter assembly and the cover; secure with the washers and plain nuts. When refitting filter elements Pre-mod. 323, it is important to ensure that the inner end is correctly located and is not crushed by tightening the nuts with the element trapped between the cover and the inner end of the casing.

Oil pressure relief valve adjustment

20. An oil pressure between 40–45 lb. per sq. in. should be obtained with the engine running at 9,700 for Mk. 2 and 10,250 r.p.m. for Mk. 3 engines at an oil temperature of 40 deg. C. If adjustment is necessary reference should be made to Part 4, Sect. 2, Chap. 7.

Metering pumps

21. Instructions for removing and refitting the metering pumps are contained in Part 4, Sect. 2, Chap. 7. If new metering pumps are fitted or it is suspected that the lubrication system is defective, it will be necessary to check the metering pumps delivery as described in that chapter.

Priming front and rear bearings

22. Instructions for priming the front and rear bearings are contained in Section 2, Chapter 1. For the rear bearing this can be facilitated by using a pump, such as a Ki-gass priming pump, mounted vertically in a box or suitable stand, and a length of pipe used to connect the priming pump outlet to the rear bearing feed pipe. A 50 lb. weight can be placed on the plunger of the priming pump and the oil forced into the bearing automatically whilst other servicing operations are performed.

FUEL SYSTEM

Priming fuel system

23. Whenever the fuel system has been dismantled for any reason, such as for cleaning the low pressure fuel filter, or any other servicing or repair operation, the fuel system must be primed as described in Section 2, Chapter 1 before any attempt is made to start the engine.

Control box and dump valve

24. The only servicing operation permitted, beyond a periodic check of the nuts and unions for tightness, is for the renewal of the control valve plunger seals as described in Part 4, Sect. 2, Chap. 6.

Slow-running adjustment

25. The slow-running stop forms a positive stop limiting the distance which the control valve plunger (throttle needle) can travel towards the closed (idling) position. It is a set screw situated in the end of the control valve plunger cover at the rear of the control box and provides the means of adjusting the slow-running (idling) speed. When a satisfactory setting has been obtained on the test bench, after initial manufacture or overhaul, the slow-running adjustment is wire-locked and sealed with a lead seal by the inspection authority, and this adjustment should not normally require alteration.

26. An increase in the slow-running speed may be due to a faulty pressure limiting

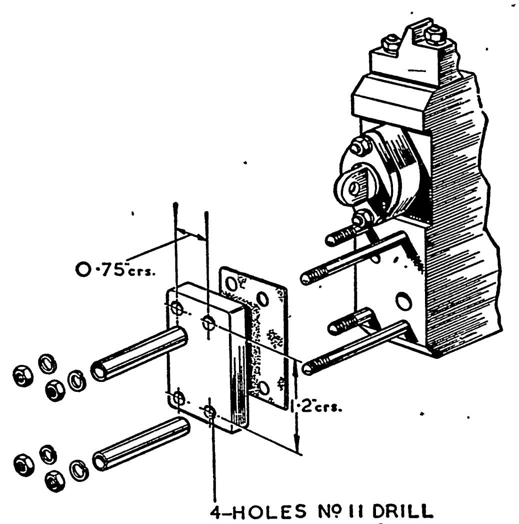

Fig. 3. Suggested blanking plate for pressure limiting valve mounting face on control box.

(A.L.66, June, 54)

valve. To check this, remove the suspected valve and blank off the mounting face on the control box (*fig.* 3). If the slow-running speed is then normal, the valve is faulty and must be exchanged for a serviceable unit, as described in Part 4, Sect. 2, Chap. 6. On Mk. 3 engines it will be necessary to reprime the fuel pumps after the valve has been refitted.

27. Recheck the slow-running speed after fitting the replacement unit. Re-adjustment of the slow-running stop to compensate for leakage past the pressure limiting valve is NOT permitted.

Pressure limiting valve

28. No servicing of the pressure limiting valve without subsequent rig testing is permitted, therefore, routine servicing is confined to a periodic check that the nuts and unions are tight and that there are no signs of fuel leakage at the joint face between the valve and the control box or at any other point. Instructions for removing and refitting the valve are contained in Part 4, Sect. 2, Chap. 6.

Overspeed governor *(Goblin Mk. 2 only)*

29. The servicing of the overspeed governor is confined to a periodic check of the nuts and unions for tightness. Instructions for removing and refitting the overspeed governor are contained in Part 4, Sect. 2, Chap. 6.

30. Deviations of governed speed from the nominal value can occur through changes in ambient atmospheric temperature and pressure, and apparent deviations may occur because the aircraft instruments are less accurate than the stroboscope used for speed settings on the test bench. If attention is paid to deviations occuring in the first case, too frequent adjustment will be made to the overspeed governor in order to contend with day to day atmospheric changes, and in the second case, the speed will be adjusted to an incorrect setting.

31. Variations between plus 50 and minus 100 r.p.m. of the nominal speed may be ignored unless they are habitual, in which case the overspeed governor should be reset to allow for different operating conditions. Variations beyond these tolerances must be investigated on the lines indicated in Section 2, Chapter 3, and adjusted if necessary according to the instructions contained in Part 4, Sect. 2, Chap. 6, but it is recommended that the aircraft instruments are checked before any adjustments to the overspeed governor are made.

Governor mechanism *(Goblin Mk. 3 only)*

32. The overspeed governor mechanism of the Mk. 3 is integral with the fuel pump(s). The general remarks given in para. 30 are equally applicable and variations beyond the tolerance given should be investigated as detailed in Section 2, Chapter 3. Instructions for adjusting the governor mechanism are given in Part 4, Sect. 2, Chap. 6.

33. Where a pair of fuel pumps is employed it is customary to set one governor to control at an engine speed 50 r.p.m. higher than the other. It is important to remember this difference in governor setting as the higher engine speed may in certain circumstances be obtained with full throttle whenever the fuel pump isolating switch is switched on. When, for example, the ambient temperature is above 8 deg. C at sea level either pump alone is capable of supplying sufficient fuel to enable the engine to attain maximum r.p.m. and therefore in these circumstances the higher engine speed will be obtained.

Fuel accumulator

34. Servicing of the fuel accumulator is confined to a periodic check of the nuts and unions for tightness. Instructions for removing, refitting, and checking the functioning of the fuel accumulator are contained in Part 4, Sect. 2, Chap. 6.

Starting valve

35. The servicing of the starting valve is confined to a periodic check of the nuts and

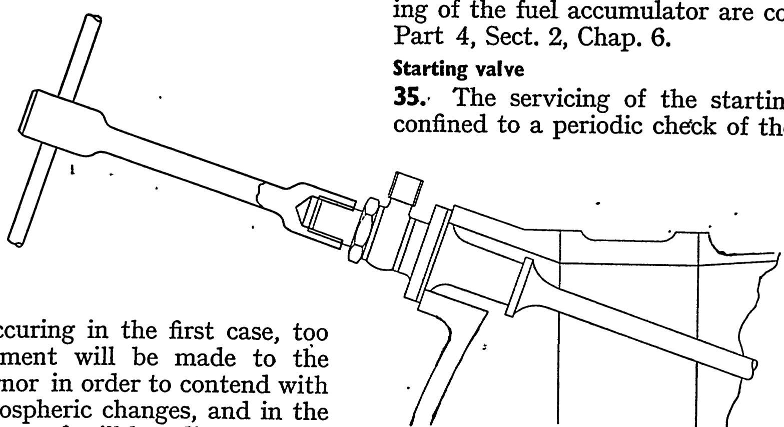

Fig. 4. Using tool T21401 to withdraw a burner

unions for tightness. Instructions for the removal, refitting, and the checking and adjustment of the starting valve setting are contained in Part 4, Sect. 2, Chap. 6.

Burners

36. Burners, combustion chambers, etc., are numbered in a clockwise direction with No. 1 combustion chamber at the top when the engine is viewed from the front. The number of the combustion chamber is stamped on the diffuser casing adjacent to the burner holder bosses. The corresponding number is also marked on the outboard edge of the adjusting shim, and on the outboard edge of the burner flange. It should be noted that No. 15 and 16 burners are on either end of the burner ring, the break in the ring occurring between the branch pipes for these two burners. As the flow characteristics vary from burner to burner, and are governed by the atomiser and the dimensions of the burner holder, the burners and their components must always be fitted in the appropriate combustion chamber which, in addition must always itself be fitted in the marked position. Throughout all operations on the burners, absolute cleanliness is essential.

37. Each of the sixteen burners is removed in the same manner. Unscrew the union nut and disconnect the flexible pipe from the burner, care being taken not to bend or distort the run of the pipe from its natural 'set'. Remove the three $\frac{1}{4}$ in. B.S.F. plain nuts (two on Mk. 3 engines) and spring washers and the locking tab from the burner flange. Screw the tool T21401 (*fig.* 4) on to the inlet union of the burner and draw the burner out of the combustion chamber; in the case of a Goblin Mk. 3 take care to maintain the original alignment of the burner as it is withdrawn and do not let its inner end drop and foul the deflector vanes. Remove the adjusting shim or shims from the face on the diffuser casing and tie it to its individual burner. Place a dust cap on the inlet union and one of the special rubber protecting caps over the orifice end of the burner. Place the burner in the transport box (Part No. T70460) to protect it from accidental damage and discard the joint washer. If the burners are not being refitted to the engine immediately, or if they will remain in store for a period exceeding seven days, they should be protected against corrosion. On removal from the engine, drain the burner of fuel, flush through with clean oil (Stores Ref. 34A/33) and blank off all orifices with air-tight blanks.

38. Carefully examine the complete burner assembly and remove any accumulation of carbon from the shroud end face taking great care not to scratch or damage the burner nor to block any of the openings in it. Ensure that the air gap is completely free of carbon. High jet temperatures can be

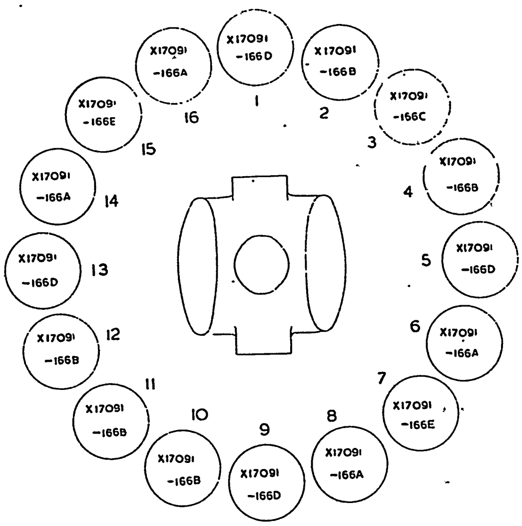

Fig. 5. Goblin Mk. 2. Diagram of burner positions with reference to part numbers and flow numbers

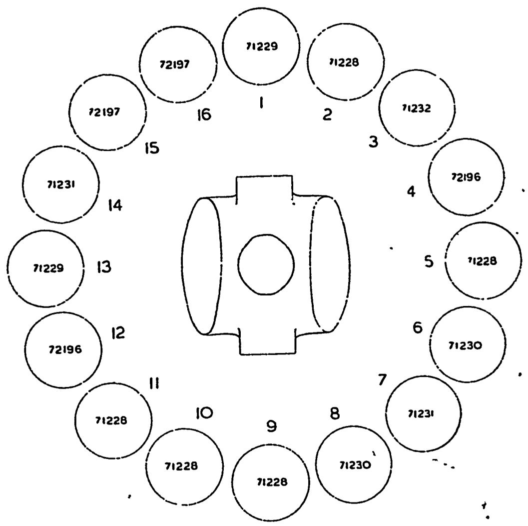

Fig. 6. Goblin Mk. 3. Diagram of burner positions with reference to part and flow numbers *(when Mod. No. 786 or 820 is embodied, No. 8 position should be read as 72197)*

(A.L.66, June, 54)

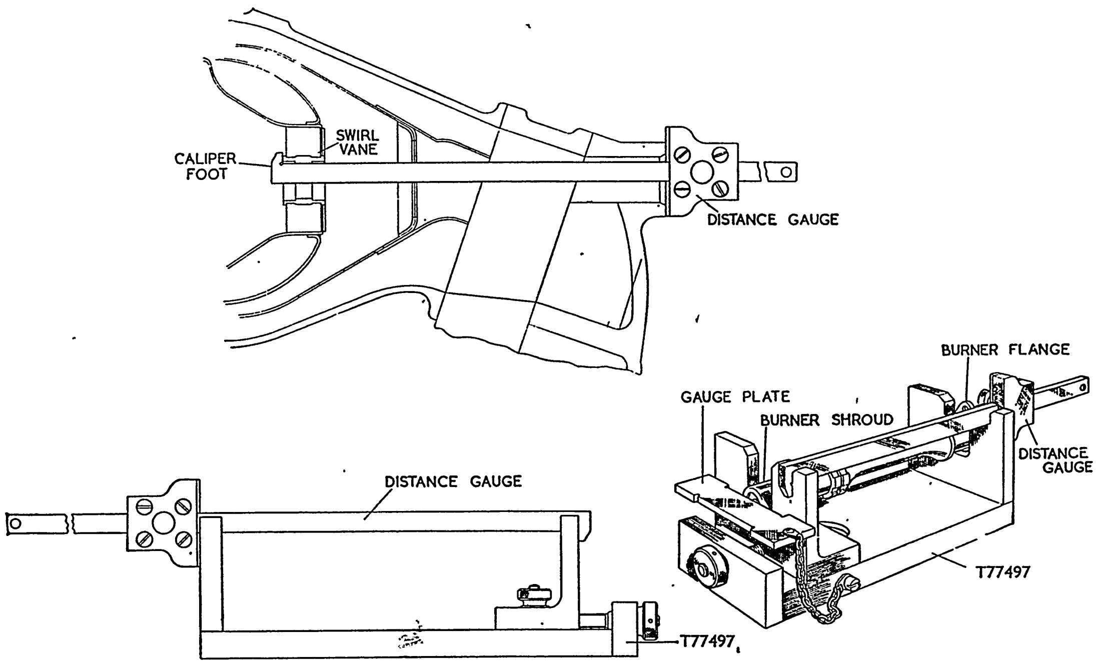

Fig. 7. Checking the burner protrusion

due to an atomiser, sleeve, and shroud being loose, causing the fuel to air ratio in that particular combustion chamber to be incorrect. If these parts are loose, the whole burner must be changed for a serviceable burner of equal calibration to the references given in fig. 5 and 6. The shroud, which secures the sleeve and the atomiser, is locked by a lock nut which is itself locked by a copper washer peened into a groove in the lock nut. Correct locking of this assembly is vital to the safety of the engine. Wear is permitted locally on the outside diameter of the burner shroud at the swirler bore location to the extent of 0·010 in. maximum depth. The minimum dimension measured across the diameter of the burner shroud where the maximum depth of wear occurs is 0·783 in.

39. When fitted in the engine, the burner must protrude 0·15–0·20 in. beyond the swirl vanes in the combustion chamber. The checking fixture, T77497, should be used to ascertain the thickness of shimming that is required to ensure the correct relationship between the burner shroud and the swirl vanes. Whilst reading the following instructions, reference should be made to fig. 7. Place the head of the distance gauge against the burner face on the diffuser casing and adjust the caliper bar until its foot contacts the rear face of the swirl vanes in the combustion chamber. Using the distance gauge, set the sliding block of the fixture and secure it in position with the thumb screw. Place the appropriate burner, with two new joint washers (Part No. 20099 Mk. 2 or 22709 Mk. 3), in the fixture, and set the gauge plate to the rear face in contact with the gauge datum face, select the required number of shims (Part No. 21134 Mk. 2 or 20824 Mk. 3) to take up the gap between the burner flange and the fixture. Insert the burner through its particular boss on the diffuser casing and secure it with the three (two, Goblin 3) plain nuts and spring washers; do not omit the locking tab. Reconnect the flexible fuel pipe to the burner, tighten the union nut and wire-lock it to the locking tab.

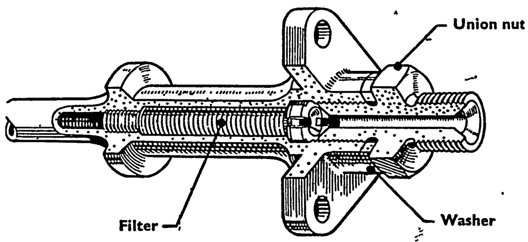

Fig. 8. The burner filter

Burner filters

40. The burner filters (*fig.* 8) must be carefully handled as damage to the filter may have the same effect as an accumulation of dirt. To remove one of the burner filters for examination or cleaning, unscrew the union nut and disconnect the flexible fuel pipe from the burner. Using a suitable box spanner, remove the fuel inlet adapter and the joint washer; and the banjo connection for a fuel pressure gauge in the case of No. 3 burner. Unscrew the filter and draw it out of the burner. Gently clean the filter by syringing it with kerosine on the inside and blow away any sediment with a jet of compressed air. Carefully examine the filter for signs of fracture, the presence of foreign matter and distortion at the filter ends. Examine the screwdriver slots and the threads for damage. Screw the filter back into the burner and tighten with the special screwdriver. When reassembling No. 3 burner, refit the pressure gauge banjo connection with a joint washer on either side to the special long inlet adapter. Screw the inlet adapter into the burner and tighten securely. Reconnect the flexible fuel pipe and tighten and wire-lock the union nut.

High pressure fuel filter (*Goblin Mk 2 only*)

41. No cleaning of the Auto-Klean Lo-Loss felt filter element is permissible. If the element is unserviceable, a new or reconditioned element (Part No. L/559AA/2) should be fitted and the unserviceable element returned through the appropriate channels for reconditioning. To remove the element from the H.P. fuel filter, disconnect the filter to barostat pipe at the union adjacent to the filter. Remove the six nuts and washers which secure the filter bowl to the filter body, and pull the bowl off the studs. Extract the split pin and remove the slotted nut, spring, plain washer and rubber washer from the support rod which secures the filter element to the filter body, and withdraw the element. Before fitting the serviceable element, ensure that the mating surfaces of the filter bowl and filter body are clean and undamaged, and that the synthetic rubber seals are serviceable and are correctly positioned. If either of the seals, filter element-to-body seal Part No. MPA 30466 and filter bowl-to-body seal MPA 27776 or the rubber washer Part No. MPA 30308 is unserviceable, a new one should be fitted. Ensure that all parts are clean and serviceable and reassemble by reversing the dismantling instructions; use a new split pin (Part No. AGS 784/50) to lock the slotted nut.

41A. When fitting new or replacement filter assemblies, the filter and filter to barostat pipe should be flushed through as follows. Disconnect the filter to barostat pipe at the barostat end. Simulate a start in accordance with the normal starting drill but with the throttle and the H.P. fuel cut-off valve levers in the CLOSED position. A suitable container must be positioned to receive the fuel which will be discharged from the open pipe connection. Re-connect the filter to barostat pipe and carry out a normal ground run, during which a check should be made for fuel leaks.

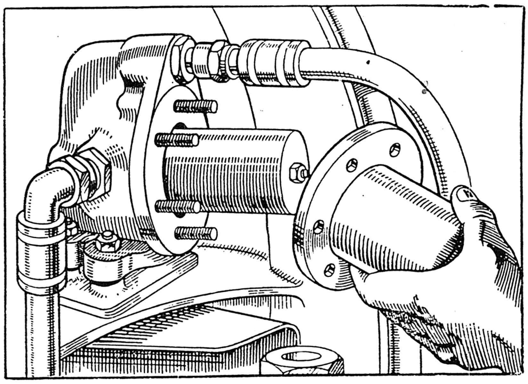

Fig. 9. Removal of H.P. fuel filter

Barostat or barometric pressure control

42. No servicing or adjustment of the barostat or barometric pressure control, other than a periodic check that the nuts and unions are tight, is permissible. If the unit appears to be defective it must be changed for a serviceable unit as described in Part 4, Sect. 2, Chap. 6.

DIFFUSER CASING

Deflector assembly (*Goblin Mk. 3 only*)

42A. A broken deflector vane or similar damage may necessitate the replacement of the deflector assembly concerned and, where this occurs in a diffuser casing which does not embody Mod. 923 (*interchangeable deflector assemblies*), it will be necessary to fit a Mod. 923 deflector assembly. Vol. 6, Part 2, Sect. E, contains instructions for carrying out such a repair at an overhaul base, but the following procedure should be adopted "in service".

(1) Measure the thickness of the diffuser casing between the deflector assembly mounting face and the floor of the diffuser passage at the upstream (inner) edge of the deflector assembly pocket.

(A.L.77, May 56)

(2) Blend the floor of the deflector assembly at the upstream edge so that the dimension from the mounting face of the deflector assembly to its floor edge corresponds with the dimension previously obtained. The maximum step allowed against the gas flow is 0·010 in. and the profile of the floor is to be blended smooth from the new edge. This blending must be continued into the side radii of the floor to reduce the step which will also occur against the gas flow in this area.

(3) Where the blending operation has removed the anodic film, a surface treatment of Ercalene or cold-setting Rockhard lacquer (*see Note to this para*) must be applied to the affected area of the deflector assembly before fitting to the diffuser casing.

(4) Record the repair in the engine record card.

Note . . .

The cold-setting Rockhard lacquer may be applied as follows. Thoroughly clean the affected area with 73 NLAVGAS *industrial methylated spirits, or benzene. Mix thoroughly equal volumes of Gittings and Hill lacquer 115/16 and 115/17, add 15 per cent of thinners 375/455 and again mix thoroughly. This mixture will provide a good brushing consistency with a final resin thickness of approximately 0·015 to 0·020 in. It should be noted that the pot-life of this mixture is about five hours. With a brush, apply one coat of lacquer to the affected area and allow to dry in air at room temperature for at least three hours before handling.*

COMBUSTION CHAMBERS

Examination in situ

43. At the specified periods, the combustion chamber must be examined externally, without being removed from the engine, as thoroughly as possible. Although this examination should cover the whole of the outer casing, experience has shown that cracking may be divided into three main categories.

(1) Longitudinal cracks in the front end of the rear outer casing which are associated with the welded joints attaching the outer interconnecting sleeves or the locating pin bosses.

(2) Longitudinal cracks in the centre of the rear outer casing, originating and terminating in the sheet metal, being in no way affected by the welded joints.

(3) Longitudinal and circumferential cracks originating at the rear ring attachment weld.

Draw marks may be evident as straight or slightly helical lines, resembling 'scriber lines', which may be from $\frac{3}{4}$ in. long to the whole length of the casing. These marks may be ignored even though they tend to become more discernible after running, as no split has ever been found either to originate from a draw mark or to follow their characteristic straight or slightly helical line.

44. Splitting may occur on the inboard side of the rear outer casing, and since splits in this position can be neither seen nor felt on an installed engine, operators are recommended when inspecting combustion chambers in situ, to take care not only to examine by sight and feel but also by running the engine at approximately cruising r.p.m. and feeling by hand around the outer casing of each combustion chamber for air leaks. Whilst the engine is running, check the joint ring between the front and rear outer casings. A split joint ring can be detected by the air blowing from the split when the engine is running at about 3,000 r.p.m. Any defect discovered will necessitate the removal of the defective combustion chamber and the fitment of a serviceable one; if it is only the joint ring which is defective, a new joint ring (Part No. 17890) may be fitted by following the instructions contained in the next paragraphs.

Inter-connectors

44A. Flashing of the fire warning light in the cockpit may be due to gas leakage from a combustion chamber inter-connector, the stream of hot gas impinging on the adjacent fire warning point. The inter-connectors should be dismantled and decarbonised, and assembled with new sealing rings. In no circumstances should inter-connectors be

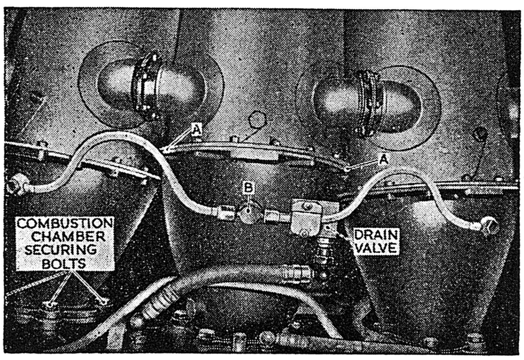

Fig. 10. Combustion chamber and drain pipes

rotated in an attempt to remedy this defect; this practice causes weakening and collapse of the inter-connector inner tubes, which may ultimately result in damage to the turbine.

Removal and dismantling

45. Combustion chambers, burners etc., are numbered as described in paragraph 36 and it is most important to ensure that the components from each assembly are kept in sets so that upon reassembly, flame tubes and scoop and colander assemblies are refitted in their original outer casings. When combustion chambers are removed, they should be marked with their position number to ensure that they are refitted in their original positions.

46. All sixteen combustion chambers are not identical, the front outer casing of the even numbered combustion chambers are shorter than those of the odd numbered ones. With the rear outer casings the reverse is true so that the overall length of all combustion chambers is the same. This ensures that the centre flanges of adjacent combustion chambers are clear of each other when in position on the engine. Combustion chambers No. 8, 9 and 10, which are the lowest three when on the engine, are each fitted with a ferrule for the attachment of the combustion chamber drain pipe and valve. No. 2 and 14 each have a screwed adapter to accommodate an igniter plug. No. 5 combustion chamber, on Mk. 3 engines, is fitted with a screwed adapter to provide the pressure tapping from the compressor delivery to the air-fuel ratio control.

47. Commence by removing the burners as described in paragraph 37. As combustion chambers No. 5 and 13 are situated at wing level, these cannot be removed until the adjacent combustion chamber either above or below has been removed first. Before commencing to remove the three lowest combustion chambers, unscrew the three banjo bolts and take off the drain pipe and drain valve (*fig.* 10). It is advisable to refit temporarily the six copper washers and the three banjo bolts. From this point the removal of each combustion chamber is identical except that the first to be removed will require the disconnection of two sets of inter-connectors. Detach the ignition leads from the igniter plugs in No. 2 and 14 combustion chamber. On Mk. 3 engines fitted with an air-fuel ratio control, disconnect the rigid pipe from No. 5 combustion chamber to the air-fuel ratio control.

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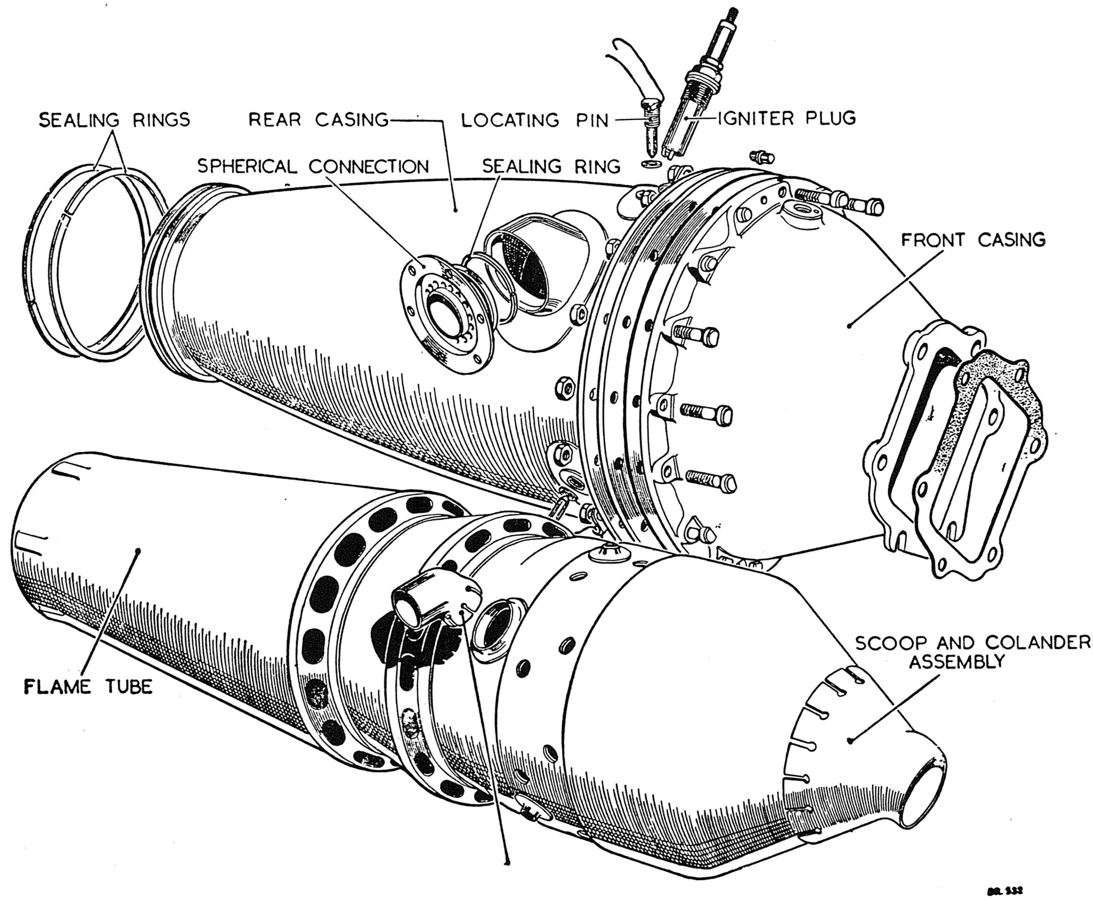

Fig. 11. Combustion chamber components (Mk. 2, and Mk. 3 Pre-mod. 786 or 820)

48. Remove the six nuts and bolts from the flange of the spherical connections; when Mod. No. 827 is embodied it will be necessary to cut the two pieces of locking wire which prevent rotation of the spherical connections, and to remove the two lock-wire tabs. Remove the four outer bolts and spring washers (also plain washers when Mod. No. 595 is embodied) securing the combustion chamber to the diffuser casing. Loosen the two inner bolts securing the combustion chamber to the diffuser casing, and tap the front outer casing of the combustion chamber lightly with a mallet to 'break' the joint with the diffuser casing. Slide the front of the combustion chamber off the diffuser casing and the two inner bolts (the securing holes are slotted for this purpose) and at the same time ease the rear end of the combustion chamber out of the junction pipe.

Dismantling (Mk. 2, and Mk. 3 Pre-mod. 786 or 820)

49. As each combustion chamber (*fig.* 11) is dismantled, its principal components should be kept in a set to avoid the interchange of components between the individual combustion chambers. Two of the combustion chambers are fitted with an igniter plug, and this with its seating washer, should be removed first as described in para. 81. Carefully ease the spherical connection complete with its seal ring from the outer inter-connecting sleeve on the outer casing of the combustion chamber, and gently pull the inner interconnecting tube from the inter-connecting stub on the flame tube; repeat these operations to remove the second inter-connector. Remove the sixteen nuts and shakeproof washers (or spring washers when Mod. No. 627 is embodied) and the lockwire tabs and bolts which fasten the front and rear

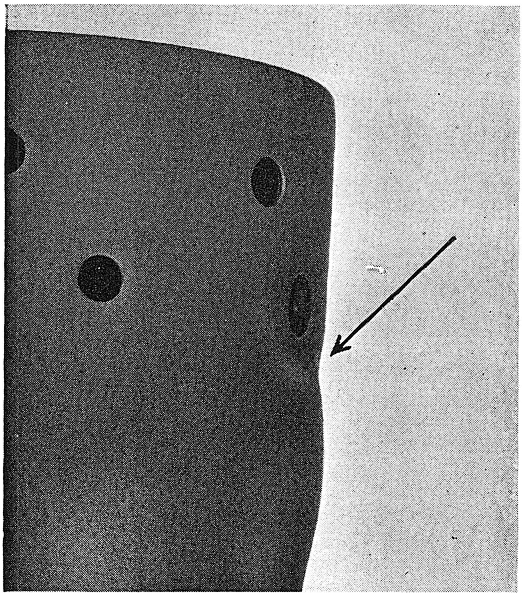

Fig. 12. Distortion of skin at locating pin boss—serviceable for a further servicing period

outer casings together. Lift off the four flange stiffening segments and separate the two outer casings. Unscrew the three locating pins which retain the flame tube in the rear outer casing, remove the washers, and draw the flame tube out of the outer casing. Separate the flame tube from the colander assembly, and remove the two

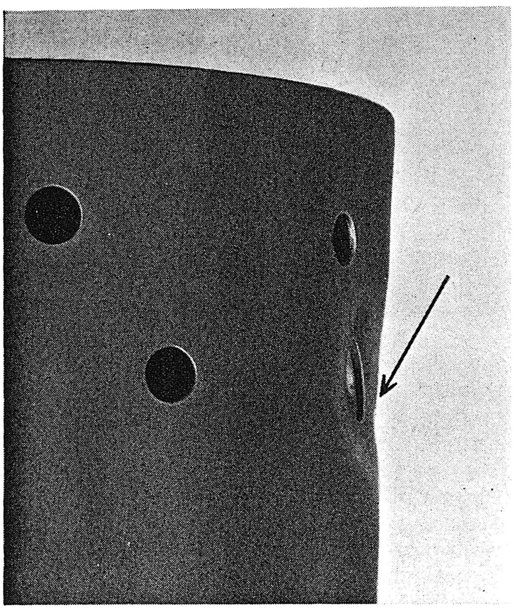

Fig. 13. Distortion of skin at locating pin boss—unserviceable but repairable

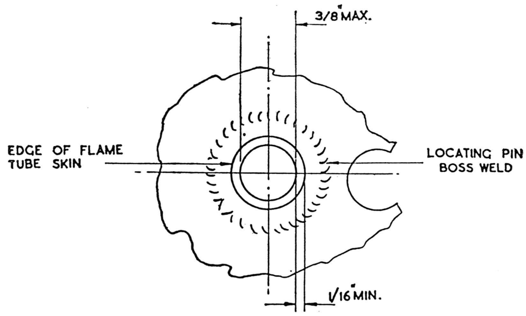

Fig. 14. Limits of locating pin boss elongation

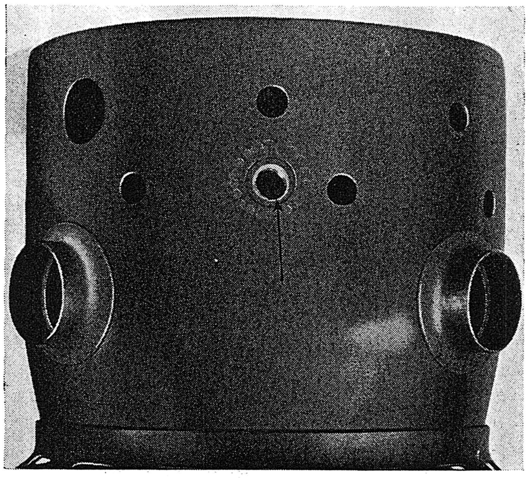

Fig. 15. Locating pin boss elongation—example of acceptable standard

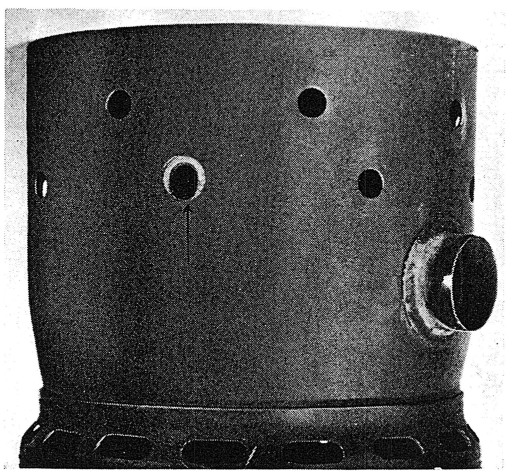

Fig. 16. Locating pin boss elongation—example of unserviceable standard which may be repaired

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sealing rings from the rear of the rear outer casing.

Dismantling (Mk. 3 Mod. No. 786 or 820 only)

49A. As each combustion chamber is dismantled, its principal components (*fig.* 30B) should be kept in a set to avoid the interchange of components between individual combustion chambers. Two of the combustion chambers are fitted with an igniter plug, and this with its seating washer should be removed first. Ease the spherical connection complete with its seal ring from the outer interconnecting sleeve on the outer casing of the combustion chamber and gently pull the inner interconnecting tube out of the interconnecting stub on the flame tube; repeat these operations to remove the second interconnector. Remove the sixteen nuts and shakeproof washers (or spring washers when Mod. No. 627 is embodied) and the lockwire tabs and bolts which secure the front and rear outer casings together. Lift off the four flange stiffening segments and separate the two outer casings. Using wrench T73360, unscrew the locating pin which retains the flame tube in the rear outer casing and draw the flame tube out of the outer casing. Remove the two sealing rings from the rear of the rear outer casing.

Cleaning

50. Carbon should be removed from the combustion chamber components by heating for twenty minutes to half an hour in an air circulating constant temperature furnace at 550 deg. C. Alternatively, combustion chamber components may be decarbonised by steeping the components for about $1\frac{1}{2}$ hours at 70 deg. C in a solution comprising 7 per cent caustic soda, 0·1–0·5 per cent liquid soap, and water to 100 per cent.

Examination

Mk. 2, and Mk. 3 Pre-mod. 786 or 820

51. A defective joint ring between the front and rear outer casings, damaged bolts, locating pins, inner interconnecting tubes, spherical connections, and sealing rings may be replaced by serviceable parts. If any other component is rejected, the checks specified in para. 68 and 69 must be made when fitting the new or serviceable replacement components. Examine the flame tube internally and externally for signs of cracking, distortion or opening of welded seams. Pay particular attention to the periphery of all

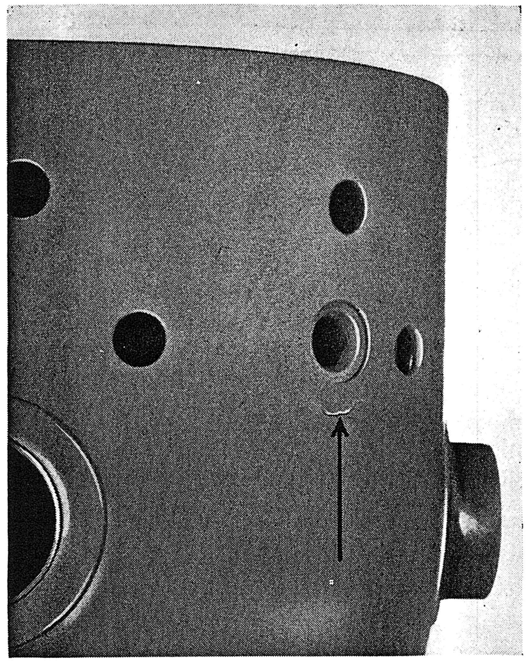

Fig. 17. Cracks adjacent to locating pin boss—acceptable standard

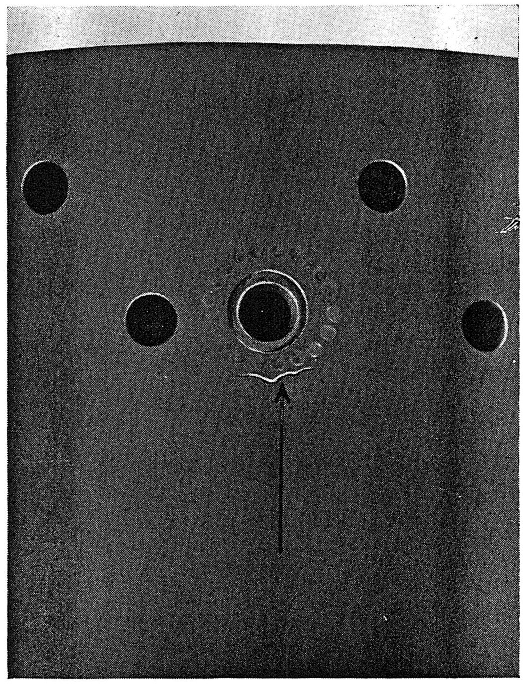

Fig. 18. Cracks adjacent to locating pin boss—serviceable for a further servicing period after welding

(A.L.66, June, 54)

air holes, sleeves, stubs and bosses. ~~Check the flanges of the front outer casing and the flange at the front of the rear outer casing for distortion; using a surface plate and marking blue if this equipment is available.~~

52. The following paragraphs indicate the extent of 'wear' which may be found after a period of running and give some guidance in classifying 'serviceability' upon routine examination by defining the extent of 'wear' and damage, cracking and distortion which may be endured by a flame tube without the risk of impairing its performance or reliability for a further period of service in an engine. It is, of course, only possible to indicate quite broadly the points to be inspected and the defects likely to be encountered. Each case must be considered in the light of the particular circumstances including the period of unexpired life, and the final decision as to the serviceability of each component must rest on the experience and knowledge of personnel who are familiar with gas turbine engines of this type.

52A. Blueing of a flame tube may be apparent during its early life before settling to a familiar dark grey colour. Flame tubes which are discoloured through blueing may be regarded as serviceable provided there are no signs of failure through cracking or buckling.

53. *Buckling and distortion of the skin* is generally confined to that section of the flame tube to which the locating pin bosses are fitted. As a result of the temperature in the combustion chamber during running, the flame tube expands lengthwise and the resultant loads are resisted by the locating pins. It will be appreciated, therefore, that if the load is not equally distributed between all three locating pins, distortion of the skin in this area will almost certainly result. The tendency for one locating pin to take the load causes a form of local distortion immediately adjacent to the locating pin bosses. Flame tubes not buckled at this section in excess of that shown in *fig*. 12, may be regarded as serviceable for a further servicing period. If the flame tube is distorted to the extent shown in fig. 13, the distortion may be removed as described in Leaflet F.7 (TR96) contained in Vol. 6, Part 2.

Locating pin boss elongation

54. This will exist to some extent in all flame tubes after a period of running. Provided it does not exceed the limits illustrated at *fig*. 14 and 15, the flame tube may be considered serviceable. *Fig*. 16 illustrates an unserviceable flame tube which can be repaired in accordance with Leaflet F.7 (TR96) contained in Vol. 6, Part 2.

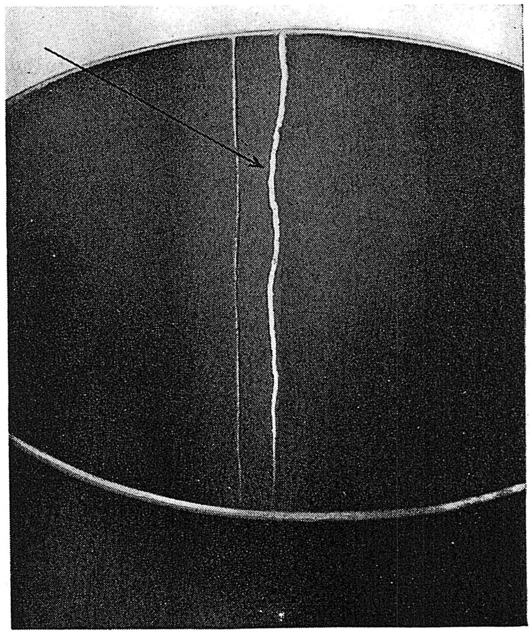

Fig. 19. Splitting at rear end seam—serviceable after repair by welding

Cracks adjacent to the locating pin boss weld

55. Such cracks frequently accompany the buckling described in paragraph 53. Further

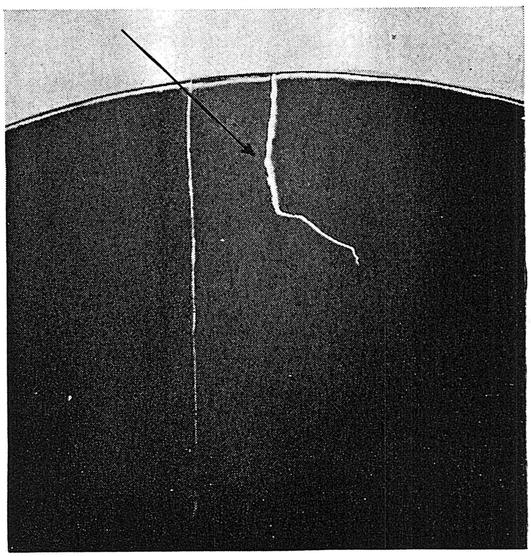

Fig. 20. Splitting at rear end seam—beyond repair

cases will be found where cracking has occurred with no buckling. *Fig.* 17 illustrates this type of defect, and providing the crack is less than $\frac{1}{8}$ in. long the flame tube may be considered serviceable. If the crack is greater than $\frac{1}{8}$ in. but not exceeding $1\frac{1}{2}$ in. in length,

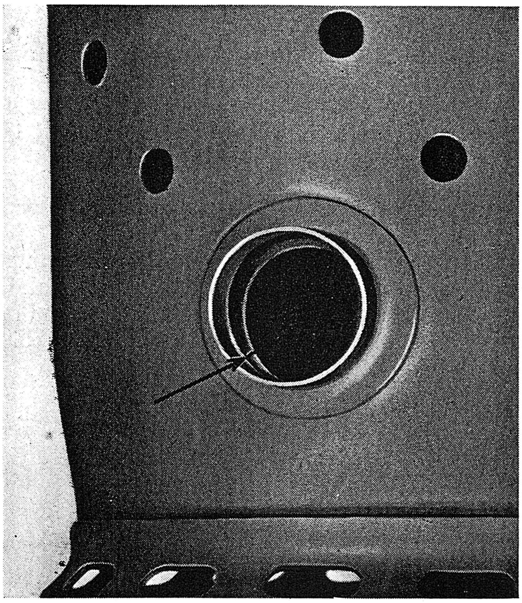

Fig. 21. Cracks in flame tube under the interconnecting stub flange—serviceable for a further servicing period

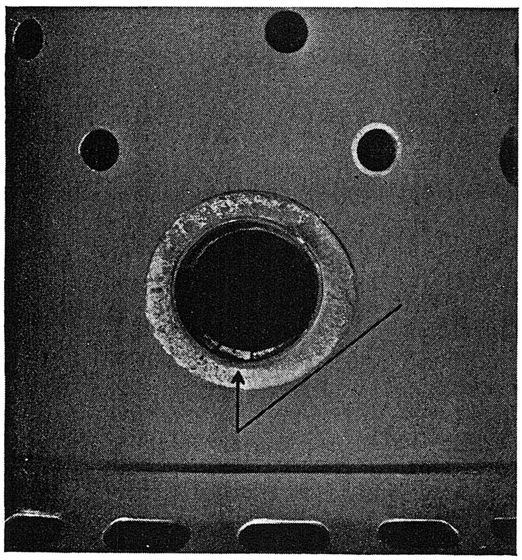

Fig. 22. Cracks in flame tube under the interconnecting stub flange—unserviceable but repairable

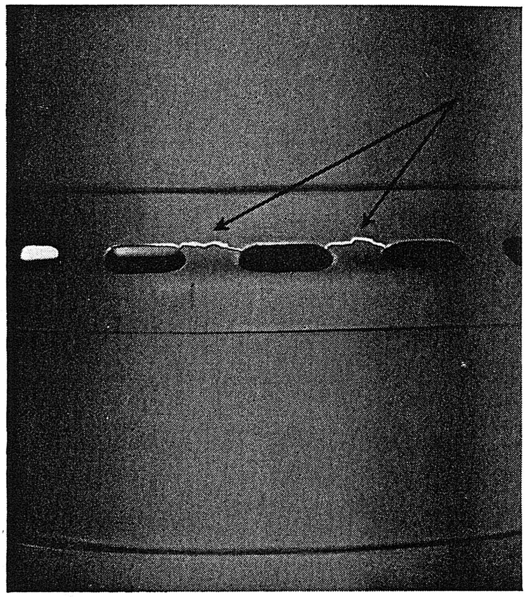

Fig. 23. Cracks at dilution windows—repairable

the flame tube may be salvaged as described in Part 4, Sect. 2, Chap. 4, after which a further servicing period can be permitted. *Fig.* 18 illustrates a repairable crack of this nature.

Rear end seam splitting

56. This defect may be repaired as described in Part 4, Sect. 2, Chap. 4. The splitting may occur at the seam or parallel to and about $\frac{3}{8}$ in. from it; a repairable failure is illustrated in *fig.* 19. Where the crack forks into the surrounding skin as illustrated in *fig.* 20, repair by welding is not recommended and the flame tube should be rejected.

Pip wear

57. Experience has shown that, providing the flame tube pip dimensions are satisfactory at the commencement of its life and that the specified clearance exists between the flame tube and the outer casing joint ring, the pips may be expected to endure 150 hours running. Re-pipping will, therefore, normally be carried out prior to completion of the life of the component. Salvage by re-pipping is described in Part 4, Sect. 2, Chap. 4.

Interconnecting stub flange

58. After periods of running to the order of 150 hours (Mk. 2) 100 hours (Mk. 3), small radial cracks may develop in the flame tube under the interconnecting stub flange. These

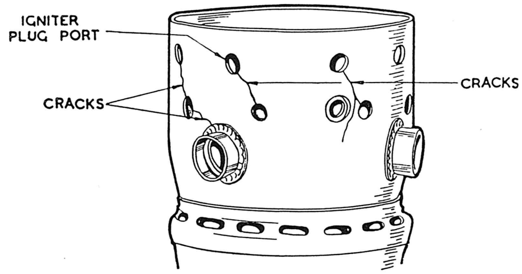

Fig. 24. Cracks between upper cooling holes, and cracks from interconnecting flange or igniter plug boss to cooling holes or dilution ports—unserviceable and beyond repair

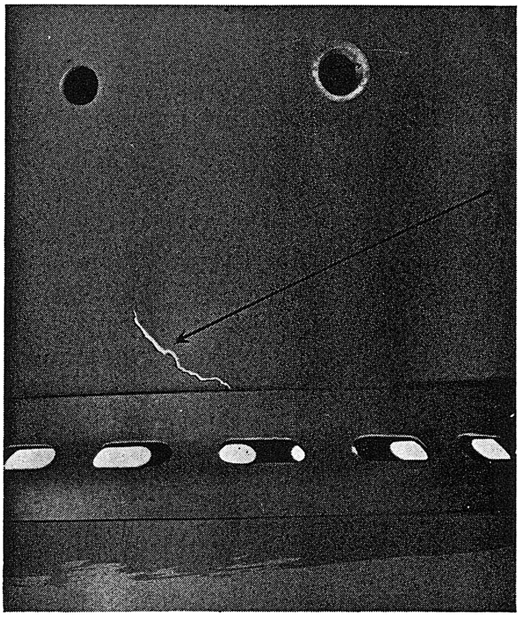

Fig. 25. Cracks from dilution windows—repairable

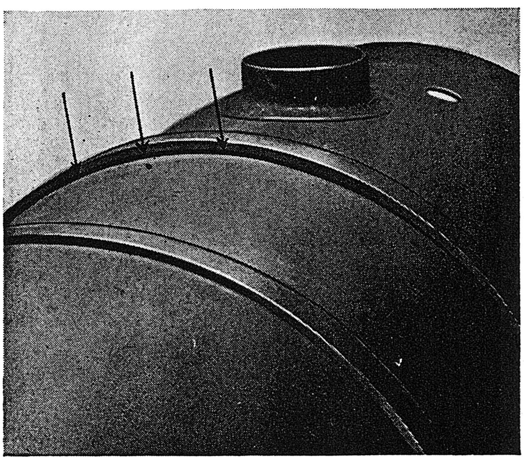

Fig. 26. Weld failure at 1st or 2nd row of dilution windows—beyond repair

cracks may be disregarded providing they do not penetrate the weld and, if numerous, are not closer than ½ in. apart. An acceptable flame tube having this type of failure is illustrated in *fig*. 21 and is considered serviceable for a further servicing period. *Fig*. 22 illustrates a flame tube which may be repaired as described in Leaflet F.3 (TR170) contained in Part 4, Sect. 2, Chap. 4.

Cracking between the dilution ports

59. Should cracking occur between the holes of the first and second row of dilution ports of the type illustrated in fig. 23, the flame tube may be repaired as described in Part 4, Sect. 2, Chap. 4.

60. All flame tubes which have developed cracks between the upper cooling holes and cracks from the interconnecting stub flange or the igniter plug boss to the cooling holes, or the dilution ports of the type illustrated in *fig*. 24, should be regarded as unserviceable and rejected as beyond economical repair.

61. All flame tubes which display cracks from the dilution windows into the flame tube skin as in *fig*. 25, may be repaired as described in Part 4, Sect. 2, Chap. 4.

62. *Fig*. 26 illustrates failure of the welded flange at the first or second row of dilution windows and this type of defect renders the flame tube beyond economical repair.

Outer casings

63. The flame tube pips will tend to wear indentations in the machined ring. The usual method of salvaging the flame tube outer casing, when the latter has been subject to excessive pip wear, is to repip the flame tube between the original pips as described in Part 4, Sect. 2, Chap. 4. On reassembly the new pips on the flame tube will bear against the bore of the outer casing between the points of previous wear. Where the outer casing has become worn due to repipping at the prescribed positions, the outer casing can be salvaged as described in Vol. 6, Part 2, Sect. F. If it is required to mark the outer casing to provide a record of inspections, etching on the locating ring at the rear end, as illustrated in *fig*. 27, is recommended. Etching elsewhere on the casing is not permissible.

64. The scoop and colander assembly (dome head) will usually be completely serviceable after normal decarbonising. Normal wear in the locating pin sleeves, which are welded to the scoop and colander assembly, may be ignored, but where the assembly has been in

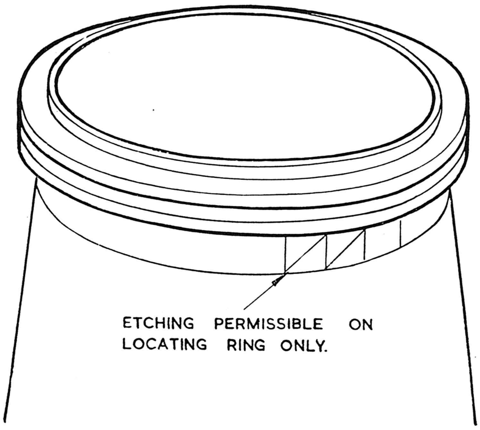

Fig. 27. Locating ring at rear end of outer casing showing permissible area for etching

service for a considerable number of hours and the wear exceeds the permissible worn dimensions specified in the Schedule of Fits, Clearances and Repair Tolerances, reducing the thickness of the sleeve metal appreciably, the assembly should be rejected and new sleeves fitted as described in Vol. 6, Part 2.

65. The locating pins will wear on the shank and possibly be burnt at the end. New locating pins should always be fitted if there is the slightest doubt about their serviceability.

66. The interconnecting tubes may be distorted during removal or may be burnt at the spherical end. If the original parts are in any way unserviceable, new parts should be fitted.

67. The spherical connections, the seal rings, the 2 B.A. bolts and the plain nuts will normally be serviceable.

Examination

Mk. 3, Mod. No. 786 or 820 only

67A. A defective joint ring between the front and rear outer casings, damaged inner interconnecting tubes, spherical connections, sealing rings and locating pins may be replaced by serviceable parts. The flame tube should be thoroughly examined internally and externally for evidence of distortion, cracking, or opening of the welded seams. Particular attention should be given to the periphery of all air holes, sleeves, stubs, and bosses. ~~Using a surface plate and marking blue, check the flanges of the front outer casing and the flange at the front of the rear outer casing for distortion~~. AL 81

67B. The following paragraphs indicate the extent of wear which may be found after a period of running and give guidance in classifying serviceability during routine examination by defining the extent of damage, distortion, cracking, and general wear which

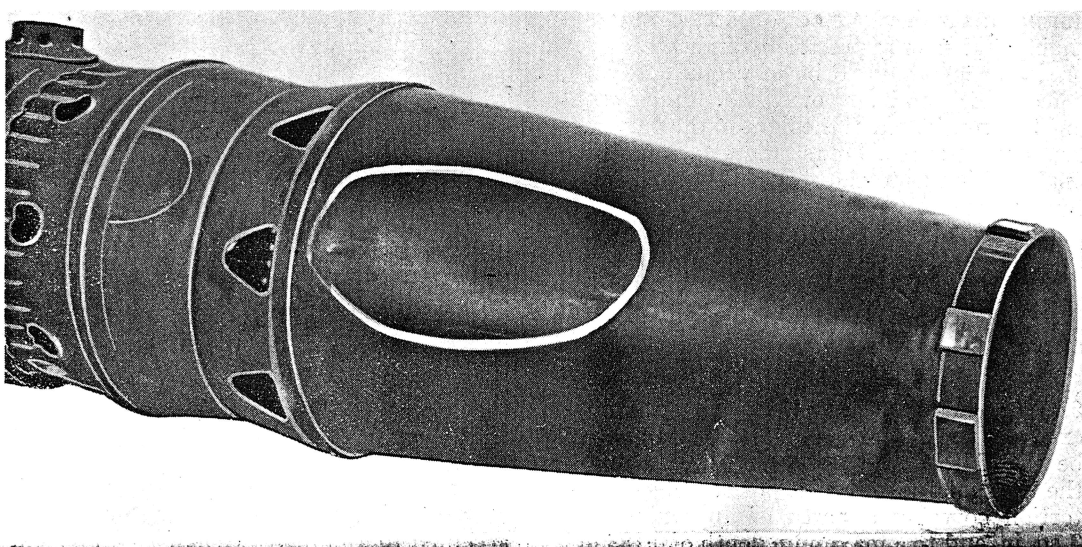

Fig. 27A. Distortion on flame tube—acceptable

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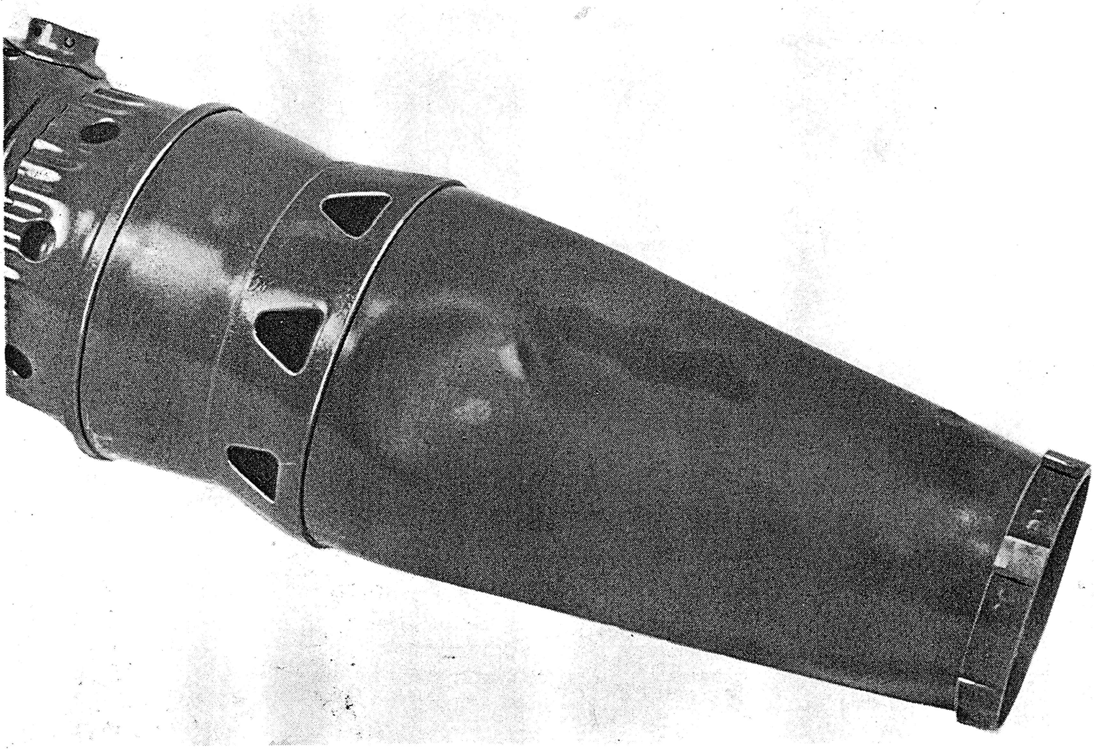

Fig. 27B. Distortion and buckling on flame tube—not acceptable

may be endured in a flame tube without its performance or reliability being impaired during a further period of service in an engine. It is only possible to indicate quite broadly the points to be inspected and the defects likely to be encountered. Each case must be considered in the light of the particular circumstances, hours run, etc., and the final decision as to the serviceability of each component must rest on the experience and knowledge of personnel with the particular type of engine.

Distortion

67C. Distortion of flame tubes (*fig. 27A and 27B*)is generally the result of operation in excess of the permitted limitations and will be found to occur slightly downstream of the triangular air dilution ports. Slight distortion covering an area of approximately 3 sq. in. and to a maximum depth of 0·125 in. can be accepted for further service provided there are no associated cracks.

Blueing

67D. Blueing of a flame tube may be apparent during its early life before settling to a familiar dark grey colour. Flame tubes which are discoloured through blueing may be regarded as serviceable provided there are no signs of failure through cracking or buckling in excess of that specified in paragraph 67C.

Interconnecting stub flange (fig. 27C)

67E. The acceptable limits for cracks in the interconnecting stub flange given in para. 58 for the Mk. 2 type combustion chamber are equally applicable to this type.

Spot welding in flutes

67F. Failure of the spot welding which secures the fluted portion of the flame tube rear section to the centre section can be accepted to a limited extent (*fig. 27D*) only and cannot be accepted where the welding has failed in adjacent flutes (*fig. 27E*).

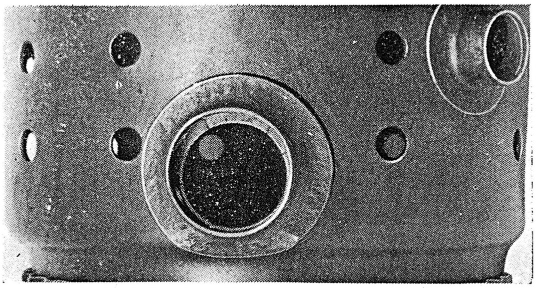

Fig. 27C. Cracking of interconnecting stub flange—acceptable

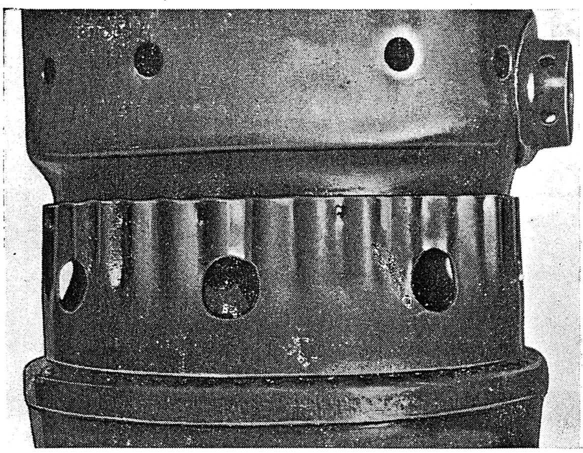

Fig. 27D. Failure of spot welding in flutes—acceptable

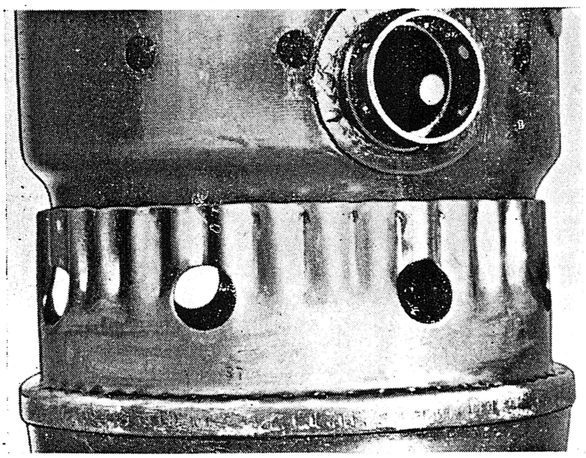

Fig. 27E. Failure of spot welding in flutes—not acceptable

Locating pads and support pads

67G. The four locating pads on the front of the flame tube and their mating support pads in the front casing should be checked for security and excessive wear. At reconditioning the total wear on any pair of mating pads must not permit a greater radial clearance than that specified in the Schedule of Fits and Clearances and Repair Tolerances.

Blueing of rear outer air casings

67H. This condition will occur when the engine is operated in excess of the permitted limitations and is generally confined to the rear third of the casing. Provided that the discolouration is not accompanied by distortion the casing is satisfactory for continued operation (*fig. 27F and fig. 27G*).

Assembly

Mk. 2, and Mk. 3 Pre-mod. 786 or 820

68. The clearance between each pip and the outer casing should be within the limits 0·003/0·015 in., but if the pips have been reformed, as described in Part 4, Sect. 2, Chap. 4, the clearance must be within the "clearance new" limits tabulated below:—

Pre-Mod. No. 226	Mod. No. 226	Joint ring salvaged to TR49	Mk. 3 engines
$\frac{0{\cdot}005}{0{\cdot}012\frac{1}{2}}$ in.	$\frac{0{\cdot}004}{0{\cdot}011\frac{1}{2}}$ in.	$\frac{0{\cdot}006\frac{1}{2}}{0{\cdot}012\frac{1}{2}}$ in.	$\frac{0{\cdot}004}{0{\cdot}011\frac{1}{2}}$ in.

Where the flame tube has been repipped, the diameter over the new pips will have been checked with ring gauge T.70452 and the pip clearance can be assumed to be correct. Insert the flame tube into its individual rear outer casing and temporarily position it by inserting the three locating pins. Stand the sub-assembly rear end uppermost and check that the annular gap is within the limits 0·020/0·042 in. Insert the three tapered feeler gauges T.70445 into the annular space between the flame tube and the outer casing (*fig.* 28) at three equidistant positions between the flame tube pips. Each of the three tapered feeler gauges must be inserted to an equal depth, so that the flame tube is concentric with the outer casing. From the graduations on the tapered feeler gauges, check that the annular gap is within the limits stated. If difficulty is experienced in centralising the flame tube in the outer casing by the method just described, the following alternative method may be employed. Having temporarily positioned the flame tube in the outer casing by inserting the locating pins, stand the sub-assembly rear end uppermost

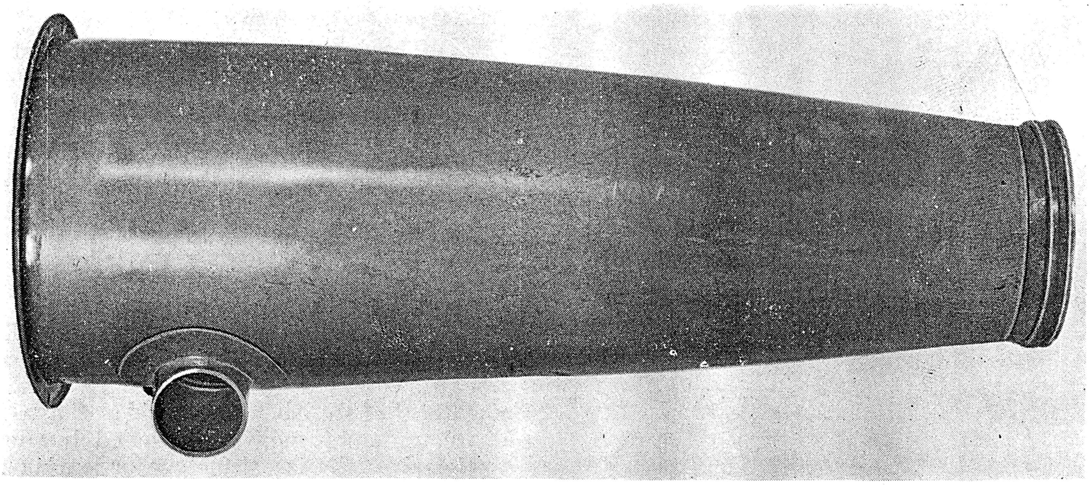

Fig. 27F. Typical example of large area of blueing and a slight brownish area. No distortion of the casing has occurred—acceptable for further service

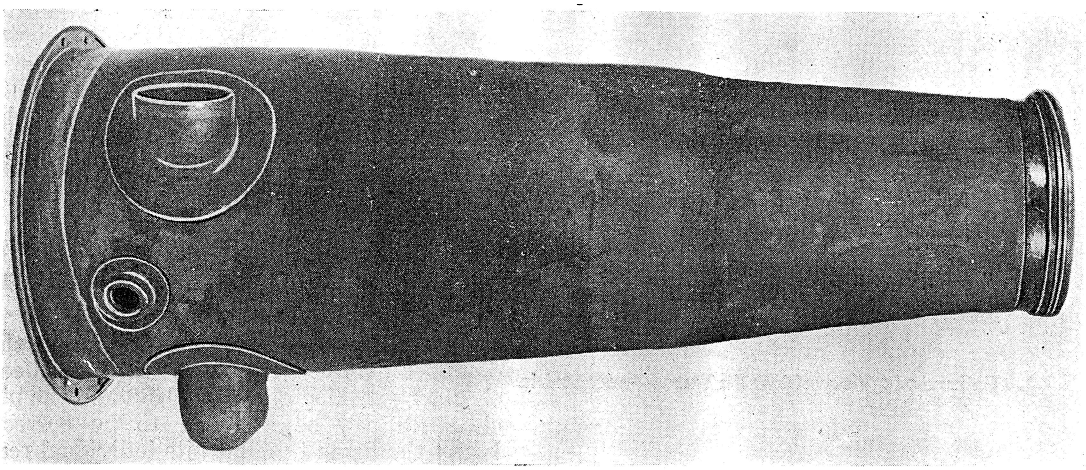

Fig. 27G. Example of severe blueing and distortion of an outer casing—not acceptable

and insert a 0·010 in. feeler (six slips of 33 S.W.G. steel with one end bent at right-angles will serve the purpose) between each of the six pips and the outer casing (*fig.* 29). With the flame tube thus centralized in the outer casing, use the tapered feeler gauges T70445 to check that the annular gap between the flame tube and the outer casing is within the limits. If the flame tube has not been re-pipped, the clearance between the pips and the outer casing must be checked with standard feeler gauges. During this check the taper feeler gauges must be left in position to ensure that the flame tube is concentric with the outer casing.

69. Remove the three locating pins and separate the flame tube from its rear outer casing. Push the individual scoop and colander assembly over the front end of the flame tube ensuring that the locating pin holes are aligned. Re-insert the flame tube complete with its scoop and colander assembly into its individual rear outer casing and retain the components in position by fitting the three locating pins; place a new plain washer (Part No. N1483) on each locating pin. Tighten the locating pins evenly. When reassembling No. 2 or 14 combustion chamber ensure that the igniter plug holes in the flame tube and in the outer casing are in line and concentric. Recheck the flame tube pip clearance as described in paragraph 68. The gap between the two bosses surrounding each locating pin must also be checked by inserting the three slip gauges T70444 into the gaps between the locating

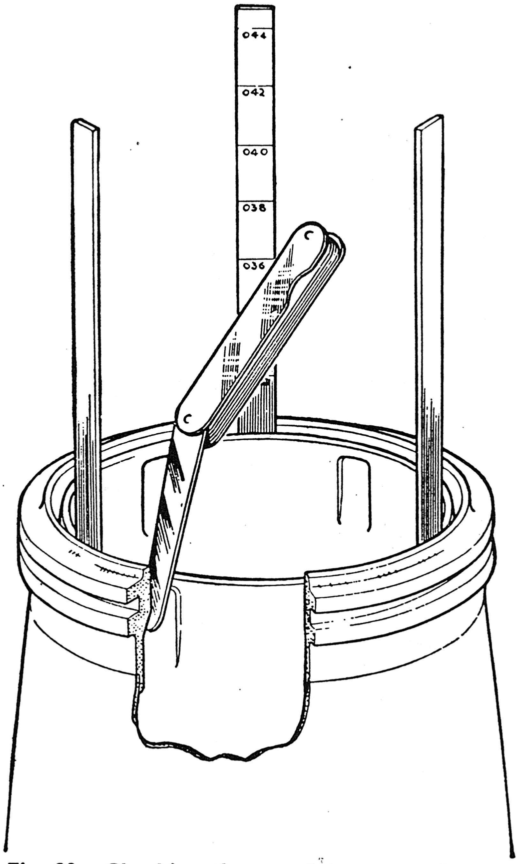

Fig. 28. Checking the annular gaps at the rear of the combustion chamber using standard feeler gauges and the three tapered feeler gauges T70445

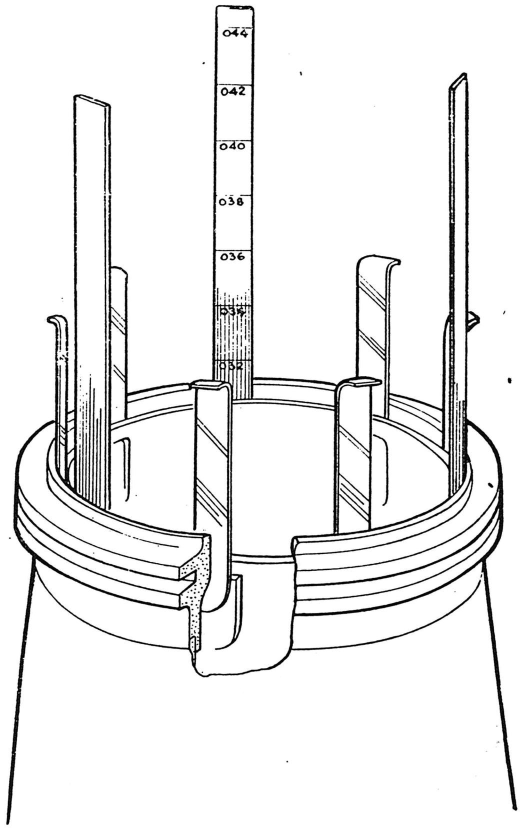

Fig. 29. Alternative method of checking annular gaps at the rear of the combustion chamber

pin bosses so that the forked end of each gauge embraces one of the locating pins (*fig.* 30). All three gaps must be checked simultaneously with the three gauges; if the gaps were checked individually, the flame tube could be displaced on the other two locating pins and an incorrect dimension measured. The assembly is satisfactory if all three gauges can be inserted at the same time. If the slip gauges will not enter it is permissible to file the pin bosses until the correct clearance is obtained.

70. Position a new joint ring (Part No. 17890) on the large flange of the correct front outer casing, and assemble the front casing to its individual rear casing, positioning the two components with the dowel in the front casing. Position the four stiffening segments on the rear casing flange, and clamp the two casings together with the sixteen bolts, shakeproof washers (or spring washers when Mod. No. 627 is embodied) and nuts; do not omit the three lock-wire tabs. The bolts must be inserted from the front and with the spring washers under the nuts. A lock-wire tab should be assembled under the nut adjacent to each of the three locating

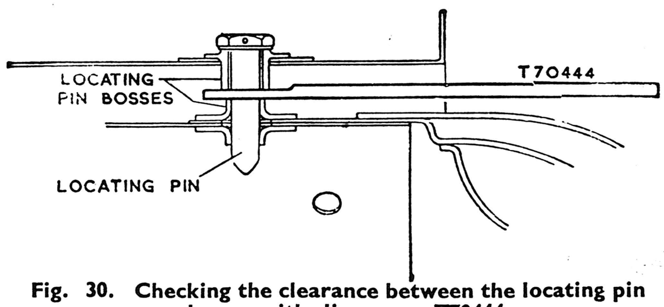

Fig. 30. Checking the clearance between the locating pin bosses with slip gauges T70444

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pins and, when Mod. No. 827 is embodied, under the nut adjacent to each of the two outer interconnecting sleeves; when Mod. No. 627 has been embodied a thinner nut is used at these positions. A lockwire tab should also be assembled under the nut adjacent to the drain pipe banjo bolt of combustion chambers No. 8 and 10. On even numbered combustion chambers, two of the bolts are shorter than the others and must be fitted at the points where the combustion chamber flange will overlap the flanges of the two adjacent odd numbered combustion chambers when they are in position on the engine that is, they should be fitted in the fifth hole each side of the dowel in the front outer casing; when Mod. No. 627 has been embodied, a thinner nut is fitted to these two bolts.

Note . . .

Unless a complete set of flame tubes to Mod. No. 646 standard is available, i.e., the modification is to be embodied in part only, it is essential that combustion chambers with flame tubes to Pre-mod. standard (snouted type) are fitted to No. 2, 3 and 4 positions. It is also essential that combustion chambers No. 4, 5, 6, 12, 13 and 14 are fitted with a rear outer casing to Mod. No. 302 standard. Vol. 2, Part 1, Leaflets No. N5 and N2 of this Air Publication refer.

71. Check the tightness of the locating pins and wire-lock them to the locking tabs. Assemble the two sealing rings in the groove at the rear of the outer casing and check that there is clearance between the rings and the grooves. When reassembling combustion chambers No. 8, 9 or 10, temporarily screw the drain pipe banjo bolt, complete with its two sealing washers, into the tapped drain hole in the outer casing.

72. Fit one seal ring to each spherical connection and check the ring for freedom in its groove. Assemble one inner inter-connecting tube to each spherical connection. Carefully push the spherical end of an inner inter-connecting tube, complete with its spherical connection, into the two inter-connecting stubs in each flame tube, ensuring that the seal ring on the spherical connection enters the flange at the end of the outer inter-connecting sleeve correctly.

Assembly

Mk. 3 Mod. No. 786 or 820 only

72A. Before assembling each combustion chamber, the four locating pads on the front of the flame tube and the mating support pads in the related front outer casing should be checked for security.

72B. Insert the flame tube into its correct rear outer casing and position with the locating pin; a new washer (Part No. 76450)

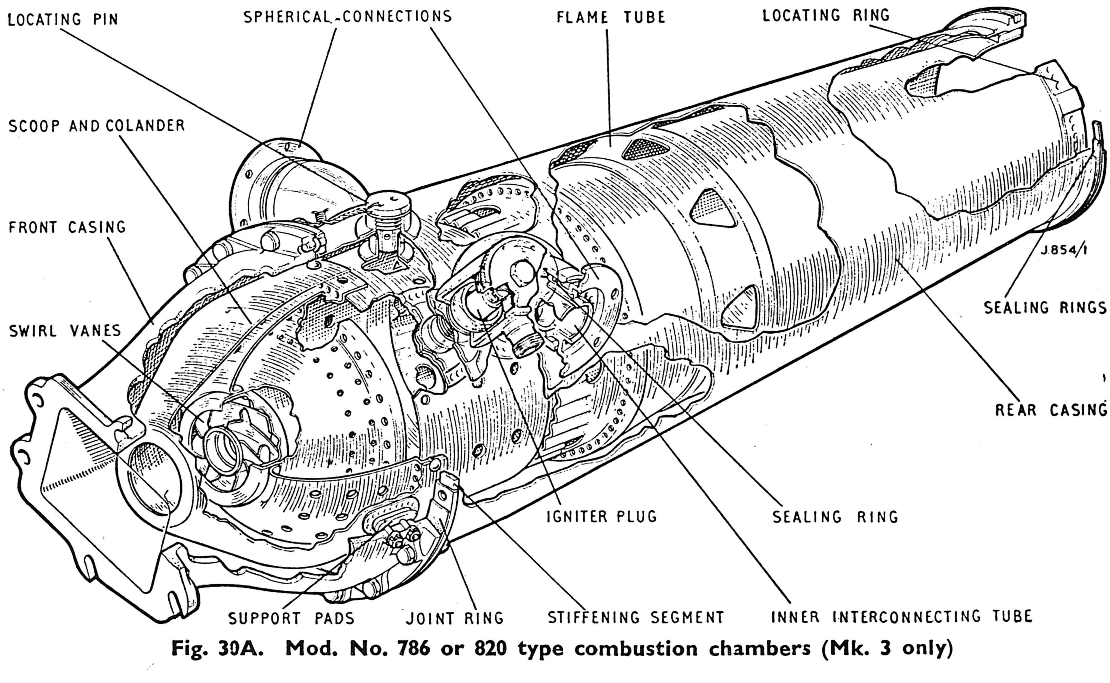

Fig. 30A. Mod. No. 786 or 820 type combustion chambers (Mk. 3 only)

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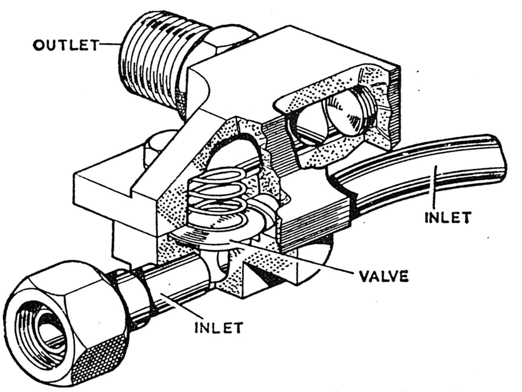

Fig. 31. Combustion chamber drain valve

should be assembled with the pin. Tighten the locating pin using wrench T73360. Stand the assembly front end uppermost and centralise the flame tube in the outer casing. Position a new joint ring (Part No. 17890) on the large flange of the front outer casing and assemble to the rear outer casing, aligning the components with the dowel in the front casing. Place the four stiffening segments on the rear casing flange and clamp the two casings together with the sixteen bolts and shakeproof washers (or spring washers when Mod. No. 627 is embodied) and the nuts; do not omit the lockwire tabs. The bolts must be inserted from the front with the spring washers under the nuts. A lockwire tab should be assembled under the nut adjacent to the locating pin and, when Mod. No. 827 is embodied, under the nut adjacent to each of the two outer inter-connecting sleeves. Mod. No. 627 introduces a thinner nut at these positions. A lockwire tab should also be assembled under the nut adjacent to the drain pipe banjo bolt of combustion chambers No. 8 and 10. On even numbered combustion chambers two of the bolts are shorter than the others and must be fitted where the combustion chamber flange will overlap the flanges of the two adjacent odd numbered combustion chambers when they are in position on the engine, that is in the fifth hole each side of the dowel in the front outer casing. Mod. No. 627 introduces a thinner nut to these two bolts.

72C. Check the tightness of the locating pin and wire-lock the pin to the lockwire tab, with the wire arranged to give a straight pull between the pin and the lockwire tab; if necessary the tab should be moved to a more convenient bolt. The remainder of the reassembly operations are identical to those described for the Mk. 2 type combustion chamber.

Refitting to engine

73. If all sixteen combustion chambers have been removed, it will probably be found most convenient to commence by refitting No. 5 and 13 which are situated at wing level when the engine is in an aircraft and which cannot be refitted after the adjacent combustion chambers above and below have both been refitted. Remove the blanking plate from the appropriate combustion chamber port in the diffuser casing. Place a new joint washer (Part No. 15302) on the face, and loosely screw the two inner set-bolts complete with plain and spring washers into the inner two of the holes tapped in the diffuser casing.

74. Smear the sealing rings at the rear end of the combustion chamber with graphite and oil and, gently compressing the sealing rings, slide the rear end of the combustion chamber into the junction pipe and its front end into position on the diffuser casing; ensure that the washers on the two inner bolts do not become trapped under the flange at the front of the combustion chamber. Put a spring washer and a plain washer on each of the remaining four bolts and screw them into the diffuser casing through the holes in the combustion chamber flange. Tighten the six bolts progressively and evenly. Check that the flange of the combustion chamber has bedded correctly on the diffuser casing and that there are no gaps between the mating faces into which a $0{\cdot}001\frac{1}{2}$ in. feeler gauge can be inserted.

75. When all sixteen combustion chambers have been refitted check that there is adequate clearance between the flanges of adjacent outer casing, and that the numbered

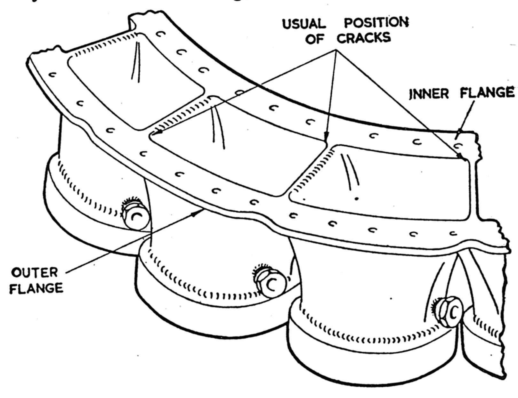

Fig. 32. Usual position of cracks in junction pipe assembly

(A.L.77, May 56)

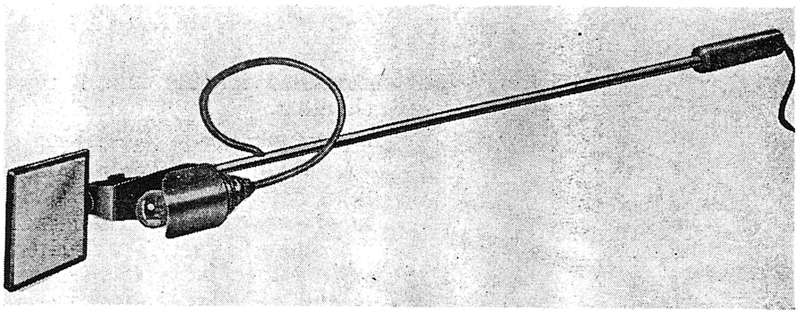

Fig. 32A—Mirror and lamp used when inspecting for cracks

sequence is correct. Refit the igniter plugs in No. 2 and 14 combustion chambers as described in para. 81 and reconnect the H.T. leads. Bolt the flanges of adjacent spherical connections together with the six 2 B.A. bolts and plain nuts. When Mod. No. 827 is embodied, a lockwire tab should be assembled under one of the bolt heads and under one of the nuts. To minimise the possibility of gas leakage at the interconnectors, particular attention should be paid to the alignment of the combustion chambers. Correct alignment can be established visually, and by checking each inter-connector spherical connection for freedom of movement laterally about its axis. Advantage should be taken of the clearance between the holes in the combustion chamber casing front flange and the retaining bolts to align adjacent inter-connector sleeves and obtain the best possible fit of the spherical connector sealing rings. The spherical connections must then be wire-locked to the two lockwire tabs on the combustion chamber outer casing flanges in a manner that will prevent rotation of the spherical connections in either direction. Refit the combustion chamber drain as described in para. 79.

COMBUSTION CHAMBER DRAIN VALVE

76. To remove the combustion chamber drain valve for cleaning or examination, having disconnected the drain pipe from the outlet union on the drain valve, break the locking wire and remove the three banjo bolts which connect the drain pipe and valve assembly to the three lowest combustion chambers. Remove the assembly and temporarily refit the six copper washers and the three banjo bolts. To dismantle the drain valve (*fig.* 31), unlock the four lock washers, and remove the two 2 B.A. plain nuts and bolts. Separate the valve seating, plate valve, and spring from the valve body which is brazed to the right-hand drain pipe. Thoroughly wash all these parts in clean kerosine. Examine the plate valve for flatness; apply a thin film of marking blue and check the contact area with the valve seating. If necessary, lightly lap the two parts together. Thoroughly wash the parts to remove any traces of lapping medium and dry with a jet of compressed air. Ensure that the spring and other parts are serviceable, and that all pipes and passages are clear.

77. Put the plate valve in the recess in the valve body and balance the spring on the valve. Place the valve seating over this sub-assembly so that the spring enters the recess in the valve seating. Hold the valve

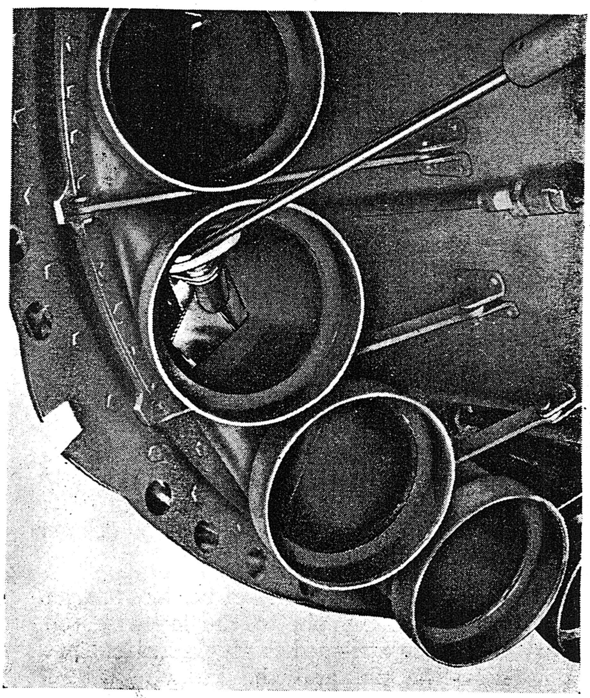

Fig. 32B—Method of using mirror and lamps when inspecting for cracks at the web joint

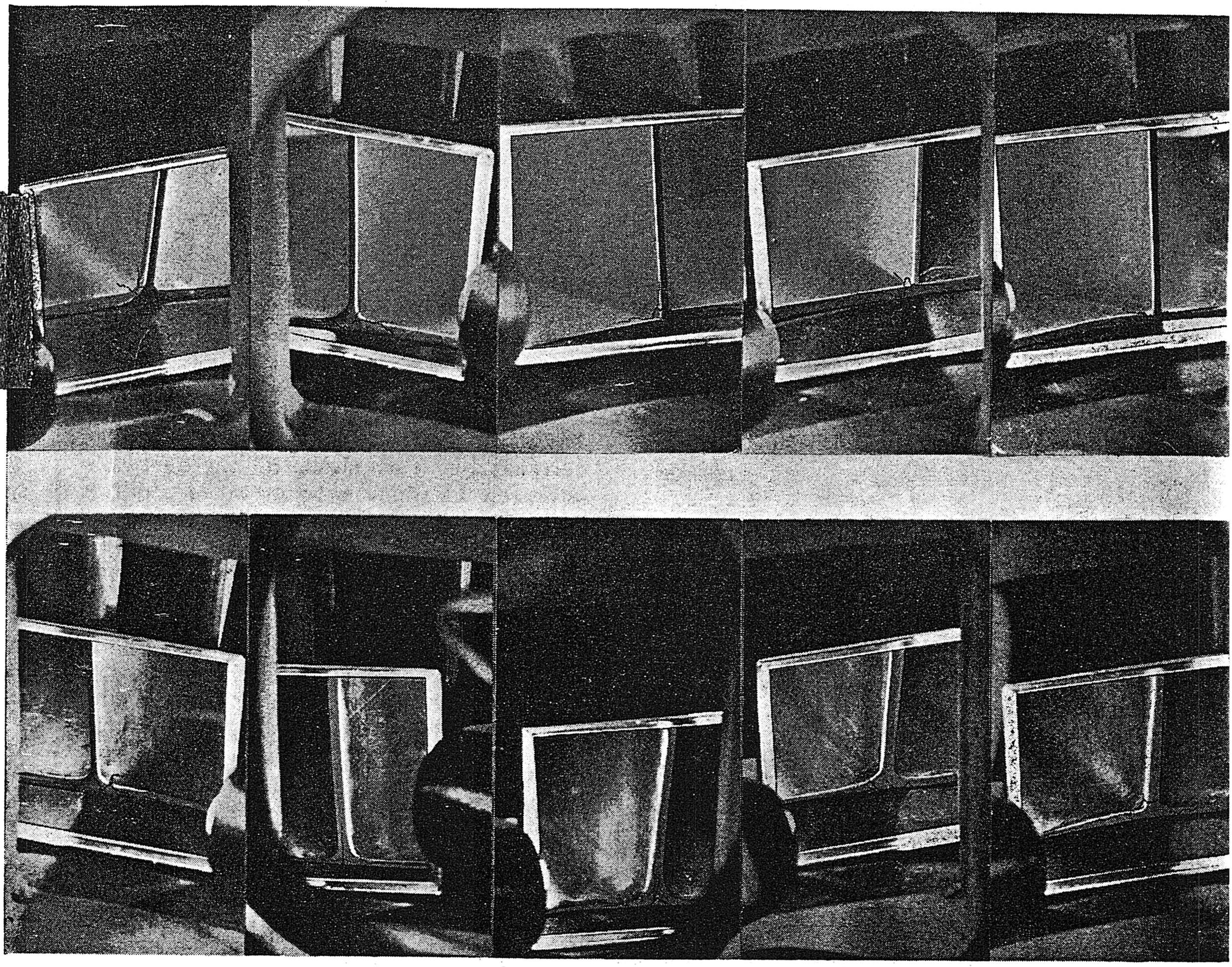

Fig. 32C—Typical examples of acceptable cracks in the web joints

seating and body together against the action of the spring and secure them with the two bolts, nuts and four new lock washers (Part No. AGS 194/2). Lock both nuts and both bolt heads.

78. When the necessary equipment is available, the drain valve should be pressure tested. The fluid to be used for this purpose is aviation kerosine (Stores Ref. No. 34A /179) and the kerosine must pass through a fabric or fine mesh gauze filter before being allowed to enter the valve. The supply pressure for testing must be capable of variation between zero and 40 lb. per sq. in. Blank off one inlet to the drain valve and connect the other to the pressure line. Apply a gradually increasing pressure to the drain valve until the valve closes; a small seepage of kerosine may still come from the outlet. The pressure at which the valve closes must not be greater than 30 lb. per sq. in. After the valve has closed, increase the pressure to 40 lb. per sq. in. and maintain this pressure. Examine the joints and ensure that no leakage occurs. Using a graduated vessel, measure the seepage past the valve. The amount should not exceed 2 cc. per minute with the inlet pressure maintained at 40 lb. per sq. in. Gradually reduce the pressure to zero and observe the pressure at which the valve opens; this should not be greater than 3 lb. per sq. in.

79. Refit the combustion chamber drain as follows. Loosely assemble the double banjo with one of the banjo bolts and two washers

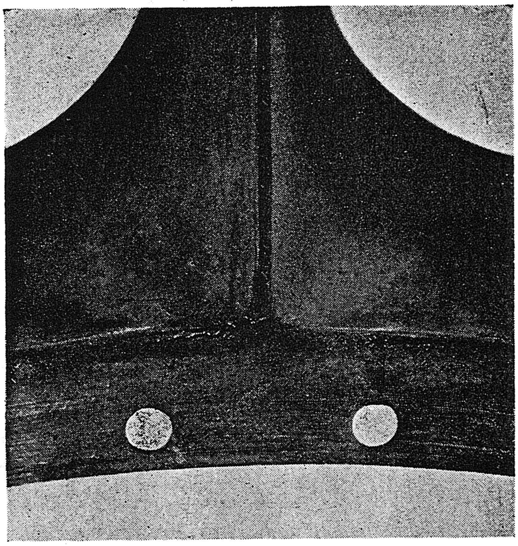

Fig. 32D. Circumferential crack in flange of junction pipe assembly—acceptable standard

(Part No. 1305/12) to the drain tapping in No. 9 combustion chamber. Similarly assemble the left-hand drain pipe to the drain tapping in No. 10 combustion chamber and loosely connect it to the double banjo, already fitted to No. 9 combustion chamber, by means of its union nut. In the same manner, assemble the drain valve and the right-hand pipe to No. 8 combustion chamber and to the second arm of the double banjo. Align the pipes, tighten and wire-lock the union nuts and the three banjo bolts, and reconnect the drain pipe to the outlet union.

JUNCTION PIPE AND SUPPORT ASSEMBLY

80. Examination of the junction pipe assembly in situ must include a thorough external and internal check for obvious or suspected evidence of damage, mainly in the form of cracking at the welded joints and from the bolt holes in the flange to which the nozzle shroud is bolted. Single cracks from bolt holes in both inner and outer flanges to the flange edge are acceptable for further service without repair. Whenever the combustion chambers are removed, opportunity should be taken to carry out a more detailed examination of the junction pipe, especially at the web joints and the inner and outer flanges as shown in fig. 32. A method of carrying out this check at the more inaccessible locations is by means of a mirror and suitable illumination on the end of a rod similar to that shown in fig. 32A. Its use when inspecting the web joint is illustrated in fig. 32B. Typical examples of acceptable cracks which were photographed into a mirror are shown in fig. 32C; similar circumferential and axial cracks which are also acceptable are shown in fig. 32D, 32E and 32F. Experience of the type of cracks illustrated has shown that gas leakage will not normally occur, and that the engine may therefore be considered serviceable for a further period between inspections. If in doubt regarding these cracks, a further guide is to place an electric torch on the outside

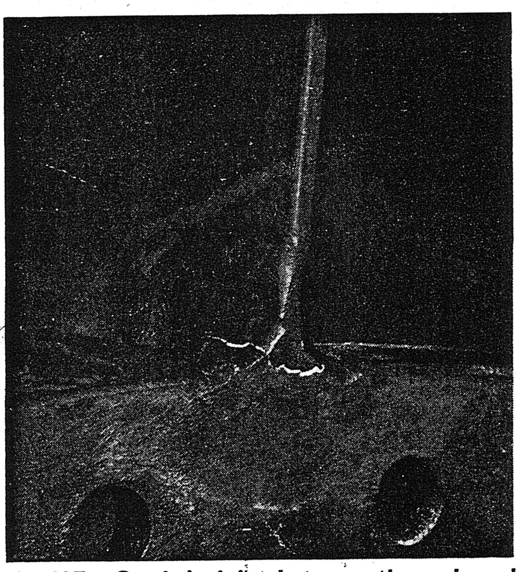

Fig. 32E. Crack in joint between the web and inner flange of junction pipe assembly—acceptable standard

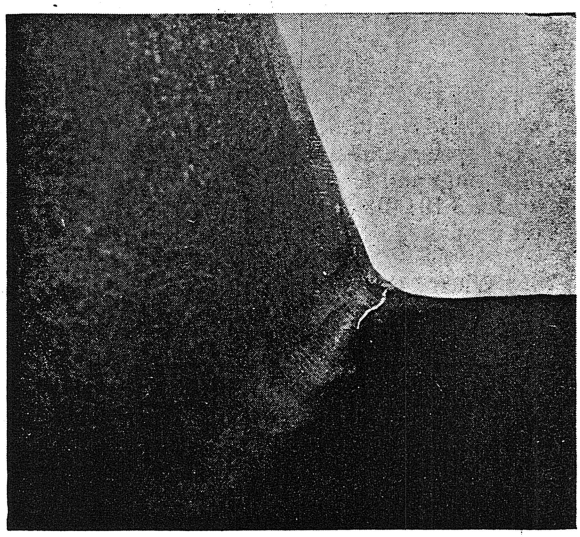

Fig. 32F. Axial crack shown in fig. 32B as seen through entry port—acceptable standard of the assembly close to the cracked area and view the inside of the assembly through the nozzle blades; if the crack under inspection shows signs of opening up and light can be seen through it, the engine must be rejected.

80A. If the cracks are beyond the limits given in the foregoing paragraphs, the junction pipe assembly may be removed for repair or replacement as described in Part 4, Sect. 2, Chap. 3.

IGNITER PLUGS

(Mk. 2 Pre-mod. No. 984 and Mk. 3 Pre-mod. 830)

81. A $\frac{3}{8}$ in. Whitworth ring spanner should be used when removing or refitting the igniter plugs and care should be taken to avoid damaging the upper sleeve. Do not dismantle the igniter plugs unnecessarily between overhauls. Remove small deposits of carbon which may be found adhering to the periphery of the igniter plug barrel. Check the igniter plug for correct gap and test for correct arcing by earthing the plug body to a combustion chamber and operating the booster coil test switch in the aircraft cockpit; do not hold this switch in the ON position for more than 20 seconds at a time. When checking the igniter plugs the centre electrode should be seen to glow for approximately $\frac{1}{4}$ in. of its length. Steady arcing should occur between the centre electrode and the earth. If the centre electrode does not glow, try the effect of changing over the primary leads to the relevant booster coil. In bright sunlight it may be necessary to shade the igniter plug before the glow can be seen. If it is considered that there is any risk of fire from the exposed arcing electrodes, a suitable ventilated transparent shroud may be improvised to enclose the end of each igniter plug during this check. Instructions for overhauling and testing these igniter plugs are contained in A.P.4282. When refitting the igniter plugs, the thread of the plug body should be lightly smeared with graphite grease prior to refitting and care should be taken that the correct external seating washer which is supplied with each new igniter plug, is fitted between the shoulder on the plug body and the combustion chamber. When the igniter plug is fully tightened in the combustion chamber, the flat marked with an arrow on the body of the plug must face forwards, that is, upstream. If necessary an external seating washer should be filed or selected to give this condition. This check is unnecessary with later type igniter plugs as four air-cooling holes are provided in the body. To obviate loosening of the centre electrode, two spanners should be used to connect the H.T. lead to the igniter plug, the lower of the two lock nuts being held whilst tightening the top nut to the lead.

HIGH ENERGY IGNITION EQUIPMENT

(Mk. 2 Mod. No. 984 and Mk. 3 Mod. No. 830)

81A. Instructions for removing and refitting the high energy ignition equipment are contained in Part 4, Sect. 2, Chap. 8, but reference should also be made to A.P.1374E and A.P.1374G for further information on the testing and repair of this equipment.

81B. To check the functioning of the system, switch on the ignition in the cockpit when the discharge at each igniter plug should be clearly audible. Alternatively, their functioning can be observed by sighting up the exhaust cone.

WARNING

The energy stored in the capacitor can, under certain circumstances, be of a lethal nature. No servicing should be attempted until at least one minute has elapsed after disconnecting the L.T. supply cable from the input plug on the condenser unit.

If the L.T. supply cable is re-connected, to check the circuit and igniter plug operation ensure that personnel are clear of the equipment before energising the unit.

JET TEMPERATURE THERMOCOUPLE

82. To remove the jet temperature thermocouple, disconnect the thermocouple cable from the terminal block on No. 1 starboard wing rib, remove the top half of the exhaust cone fireguard as described in paragraph 104 and unscrew the union nut which secures the thermocouple to the exhaust cone. Carefully unclip the thermocouple cable from inside the lower half of the fireguard and remove the thermocouple complete with its cable.

83. The jet temperature thermocouple and its cable should be carefully examined for signs of visible damage or fretting of the cable.

84. When refitting the jet temperature thermocouple, the threads should be treated with anti-seize grease D.T.D.392 (Stores Ref. 34B/88) to prevent seizure. Refit the fireguard as described in para. 106.

IMPELLER

Assessment of damage

85. At the specified periods the impeller must be cleaned and examined as thoroughly as possible without removing it from the engine. The impeller should be cleaned with kerosine, or gasoline (leaded or unleaded), or white spirit, regardless of whether it has been anodised only or has been anodised and coated with Rockhard lacquer, and then wiped over lightly with temporary rust preventative PX–1 (Stores Ref. 34B/527) or with clean engine oil, to ensure protection against corrosion; trichlorethylene must not be used for cleaning this component.

86. Damage to impeller vanes cannot, normally, be blended out *in situ*. Owing to the high rotative speeds, the removal of even small amounts of metal from the impeller vane tips can cause severe out-of-balance forces, which can only be corrected if the extent and position of the out-of-balance is determined by dynamic balancing. This necessitates removal of the impeller from the engine. Furthermore, except to the limited extent mentioned in para. 97, the removal of the protective anodic film creates a condition which is conducive to inter-crystalline corrosion; coating the exposed areas with a chemical or lacquer compound does not provide effective protection for any worthwhile period of running. Consequently, after any operations which involve the removal of portions of the anodic film, the impeller must be vapour blasted and re-anodised.

87. The following paragraphs and illustrations (*fig.* 33 *to* 47 *inclusive*) are intended as a guide in assessing acceptable limits of damage to impeller vanes which may have occurred as the result of impact with foreign matter and describe, as far as possible, the nature of the damage as it would be viewed through the aircraft air-intake ducts.

88. The illustrations, which are full size, can serve only as a guide since in practice no two indentations will be identical. Acceptance or rejection of the engine will, therefore, rest on a correct comparison of the acutal damage with that shown in the illustrations, and will depend to a very large extent upon the experience of the person conducting the examination.

89. The extent of acceptable damage represents a widening of the limits previously permitted, the relaxation being made possible from experience in the operation of impeller with damaged vane leading edges.

90. The high rotational speed of this component is accompanied by high stresses and any interruption in the surface finish constitutes an area in which these stresses can concentrate; this is particularly so in the shaded area, in fig. 33, the more rapid the change of contour the greater will be the tendency for stress concentration.

91. Where the impact has caused the material to spread so that it protrudes above the convex face of the vane, the consequent interruption in airflow will result in the formation of a black oily deposit with every appearance of a crack running at right-angles to the leading edge. This deposit must be removed, using a cloth pad soaked in an approved cleaning fluid (see para. 85) securely attached to a length of rod and the area re-examined for evidence of cracking.

92. It is important to differentiate between damage of an acceptable standard which has resulted in smoothly flowing contours on the leading edge and that which causes a sharp notch effect which would serve as a point for severe stress concentration on the surface of the vane.

93. Fig. 34 illustrates damage which is in the nature of a bruise and which is of an acceptable standard; little penetration has resulted and there is no interruption on the vane surfaces. Fig. 35 and 36 illustrate examples of acceptable damage as seen through the port air-intake, and fig. 37 indicates the appearance of the damage illustrated in fig. 36 when seen through the starboard air-intake.

94. Typical of the damage falling within the category of smooth indentations is that shown in fig. 38, 39, and 40. In these photographs it will be noted that the indentation is approximately 0·125 in. deep and smoothly radiused in contour. The displacement of material due to the impact is clearly seen in fig. 38, and is acceptable provided that a careful examination discloses no cracking such as shown in fig. 44.

95. Fig. 41 and 42 represent the maximum extent of damage which can be accepted within one inch of the vane tip. Damage of this type will not be smooth but must be free from cracks. Fig. 43 is typical of the damage caused by sharp-edged objects and although the notch effect is not very severe, the

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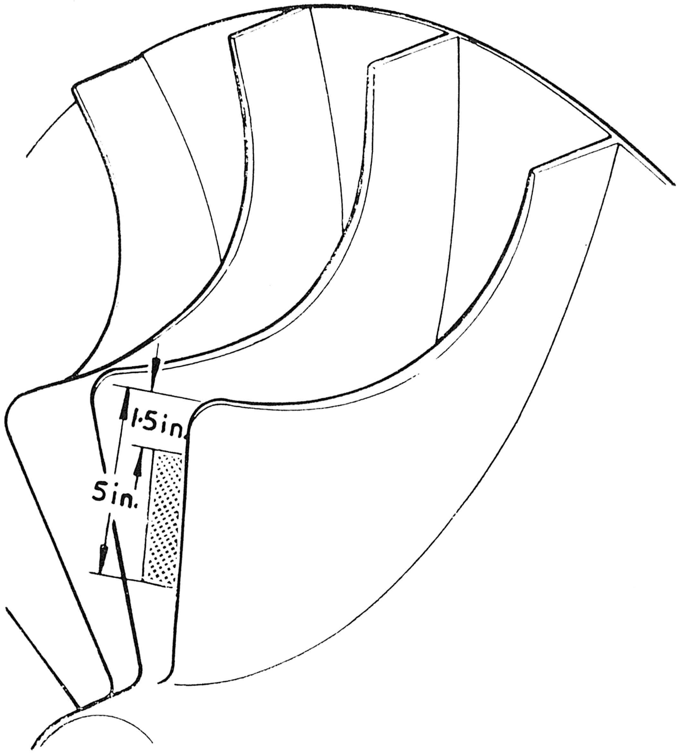

Fig. 33. The shaded area on the leading edge represents the critical area of the impeller vane. In this area only damage of a smoothly flowing contour is permitted; the surrounds must be free from cracks.

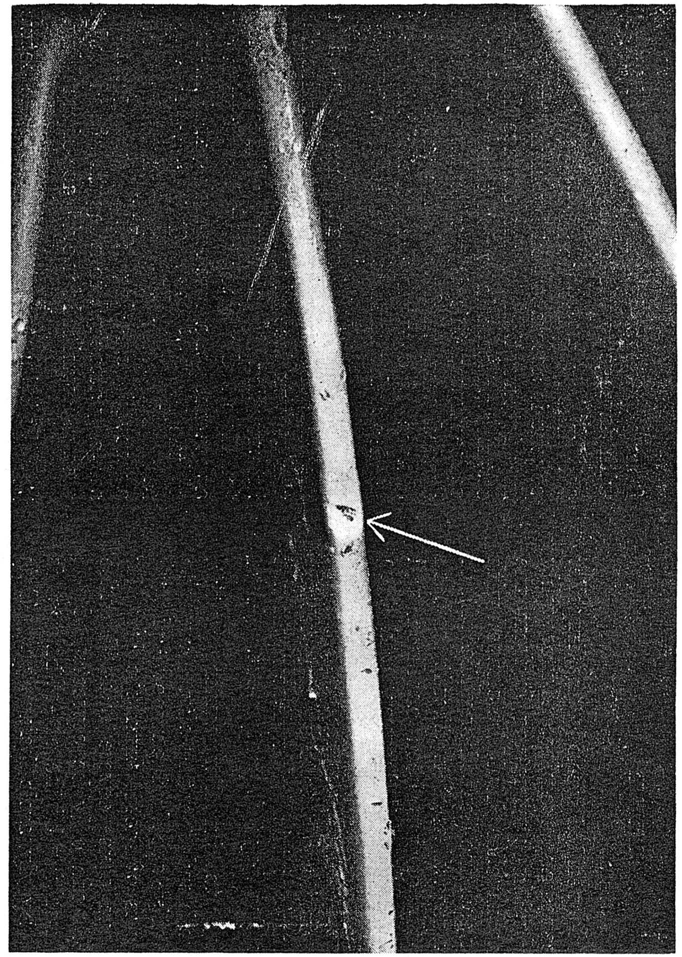

Fig. 34. Little penetration has resulted and there is no interruption on the vane surfaces. The type of damage is in the nature of a bruise and is of an acceptable standard.

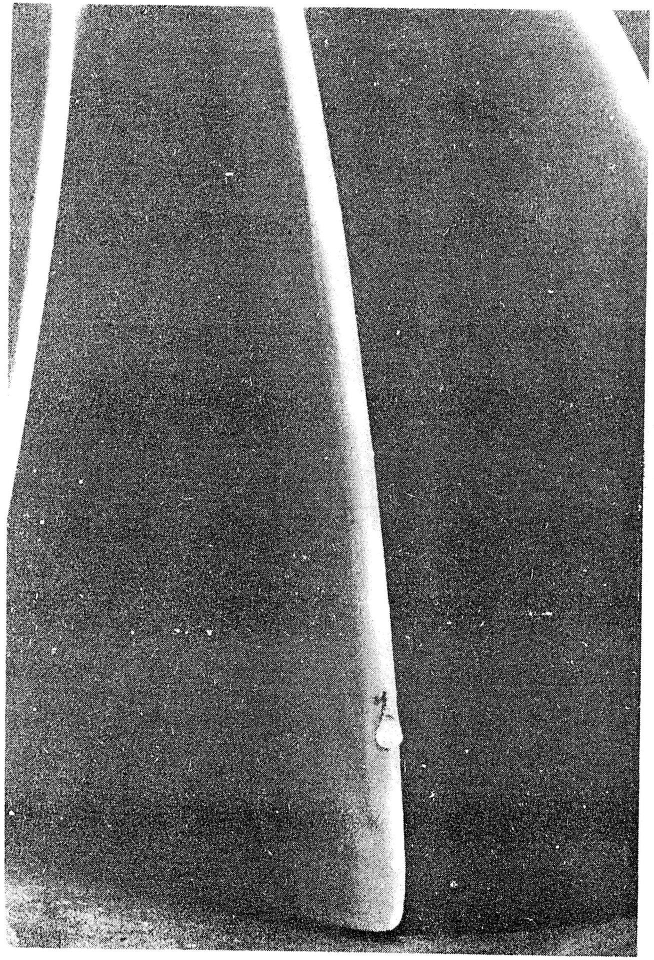

Fig. 35. Damage of an acceptable standard, viewed through port intake

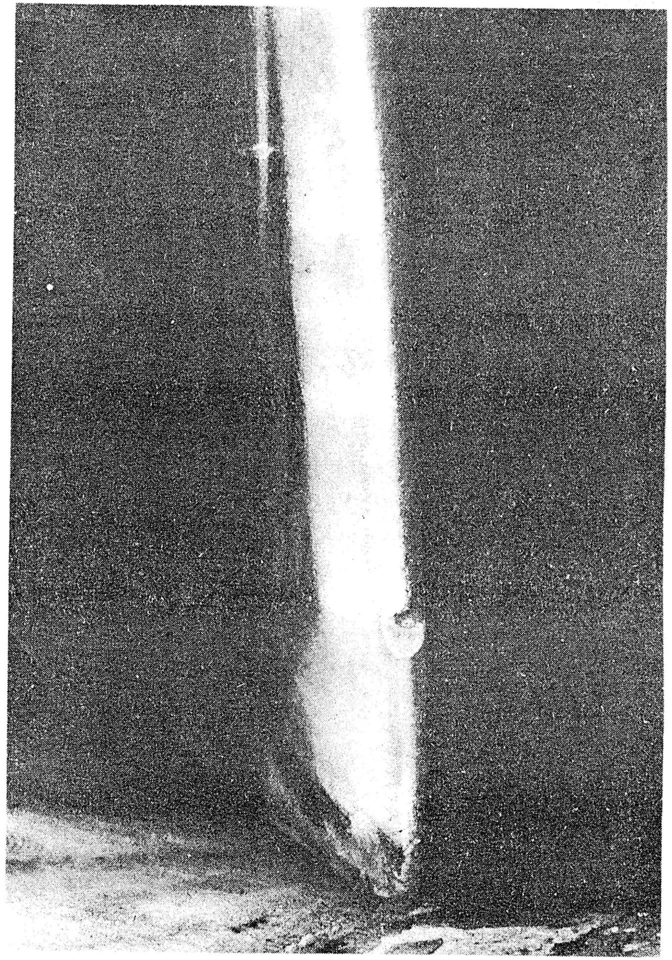

Fig. 36. Damage of an acceptable standard, viewed through port intake

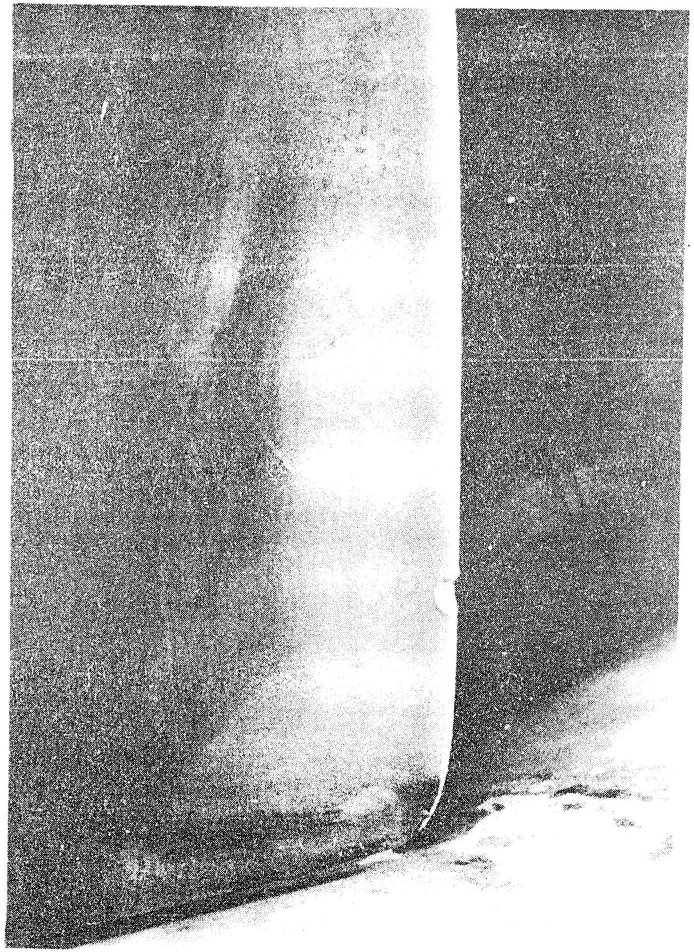

Fig. 37. Damage shown in fig. 36, viewed through starboard intake

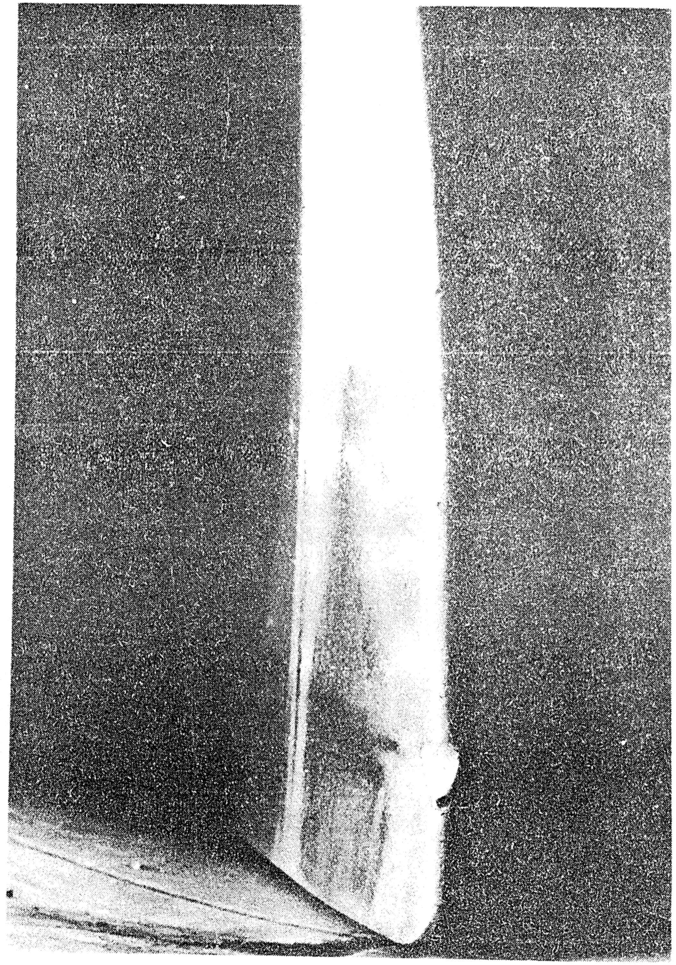

Fig. 38. Impact has resulted in damage of a smoothly flowing contour and represents the maximum extent of damage which is acceptable at any position on the leading edge. View through port intake

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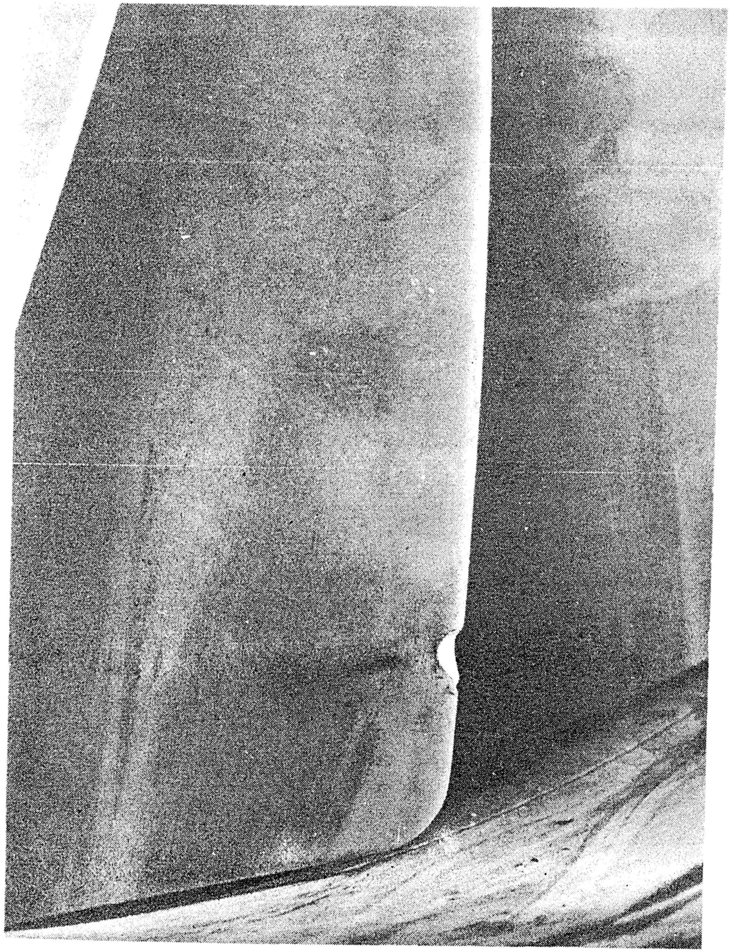

Fig. 39. Damage in fig. 38 as seen through starboard intake, enables the depth of the damage to be established

Fig. 40. Enlarged view of the damage shown in fig. 38 and 39. The smooth nature of the surface of the indentation is clearly seen and the extent of the interruption on both convex and concave sides of the vane, which is free from cracks, is emphasised. The small indentation is of an acceptable standard. Magnification $\times$ $3\frac{1}{2}$

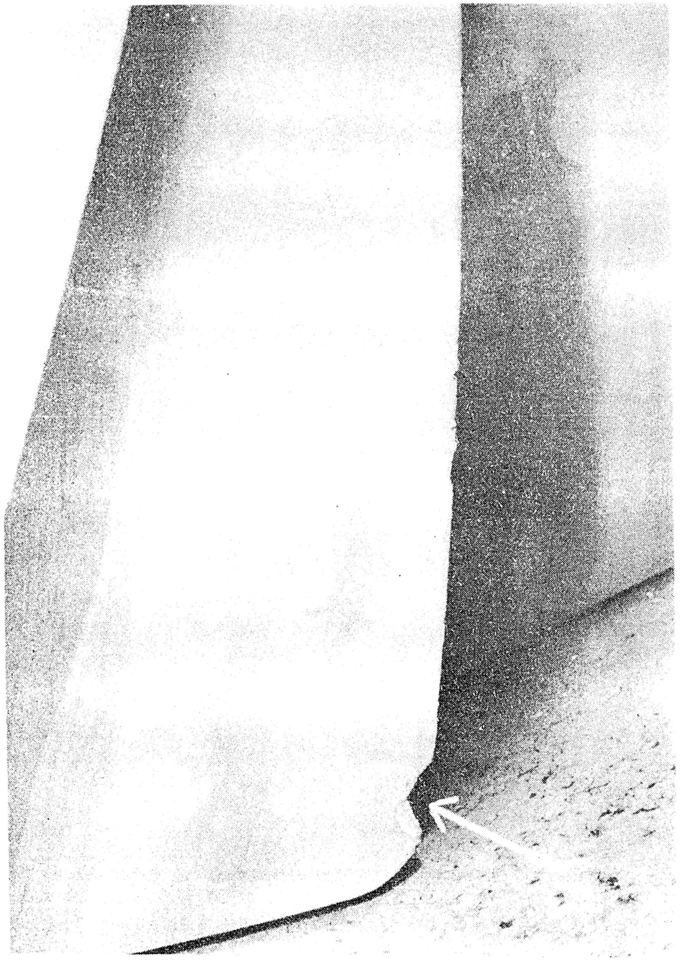

Fig. 41. This example represents the maximum extent of damage which can be accepted within 1·0 in. of the vane tip. Damage of this type is not smooth but must be free from cracks.

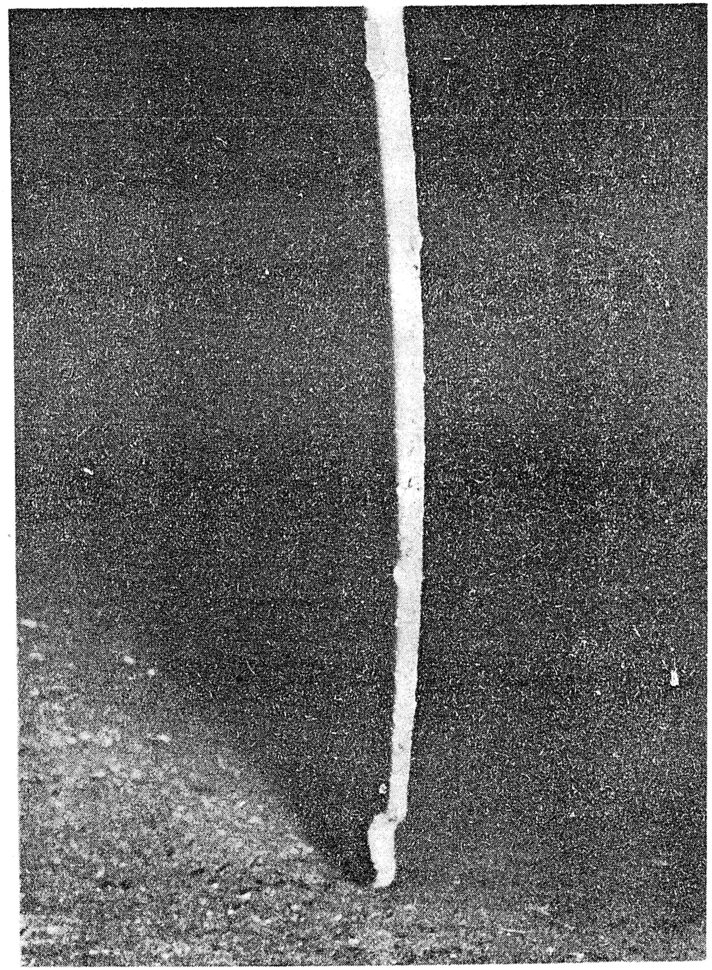

Fig. 42. Damage illustrated in fig. 41, viewed through the port air-intake

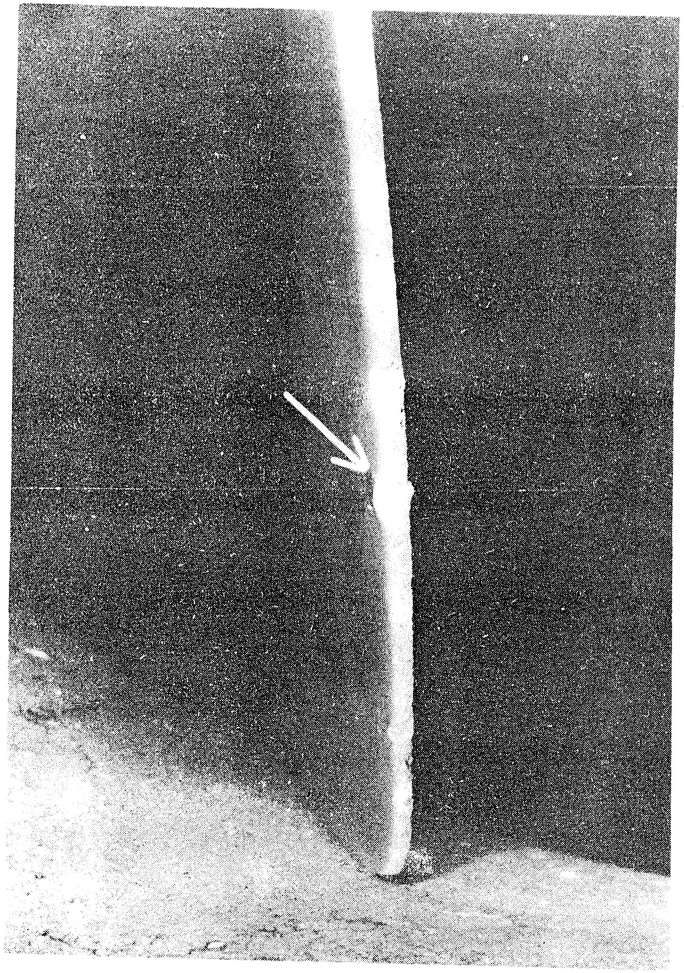

Fig. 43. This is typical of the damage caused by sharp-edged objects. Whilst this notch is not very severe the spreading over the convex face has resulted in the formation of a crack (indicated by arrow). Damage of this type is not acceptable at any position on the vane.

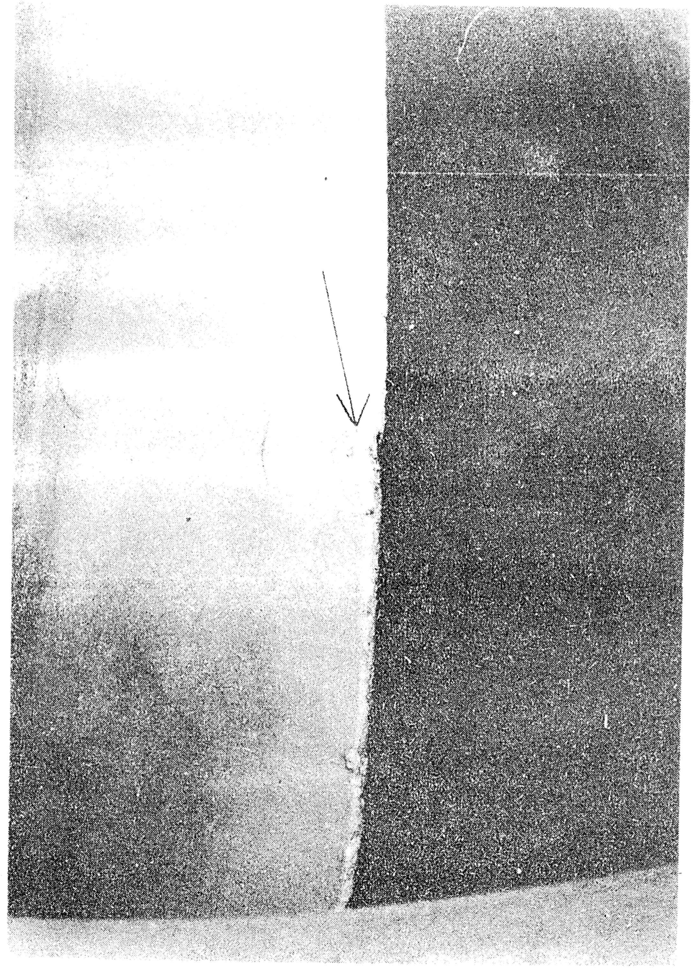

Fig. 44. Damage in fig. 43 viewed through starboard intake. The nature of the interruption to the convex face is clearly seen and the crack occurs at the boundary of the extrusion. The need for inspection through both intakes is clearly indicated in this defect.

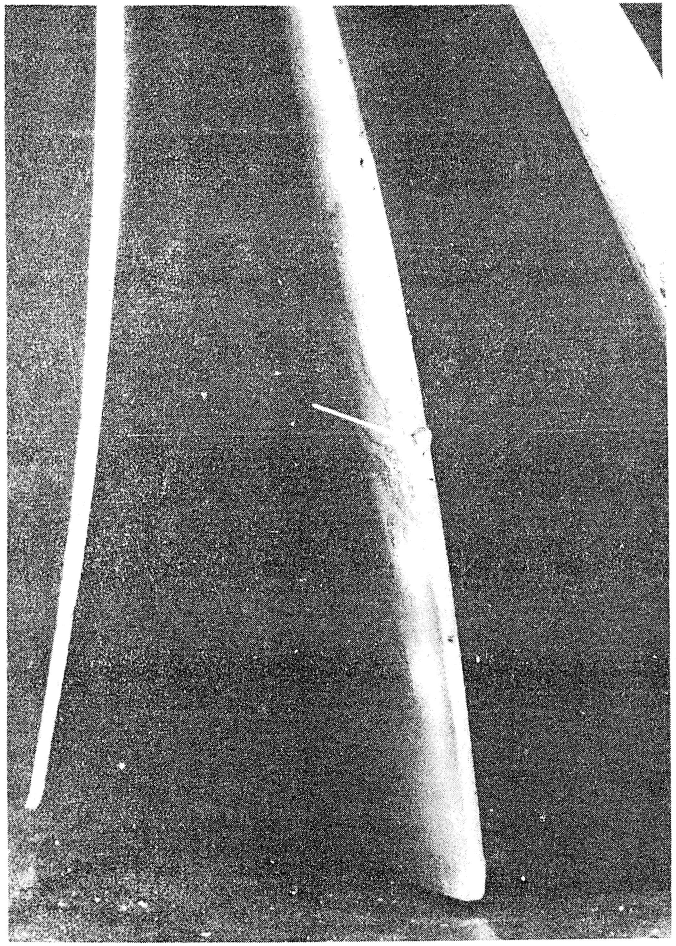

Fig. 45. A further example of damage which has resulted in a notch effect and is not acceptable in any part of the leading edge other than within the last inch at the tip. In this particular case there is little evidence of damage when viewed through the starboard intake.

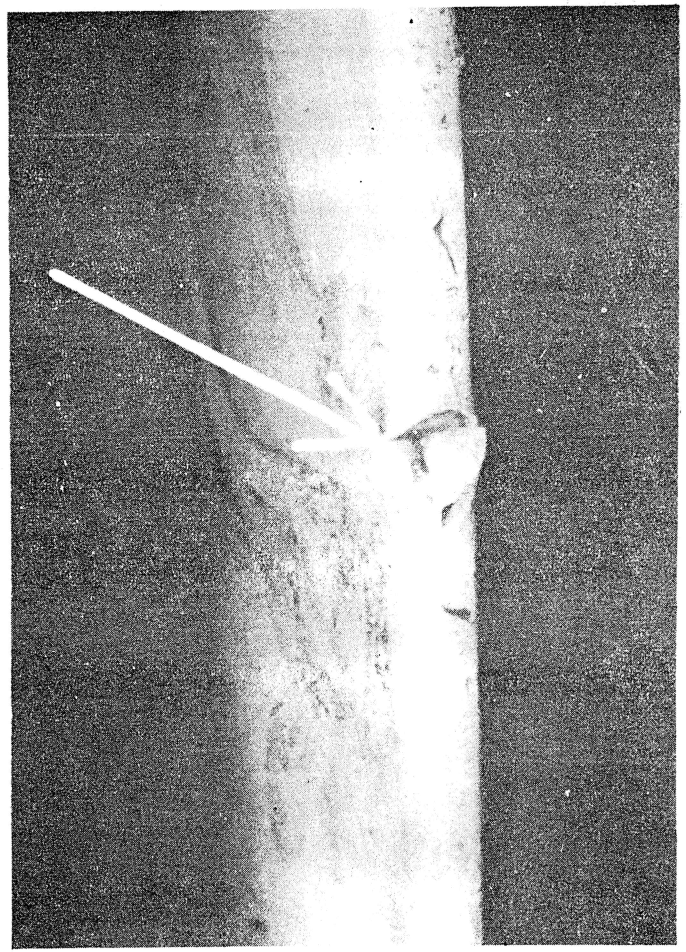

Fig. 46. Enlarged view of damage shown in fig. 45 in which the notch effect is clearly seen. The rapid change in contour caused by impact with a sharp edged object occurs at the point indicated by the arrow. Magnification 5.

spreading over the convex face has resulted in the formation of a crack at the point indicated by the arrow; damage of this type is not acceptable at any position on the vane. Fig. 44 illustrates the damage shown in fig. 43 as seen through the starboard air-intake, the nature of the interruption to the convex face is clearly shown and the crack occurs at the boundary of the extrusion as indicated by the arrow. These two illustrations clearly indicate the need for examination through both air-intakes.

Fig. 47. This is a typical form of notch effect in which the stress concentration has resulted in a crack. Whilst failures of this nature do not normally reach this stage during a single flight it emphasises the need of careful and frequent examination for cracks in the region of all damaged areas.

96. It is important with regard to the notch effect, that the indentation can be quite small and yet form a nucleus for stress concentration, particularly in that section of the leading edge indicated by fig. 33. The distinction between smooth and notched indentations is clearly seen by comparing fig. 38, 39, and 40 with fig. 45 and 46. In these latter illustrations, the damage depicted has been caused by a sharp-edged object resulting in something like a "V"-shaped indentation, and unless specifically stated otherwise in these instructions, must result in the rejection of the impeller.

97. Impact damage of the type under consideration will inevitably result in a loss of protection against corrosion normally afforded by the anodic film and the rate of corrosion attack will depend upon the conditions under which the aircraft is operating. In general this loss of protection can be disregarded if the aircraft is in continuous operation or the engine has not more than 25 hours running time before the end of its service life. If the engine is likely to be standing idle for a period of seven days or more the impeller vane edges should be sprayed or painted with the temporary rust preventative PX-1 (Stores Ref. 34B 527).

Examination of damage

98. Using a strong light, each vane should be placed in the bottom vertical position and examined independently through the port and starboard air-intake ducts. To enable new damage to be readily assessed a record should be made of the damage found at each examination. A critical examination preferably using an introscope should be carried out at the specified period.

99. Examination through the port air-intake duct will show the damaged area looking directly at the leading edge and will indicate the nature of the material spreading which has occurred under impact (*fig.* 34, 35, 36, 38, 42, 43 *and* 45).

100. Inspection through the starboard air-intake duct will give a view on the convex side of the vane and enable the approximate depth of the damage to be assessed (*fig.* 37, 39, 41, 44 *and* 47). Fig. 47 shows a typical form of notch effect in which the stress concentration has resulted in a crack. Failures of this nature do not normally reach this stage during a single flight, but the condition emphasises the need of careful examination for cracks in the region of all damaged areas.

101. The normal abrasive pitting which will be found on the impeller vanes after even a few hours running may be ignored; normal abrasive pitting appears as a light even sand-blasted effect.

102. When examining the impeller the rear face of the impeller pivot flange is cut back with the effect, that when the pivot is fully home in the impeller, there is a space slightly more than $\frac{3}{64}$ in. wide and $\frac{3}{4}$ in. deep, between the edge of the pivot flange and the impeller hub. Therefore, the gap, which is used for tooling purposes during manufacture and reconditioning, is intentional and does not indicate that the pivot has moved away from the impeller.

Crack detection

102A. It is recommended that impellers should be subjected to the Ardrox dye penetrant crack detection process at each Primary Star or Main Check 2 servicing period; this process can be applied to uninstalled engines (*method* 1), para. 102C, or to installed engines (*method* 2), para. 102D. Should any damage, however, be observed during a "between flights" inspection, a more detailed examination of the affected area must be carried out, and, if any doubt exists as to the serviceability of the impeller, crack detection in accordance with method 2 should be applied. The process involves the thorough cleaning of the impeller, and the application of a red coloured penetrant fluid, which creeps into all surface voids, such as cracks, etc. Excess penetrant is then removed from the surface of the impeller, and the defect is developed by the application of a spray of fine white powder in a solvent. Cracks, and other flaws, will be shown up as irregular red lines, or as a series of red dots, on a white background. Such defects will be observed readily if they exist on the main surfaces of the impeller backplate and vanes, but will be more difficult to locate at the roots and outer edges of the vanes, and at the periphery of the backplate, fig. 47A. Every effort should be made to ensure that these difficult areas do not escape examination. When either method of the process is being applied, all cleaning and spraying should be carried out through the starboard air-intake in the top left-hand area between the 9 and 12 o'clock position, and inspection should be carried out through both air-intakes, using an extended inspection lamp and mirror. On some Goblin impellers which have not been treated with Rockhard lacquer, marks may be seen which resemble pencil lines running from the impeller hub down the root of the vanes, these marks may be thought to be cracks but it is unlikely that they will be confirmed as cracks when checked by the Ardrox Process. These marks are due to the chalk content in the water bath, in which the impellers are washed after anodising, leaving a tide mark. Such marks should be examined carefully to prevent unnecessary repetition of the Ardrox Process.

102B. The following tools and materials will be required:—

Description	Stores reference
ARDROX 996–P Penetrant	4A/2318
ARDROX 996–D1 Developer	4A/2319
ARDROX 996–SL Flaw Detection Kit	4A/2320
White Spirit	34D/246

Uninstalled engines (method 1)

102C. During each of the following operations, the impeller should be gently rotated to ensure that all accessible surfaces are dealt with. Proceed as follows:—

(1) Thoroughly clean the impeller, using clean rag soaked in white spirit, and make certain that all traces of contamination are removed.

(2) Using clean rag, or a jet of compressed air, thoroughly dry the impeller.

(3) Using a brush, or the spray which is issued in the crack detection kit, apply Ardrox 996–P Penetrant to the impeller. Allow the penetrant to remain for a minimum period of 20 min.

(4) Use a rag soaked in white spirit to remove all penetrant from the surface of the impeller. It is most important that this operation should be carried out thoroughly, otherwise spurious indications will be given when the next operation is applied.

Tech Pubs 30

April, 1960

ADMIRALTY
AIR MINISTRY

GOBLIN MK.2 & 3 AERO-ENGINES

ADVANCE INFORMATION LEAFLET NO. 1/60

Insert this leaflet in A.P.4121B & C, Vol.2, Part 3, Sect.3, Chap.1, to face para.102A.

GOBLIN MK.2 AND 3 IMPELLERS
CRACK DETECTION TESTS

1. With the introduction of Goblin Modification 1087, impeller failures due to cracking have been reduced to negligible proportions, and the instructions given in para.102A to 102D are now applicable only to pre-mod.1087 Goblin engines.

Notes

(1) The information contained in this leaflet will be incorporated by normal amendment list action in due course.

(2) If, after receipt of this leaflet, an amendment list with a prior date and conflicting information is received, the information in the leaflet is to take precedence.

ENGINEER

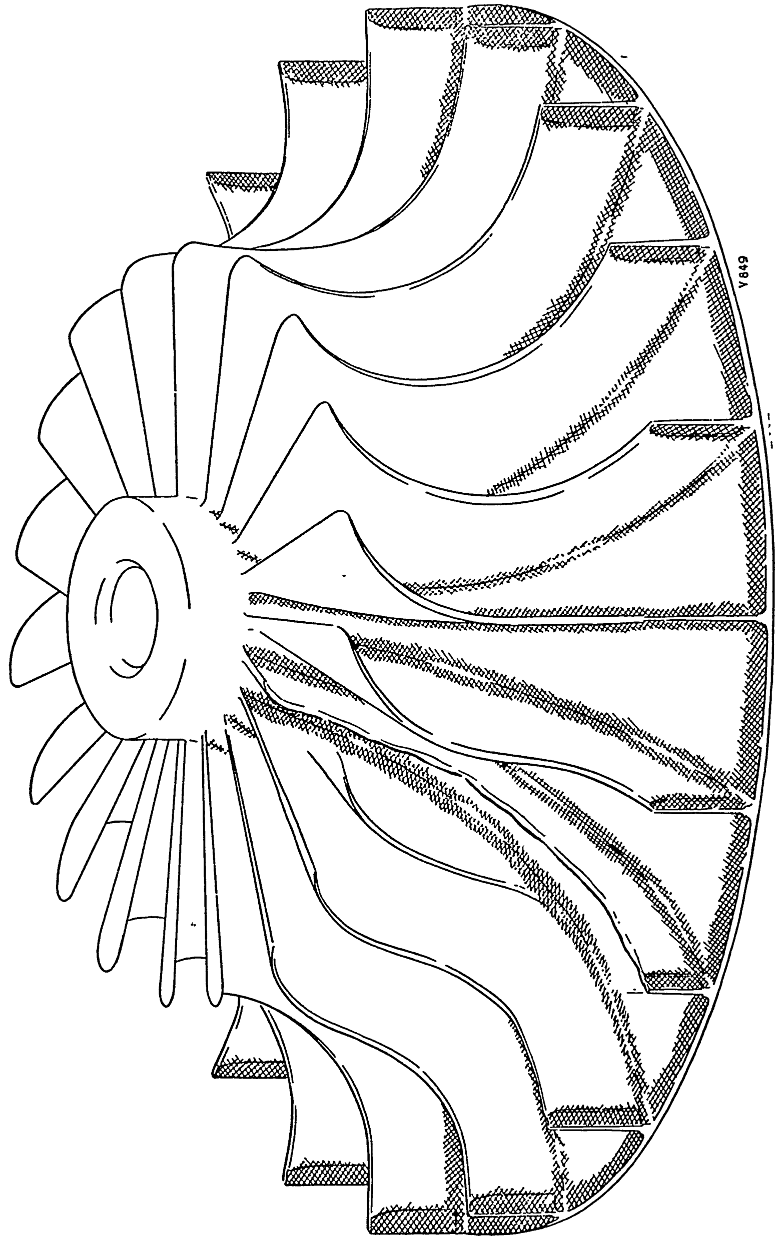

Fig. 47A. Shaded areas on impeller indicate positions which must be examined carefully for cracks and flaws

(5) By means of the spray apparatus which is contained in the kit, apply Ardrox 996–D1 Developer to the impeller; this should be allowed to stand for 5 to 10 min.

(6) Using a suitable means of illumination carefully and thoroughly inspect the impeller for defects.

(7) Repeat Op. 1 and 2 to remove the developer.

Installed engines (method 2)

102D. When applying this method, the aircraft should be positioned within easy reach of a compressed air supply which is capable of delivering pressure up to 60 lb. per sq. in., and of a source of electricity for the operation of a hand lamp placed in the starboard air-intake. To ensure that all accessible surfaces of the impeller are treated, it will be necessary for an assistant to rotate the engine by exerting slight pressure on the impeller vanes, with the aid of a suitable wooden lever inserted through the port air-intake. To guard against a possible fire risk, due to the presence of unevaporated white spirit used for the final cleaning of the impeller, it is recommended that no attempt be made to start the engine for at least ½ hr. after completion of the impeller check. To apply this method, proceed as follows:—

(1) Attach the Ardrox 996 Venturi spray unit to the special 6 ft. 9 in. spray gun, connect the gun to the compressed air supply, and spray the impeller with white spirit at a pressure of about 60 lb. per sq. in. The white spirit should be supplied from a one-gallon tin standing on the wing of the aircraft.

(2) Thoroughly brush the impeller with the nylon brush, making sure that all accessible surfaces are cleaned.

(3) Respray the impeller with white spirit.

(4) Disconnect the supply of white spirit, and use the spray gun to thoroughly dry the impeller with compressed air. Ensure that all surfaces of the impeller are dried completely.

(5) Attach the penetrant spray tin to the gun, and, using a reduced air pressure of between 25 and 30 lb. per sq. in., thoroughly spray all accessible surfaces of the impeller with Ardrox 996–P Penetrant. Allow the penetrant to remain for a minimum period of 20 min.

(6) Re-attach the venturi spray unit to the gun, and spray the impeller with white spirit at a pressure of about 60 lb. per sq. in. to remove all penetrant from the impeller surfaces.

(7) Thoroughly dry the impeller with compressed air.

(8) Attach the developer spray tin to the gun, and, using a reduced air pressure of between 25 and 30 lb. per sq. in., apply a thin, even film of Ardrox 996–D1 developer to all accessible surfaces of the impeller; over-application must be avoided, or fine cracks may be masked. Allow the developer to stand for 5 to 10 min.

(9) Using a suitable means of illumination, and an extension mirror, carefully and thoroughly inspect the impeller for defects.

(10) Repeat Op. 1, 2, 3, and 4 to remove the developer.

EXHAUST CONE/TURBINE CLEARANCE, CHECKING WITHOUT REMOVING THE EXHAUST CONE (Pre.mod. 212 only)

103. The clearance between the inner cone baffle and the turbine disc at the smallest point must not be less than 0·18 in. To check this clearance without removing the exhaust cone from the engine, make up a tool as shown in fig. 48 and carefully push it up the exhaust cone. If the bent-over end of the tool will slip between the inner cone and the turbine disc it may be assumed that the clearance is satisfactory. The check should be repeated at eight points around the circumference of the inner cone; the fairings make excellent guides for this purpose. This check is primarily intended to prove that the baffle at the front of the inner cone has not become detached.

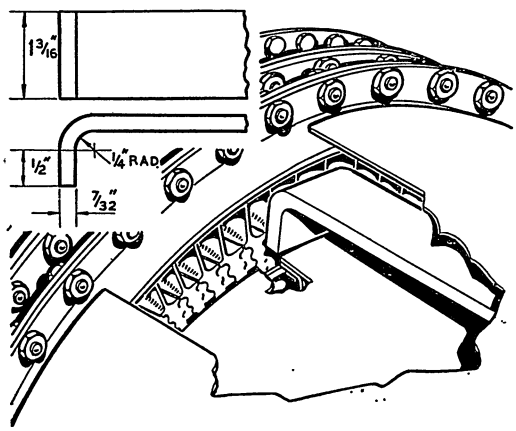

Fig. 48. Tool for checking clearance between exhaust cone and turbine disc

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REMOVAL OF FIREGUARD AND EXAMINATION OF EXHAUST CONE

104. In order to examine the exhaust cone in situ, remove the fireguard (*fig.* 49) as follows. Remove the three ¼ in. B.S.F. bolts securing the fire extinguisher coil support brackets to the top half of the fireguard or, if Mod. 497 and Vampire Mod. No. 844 have been embodied, remove the fireguard extensions by releasing the two DZUS fasteners on each extension. Remove the ¼ in. B.S.F. bolt securing the gun heater support bracket at the starboard side of the top half of the fireguard. If the thermocouple is at the pre-Mod. 404 position, disconnect the thermocouple cable from the clips at the outer starboard side of the fireguard top half. Slacken off the six 2 B.A. plain nuts on the pinch bolts which clamp the two halves of the fireguard together until the pinch bolt washer is released from the clip on the fireguard and the pinch bolt can be swung clear. (*Mk. 3 only*). Remove the locking pins and release the six latch clips which clamp the two halves of the fireguard together; when Mod. No. 857 is embodied the two rear fasteners are of the Mk. 2 type. Carefully lift the top half of the fireguard clear of the engine. Unclip the thermocouple leads from inside the lower half of the fireguard. Remove the bolts securing the gun heater pipe connections to the exhaust cone heater muff. Lower the bottom half of the fireguard from the engine.

105. Examine the exhaust cone and turbine shroud mating flange for cracks. Cracking from all bolt holes to the periphery of the flange is permissible, but cracking from hole to hole is not permissible. Thoroughly examine the outer cone for cracks, paying particular attention to the point at which it is welded to the flange. Examine all welded seams for soundness or indications of gas leaks. Examine for gas leaks along the periphery of the outer cone flange/turbine shroud joint. If there are any gaps between the mating faces of these

(continued overleaf)

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flanges into which feeler gauges can be inserted, the exhaust cone or the turbine shroud must be replaced by a serviceable component according to which flange is distorted. Use an electric light to ascertain that the rear (trailing) edge of each of the fairings inside the exhaust cone are not cracked or split open; later production exhaust cones have fairings made from one piece and there is no likelihood of separation. Ensure that the extension flange, which carries the propelling nozzle at the rear of the outer cone, has not broken away. Check the security of the inner cone by grasping the apex of the cone and shaking it. Buckling and dents up to the depth of $\frac{3}{4}$ in. may be ignored during operation providing a careful examination for cracks is made. All buckles and dents in the inner and outer cones are to be removed by using a rubber mallet to restore the original shape. Where buckling is apparent on the inner cone adjacent to the fairings in line with the support tubes, a periodic check of the clearance between the inner cone baffle and the turbine disc should be made as described in para. 103.

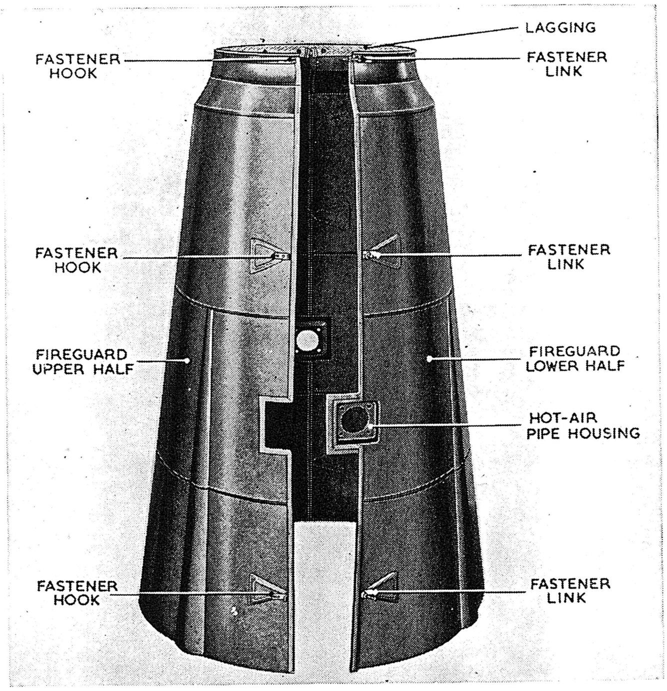

Fig. 49. Exhaust cone fireguard

106. When refitting the exhaust cone fireguard it is important to ensure that the rear end of the fireguard fits snugly round the nozzle extension ring and that the front end fits snugly round the fireguard support ring which is carried by the nozzle shroud ring bolts. It is also important that the edges of the two halves of the fireguard and of the air heater pipe housing apertures align and close up evenly. Position the bottom half of the fireguard over the exhaust cone guiding the stiffened edges of the hot-air pipe cut-outs into the corresponding grooves in the frames of the hot-air housing. Secure the gun heater pipe connections to the exhaust cone heater muff. Clip the thermocouple lead to the inside of the lower half of the exhaust cone fireguard. Lower the top half of the fireguard over the exhaust cone (*Mk. 2 only*). Swing the pinch bolts into position over the hooks and progressively tighten the nuts to draw the two halves of the fireguard evenly together. (*Mk. 3 only*). Locate each of the six latch bolts, on the fireguard bottom half, in the hook on the top half of the fireguard and draw the two halves of the fireguard together evenly by depressing the six latch clips; when Mod. No. 857 is embodied, the two rear fasteners are of the Mk. 2 type. Insert and tighten up the $\frac{1}{4}$ in. B.S.F. bolts securing the gun heater pipe support bracket, at the starboard side of the top half of the fireguard. If Mod. 404 has not been embodied, secure the thermocouple lead in the two clips at the outer starboard side of the fireguard top half. The fireguard should normally form a close fit around the propelling nozzle. Local gaps only up to 0·006 in., measured by feeler gauges, are permitted, except on Mk. 2 engines fitted with a $16\frac{1}{8}$ in. propelling nozzle (Mod. No. 936); when the Inconal packing strip on the fireguard has been changed to steel (Mod. No. 968), 0·012 in. is permissible.

106A. When Mod. No. 903, which introduces a baffle in the inside of the fireguard lower half is embodied, it is possible for the baffle to foul No. 9 combustion chamber, which if permitted can result in a grave fire hazard. Therefore, when fitting a modified fireguard, check that there is at least $\frac{1}{16}$ in. gap between the top edge of the baffle and the outer casing of No. 9 combustion chamber. If the clearance is less than this, it is permissible to file not more than 0·1 in. off the baffle plate immediately adjacent to the combustion chamber.

EXHAUST CONE ASSEMBLY

Removing and dismantling

107. With the exhaust cone fireguard removed, break the locking wire on the four flexible joints in the cooling pipes and unscrew the gland nuts. Remove the forty-five $\frac{7}{16}$ in. nuts and bolts which secure the exhaust cone to the turbine shroud. When Mod. No. 911 is embodied the nuts and bolt heads are locked with double tab-washers. Carefully remove the exhaust cone, easing the rear portions of the air cooling pipes away from the pipes attached to the forward portion of the engine.

108. Due to the heat to which the exhaust cone assembly is subjected during running, all nuts, bolts, and studs should be soaked in penetrating oil for a minimum period of two hours before dismantling and rotated slowly during removal, otherwise they are liable to fracture and shear. Should this occur it may be difficult to remove the sheared portion.

109. Commence dismantling the tail pipe assembly with the front end mounted on the wooden base T.71200. Remove the thirty nuts and bolts and lift off the propelling nozzle.

110. Reverse the tail pipe so that it stands on its rear end. Remove the split pin and unscrew the large nut in the centre on the inner cone baffle using the box spanner T.70259. Release the tab-washers and remove the twelve bolts securing the baffle to the inner cone and lift off the baffle. Mark each of the eight fairings with a chalked number and chalk the corresponding number on the inner and outer cones adjacent to the position of the respective fairings. Break the locking wire and remove the four cap-nuts and washers from the ends of the two rear support tubes. Drive out the support tubes

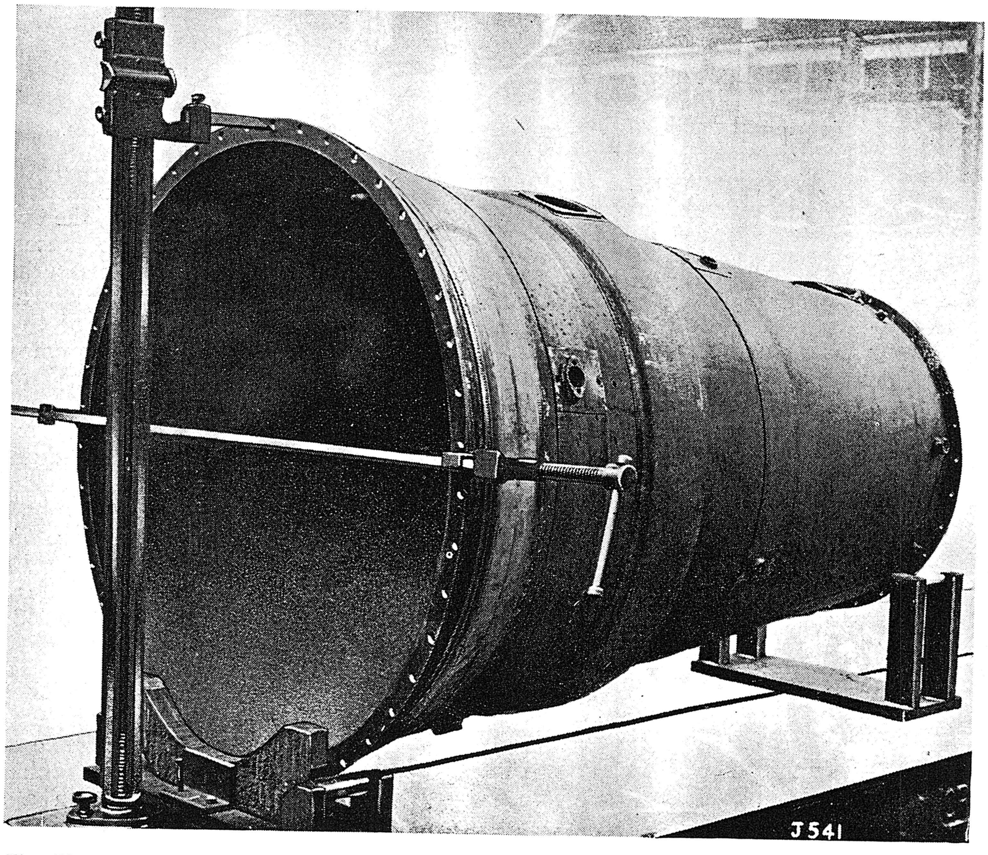

Fig. 50. Checking ovality of the outer cone front flange also showing cramp in position to correct regular ovality

with the brass-ended drift T.70277. Remove the bolts and spring washers from the four air-pipe adapters fitted to the ends of the front support tubes. Take off the adapters and drive out the two support tubes with the brass-ended drift T.70278. As the second of the two tubes is removed, the large air tube will be released and should be taken out. Lift out the inner cone. Break the locking-wire and remove the three set-screws and spring washers securing each of the eight support tube fairings and take out the fairings, four from the front end and four from the rear. Break the locking-wire and unscrew the blanking plugs and nuts, and one thermocouple from the outer cone.

Examination

111. The following paragraphs and illustrations provide a general guide to show the repair which may be carried out on the tail pipe assembly and the propelling nozzle. Experience has shown that only on rare occasions need parts of the assembly be rejected and then usually because of fatigue or distortion. Welding repairs should preferably be carried out by the argon-arc process. When this method is used the finished weld is cleaned with a rotary wire brush and only blended where stated. Repair Leaflets are normally contained in Vol. 6, Part 2, of this Air Publication, but certain repairs which permit the use of oxy-acetylene welding or which do not require special equipment are contained in Part 4, Sect. 2, Chap. 5.

Outer exhaust cone

112. All dents, buckles and skin distortion can be removed by normal sheet metal repair methods. Care must be taken that metal is not made which cannot subsequently be lost.

113. *Front and rear flanges.* Some degree of ovality and distortion can be expected on the front and rear flanges. Fig. 50 shows the method of checking distortion and ovality of the front end flange and also the method of removing uniform ovality by the use of a single clamp. The exhaust cone is rotated on rollers and the flange checked with a large height gauge. The ovality measured at the inner and outer diameter of the flange must not exceed a total of 0·050 in. Distortion and irregular ovality of the flanges are removed by the use of a shaped block and clamps as shown in fig. 51. Cracking of the exhaust cone front flange is permissible from all bolt holes to the periphery of the flange. Cracking from hole to hole is not permissible.

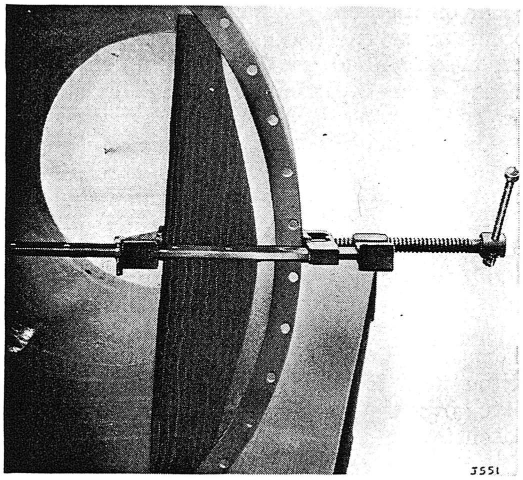

Fig. 51. Using wooden block and cramp to correct distortion and irregular ovality of outer cone front flange

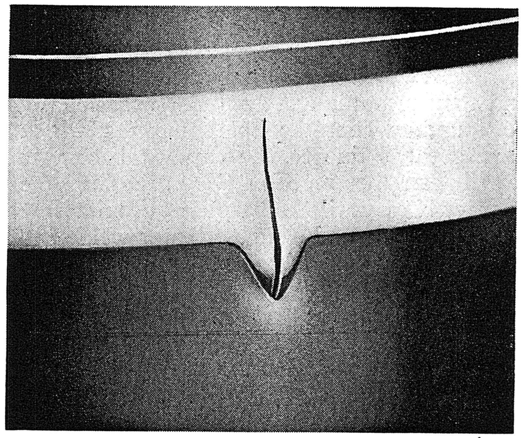

Fig. 52. Dent accompanied by crack in heater muff

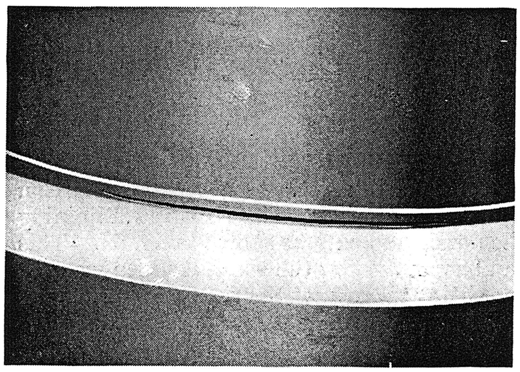

Fig. 53. Repairable split in the stitch weld on heater muff flange

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114. *Gun heater muff.* The most common failures on the outer exhaust cone assembly occur on the gun heater muff, and generally occur as severe dents caused by thermal expansion and contraction. These dents will often be accompanied by a small crack, as shown in fig. 52, which may be repaired by welding. Even though a crack is not present the dent should be welded, as cracks will otherwise develop with subsequent operations. Damage may often extend to the stitch weld on the flange of the heater muff and can be repaired as described in the relevant Repair Leaflet. Fig. 53 illustrates a repairable crack of this nature. Where damage is severe and extends across the stitch weld it will be necessary to weld a patch over the weak point and to extend the patch to the exhaust cone skin.

115. *Oil heater muff.* Damage rarely occurs to the oil heater muff, but repairs similar to those described for the gun heater muff will apply.

116. *Thermocouple adapters and support tube bushes.* Damage to support tube bushes and thermocouple adapters will occasionally be found. Thermocouple adapters which have sheared due to the cap-nut becoming seized can be rectified by grinding the adapter back until the base is approximately 0·020 in. thick and a new adapter welded to this base. Failure of the support tube bush is caused by seizure of a cap-nut causing the internal thread to strip. This necessitates replacing the existing bush by a new one, preferably using the argon-arc welding process.

Propelling nozzle and venturi cuff

117. Dents and distortion are the most common form of damage to the propelling nozzle and venturi cuff. Fig. 54 shows a typical example of damage due to the exposed position of the assembly which can be rectified by normal sheet metal repair methods.

118. *Distortion between rivets.* Distortion will be found between the spacers adjoining the nozzle and cuff, as shown in fig. 55. This can be removed by the use of wooden wedges, care being taken that the rivets or spacers are not loosened during the operations.

119. *Ovality.* To check the ovality of the propelling nozzle assembly, two gauges

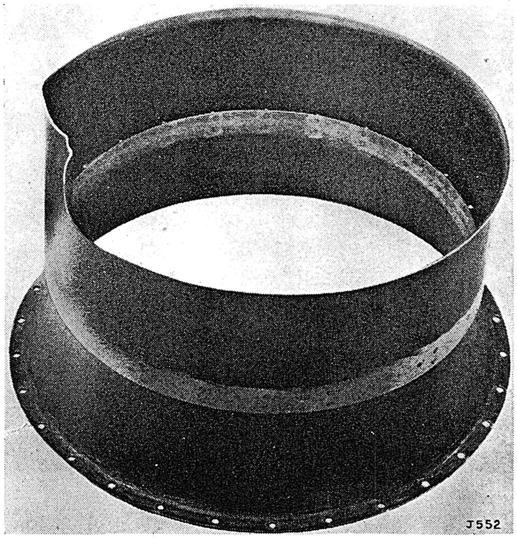

Fig. 54. Venturi cuff and propelling nozzle—showing typical damage

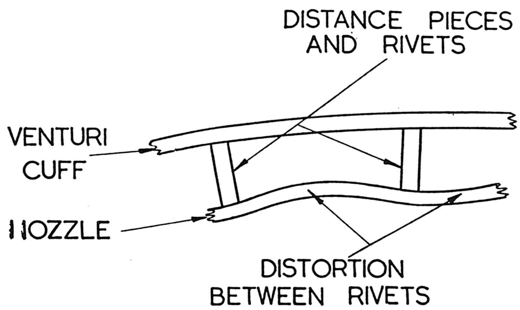

Fig. 55. Distortion between venturi cuff rivets

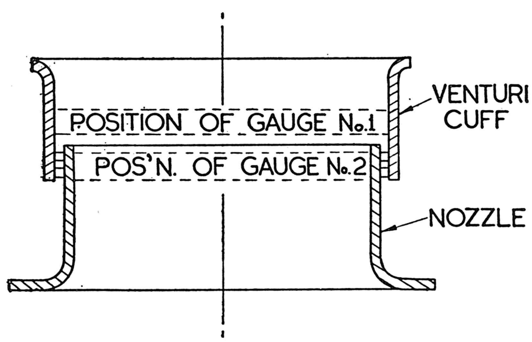

Fig. 56. Venturi cuff and propelling nozzle showing gauge positions for checking ovality

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121. *Replacement of rivets.* Where any of the spacers between the propelling nozzle and the venturi cuff are loose an inspection should be made in order to ensure that the rivets have not become worn by vibration. If this is found to be the case the worn rivets should be removed and replaced.

121A. If it is necessary to change a damaged propelling nozzle for a serviceable nozzle, reference must be made to the information contained in Part 4, Sect. 2, Chap. 5.

Inner cone

122. *Dents and buckles to skin.* The removal of dents and buckles, various types of which are shown in fig. 57 and 58, can be carried out with the use of normal sheet metal tools. The removal of dents from the rear end of the inner cone will require a special anvil, shaped to fit the cone behind the small diaphragm, welded to a standard "H" section beam, or girder; the beam is then solidly mounted on a suitable stand as illustrated in fig. 59.

123. *Cracking of support tube holes.* The support tube holes and reinforcing flanges should be examined. If cracks are found they should be welded, preferably by the argon-arc process, provided the cracks do not exceed ½ in. length.

124. *Large and small diaphragms.* The large and small diaphragms will also need careful examination, the most common point of failure being cracks at the head of the "key-hole" slot and the spot welding parting from the inner cone, as indicated in fig. 60. The cracks at the "key-hole" slot can be welded in accordance with Repair Leaflet G.7 contained in Vol. 6, Part 2. Parting of the diaphragm from the skin may be repaired in the following manner. The number of spot welds on each section between the "key-hole" slots of the large diaphragm is increased to six and the size of the spot weld is increased to $\frac{3}{16}$ in. diameter. The small diaphragm is re-spot welded but retains four spot welds and the ⅛ in. diameter spots. This in effect consists of embodying, or partially embodying, Mod. No. 444.

125. *Baffle plate and stiffeners.* Failures on the baffle plate will occur at the stiffeners as shown in fig. 61, and will need a number of small weld repairs. If the fracture occurs right across a stiffener it is no longer serviceable and should be replaced. Completely fractured stiffeners are shown in fig. 62. When Mod. No. 444 is embodied in the later type of baffle plate, the stiffeners are deleted. Care must be taken when removing the baffle from the inner cone as the bolts are easily sheared in the flange.

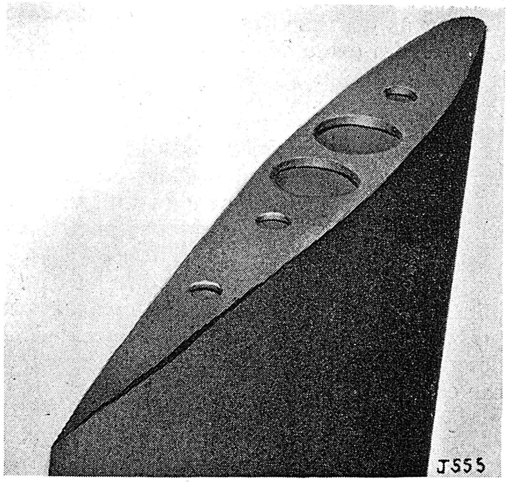

Fig. 65. Repairable damage to fairing where skin is breaking away from outer plate

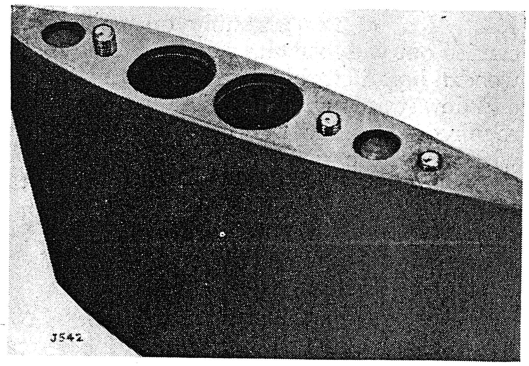

Fig. 66. Broken bolts in fairing

Support tubes and fairings

126. *Bent support tubes.* In the majority of cases, support tubes will be found slightly bent. The bends should be straightened with a rubber mallet, the tube being placed between two blocks of wood, and checked with V-blocks and a surface table.

127. *Indentation and fretting.* As the support tubes are floating they should also be examined for indentation and fretting, caused by the fairings. The maximum permissible depth of fretting is 0·010 in. and if within this limit the sharp edges can be removed by

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blending. If the fretting exceeds this limit the tube should be repaired by argon-arc welding as described in the relevant Repair Leaflet. An example of this type of damage is shown in Fig. 63.

128. *Cracks and distortion to fairings.* The fairings can be repaired by welding, using the argon-arc process. Fig. 64 shows an example of fatigue failure of both skin and welding which is beyond repair. Repairs are confined to the rectification of weld failure at the formers and to small cracks on the corner joints as shown in fig. 65. The skin should be pressed back into position and welded as described in the relevant Repair Leaflet, to the cone and case.

129. *Bolts sheared in fairings.* The broken ends of bolts which may have sheared during dismantling of fairings, as shown in fig. 66, can often be removed if treated to a further application of penetrating oil.

Reassembling and refitting

130. Most of the assembly operations are carried out with the outer cone standing on a wooden board on the floor, first with the rear end downwards and then the front flange as required. All screw threads should be coated with anti-seize grease ZX–13 (Stores Ref. 34B/88) to reduce risk of seizure and to facilitate dismantling at a later date.

131. Ensure that the front and rear fairings are free from dents, and that the threads of the three bolt holes in each of the eight fairings are clean. Ensure that the four support tubes are free from burrs. Loosely assemble each of the four front and four rear fairings to the outer cone, according to the chalk marks made during dismantling, with plain washers and three $\frac{1}{4}$ in. B.S.F. bolts. Slide the two large support tubes through the fairings at the front of the outer cone and the two small tubes through the fairings a the rear of the outer cone. Align the fairings with the support tubes and tighten the fairing securing bolts. Wire-lock the bolts together with 22 S.W.G. stainless steel wire. Adjust the protrusion at each end of the support tubes; if necessary filing one end of each to obtain the correct protrusion. The front support tubes should not project more than 0·29 in. and the rear tubes not more than 0·15 in. Mark the outer cone and each support tube with chalk to identify the correct assembly relationship, then remove the support tubes from the outer cone.

132. Before assembling the inner cone, ensure that each support tube slides freely in the bushes and, if necessary, mark the inner cone with chalk to facilitate assembly. Apply a thin film of anti-seize grease to each support tube. Position the inner cone inside the outer cone, then slide one of the front

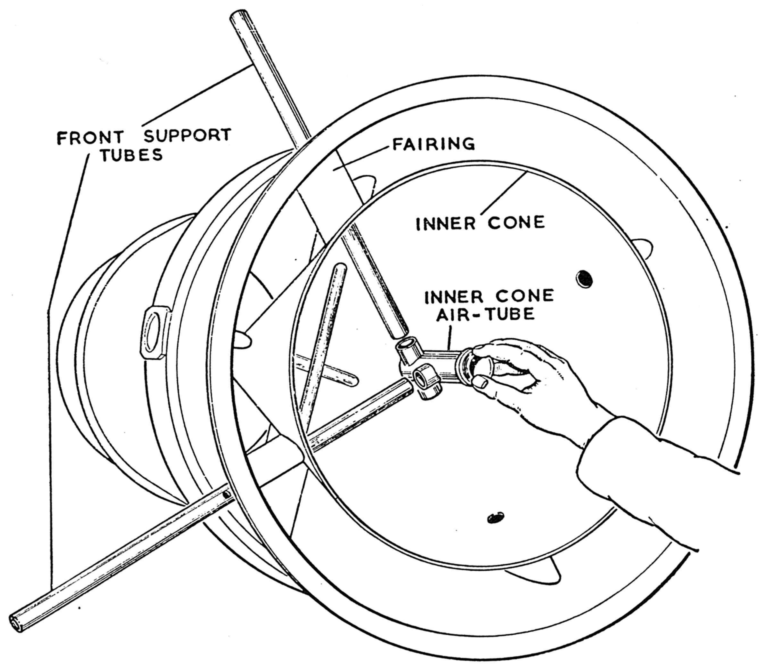

Fig. 67. Assembling the inner cone air tube

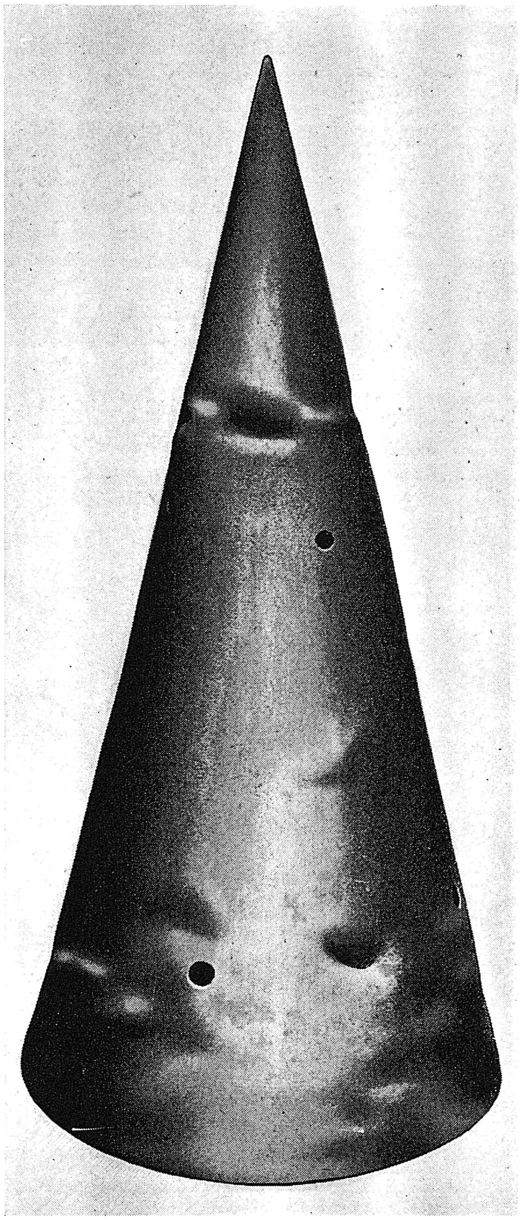

Fig. 57. Inner cone—repairable dents

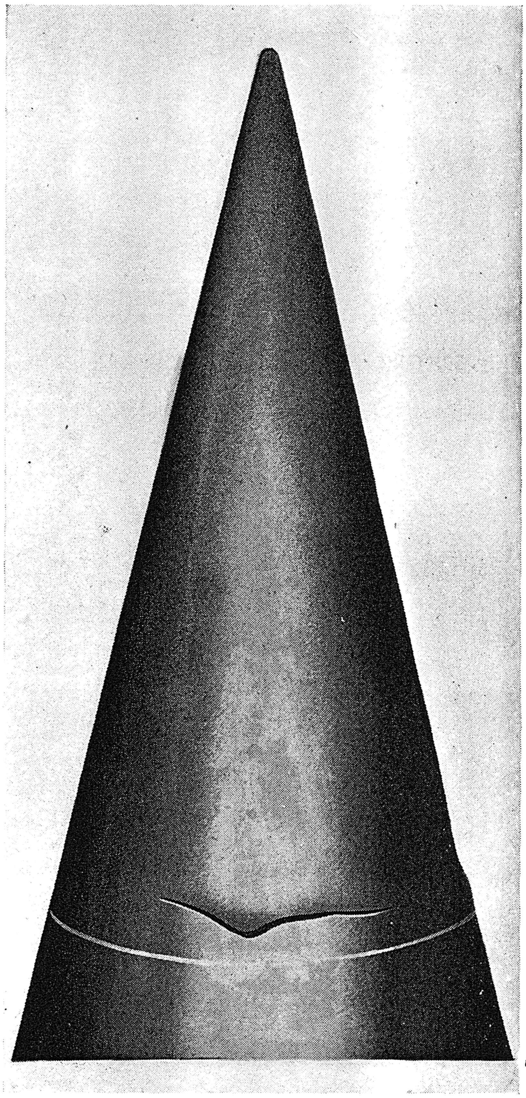

Fig. 58. Inner cone—non-repairable cracking and buckling

manufactured from flat stock 2 in. × $\frac{1}{8}$ in. should be made to the following dimensions:—

Nominal size of Propelling Nozzle	Gauge 1	Gauge 2
16 in.	16·560 in.	15·960 in.
16$\frac{1}{8}$ in.	16·685 in.	16·085 in.
16$\frac{1}{4}$ in.	16·810 in.	16·210 in.
16$\frac{3}{8}$ in.	16·935 in.	16·335 in.
16$\frac{1}{2}$ in.	17·060 in.	16·460 in.
16$\frac{5}{8}$ in.	17·185 in.	16·585 in.

Note . . .

If there is any doubt with regard to the nominal size of the propelling nozzle reference to Part 4, Sect. 2, Chap. 5, will enable the nominal diameter to be established.

120. Fig. 56 shows the position in which these gauges are used. A tolerance of minus 0·040 in. is permissible and ovality can be removed by the use of wooden formers and cramps in a manner similar to that employed for the outer exhaust cone.

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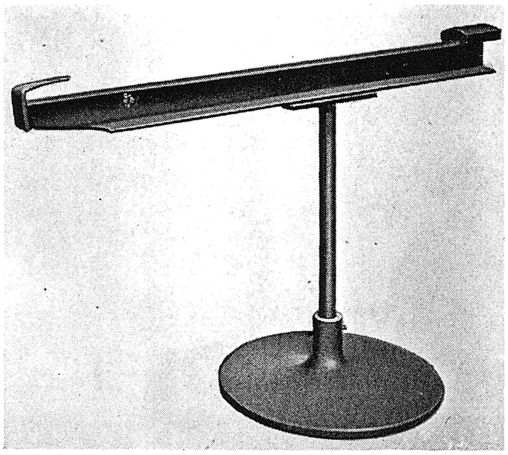


Fig. 59. Girder and anvil for repair of inner cone

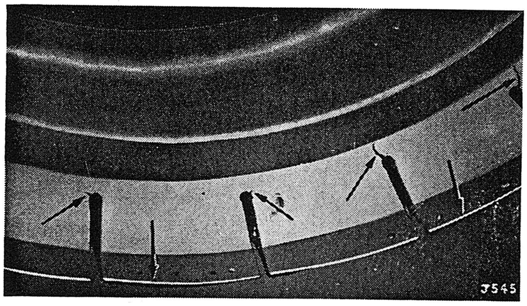


Fig. 60. Typical failures on large diaphragm

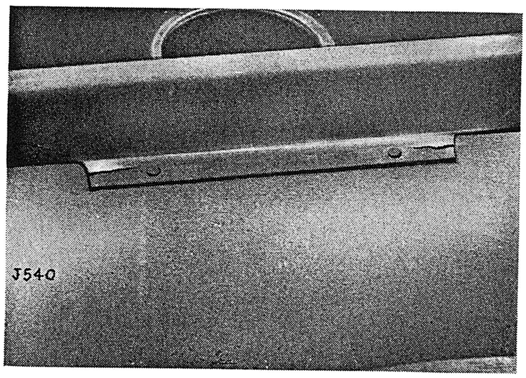


Fig. 61. Repairable damage to baffle plate stiffener

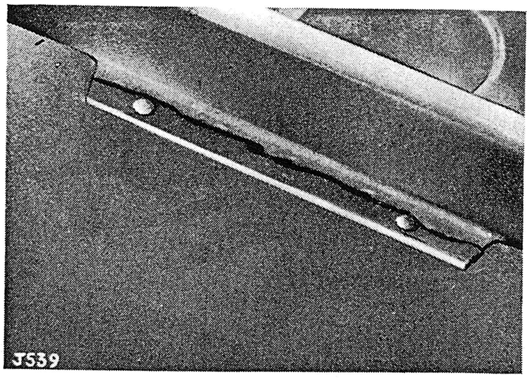


Fig. 62. Non-repairable damage to baffle plate stiffener

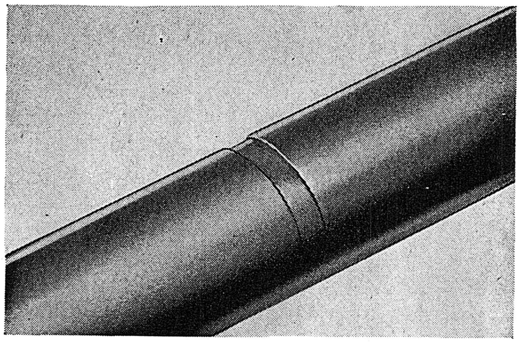


Fig. 63. Support tube indentation and fretting

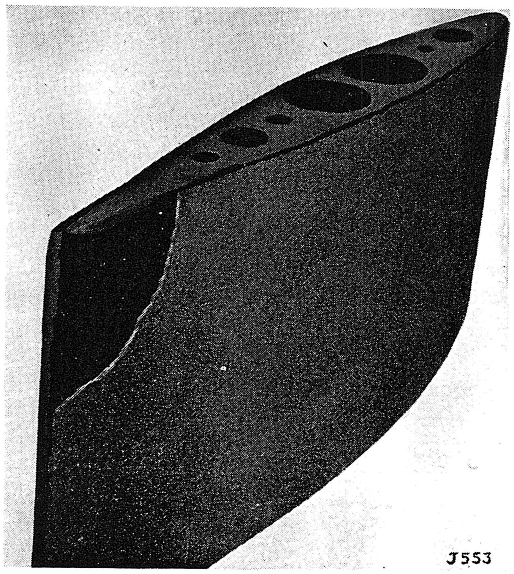
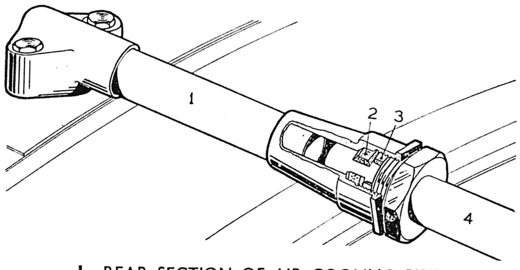


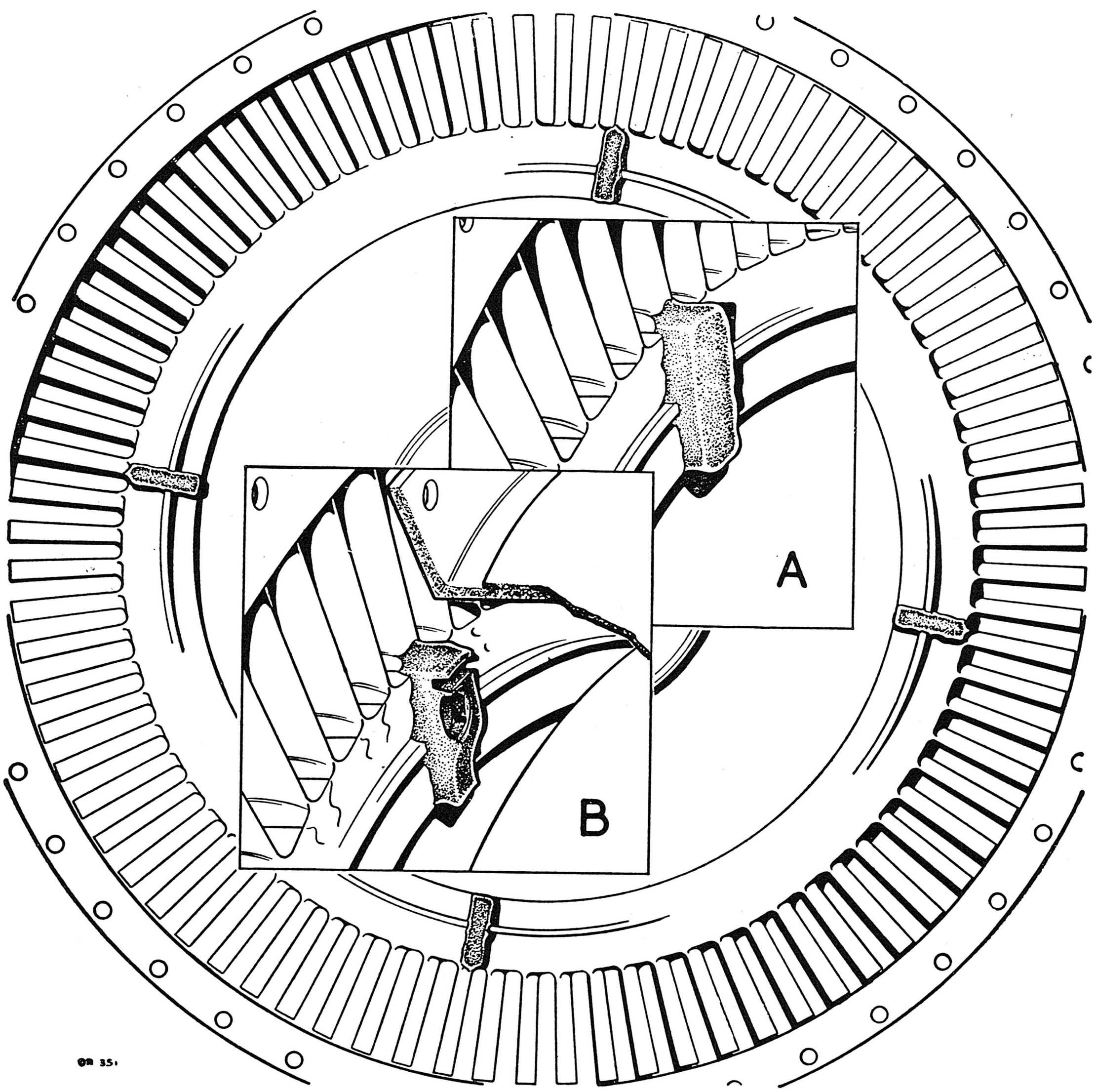
Fig. 64. Fairing rejected for fatigue of the skin and welding failure



1 REAR SECTION OF AIR COOLING PIPE
2 FLEXIBLE JOINT
3 WASHER
4 FRONT SECTION OF AIR COOLING PIPE

Fig. 70. Flexible connection in air cooling pipe

the support tube ends are free from burrs. Place a copper washer on each rear support tube cap-nut, apply anti-seize compound to the threads and screw the four cap-nuts into the tail pipe over the ends of the support tubes. Place a copper joint washer on each front air supply boss and secure each supply pipe to the tail pipe with two bolts and single spring washers. Screw the four large and four small thermo-couple boss blanking nuts to their bosses and wire-lock them in pairs.



A—Plasticine without indentation, before assembly of exhaust cone
B—Plasticine with indentation, after assembly of exhaust cone

Fig. 71. Measuring the tail pipe/turbine disc clearance

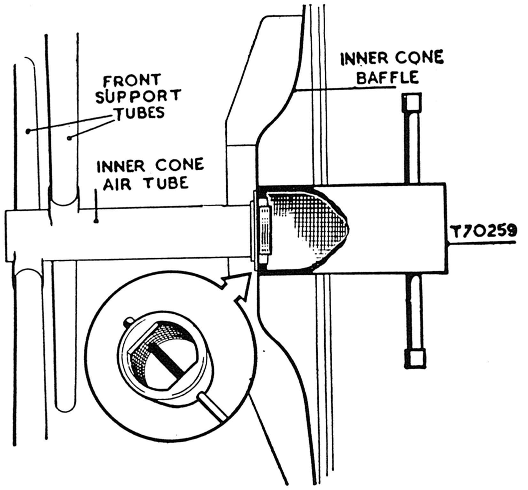


Fig. 68. Tightening the baffle securing nut

support tubes through the outer cone and fairing until it enters into the bush of the inner cone. Similarly slide one of the rear support tubes through the outer cone and fairing into the bush of the inner cone. Enter the remaining front and rear support tubes into their inner cone bushes. Using a soft drift, progressively tap each support tube through the inner cone and the opposite fairings of the outer cone. Withdraw each front support tube a little over half-way from the assembly, support the air tube in position in the inner cone (*fig.* 67) and, using the special drift, lightly tap the support tubes back through the air tube and the outer cone.

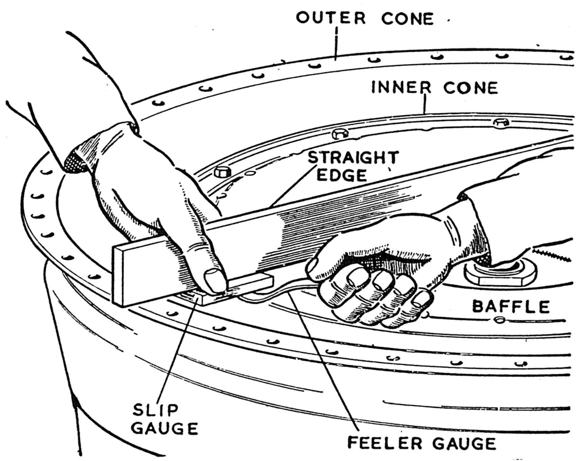


Fig. 69. Checking the axial clearance between the inner and outer cone front flanges

133. Ensure that the baffle is free from burrs and that the securing nut and set-bolt threads are undamaged. Place the inner cone baffle on the shoulder at the threaded end of the inner cone air tube and lightly screw the baffle securing nut on to the air tube. Using new tab-washers, screw in and tighten the twelve $\frac{1}{4}$ in. B.S.F. set bolts to secure the baffle to the flange of the inner cone. Using spanner T70259, tighten the baffle securing nut (*fig.* 68) and lock with a $\frac{1}{16}$ in. split pin. Screw in each set-bolt securely with one of the flats positioned tangentially; bend one tab of the tab-washer over the flat of the bolt head and the other leg down the inner edge of the baffle securing ring to lock each bolt.

134. The following checks must be made to ensure concentricity of the inner cone in the outer cone which should be within the limits stated in the Schedule of Fits, Clearances and Repair Tolerances, otherwise it will be necessary to select another inner cone. Set the assembly horizontally on a surface table with the front and rear flanges resting on roller brackets T71244; it will be necessary to place packing under the rear roller bracket until the outer cone front flange face is square to the surface table. Set the stylus of a dial test indicator on the surface of the inner cone at a distance two inches from the apex, then rotate the exhaust cone assembly about its horizontal axis. Ensure that the front flange face of the outer cone remains square to the surface table and take continuous readings of the dial test indicator to check that the eccentricity of the inner cone is within the limits. Set the stylus of the dial test indicator to the outside surface of the forward end of the inner cone, rotate the cone and take continuous readings of the dial test indicator to check that the eccentricity of the forward end of the inner cone is within the limits.

135. Using feeler gauges, check that the clearance between each fairing and the inner cone is within the limits. Stand the assembly rear end downwards on a wooden base board, place a straight edge across the front flange of the outer cone and using a slip gauge and feeler gauges, check that the gap between the straight edge and the flange of the inner cone is 0·22 to 0·28 in. (*fig.* 69)

136. Before assembling the support tube cap-nuts, air supply pipes and thermocouple nuts, ensure that all threads are free and that

137. Coat the threads of the thirty $\frac{1}{4}$ in. B.S.F. bolts with anti-seize grease and secure the propelling nozzle and venturi cuff assembly to the rear flange of the outer cone. The bolts should be inserted from the front of the exhaust cone flange. Check that the dimensions of the nozzle are within the limits.

138. Before a new or reconditioned exhaust cone is fitted to an engine, the clearance between the baffle at the front of the inner cone and the turbine disc must be checked as described in para. 139. Apply anti-seize grease to the forty-five $\frac{7}{16}$ in. bolts and ensure that the gland nut, gland nut washer, and flexible joint are correctly positioned on the four air cooling pipes attached to the forward portion of the engine (*fig*. 70). Position the exhaust cone at the rear of the engine, carefully enter the four air cooling pipes into their connections in the rear section of each air cooling pipe, which is attached to the exhaust cone. Fasten the exhaust cone to the turbine shroud with the bolts and nuts; when Mod. No. 911 is embodied the nuts and bolt heads are locked with forty-two double tab-washers (Part No. N5128) and two triple tab-washers (Part No. N7982). Tighten and wire-lock the four gland nuts. Refit the fireguard.

Exhaust cone/turbine disc clearance

139. Before a new or reconditioned exhaust cone is fitted to an engine the clearance between the baffle at the front of the inner cone and the turbine disc must be checked as follows.

140. Affix four strips of plasticine equidistantly around the outer rim of the rear of the turbine disc, as indicated in fig. 71, avoiding those positions where portions of the balancing rim have been removed. Each strip should be approximately $\frac{1}{2}$ in. wide and $\frac{1}{2}$ in. thick, which is slightly thicker than the maximum permissible clearance between the disc and inner cone. The strips should be positioned to cover the 'fir-tree' roots of the turbine blades, and should radiate inwards towards the centre of the turbine disc for about two inches. Cover the surface of the plasticine with french chalk or oil so that it does not adhere later to the baffle at the front end of the inner cone. Inset 'A' on fig. 71 shows the appearance of the plasticine at this stage.

141. Secure the exhaust cone to the turbine shroud by three or four of the bolts and nuts. The correct assembly of the air cooling pipes, coming from the front of the engine to the rear sections on the exhaust cone, can be checked at the same time.

142. Remove the exhaust cone and measure the thickness of the plasticine at the position corresponding to the clearance between the tail pipe baffle and the turbine disc. This should be not less than 0·18 in. Inset 'B' in fig. 71 shows the appearance of the plasticine after the exhaust cone has been fitted and removed. Clean off all traces of plasticine.

TURBINE

Turbine blades, examination

143. The turbine blades can be examined to a limited extent only, with the aid of a portable spot light up the exhaust cone, whilst the exhaust cone is attached to the engine. The nozzle (static) blades can only be seen under these conditions, through the spaces between the turbine blades, and can, therefore only be examined very superficially. Any indications of damage observed will necessitate dismantling the engine to the extent indicated in the following paragraph.

Dismantling necessary for close examination of the turbine and nozzle blades

144. To examine the turbine blades, the fireguard and exhaust cone must be removed as described previously. Since under these conditions, the nozzle (static) blades can be examined only between the turbine blades, opportunity must always be taken to examine them more thoroughly whenever the combustion chambers are removed. For a still more detailed examination of the blades, the turbine disc can be removed as described in Part 4, Sect. 2, Chap. 2.

145. The blades should be examined thoroughly for signs of damage or looseness, and the following paragraphs and illustrations (*fig*. 72 *to* 86) are intended as a guide in determining, by visual inspection, the maximum damage which may be tolerated on the nozzle and turbine blades for continued operation. This guide is intended for field use and does not supersede approved repair schemes. Where damage to turbine blades is in excess of that indicated, reference should be made to Part 4, Sect. 2, Chap. 2, Leaflet D.1, which describes the limits of repair which are acceptable in service, and the method of correcting unbalance in a turbine disc assembly to which such repairs have been applied.

146. In general, it will be found that the damage is confined to the trailing edges of the nozzle blades and the leading edges of the turbine blades. In assessing the standard

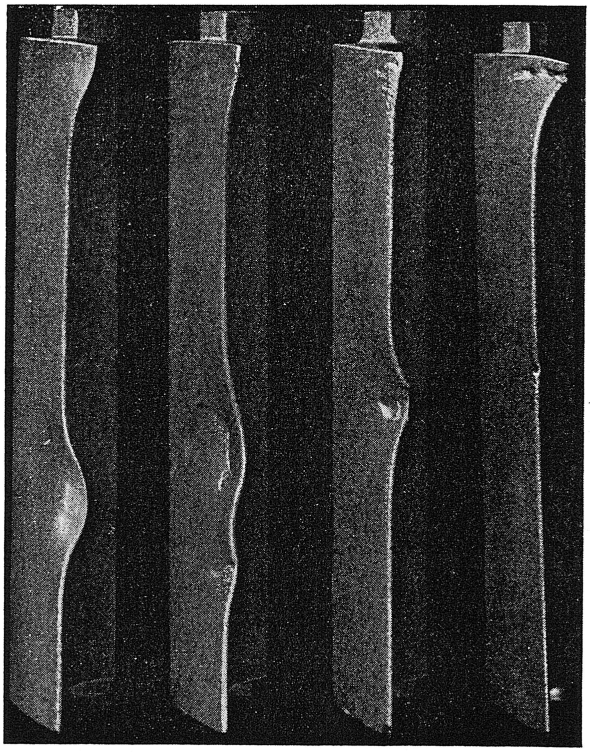


Fig. 72. *Maximum extent of acceptable damage to nozzle blades*

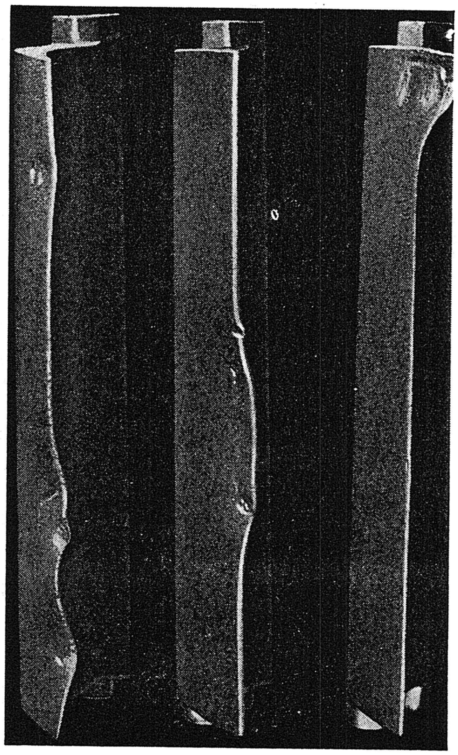


Fig. 73. *Damage to nozzle blades—not acceptable*

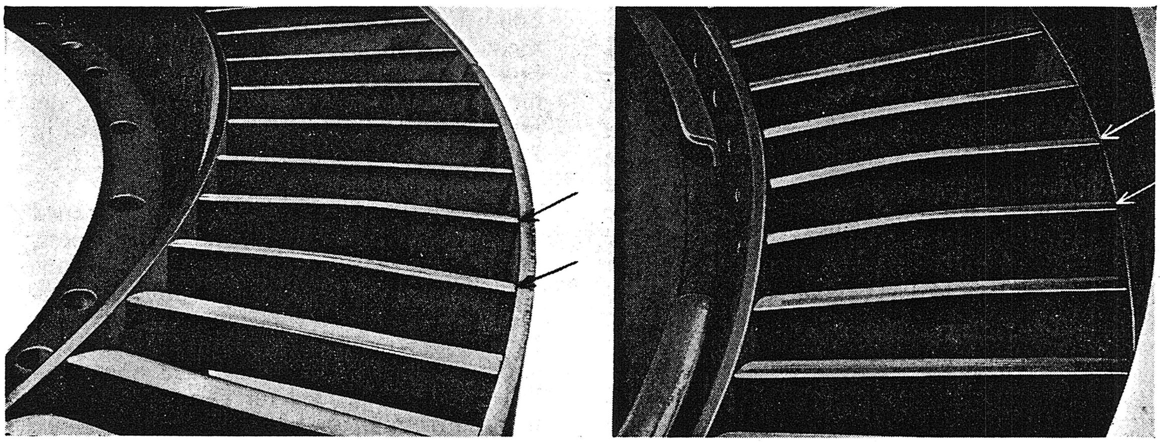


Fig. 73A. *Bowed nozzle blades which are acceptable*

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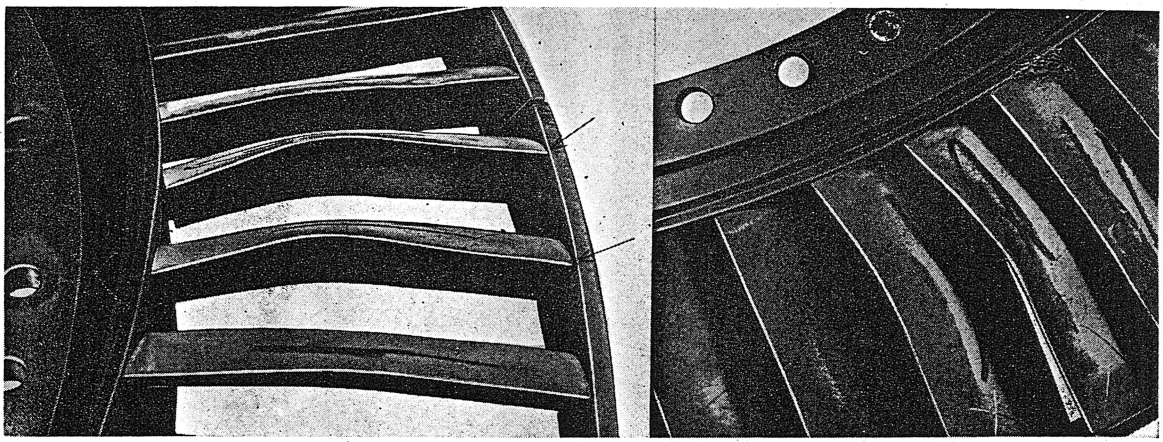

Fig. 73B. Bowed nozzle blades which are not acceptable

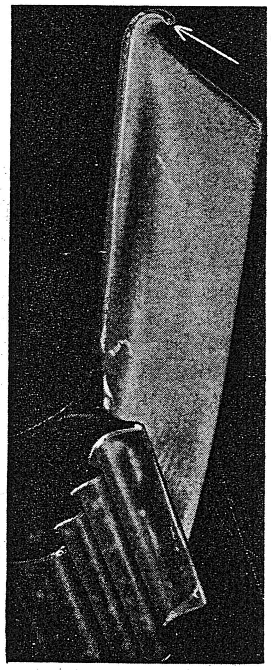

Fig. 74. Acceptable curl at tip of turbine blade (refer also to fig. 75)

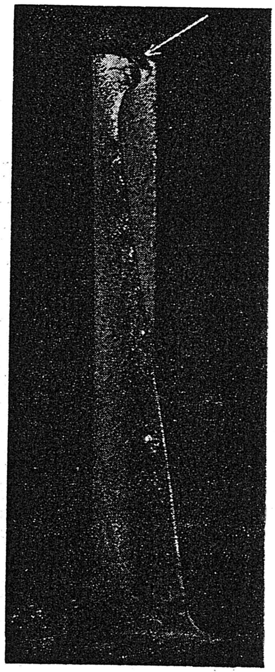

Fig. 75. Acceptable curl at tip of turbine blade (refer also to fig. 74)

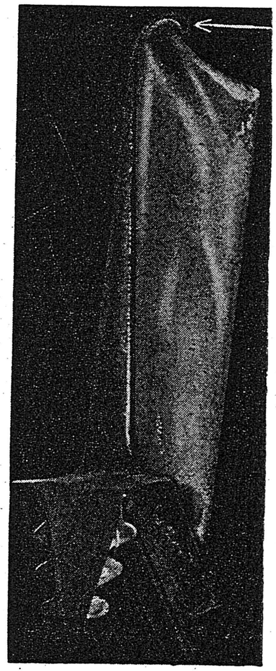

Fig. 76. Curl at tip of turbine blade—not acceptable (refer also to fig. 77)

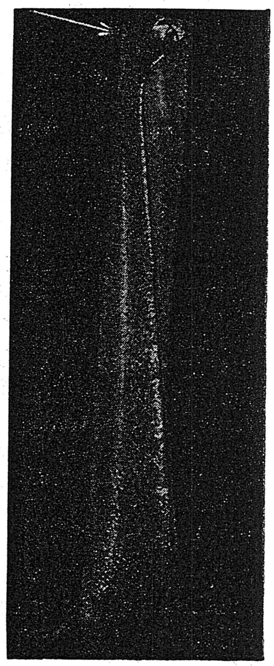

Fig. 77. Curl at tip of turbine blade—not acceptable (refer also to fig. 76)

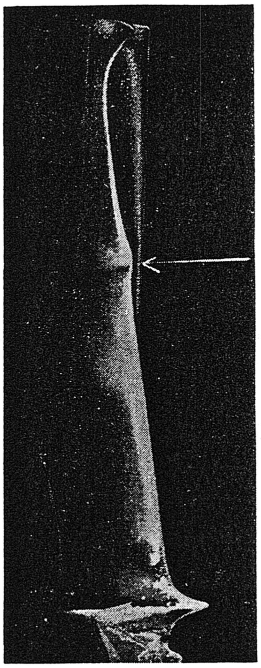

Fig. 78. Acceptable damage to turbine blade

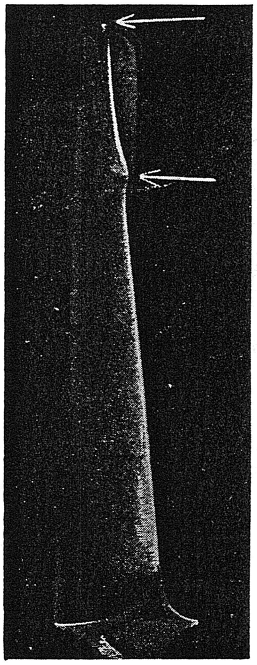

Fig. 79. Acceptable tear at tip of turbine blade

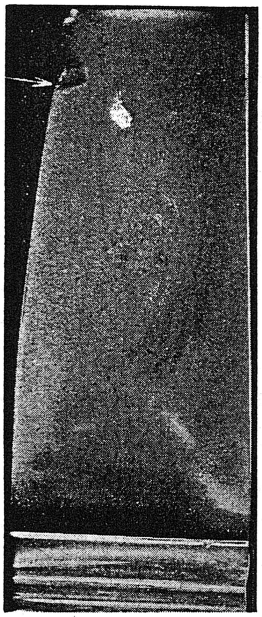

Fig. 80. Tear at tip of turbine blade—not acceptable (refer also to fig. 81)

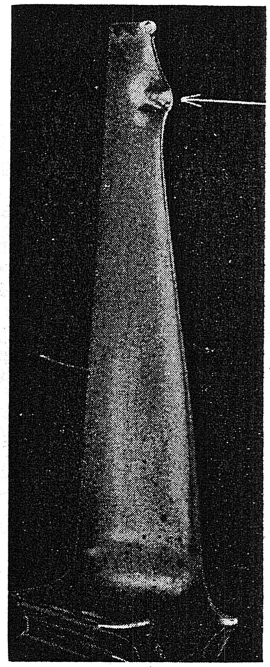

Fig. 81. Tear at tip of turbine blade—not acceptable (refer also to fig. 80)

of acceptance, consideration must be given to the general condition of the assembly as a whole and whilst quite severe damage is acceptable on isolated blades, some increase of operation temperature can be expected if the majority of the blades are severely damaged and subsequent turbine deterioration will consequently be more rapid. Blades of the three-pin type (*pre-mod. No. 828*) should be checked for sheared pins. Damage of the type depicted in the illustrations is the result of the passage of foreign matter through the engine and it is, therefore, essential that an examination of the engine air-intake ducts and flame tubes is made when turbine damage is observed.

147. Fig. 72 shows examples of the maximum extent of damage which is acceptable to the nozzle blades for continued operation, whilst fig. 73 shows damage which is not acceptable. Cracks in the trailing edge may be blended out provided that they do not exceed $\frac{1}{8}$ in. length. If the cracks are beyond these limits, the blade must be rejected. Cracks extending to a depth of $\frac{3}{8}$ in. are acceptable in the leading edge of the nozzle blades.

148. Surface damage is generally confined to the camber surface in the form shown on the second blade from the left in fig. 72 and is acceptable if its depth does not exceed one third the thickness of the blade, but sharp edges should be blended smooth. If it is necessary to resort to blending, the turbine disc can be removed as described in Part 4, Sect. 2, Chap. 2, but care must be taken to ensure that it is correctly refitted otherwise the balance of the rotating assembly will be seriously upset.

148A. Fig. 73A shows examples of the maximum extent of bowing which is acceptable in the nozzle blades for continued operation, whilst fig. 73B shows bowing which is not acceptable. If a straight edge exactly the length of a blade is held against the concave face of the leading edge of the blade, and the bow, when checked with feelers, does not exceed 0·035 in., the blade is acceptable for continued operation. Similarly, if the bow of the trailing edge, when checked in the same way, does not exceed 0·100 in., the blade is acceptable for continued operation. If the bow exceeds either of these limits, the blade must be rejected.

148B. Any nozzle blade which is damaged or bowed beyond the permissible limits may be replaced by a new blade. Reference should be made to Part 4, Sect. 2, Chap. 3 for instructions for removing the nozzle ring assembly from the engine and renewing damaged blades.

149. In assessing damage to the turbine blades, the following points must be carefully considered:—

(1) Position and depth of the damage along the length of the blade.

(2) The shape and size of the damage.

(3) The nature of the damage, i.e., crack, tear or bruise.

150. In positioning the damage, the blade is, for convenience, considered in three sections, i.e., the outer, middle and inner third. In the outer third, damage to a depth of 0·050 in. is acceptable, and in the middle third to a depth of 0·030 in. No damage of any kind is acceptable in the inner third.

151. The extent of acceptable curl at the blade tip may be seen by comparing fig. 74 and 75 (acceptable) and fig. 76 and 77 (not

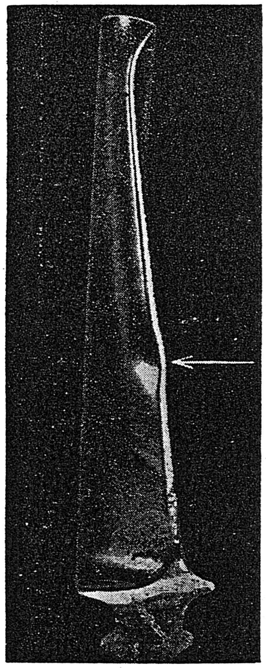

Fig. 82. Acceptable bruise in leading edge of turbine blade

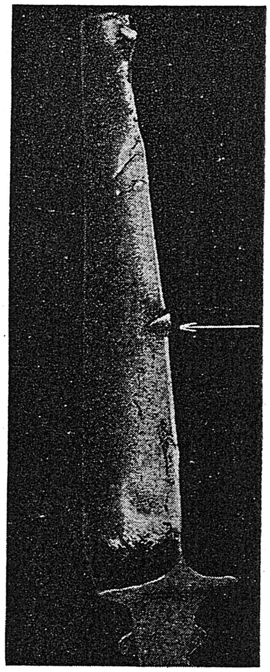

Fig. 83. Bruise in leading edge of turbine blade—not acceptable

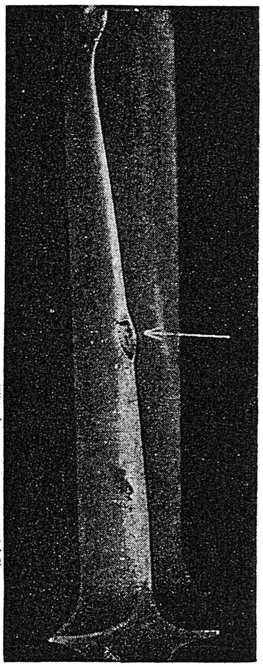

Fig. 84. Acceptable damage to turbine blade

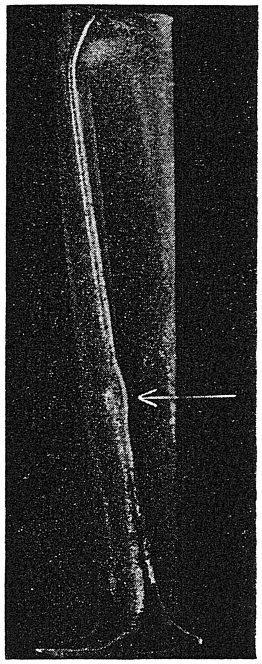

Fig. 85. Acceptable damage to turbine blade

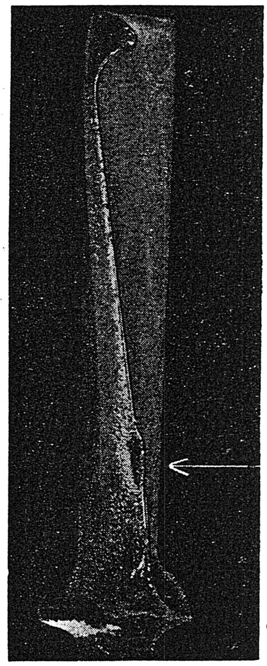

Fig. 86. Damage to turbine blade—not acceptable

(A.L.77, May 56)

acceptable). Other acceptable damage is limited to smooth bruises, but small tears at the tips are also acceptable. Cracks of any kind, and bruises with a sharp lip or change of section must be rejected. These points are illustrated by the comparison of fig. 79 (acceptable tear) and fig. 80 and 81 (not acceptable), and fig. 82 (acceptable bruise) and fig. 83 (not acceptable).

152. The removal of any blade, nozzle or turbine, renders it unserviceable and it must be replaced by a new blade. As it would necessitate the rotating assembly being dynamically rebalanced, replacement of turbine blades in the field is not permissible.

153. Sometimes turbine blades will be found to be slack in the turbine disc Provided this does not permit more than 0·030 in. blade movement at its tip in a circumferential direction or more than 0·010 in. fore and aft movement (axially) at its root, the slackness will be taken up by thermal expansion when the engine is running. Slackness in excess of these amounts justifies rejection of the engine.

154. Cracking of the nozzle shroud and turbine shroud flanges from the bolt holes to the periphery of the flange may be observed when examining the turbine. Cracking is permissible from all bolt holes to the periphery of the front and rear flanges of both the turbone shroud and the nozzle shroud. Cracking is also permissible from all bolt holes to the periphery of the front tail pipe flange. Cracking from hole to hole is not permissible. One or two cracks in either shroud which extend into, or occur in, the bore in a longitudinal direction, must not exceed a maximum length of $\frac{3}{8}$ in. from the flange face of the turbine shroud, and $\frac{1}{2}$ in. from the rear face of the nozzle shroud.

155. There is a tendency for the nuts securing the eye-bolts of the nozzle shroud struts to slacken off, due to the bedding down of the eye-bolt shims after a certain period of engine running. At the intervals specified in the Servicing Schedule, the security of the sixteen eye-bolt nuts should be checked. Where Mod. No. 519 has been embodied, these sixteen nuts are locked with tab-washers (Part No. N1459).

Turbine/shroud clearance check and adjustment

156. At the intervals specified in the aircraft Servicing Schedule, or upon receipt of a new or reconditioned engine as a check against rough handling in transit, the turbine blade tip clearance should be checked.

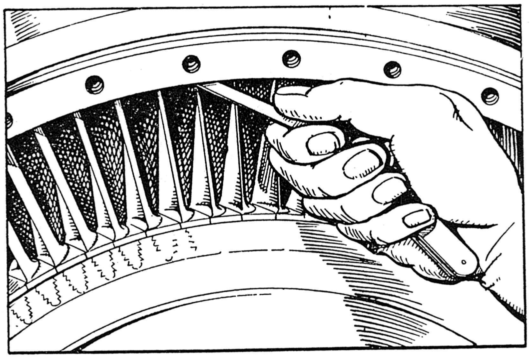

Fig. 87. Measuring the turbine blade tip clearance

157. Insert feeler gauges into the gap between the turbine disc blade tips and the turbine shroud (*fig.* 87) and rotate the disc to find the blade which gives the smallest clearance; mark that blade with chalk. Insert feeler gauges between the marked blade and the turbine shroud at sixteen points, each one in line with a combustion chamber, measure the total feeler thickness with a micrometer and check that the blade tip clearance is nowhere less than the minimum specified in para. 161. If the clearance is less than this minimum at any point the shroud may be either distorted, or eccentric to the turbine disc. Distortion of the shroud may be rectified as described in Part 4, Sect 2, Chap. 3, whilst eccentricity may be corrected by taking advantage of the clearance in the turbine shroud bolt holes. Before attempting to adjust the position of the turbine shroud, the sixteen clearances, which were measured, should be written down on a 'clock face' diagram so that the position may be considered and the direction in which the turbine shroud must be moved ascertained. Slacken each of the bolts fastening the turbine shroud to the nozzle shroud, and gently ease the turbine shroud until the clearance is as near equal as possible at all sixteen points and is nowhere less than the minimum stated.

158. If sufficient blade clearance cannot be obtained, even after replacement of the dowel bolt by a standard bolt Part No. N.8242 (mod. 987), remove the turbine shroud, and measure the bore at eight equidistant positions to ascertain the mean diameter. Where this mean is less than the minimum drawing dimension of 27·680 in. the shroud has shrunk and must be replaced by a new one. When the mean diameter of the original shroud is correct, the low clearance must be indicative of blade stretch or rear end settlement and the engine must therefore be rejected.

159. If after fitment of a new turbine shroud, the clearance specified in the para. 161 still cannot be obtained, then both shroud shrinkage and blade stretch are present and the engine must therefore be rejected and returned to a repair depot.

160. When satisfactory conditions have been attained, retighten the bolts and nuts, and recheck the clearance at all sixteen points to ensure that the turbine shroud has not been displaced whilst tightening the bolts.

161. The minimum turbine blade tip clearance for a new, or reconditioned, engine is specified in the Schedule of Fits, Clearances, and Repair Tolerances (Vol. 2, Part 6), to which reference must be made when checking the clearance during installation of a new or reconditioned engine. Blade creep and a certain amount of shroud distortion will reduce this clearance during the running life of the engine and, therefore, a reduced minimum clearance of 0·055 in. is permitted in these circumstances.

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Chapter 2

(*Completely revised*)

INSPECTION FOR DAMAGE AFTER SHOCK LOADING

Note.—*This chapter applies to Goblin Mk 2 and 3 aero-engines*

LIST OF CONTENTS

GENERAL

1. This chapter describes the necessary examination of an engine which has been shock loaded as the result of a crash landing. To provide a correct assessment of the damage sustained and at the same time avoid unnecessary work the checks should be made in the order given in the following paragraphs.

INSPECTION OF ENGINE

2. Remove the engine from the airframe, as described in Sect. 1, Chap. 2, and transfer it to the dismantling and assembly stand W.D.6400. Remove the exhaust cone assembly as described in Chapter 1 and make a thorough visual examination of the whole engine for external damage. Particular attention should be given to the mounting flanges of the oil sump and the bottom accessory box for indications of fracture when there is evidence of impact between these components and the aircraft cowling. The engine must be rejected if distortion or cracks are confirmed.

3. Check the freedom of the mainshaft assembly. Spin the main shaft as fast as possible by hand, listening for any unusual noises during the time taken for the mainshaft assembly to cease rotating; observe that there is a slight tendency for the assembly to swing back as rotation ceases. Noises from some of the accessories, in particular the fuel pump(s) and air compressor, will be audible during the run down; if in doubt these accessories should be removed.

4. If the oil sump and the bottom accessory box flanges are undamaged, carefully examine the sump floor for signs of collapse and cracking in the region of the metering pumps. The examination will be facilitated if the engine is rotated in the stand until the underside of the sump is vertical or facing slightly upwards. Remove all dirt, oil and loose paint, and paint the floor with a solution of 25 to 30 per cent lard oil or other suitable oil, in kerosine heated to 80 deg. C. Wipe off the excess oil, coat the oil sump with chalk and examine for cracks. If necessary, remove the damaged oil sump and fit a serviceable assembly, as described in Part 4, Sect. 2, Chap. 7.

5. Examine the engine mounting eyes and the immediate surrounding area of the diffuser casing for cracks or distortion. Remove the paint from the areas concerned and apply a solution of 25 to 30 per cent lard oil in kerosine heated to 80 deg. C. Wipe away excess oil and coat with chalk. Examine for cracks; if satisfactory, remove the oil and chalk, and repaint.

Note . . .

Where the materials are available, Met-L-chek dye and developer may be used instead of oil and chalk. If this alternative is employed, particular care must be taken that the suppliers' instructions are strictly adhered to and the dye thoroughly removed by washing after use.

6. Check the turbine blade/turbine shroud clearance as described in Chapter 1. Refit the exhaust cone assembly.

7. Install the engine in the airframe, as described in Section 1, Chapter 1. Start the engine and carry out all normal ground running checks, particular attention being given to possible fuel, oil, or gas leakage. Using a slave recording instrument and compensating leads where necessary, check the rear bearing temperature. Run the engine up to a maximum permissible r.p.m. and maintain this speed for approximately 5 minutes; the rear bearing temperature must not exceed 90 deg. C. (Mk. 2) or 110 deg. C. (Mk. 3). Check the time taken for the engine to run-down during stopping as described in Section 2, Chapter 2.

8. The slave recording equipment required for checking the rear bearing temperature should be assembled as follows. Connect a Mk. 1 engine cylinder indicator, Ref. No. 6A/1305, to the terminal block mounted on starboard wing rib No. 1, in the engine bay, using a compensating lead type A, Ref. No. 6A/841. It is essential that correct polarity is maintained throughout; the copper lead is identified by a RED or GREEN coloured sleeve, and the constantan by a BLUE sleeve. The copper lead must be connected to the positive terminal of the indicator. The shunt, which will be found fitted to the indicator as supplied, must be removed for the purpose of this test, and should be refitted after the test has been completed.

9. Provided that the results of all the foregoing examinations and checks are satisfactory, the engine may be considered to be serviceable.

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a measuring jig T73414. The procedure is detailed in the next two paragraphs.

7. The following instructions should be read in conjunction with fig. 3 to which the sub-para. letters refer:—

(a) The clearance between the impeller vanes and the front casing must not be less than 0·054 in. (Mk. 2), or 0·064 in. (Mk. 3), when measured with the main axis of the engine vertical, air-intakes downwards, so that the thrust bearing end float is fully taken up in the forward position.

(b) During initial manufacture, the unions are machined when in position in the front casing, to an effective length of 0·878/0·882 in.; and the actual dimension is stamped on the front casing adjacent to each union. In these instructions, it has been assumed that the unions have been machined, in position, to the maximum effective length, i.e., 0·882 in. The method of correcting the observed readings for shorter unions is contained in para. 8.

(c) The nominal length of the longer setting pin (item 6 of T73414) is 0·965 in. There is a tolerance of $\pm$ 0·001 in. on this length and the actual length is marked on the pin. It is, however, considered unnecessary to take this manufacturing tolerance into account.

(d) Insert the longer setting pin into the measuring jig T73414. Slacken the clamping screw to permit the indicator to be slid to and fro as required. By altering the position of the dial test indicator in the jig, set the indicator to read PLUS 0·029 in. (Mk. 2), or 0·019 in. (Mk. 3) as applicable, then retighten the clamping screw. Final adjustment of the setting will be made in the usual way by turning the bezel of the indicator. When this has been done, a zero reading will correspond to the minimum permissible clearance.

(e) Prepare three lead-tipped plugs T73411, as described in sub-para. (f).

Note . . .

The lead tip, which can be manufactured locally, consists of a 1 in. length of $\frac{3}{32}$ in. diameter lead and is secured in the body of the plug by a $\frac{1}{32}$ in. diameter silver steel pin; the ends of this pin must be below the surface of the plug. To renew the lead tip, knock out the silver steel pin, insert a new length of lead, drill through the existing holes using a $\frac{1}{32}$ in. drill, and refit the silver steel pin.

(f) Using the cutting jig T73413, trim the three lead-tipped plugs until, when each is inserted in the measuring jig, a reading of 0·005 in. is observed on the dial test indicator. This represents the maximum effective union length, PLUS the minimum permissible clearance, PLUS 0·005 in.

(g) Insert the three trimmed lead-tipped plugs into the unions in the front casing. Secure them with the special cap nuts T73412. Rotate the impeller by hand. Remove the lead-tipped plugs.

(h) Recheck the lead-tipped plugs in the measuring jig. If a reading below zero is observed on the dial test indicator, the clearance is below the permissible minimum; but if necessary, correct the observed reading for any variation in the effective length of the union, as described in para. 8.

8. If the effective length of the union is less than 0·882 in. (i on Fig. 3), i.e., if 878, 879, 880, or 881 is stamped on the front casing adjacent to the union, the difference between that number and 882 (thousandths of an inch) must be ADDED to any reading observed on the dial test indicator.

9. Return the engine to the horizontal position in the stand. Check the turbine blade/turbine shroud clearance as described in Chapter 1. Refit the exhaust cone assembly.

10. Install the engine in the airframe, as described in Section 1, Chapter 1. Start the engine and carry out all normal ground running checks, particular attention being given to possible fuel, oil, or gas leakage. Using a slave recording instrument and compensating leads where necessary, check the rear bearing temperature. Run the engine up to a maximum permissible r.p.m. and maintain this speed for approximately 5 minutes; the rear bearing temperature must not exceed 90 deg. C. (Mk. 2) or 110 deg. C. (Mk. 3). Check the time taken for the engine to run-down during stopping as described in Section 2, Chapter 2.

11. The slave recording equipment required for checking the rear bearing temperature consists of temperature recording instrument (*Stores Ref*. 6A/197 or 6A/1305) together with compensating leads de Havilland assembly Part No. 15N/461, 15N/463 and 12N/309A. A.P.4099J, Vol. 3, Part 1, pages 172 and 178 refer to the first two assemblies and page 215 to the later assembly. Terminal blocks (*Stores Ref*. 5C/430) are used to connect the three leads. When connecting these leads, and making the connection at the instrument head and to the rear bearing terminal block on the starboard wing root, it is important that 'positive' to 'positive' connections, correctly tightened, are made throughout the circuit. When available, 10 ft. compensating lead type A (Stores Ref. 6A/841) should be used in place of the lead assembly.

12. Provided that the results of all the foregoing examinations and checks are satisfactory, the engine may be considered to be serviceable.

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SECTION 4

PRESERVATION AND STORAGE