PART 4

MINOR REPAIRS

RESTRICTED

PART 4

MINOR REPAIRS

LIST OF SECTIONS

***Note.**—A list of chapters appears at the beginning of each section*

1 Tools and equipment

2 Replacement, adjustment and rectification

SECTION I

TOOLS AND EQUIPMENT

RESTRICTED

Section 1

TOOLS AND EQUIPMENT

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

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GENERAL

1. This section lists the servicing and dismantling and repair tools necessary to effect the operations described in Part 3 and Part 4, Section 2. Where necessary, special instructions for the use of these tools is given in the relevant chapters of the respective parts.

FLIGHT SERVICING KIT No. 1

Table 1

Stores Ref.	Part No.	Nomenclature	Application
1L/138	—	Spanner, bi-hex ring, $\frac{1}{2}$ in. × $\frac{9}{16}$ in. Whit.	General use
1L/139	—	Spanner, bi-hex ring, $\frac{5}{8}$ in. × $\frac{3}{4}$ in. Whit.	General use
1L/141	—	Spanner, bi-hex ring, $\frac{7}{8}$ in. × 1 in. Whit.	General use
1L/31	—	Spanner, bi-hex ring, $\frac{1}{8}$ in. × $\frac{3}{16}$ in. Whit.	General use
1L/32	—	Spanner, bi-hex ring, $\frac{1}{4}$ in. × $\frac{5}{16}$ in. Whit.	General use
1L/33	—	Spanner, bi-hex ring, $\frac{3}{8}$ in. × $\frac{7}{16}$ in. Whit.	General use
1L/154	—	Spanner, O.J.D.E. $\frac{1}{8}$ in. × $\frac{3}{16}$ in. Whit.	General use
1C/2229	T32109	Spanner, box, D.E. $\frac{1}{8}$ in. × $\frac{3}{16}$ in. Whit.	General use
64KK/43	T32112	Spanner, box, D.E. $\frac{1}{2}$ in. × $\frac{9}{16}$ in. Whit.	General use
1A/4106	—	Bar, tommy, $\frac{1}{4}$ in. dia. × 5 in. long	Use with T21401
36FF/4054	T.2300–193	Bar, tommy, $\frac{3}{8}$ in. dia. × 9 in. long	Use with T32112
1A/4073	—	Fingers, mechanical	General use
64KK/1042	T75482	Tool, lockwire	General use
64KK/816	T72143	Spanner, claw	Generator nuts
64KK/39	T70260	Spanner, claw	Starting valve nuts (Mk. 2 only)
64KK/130	T21401	Extractor, burner	Burner removal
64KK/120	T70167	Block, vice	Cabin supercharger clutch (Mk. 2 only)
64KK/1286	T77382	Spanner, crowfoot	Starter motor nuts
36FF/123	T70171	Spanner, ring special	Cabin supercharger clutch drive (Mk. 2 only)
—	T76803	Spanner, crowfoot	Thermo couple nut
1B/4486	—	Indicator, revolution, Type A	Engine speed check (instrument section lock-up)
184467	—	Gun lubricating universal	
184469	—	Nozzle assembly hydraulic, push on	

(A.L. 70, Sep. 54)

Table 2

Stores Ref.	Part No.	Nomenclature	Application
64KK/930	T72802	Spanner, ring, S.E.	Fuel pump nut (Mk. 2 only)
64KK/805	T71808	Gauge, pressure	Fuel system checks
64KK/813	T72803	Gauge, pressure	Fuel system checks (starting valve)
64KK/931	T73445	Pipe, isolating	Fuel system checks (isolating governor) (Mk. 2 only)
64KK/1282	T77497	Jig, measuring	Burner protrusion
64KK/891	T73360	Wrench	Combustion chamber (when Mod. No. 820 is embodied) (Mk. 2 only)
64KK/798	T72179	Spanner, 0·525 in. A.F.	Combustion chamber
64KK/45	T70802	Block, form	Combustion chamber, pip removal (Pre-mod. 820)
64KK/37	T70451	Ring, gauge	Combustion chamber, before forming (Pre-mod. 820)
64KK/38	T70452	Ring, gauge	Combustion chamber, after forming (Pre-mod. 820)
64KK/845	T74245	Tool, forming	Combustion chamber, repipping (Pre-mod. 820)
64KK/131	T70444	Gauge, slip, special (3 off)	Combustion chambers, checking during assembly (Pre-mod. 820)
64KK/132	T70445	Gauge, feeler, special (3 off)	Combustion chambers, checking during assembly (Pre-mod. 820)
64KK/44	T71154	Syringe, inhibiting	Turbine disc
6C/152	—	Lens, magnifying, lock-up	Blade crack detection (instrument section)
64KK/1032	T73413	Sharpener, measuring tin	Checking impeller front casing clearance
64KK/921	T74611	Spanner, serrated	Cabin supercharger (Mk. 2 only)
64KK/912	T73347	Block, vice	Air filter
64KK/208	T70262	Spanner, spline	Air filter
64KK/232	T70258	Spanner, claw	Fuel pump
64KK/216	T70038	Tool, insertion	Control box seals
64KK/993	T75590	Guide	Control box plunger
64KK/220	T70259	Spanner, tube	Exhaust cone
64KK/221	T70277	Drift, special	Exhaust cone
64KK/222	T70278	Drift, special	Exhaust cone
64KK/321	T71244	Bracket, roller	Exhaust cone
64KK/836	T73913	Extractor	Governor drive housing
64KK/655	T70988	Tool, peening	Nozzle ring, studs
64KK/656	T70989	Fixture, holding	Nozzle ring
64KK/784	T70252	Tackle, lifting	Nozzle ring
64KK/780	T70186	Tackle, lifting	Turbine disc (Pre-mod. 398)
64KK/996	T74332	Tackle, lifting	Turbine disc (Mod. No. 398)
IL/156	—	Spanner, torque, Model A.1, 5 to 50 lb. ft.	Turbine disc
IL/178	—	Adapter $\frac{1}{2}$ in. sq. socket × $\frac{3}{8}$ in. sq. plug	Use with IL/156

SPECIAL TOOLS

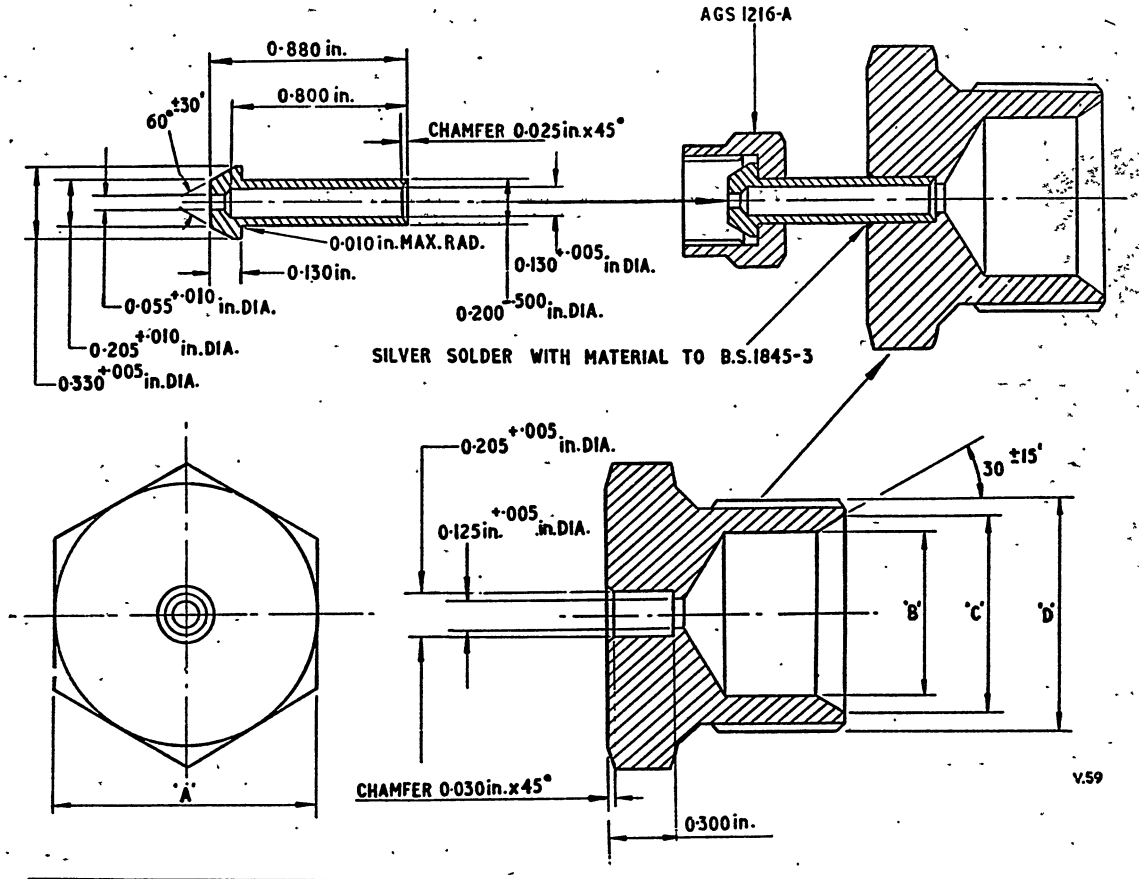
Table 3

In addition to the tools available in the flight servicing kits the tools listed below are necessary to facilitate certain minor repairs

Stores Ref.	Part No.	Nomenclature	Application
64KK/1135	T73329	Plates, adapter	Centre housing
64KK/1136	T74138	Gears, dummy	Accessory boxes

ADAPTERS AND BLANKS FOR FLEXIBLE PIPES

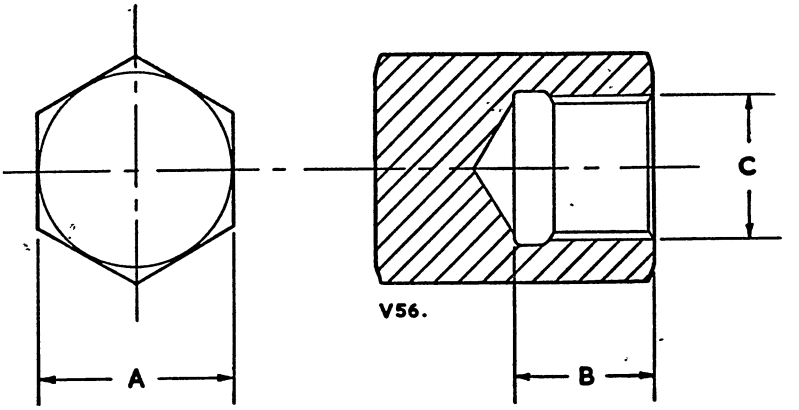
2. The following adapters and blanks will be required when pressure testing flexible pipes, as described in Sect. 2, Chap. 10. During manufacture the materials and sections should be chosen with the specified test pressures in mind and all undercuts and corners should be generously radiused. Joint surfaces must be smooth and free from tool marks.



A (in.)	B (in.)	C (in.)	D (in.)
0·715 — ·005	$\frac{9}{32}$	0·405 + ·010	$\frac{1}{4}$ B.S.P.
0·820 — ·005	$\frac{13}{32}$	0·545 + ·010	$\frac{3}{8}$ B.S.P.
1·010 — ·008	$\frac{17}{32}$	0·685 + ·010	$\frac{1}{2}$ B.S.P.
1·100 — ·008	$\frac{5}{8}$	0·755 + ·010	$\frac{5}{8}$ B.S.P.
1·200 — ·010	$\frac{3}{4}$	0·900 + ·010	$\frac{3}{4}$ B.S.P.

Fig. 1. Adapter for pipes terminating in union nut

(A.L.70, Sep., 54)



	A (in.)	B (in.)	C (in.)
	0·500 — ·005	0·525	$\frac{1}{8}$ B.S.P.

Fig. 2. Cap-nut for blanking banjo type end fittings (use with banjo bolt and washers)

SECTION 2

REPLACEMENT, ADJUSTMENT AND RECTIFICATION

SECTION 2

REPLACEMENT, ADJUSTMENT, AND RECTIFICATION

LIST OF CHAPTERS

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

1 General information

2 Main rotating assembly

3 Structural casings and accessory boxes

4 Combustion chambers

5 Exhaust system

6 Fuel system components

7 Lubrication system components

8 Ignition system

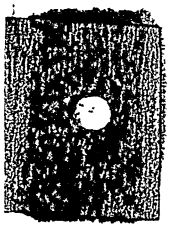
9 Miscellaneous

10 Flexible pipes

Chapter 1

GENERAL INFORMATION

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



LIST OF CONTENTS

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General

1. The method of servicing the engine in accordance with the instructions contained in the Aircraft Servicing Schedule is described in Part 3, Sect. 3, Chap. 1, but the instructions for carrying out any replacement, major adjustment, or rectification found necessary as a result of fault diagnosis or routine servicing are contained in this section.

2. The chapters in this section contain instructions for repair by replacement, that is for removing and refitting those accessories, components, or parts, which are not dealt with in the above chapter, and which can be removed and refitted without the facilities of a complete repair depot. In addition, instructions are included for carrying out adjustments and repairs to accessories, components, or parts, which can be performed without complete reconditioning of the engine or accessory.

3. Operations which require the removal of the engine from the airframe have not been excluded on this account and a workshop stand in which the engine can be rotated may be necessary to gain access to components on the underside of the engine. Instructions for removing the engine from the airframe and for its subsequent reinstallation are contained in Part 3, Sect. 1.

4. Wherever possible, the part number of new parts or consumable items that may be required at reassembly, is quoted to assist the tradesman to ensure that these essential renewals are available before operations are commenced.

5. The general information given in Part 3, Sect. 3, Chap. 1, para. 3 to 9, is equally applicable when carrying out the operations described in this section. When changing an engine-driven accessory on an engine which has completed a number of flying hours, thoroughly examine the splines within the drive in the engine and on the spindle of the accessory. Where applicable the splines at each end of any coupling, drive, or quill shaft should similarly be examined. There should not be any appreciable evidence of wear in the form of "stepping" on the flanks of the splines and reference should be made to the Fits, Clearances and Repair Tolerances contained in Part 6 of this volume, to ascertain the maximum wear permissible.

Anti-corrosion precautions

6. New or re-conditioned fuel system components, or an engine-driven accessory, drawn from stores, will have received protective treatment, therefore, before fitting these accessories to the engine, the necessary blanks must be removed and all surplus inhibiting oil drained off. When an accessory which has been removed is not being refitted to the engine immediately, or is not being dismantled for reconditioning within a week, and will, therefore, remain in store or in transit for a period exceeding seven days, it must be protected against corrosion as described in Part 3, Sect. 4. If, when installed, engine-driven accessories are to remain unconnected to the aircraft services, their connections must be blanked off with airtight caps immediately they have been drained.

Chapter 2

MAIN ROTATING ASSEMBLY

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

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Turbine blades	3	*Refitting the turbine disc*	9

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Turbine disc securing bolts and nuts, and method of locking (Mod. No. 398) ...	1	*Removing the turbine disc with the combined extractor and lifting fixture T74332 and (inset) sectional view of extractor bolts*	3
Turbine disc securing bolts and nuts, and method of locking (Pre-mod. 398) ...	2	*Combined extractor and lifting fixture T70186 arranged for lifting purposes and (inset) the extractor bolts being used to release the turbine disc from the hub shaft*	4

IN-SERVICE REPAIR SCHEMES

	Leaflet
Repair of damaged turbine blades ...	D.1

1. The limits of acceptable damage to the impeller vanes, and to the turbine blades, are given in Part 3, Sect. 3, Chap. 1. For the reasons stated in para. 2, there are no minor repairs, replacements, or rectification which can be carried out on the impeller in service, but turbine blade repairs are permissible within certain limits.

Impeller vanes

2. Damaged impeller vanes cannot normally be blended out in situ. Owing to the high rotational 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. Furthermore, the removal of the protective anodic film, which would occur if damaged areas were blended, creates a condition which is conducive to inter-crystalline corrosion, and 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 involving the removal of portions of the anodic film, the impeller must be vapour-blasted and re-anodised, which necessitates dismantling the engine.

Turbine blades

3. Turbine blade repairs which are acceptable in service are described in Leaflet D.1, at the end of this chapter. This leaflet also describes the method of correcting unbalance in a turbine disc assembly to which such repairs have been applied. The removal of turbine blades is not permissible, and damage which cannot be repaired within the limits stated will necessitate the return of the engine to a repair depot.

Removing the turbine disc

4. The removal of the turbine disc is necessary to gain access to the nozzle blades for the purpose of certain blade repairs described in Part 3, Sect. 3, Chap. 1, and for the removal of the nozzle ring assembly as described in Chap. 3. When Mod. No. 398 is embodied the turbine disc is secured to the hub shaft by ten bolts, eight of which utilize nuts behind the turbine disc rear face. The remaining two bolts are positioned 180 degrees apart and are inserted from the opposite side, through the turbine disc to screw into threads in the hub shaft flange (*fig.* 1). On engines Pre-mod. 398 the turbine disc is secured to the hub shaft by eight bolts and nuts (*fig.* 2), and the remaining two equidistantly spaced holes are used only in conjunction with the extractor when removing the turbine disc.

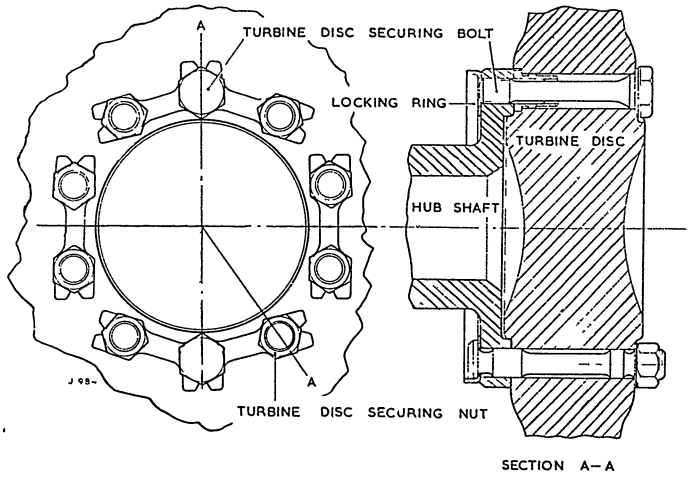

Fig. 1. *Turbine disc securing bolts and nuts, and method of locking (Mod. No.* 398)

5. To remove the turbine disc "in the field" it will be necessary to remove the engine from the aircraft as described in Part 3, Sect. 1, Chap. 2, and the fireguard and tail pipe from the engine, as described in Part 3, Sect. 3, Chap. 1. The engine should then be mounted in the dismantling and assembly stand 4Q/3964, in a horizontal position. During initial build of the engine, the turbine disc and hub shaft are lightly etched to indicate their correct assembly position, but the marks are often difficult to identify on an engine that has been in service. Severe out-of-balance of the rotating assembly will be caused if the turbine disc is refitted 180 degrees from its original position. It is, therefore, essential to ensure that there are relative marks on each component before the disc is removed. Similarly, the nuts and bolts are numbered, and these must be checked before removal to ensure that they will be refitted in their original numerical positions.

6. *Engines with Mod. No.* 398 *embodied.* Turn down the turbine disc nut and bolt tab-washers and, using a suitable ring spanner, remove the eight nuts and two tandem tab-washers; slacken the two bolts which secure the turbine disc to the hub shaft. Using the stand turning handle, rotate the engine to

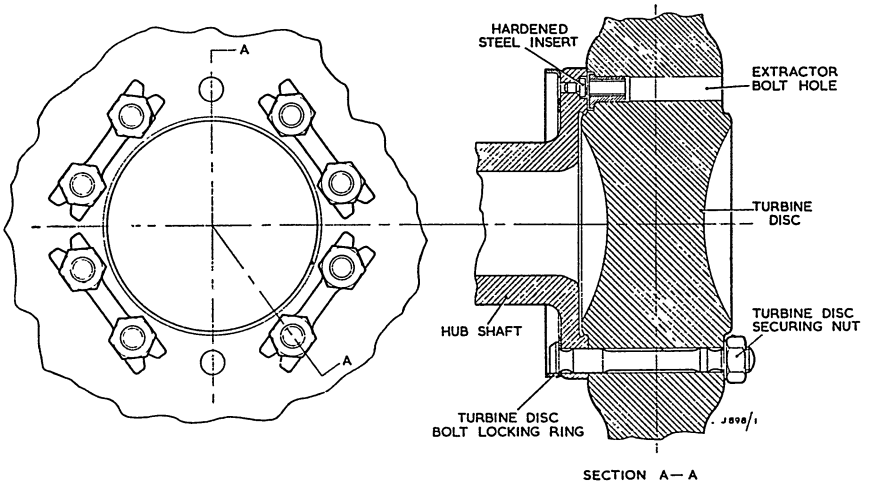

Fig. 2. *Turbine disc securing bolts and nuts, and method of locking (Pre-mod* 398)

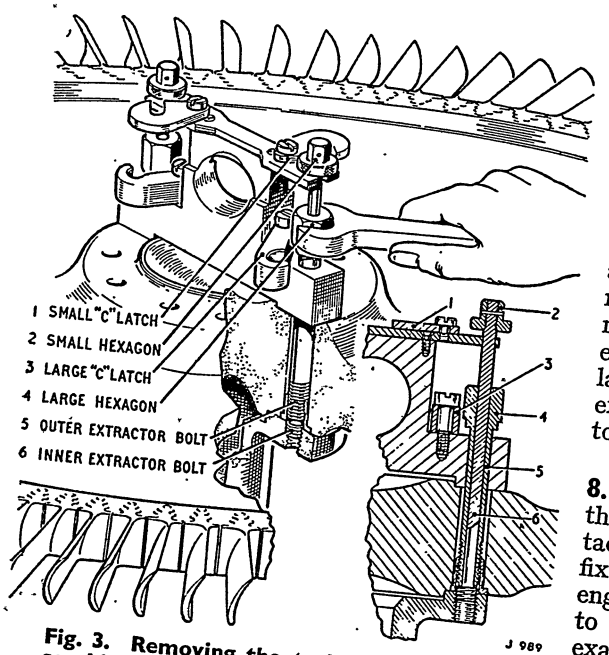

Fig. 3. Removing the turbine disc with the combined extractor and lifting fixture T74332 and (inset) sectional view of extractor bolts

secure the turbine disc to the hub shaft. Using the stand turning handle, rotate the engine to the vertical position with the turbine disc uppermost. Fit the combined extractor and lifting fixture T70186 (*fig.* 4) to the turbine disc, then proceed as follows. Swing the 'C' latches clear of the extractor bolts and screw in the bolts, applying half a turn to each alternately, to release the turbine disc. When the disc is released from the hub shaft, unscrew the extractor bolts sufficiently to enable the 'C' latches to be swung into engagement with the extractor bolts, and then re-tighten the bolts to hold the latches in position.

8. Having released the turbine disc from the hub shaft, connect the hook of the lifting tackle to the lifting eye of the extracting fixture and lift the turbine disc clear of the engine. The disc should then be transferred to the inspection stand T71198. Carefully examine the turbine disc bolt locking ring for any damage sustained through the bolt heads turning during the removal of the

the vertical position with the turbine disc uppermost. Remove the two turbine disc bolts and the two triple tab-washers, fit the combined extractor and lifting fixture T74332 (*fig.* 3) to the turbine disc, then proceed as follows. Swing the large 'C' latches clear of the outer extractor bolts, and turn the upper, smaller, hexagons to engage the threads of the inner extractor bolts in the hub shaft until the upper, smaller, 'C' latches prevent further engagement of the bolt threads. Unscrew the inner bolts half a turn and swing the upper 'C' latches out of engagement. Using a suitable spanner on the lower, larger, hexagons, screw in the outer extractor bolts, applying half a turn to each alternately to remove the turbine disc. When the disc is released from the hub shaft, unscrew the inner bolts until they are clear of the hub shaft threads and unscrew the outer bolts sufficiently to enable the large 'C' latches to be swung into engagement with the extractor bolts which are then re-tightened to hold the latches in position.

7. *Engines Pre-mod. 398.* Turn down the turbine disc nut tab-washers and using a suitable ring spanner, remove the eight nuts and the four tandem tab-washers which

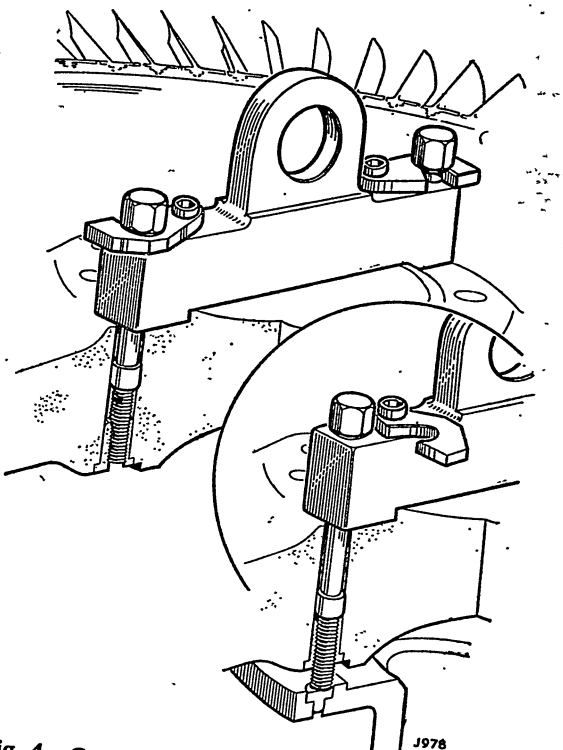

Fig. 4. Combined extractor and lifting fixture T70186 arranged for lifting purposes and (inset) the extractor bolts being used to release the turbine disc from the hub shaft

turbine disc securing nuts. If the locking ring is damaged, the engine must be rejected as a replacement ring cannot be fitted without dismantling the main shaft assembly, which would necessitate dynamic balancing of the rebuilt assembly.

Refitting the turbine disc

9. The turbine disc must be mounted on the hub shaft with the marks checked on these components during dismantling, aligned to correspond. Severe out-of-balance of the rotating assembly will be caused if the disc is refitted 180 degrees from its original position. Similarly, the eight nuts, and the two bolts (if fitted), must be refitted to their original positions.

10. *Engines with Mod. No. 398 embodied.* To refit the turbine disc, rotate the engine on the stand trunnion arms to the vertical position, with the hub shaft uppermost. Place the combined extractor and lifting fixture (T74332) on the disc and, with the small 'C' latches in position, screw the inner bolts through the bolt holes in the turbine disc. With the large 'C' latches also in engagement with their respective bolts, screw the outer bolts into the disc until the latches are nipped. Lift the disc on to its correct position on the hub shaft. Remove the extractor, position two new tandem tab-washers Part No. N3771, and two new triple tab-washers Part No. N3769 (Pre-mod. 704) or N4507 (Mod. No. 704) as shown in fig. 1, and refit the eight turbine disc securing nuts and two bolts. Turn the engine to a horizontal position. Using a standard $\frac{7}{16}$ in. B.S.F. socket and torquometer wrench TQ 50A (Stores Ref. 1C/6447), tighten the nuts and bolts uniformly to ensure that the disc is pulled squarely on to the hub shaft, with a torque of 400 to 450 lb. in. Bend up the tabs to lock the nuts.

11. *Engines Pre-mod. 398.* To refit the turbine disc, rotate the engine to the vertical position with the hub shaft uppermost. Place the combined extractor and lifting fixture (T70186) on the turbine disc and with the 'C' latches in position screw the extractor bolts into the extractor bolt holes. Lift the disc on to its correct position on the hub shaft. Remove the extractor, fit four new tandem tab-washers (Part No. N.1601) as shown in fig. 2, and refit the eight securing nuts. Turn the engine to a horizontal position. Using a standard $\frac{7}{16}$ in. B.S.F. socket and the torquometer wrench TQ 50A (Stores Ref. 1C/6447), tighten the nuts uniformly to ensure that the disc is pulled squarely on to the hub shaft, with a torque of 260 to 390 lb. in. Bend up the tabs to lock the nuts.

12. The turbine shroud/turbine disc tip clearance must then be checked as described in Part 3, Sect. 3, Chap. 1. When the tail-pipe is assembled to the engine the tail-pipe turbine disc clearance, which is also described in that chapter, must be checked.

LEAFLET D.1

REPAIR OF DAMAGED TURBINE BLADES

1. Turbine blades which have sustained damage beyond the limits detailed in Part 3, Sect. 3, Chap. 1 may be repaired as described in this Leaflet. These repairs, which are permissible in service, involve the correction of resulting unbalance in the turbine disc assembly, and this operation is also described. Damage which is in excess of the repairable limits will necessitate the return of the engine to a Repair Base.

2. It is important to note that damage which is due to excessive operational temperatures cannot be rectified by the application of these instructions. Furthermore, it is not permissible to use these repair methods at reconditioning, as the existing repair scheme T.R.164 must then be applied, and any blades which may have been rectified in service beyond the limits specified in T.R.164 must be renewed.

3. It is preferable to remove the turbine disc assembly from the engine (*see para. 4 of the foregoing chapter*) before attempting any of the repairs detailed in this Leaflet.

4. Final acceptance of the balance of an engine, to which any of these repairs has been applied, will depend on engine run, and in some cases on flight, to ascertain that the engine is sufficiently smooth, and that the maximum jet pipe temperature is within the limits.

Acceptance of damage without blending

5. A turbine blade in which damage is of a smooth nature, i.e. bruises, and bent corners which are free from sharp indentations, or nicks, is acceptable without repair, provided that such damage is within the limits stated in para. 6, 8, and 12.

Bent tip corners (*fig.* 1)

6. A blade is acceptable if the corner of its tip is bent, provided that the angle of bend does not exceed 90 deg., and that any nicks are smoothed out. It is not permissible to straighten a bent corner.

7. Where the corner is nicked severely, or is bent to an angle greater than 90 deg., the damaged portion of the blade may be filed off

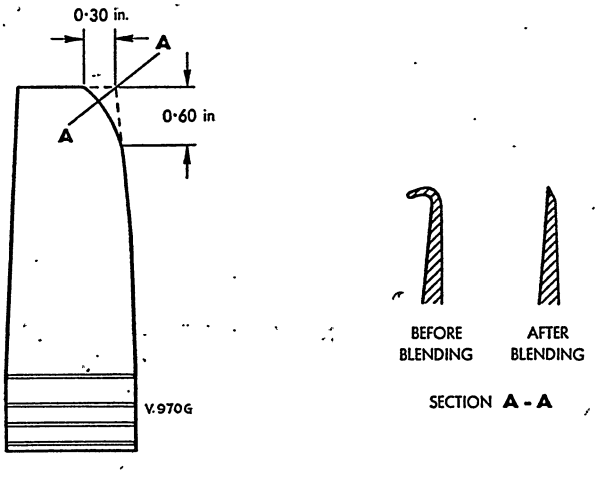

Fig. 1. *Limits of blending on blade tip corner*

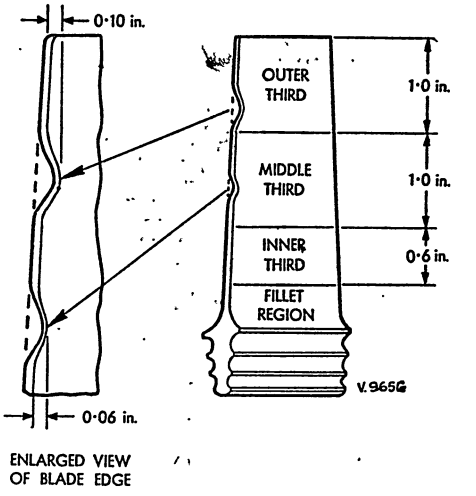

Fig. 2. *Permissible bruises in blade edge*

(*A.L.85, June 58*)

and blended up to the limitations shown in fig. 1, so that the original blade section is restored. The removal of the maximum permissible amount from a number of blades, however, may result in an increase in fuel consumption, accompanied by a rise in jet pipe temperature, and, therefore, not more than one third of the total number of blades may be blended to the maximum permissible extent.

Smooth bruises in blade edges

8. Smooth bruises in the edge of a blade (*fig.* 2) are acceptable only in the middle, and outer third, provided that any such bruise does not exceed a depth of 0·060 in. in the middle third, or 0·100 in. in the outer third. Where major bruises exist, they may be blended into a smoother form, as described in the following paragraph, but the depth of any bruise which remains after such blending must not exceed the limits stated above.

Indentations in blade edges

9. A blade which has sustained impact damage to its edges, fig. 3, may be filed and blended, but the depth of blending must not exceed the limitations shown in the following table.

Position on blade edge	Maximum depth of blending (in inches) (dimension X in fig. 3)
Tip	0·060
1 in. from tip	0·045
2 in. from tip	0·030
2·6 in. from tip	0·020

No damage whatever is permissible below the 2·6 in. position, i.e., in the fillet region of the blade. All blending must be carried out evenly and progressively between the specified positions, and, if necessary, the blade may be blended along its edge for the entire 2·6 in.

10. Normally, impact damage occurs on the leading edge of a blade, but where damage is found on the trailing edge, this may also be blended, provided that the total reduction in

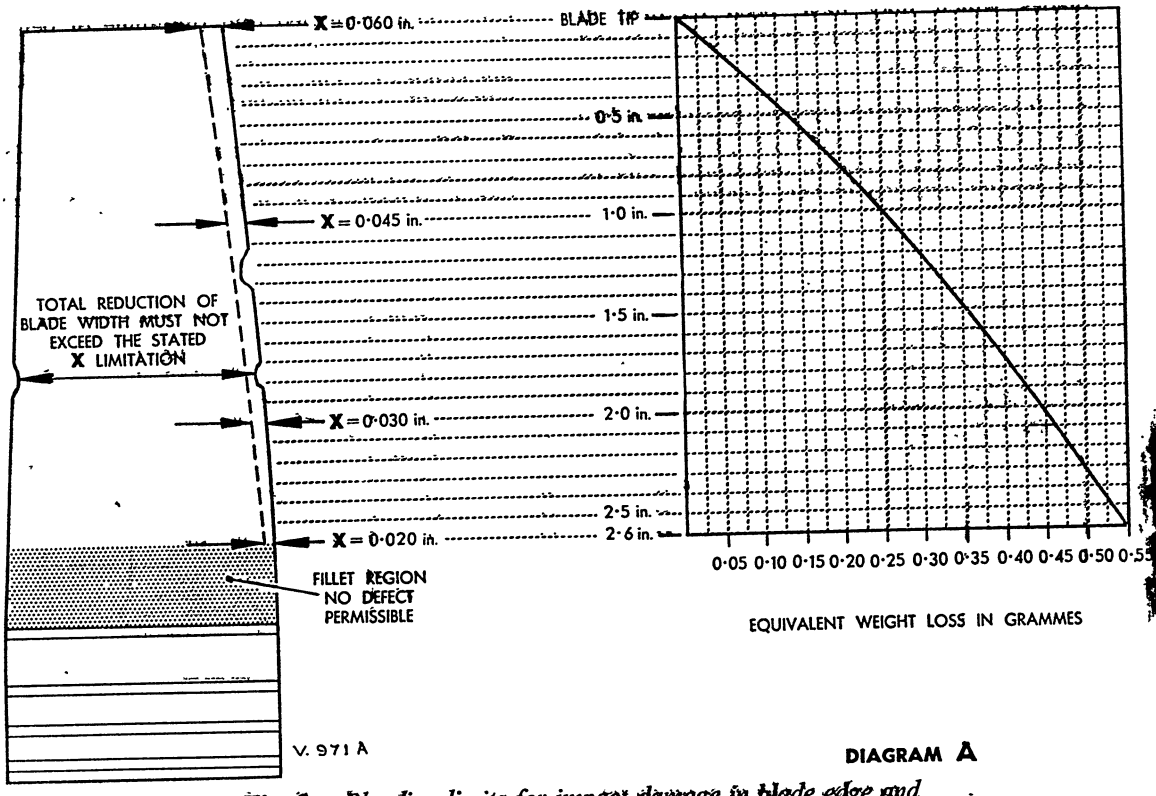

Fig. 3. *Blending limits for impact damage in blade edge and diagram A for calculating weight loss*

the blade width does not exceed the stated limitation for dimension X at any point.

11. Where isolated blades have sustained damage which cannot be repaired within the limits shown in fig. 3, blending is permissible to the extent shown in fig. 4. It must be understood, however, that such major blending, if applied to a number of blades,

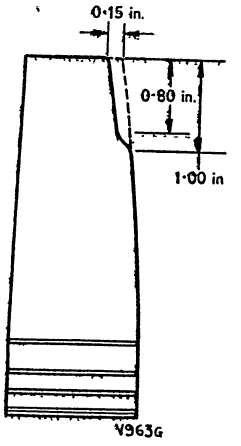

Fig. 4. *Major blending limits in blade edge*

may cause a considerable increase in fuel consumption, together with a rise in jet pipe temperature, and, therefore, not more than 10 blades may be rectified in this way. Furthermore, any blades which have been blended in this manner must be included as part of the permissible total number of blades in which bent tip corners have been filed off (*refer to para.* 7).

Indentations and bruises in the convex surface

12. Indentations and bruises in the convex surface of a turbine blade are acceptable without repair, provided that they are smooth in nature, and that their maximum depth does not exceed 0·080T, where T equals the thickness of the blade section at the point of damage. Where this type of damage is accompanied by sharp nicks, etc., it will be found, generally, that a build-up of metal occurs around the edges of the indentation, or bruise. This metal must be filed off, and blended, and the sharp nicks must also be blended, within the limits shown in fig. 5. Normally, damage of this nature is difficult

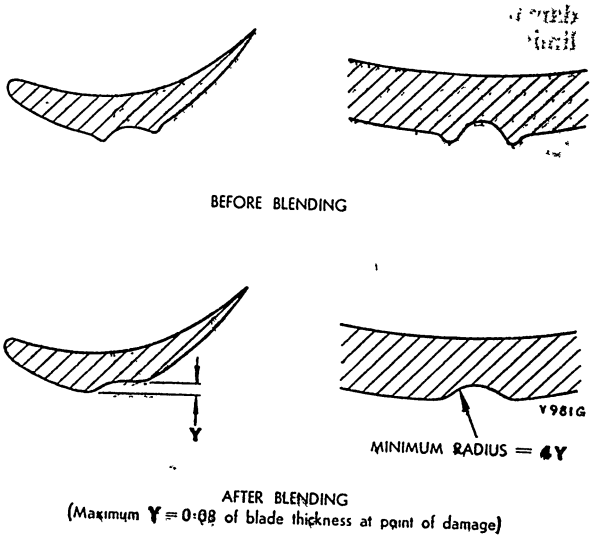

Fig. 5. *Damage to convex surface of blade*

to repair in the inner third of a blade which is in position on the turbine disc, but where such repair is possible, the blended area must not exceed the limits shown in fig. 6.

Finish

13. In all blending operations, the original curvature of the blade edges must be restored.

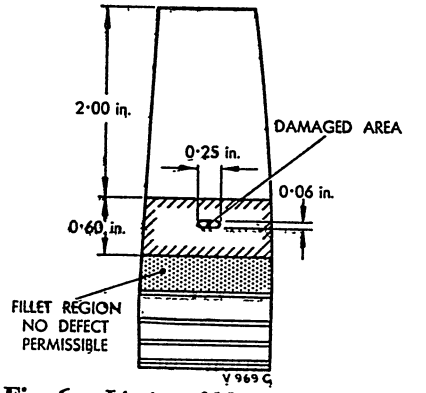

Fig. 6. *Limits of blending in convex surface of inner third of blade*

All repairs must be carefully finished and polished using Cloth 00, and all file marks must be removed.

Template for blend limitations

14. To facilitate the identification of repairable damage, a simple template, fig. 7, may be made up from local sheet metal resources.

Such a template may be used to check that damage to a blade is within the repairable limits, and also to check that the finished repair is within the acceptable limits. The use of three templates is recommended, one each to meet the requirements of the limits of repair shown in fig. 1, 3, and 4.

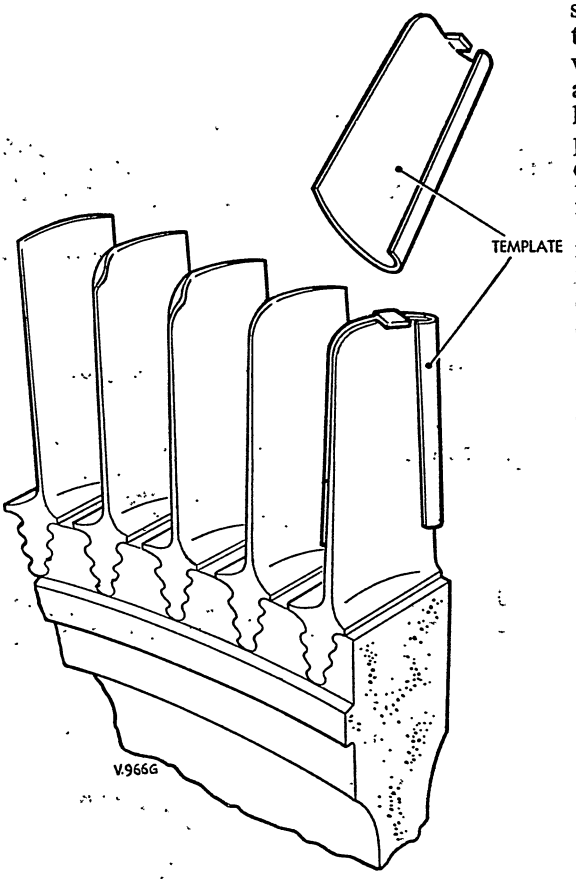

Fig. 7. *Template for checking blade*

Effect of repair on balance of main shaft assembly

15. The rectification of turbine blade damage may cause unbalance in the main shaft assembly, and, after all the necessary repairs have been carried out, additional blades may have to be blended to reduce the unbalance to a minimum.

16. The amount of metal removed from a turbine blade produces a corresponding unbalancing effect at the balancing ring. This unbalance is referred to as weight loss, and its varying values have been calculated. The following paragraphs describe the method of ascertaining the weight loss, according to the nature of the repair which has been carried out.

Unbalance due to minor blending

17. Where blades have been repaired within the limits indicated in fig. 3, reference must be made to diagram A in that figure, which shows the relevant weight loss according to the length of blend. To use this diagram, work from the blade tip, and note the point at which the blend commences. Follow the horizontal line across from this point to the position where it meets the curve, and read downwards to the equivalent weight loss. Repeat this procedure from the end of the blend. The difference between the two readings obtained indicates the overall weight loss for the entire blend. Application of the diagram is shown in the following detailed examples:—

(1) A blend which commences at the blade tip, and is taken to the full permissible depth for a distance of 1 in. along the leading edge, will produce an unbalance of 0·25 gm.

(2) A blend commencing 1 in. from the blade tip, and taken to the full permissible depth for a distance of 1 in. down the leading edge, will produce an unbalance of 0·20 gm. This figure is obtained by subtracting the weight loss reading at the 1 in. position (start of blend) from the reading at the 2·0 in. position (end of blend), i.e., 0·45 minus 0·25 gm.

(3) A blend along the entire 2·6 in. of the leading edge, taken to the full permissible depth, will produce an unbalance of 0·55 gm.

Unbalance due to major blending

18. Unbalance due to blending within the limits shown in fig. 1, or 4, may be calculated by reference to fig. 8. Each of the squares marked A, and B, in fig. 8, represents a square of 0·1 in., and has an equivalent weight loss as indicated. By measuring the extent of the blend, and identifying these measurements with the appropriate A, and B squares, the weight loss due to blending can be calculated. The following examples show how this method of assessing unbalance may be applied.

(1) A blade corner which has been blended, within the limits shown in fig. 1, for a distance of 0·3 in. along the tip edge, and of 0·4 in. along the leading edge, will include 3·5 squares marked A, and approximately 2 squares marked B. Since each A square represents a weight loss of 0·06 gm., and each

B square a weight loss of 0·12 gm., the total unbalance in this instance will amount to 3·5 times 0·06 gm., plus twice 0·12 gm.: a total of 0·45 gm.

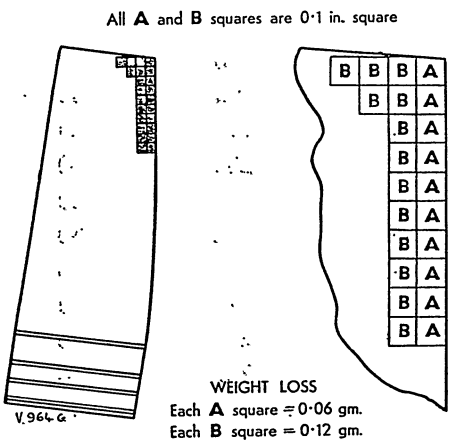

Fig. 8. *Diagram for calculating weight loss due to major blending*

(2) The leading edge of a blade which has been blended within the limits shown in fig. 4, for a distance of 0·6 in., and to a depth of 0·15 in., will include 5·5 squares marked A, and approximately 5 half-squares marked B. The unbalance, therefore, will amount to 5·5 times 0·06 gm., plus 2·5 times 0·12 gm.: a total of 0·63 gm.

19. A blade which has been blended to the full limit shown in fig. 1, will produce an unbalance of 0·75 gm. Similarly, a blade which has been blended to the full limit shown in fig. 4, will produce an unbalance of 1·00 gm.

Correction of unbalanced conditions

20. It will be understood that no appreciable unbalance will result where two blades, which are situated approximately diametrically opposite, have been blended by an equal amount. Similarly, a blade to which major blending has been applied, may be balanced by two or three diametrically opposite blades in each of which only minor blending has been necessary. Therefore, when all the weight losses have been calculated, those blades which may be said to balance each other out, should be marked with chalk. The remaining blended blades (*unmarked*) will have a cumulative effect on the balance of the turbine disc as a whole, and to assess this effect it will be necessary to construct a related, simple diagram of force.

21. Firstly, a diagram must be constructed showing the positions of the unmarked blades on the disc, and from this figure a force diagram is built up. The upper drawing in fig. 9 shows a typical diagram of a turbine disc in which blended blades A, B, C, and D are to be considered. When constructing such a diagram, the angular position of the blades concerned may be obtained by reference to Table 1 and fig. 10, but any one of these blades may be identified as the datum blade.

22. To assess the cumulative effect of unbalanced blades, such as the four blades shown in fig. 9, proceed as follows:—

(1) Selecting any one of the blades as a datum (*blade A in the upper diagram in fig. 9*), construct a diagram with this blade at T.D.C., and mark in the weight loss caused by blending. Draw a vertical line from the blade to the centre of the disc, point X.

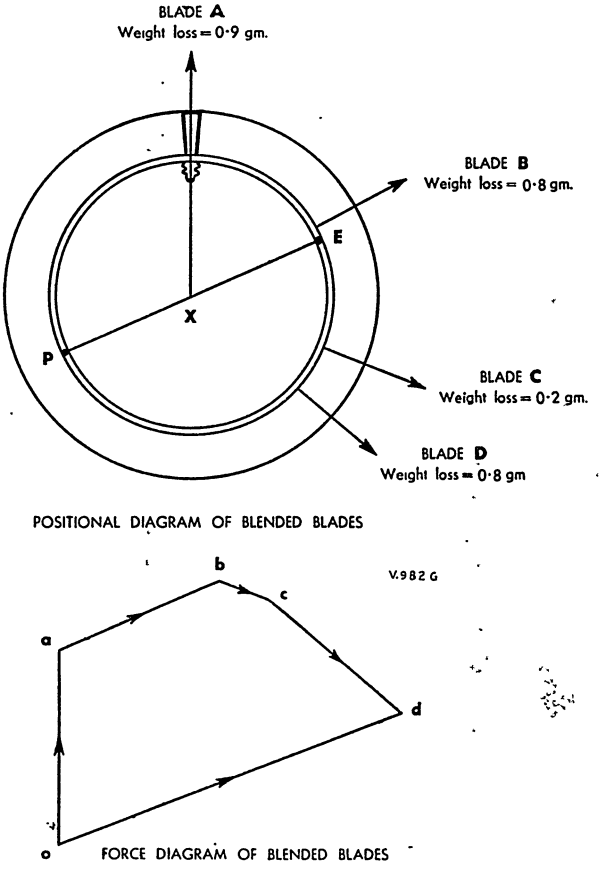

Fig. 9. *Diagram for calculating unbalance in turbine disc assembly*

TABLE 1
Angular Position of Turbine Blades

Blade No.	Degrees	Minutes	Blade No.	Degrees	Minutes
Datum	*Zero*				
1	4	20	42	182	00
2	8	40	43	186	20
3	13	00	44	190	40
4	17	20	45	195	00
5	21	40	46	199	20
6	26	00	47	203	40
7	30	20	48	208	00
8	34	40	49	212	20
9	39	00	50	216	40
10	43	20	51	221	00
11	47	40	52	225	20
12	52	00	53	229	40
13	56	20	54	234	00
14	60	40	55	238	20
15	65	00	56	242	40
16	69	20	57	247	00
17	73	40	58	251	20
18	78	00	59	255	40
19	82	20	60	260	00
20	86	40	61	264	20
21	91	00	62	268	40
22	95	20	63	273	00
23	99	40	64	277	20
24	104	00	65	281	40
25	108	20	66	286	00
26	112	40	67	290	20
27	117	00	68	294	40
28	121	20	69	299	00
29	125	40	70	303	20
30	130	00	71	307	40
31	134	20	72	312	00
32	138	40	73	316	20
33	143	00	74	320	40
34	147	20	75	325	00
35	151	40	76	329	20
36	156	00	77	333	40
37	160	20	78	338	00
38	164	40	79	342	20
39	169	00	80	346	40
40	173	20	81	351	00
41	177	40	82	355	20

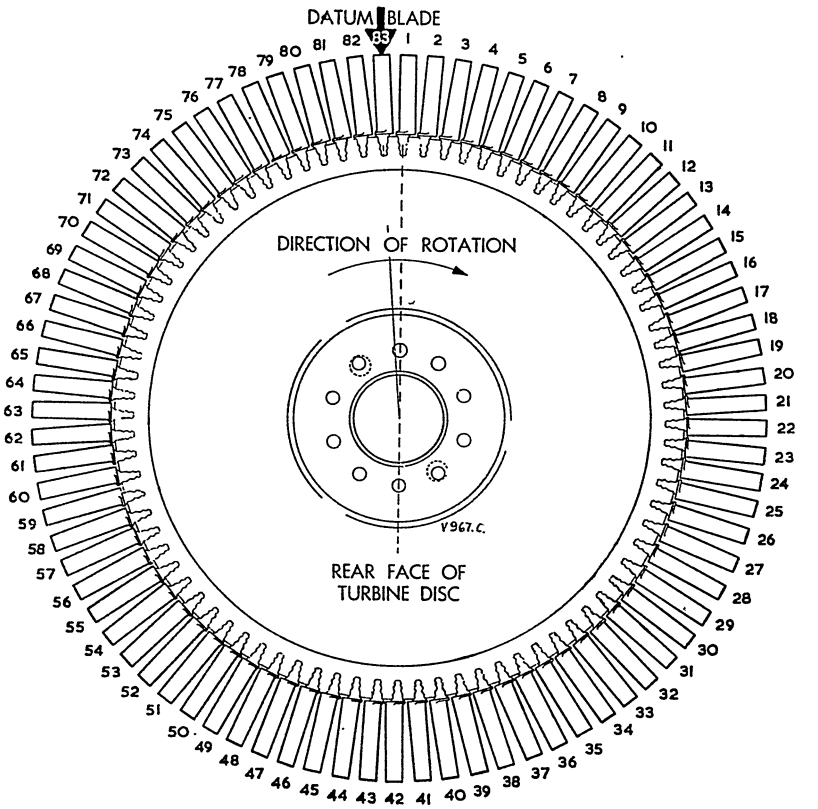

Fig. 10. *Diagram showing numbering of turbine blades*

(2) Mark on the diagram the positions of the remaining blended blades (B, C, and D), and their respective weight losses.

(3) Refer to the lower diagram in fig. 9 and, using a convenient scale, draw a line oa parallel to the line AX, whose length is equal in magnitude to the weight loss caused by the blending of blade A.

(4) Proceed clockwise around the disc to blade B, and draw a line ab, which is equal in magnitude and direction to the weight loss caused by the blending of blade B.

(5) Proceed to blade C, and draw a line bc, equal in magnitude and direction to the weight loss of blade C.

(6) Continue to blade D, and draw a line cd, equal in magnitude and direction to the weight loss of blade D.

(7) Join the points o and d.

(8) On the upper diagram, mark a line PE, which passes through the centre of the disc, and which forms an angle with the datum line AX equal to the angle aod.

(9) The length of the line od represents the total magnitude of the unbalance in the turbine disc caused by the blending of blades A, B, C, and D. Therefore, the disc is light at point E by this amount. Point P, being diametrically opposite to point E, indicates the position on the disc where balancing corrections must be made to the blades.

(10) Where the total amount of unbalance is less than 1 gm., no further work is necessary. If, however, the unbalance is greater than this figure, one or two blades at point P must be blended by an amount which is sufficient to reduce the unbalance to below 1 gm.

(A.L.85, June 58)

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Chapter 3

(This chapter supersedes that issued wth A.L. No. 57 and 67)

STRUCTURAL CASINGS AND ACCESSORY BOXES

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

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1. This chapter contains instructions for removing and refitting the structural casings and accessory boxes and will in due course include instructions for carrying out minor repairs to the components. The general information contained in Chapter 1 of this section should be referred to as necessary.

Top accessory box

Removal

2. To remove the top accessory box, it will first be necessary to remove the engine-driven accessories in accordance with the instructions contained in Chapter 9, then proceed as follows. Mk. 2 only, disconnect the electrical connections on the oil temperature gauge resistance bulb in the thermometer pocket on the port side of the accessory box, and disconnect the oil pressure gauge pipe from the double banjo union on the top of the accessory box. Remove the banjo bolt from the top end of the oil supply pipe to the top accessory box from the starboard side of the accessory box cover, and the cap-nut at the bottom end. Remove the pipe and sealing washers. Remove the two split pins, nuts and plain washers, and detach the lifting eye. Remove the nuts, plain and spring washers from the two long front casing studs, one each side of the tachometer drive, then the seven nuts, plain and spring washers from the accessory box flange, easing the box off the studs as necessary to facilitate removal of the nuts. Lift the accessory box off the engine ensuring that the top vertical drive shaft, which may come away with the accessory box, does not fall out.

Refitting

3. The joint washer (Part No. 23586), must be renewed if there is any doubt with regard to its serviceability. Place the joint washer in position, and insert the vertical drive shaft in the centre housing top vertical drive. Lower the top accessory box into position, turning the impeller as necessary to facilitate engagement of the drive shaft splines. Refit the nine plain and spring

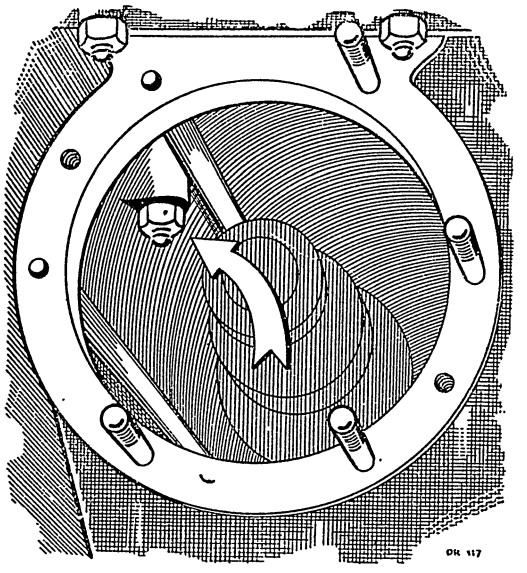


Fig. 1. Internal nut securing the bottom accessory box

washers and the plain nuts; owing to the limited clearance, these nuts must be tightened progressively to avoid binding on the casting. Assemble the lifting eye to the rear pair of long studs and secure it with the two castellated nuts, washers, and new split pins. Refit the oil supply pipe to its connections on the starboard side of the accessory box. Mk. 2 only, connect the leads to the oil temperature gauge bulb on the port side, and connect the oil pressure gauge pipe to the double banjo union on the top of the accessory box. Refit the engine-driven accessories, as described in Chapter 9.

Bottom accessory box

Removal

4. To remove the bottom accessory box, it will first be necessary to remove the engine-driven accessories and the starter, as described in Chapter 9. Remove the fuel pump or pumps with the adapter(s), and in the case of Mk. 2 engines, the control box, dump valve and the pressure limiting valve as a unit, the overspeed governor, and the fuel accumulator, or Mk. 3 only, the control box and pressure limiting valve as a unit, and the barometric pressure control (Pre-mod. 700 only), in accordance with the instructions contained in Chapter 6. Remove the oil sump, as described in Chapter 7. Before the bottom accessory box can be removed, it will be necessary to remove the overspeed governor unit drive housing, or in the case of Mk. 3 engines, the starboard fuel pump drive housing, to gain access to an internal nut, indicated by the arrow in fig. 1, which secures the bottom accessory box to a stud on the front casing.

5. Remove the two countersunk screws which hold the drive housing flange. Mk. 2, using the extractor (T73913) withdraw the housing as shown in fig. 2. Mk. 3, using a soft drift inserted through the port drive housing, tap off the starboard housing. Bend back the tab of the locking washer, and remove the internal nut from the front casing stud. Remove the remaining thirteen nuts, plain and spring washers, easing the accessory box down as necessary to remove the nuts completely. Remove the bottom accessory box and the vertical drive shaft.

Refitting

6. The joint washer (Pt. No. 23587) fitted between the bottom accessory box and the front casing, must be renewed if there is any doubt with regard to its serviceability. It will be found most convenient to insert the bottom accessory box drive shaft into the splines in the accessory box. Turn the impeller whilst pushing the accessory box into position to facilitate engagement of the splines on the vertical shaft with those in the centre housing. Assemble the thirteen plain and spring washers, screw on, and progressively tighten the nuts. Using a new tab-washer (Part No. N1383), assemble, tighten, and lock the internal nut. Apply a thin film of jointing compound to the flange of the drive housing, refit the housing, and secure it with the two countersunk screws. Refit the oil sump, the fuel system components, and

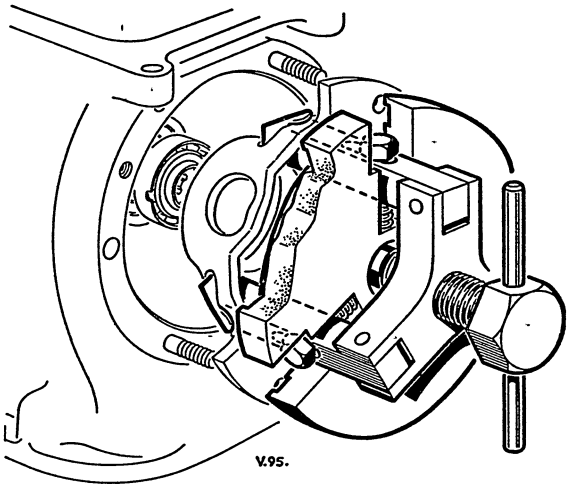


Fig. 2. Extracting the overspeed governor drive housing (Mk. 2)

the engine-driven accessories in accordance with the instructions contained in the relevant Chapters of this section.

Centre housing

Removal

7. Before the centre housing can be removed, it will be necessary to remove the oil sump and the bottom accessory box, which should be treated as one unit, and the top accessory box as decribed in para. 2 to 5. Ensure that both vertical drive shafts have been removed before proceeding with further dismantling. The rear flange of the centre housing is a close fit in the front casing aperture, and to avoid difficulty, the instructions relating to its withdrawal must be carefully followed.

8. Remove the ten nuts, spring washers, and plain washers, from the centre housing cover plate, and remove the cover plate. The Klingerit joint washer should be discarded. Remove the two countersunk screws from the centre housing front flange, and free the centre housing assembly by tapping it with a soft metal drift entered through the top accessory box vertical drive shaft aperture. When the rear flange of the centre housing is free from its aperture in the front casing, turn the housing in a clockwise direction, about its vertical axis, as viewed from the top accessory box location, at the same time drawing the housing forward until a point is reached at which the centre housing will readily withdraw from the aperture in the front casing.

Note . . .

It is important that during the withdrawal operations, the vertical axis of the centre housing must be kept upright and not tilted in any direction; force must not be used.

Refitting

9. It will be found that the centre housing will enter easily into the aperture in the front casing if given the correct angle of approach; this must be found experimentally by rotating the housing about its vertical axis. Apply a thin film of "Wellseal" jointing compound to the front flange of the centre housing. Ensure that the accessory drive shaft is right back in the splines of the pivot shaft. Manœuvre the housing into the front casing, and engage the accessory drive shaft splines. When the centre housing has been refitted, mount the two alignment adapter plates (T73329), complete with dummy gears (T74138), in place of the top and bottom accessory boxes. Check the alignment by inserting the top and bottom vertical drive shafts. The alignment is satisfactory if, when each vertical drive shaft is lifted, it is free to drop back into position under its own weight. Remove the alignment adapters, and refit the accessory boxes, and the components and accessories, in accordance with the instructions given in para. 2 to 6. A new joint washer (Part No. 19152) should be fitted to the centre housing cover plate.

Note . . .

Prior to the introduction of Mod. 548, *the dowel hole in the face of the centre housing front flange was reamed to final size* (0·2500/0·2505 *in.*) *on assembly, which meant that the centre housing was not interchangeable. Where Mod.* 548 *has been embodied, the dowel hole in the centre housing front flange is reamed to final size* (0·2530/0·2535 *in.*) *during machining of the centre housing, which allows interchangeability between engines of the same mark, and also between Mk.* 2 *and Mk.* 3 *engines. Therefore, to enable an unmodified centre housing to be fitted to an engine other than the engine from which it was removed, Mod.* 548 *must be embodied by reaming the dowel hole in the centre housing front flange to the larger dimension.*

Nozzle ring assembly

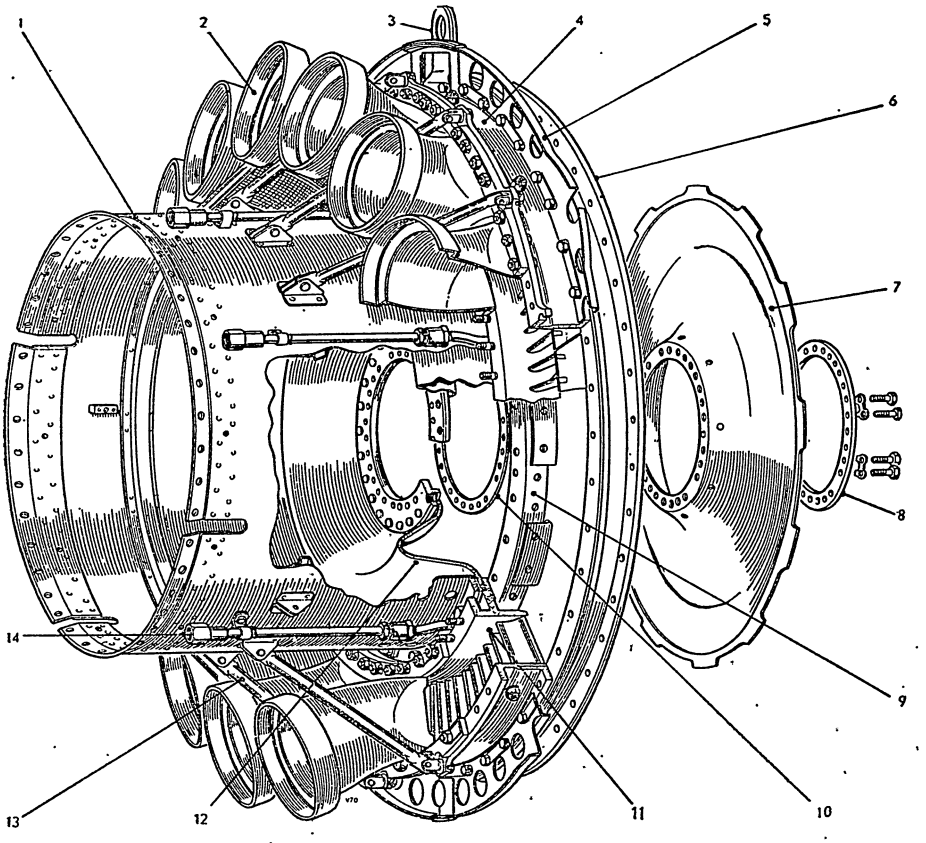
10. Any nozzle blade which is damaged or bowed beyond the limits given in Part 3, Sect. 3, Chap. 1, must be replaced by a new blade. Instructions for renewing nozzle blades "in service", having removed the complete nozzle ring and blades from the nozzle ring assembly, are given in para. 36 to 40.

Removal

11. To renew damaged nozzle blades or to change the complete nozzle ring and blades, it will be necessary to remove the nozzle ring assembly, which consists of the nozzle ring and shroud, the junction pipe assembly and the support cylinder (*fig.* 3 *and* 4). To carry out the following operations, the engine must be removed from the aircraft and mounted in the dismantling and assembling stand 4Q/3964.

12. Remove the combustion chambers as described in Part 3, Sect. 3, Chap. 1, and remove the turbine disc as described in Chapter 2.

(A.L.78, June 56)



1 SUPPORT CYLINDER
2 JUNCTION PIPE ASSEMBLY
3 LIFTING EYE
4 NOZZLE SHROUD
5 FIREGUARD SUPPORT RING
6 TURBINE SHROUD
7 INSULATING PLATE
8 PACKING PLATE
9 INSULATING-PLATE SUPPORT RING
10 INSULATING WASHER
11 NOZZLE RING
12 DIAPHRAGM
13 NOZZLE SHROUD STRUTS
14 NOZZLE RING COOLING PIPES

Fig. 3. Nozzle ring assembly (Mk. 3)

13. With the engine vertical and the hub shaft uppermost, remove the twenty-eight insulating plate retaining bolts and the fourteen double tab-washers. Remove the thirty-two bolts and plain washers from the flange at the junction of the support cylinder and the centre casing. *Mk. 3 only.* Break the locking wire on the six flexible joints in the nozzle ring cooling pipes and unscrew the gland nuts. Assemble the lifting tackle T70252 by attaching the bridge pieces with two pairs of bolts to the turbine shroud flange, and lift the complete assembly clear of the engine. If a rear bearing thermocouple is fitted, it will be necessary to ease the thermocouple lead clear of the support cylinder whilst the assembly is being lifted off. Lower the nozzle ring assembly on to a bench and remove the lifting tackle.

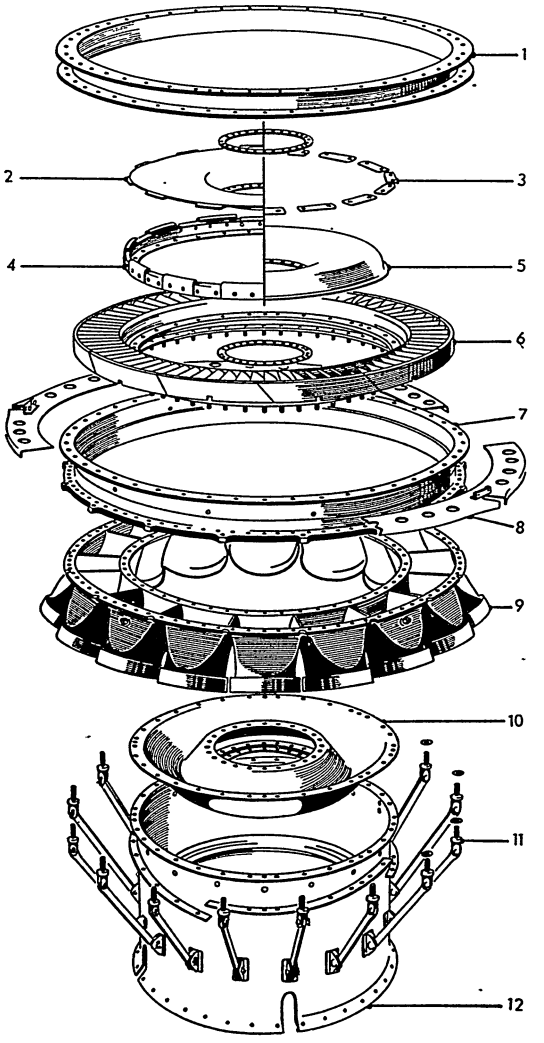
Dismantling

14. With the nozzle ring assembly positioned on a bench with the rear end uppermost, remove the forty-five nuts and bolts which secure the turbine shroud to the nozzle shroud, and remove the turbine shroud, the two halves of the fireguard support ring, and the lifting eye. Where Mod. No. 987 has not been embodied, one of the lifting-eye bolts is a dowel bolt and is a close fit in the bracket and in the turbine shroud.

15. *Mk. 2 only.* Turn back the tab-washers and unscrew the thirty nuts and bolts which secure the diaphragm and support cylinder; twenty of these bolts also hold the ten retaining plates for the insulating plate. Remove the retaining plates, insulating plate, and the packing plate and insulating

washer on the inner flange of the insulating plate.

16. *Mk. 3 only.* Rotate the insulating plate so that it is free of the securing claws and lift it off the assembly; remove the packing plate and insulating washer from the inner flange of the insulating plate. Turn back the tab-washers and unscrew the thirty nuts and bolts which secure the diaphragm and support cylinder. Twelve of the nuts, which are located inside the insulating plate support ring, also secure the rear portions of the six nozzle-ring cooling pipes, which should be removed as they are released. Remove the insulating plate support ring.



1 TURBINE SHROUD
2 INSULATING PLATE (Mk. 3)
3 INSULATING-PLATE RETAINING PLATES (Mk. 2)
4 INSULATING-PLATE SUPPORT RING (Mk. 3)
5 INSULATING PLATE (Mk. 2)
6 NOZZLE RING
7 NOZZLE SHROUD
8 FIREGUARD SUPPORT RING
9 JUNCTION PIPE ASSEMBLY
10 DIAPHRAGM
11 NOZZLE SHROUD STRUTS AND EYEBOLTS
12 SUPPORT CYLINDER

Fig. 4. Nozzle ring assembly dismantled

17. The remaining dismantling operations are the same for Mk. 2 and Mk. 3 engines. Reverse the assembly, and remove the split pins and shackle pins which hold each end of the sixteen nozzle shroud struts. Remove the struts and the support cylinder with its bolt locking ring; the latter cannot be removed from the support cylinder. Tie the nozzle shroud struts and pins together.

18. Tap out the diaphragm plate from the assembly. Turn back the tabs of the double tab-washers and unscrew the forty-eight nuts which secure the junction pipe assembly to the nozzle ring. Lift out the nozzle ring from the nozzle shroud.

Reassembly

19. Before assembling the nozzle ring assembly, examine all components for damage. If the nozzle shroud, turbine shroud, or junction pipe assembly are damaged beyond the acceptable limits given in Part 3, Sect. 3, Chap. 1, they may be changed for serviceable components, but the support cylinder must not be changed. If the turbine shroud has become distorted remedial action as described in para. 35 should be taken. All screw threads should be coated with Ragosine L.M. grease, Spec. D.T.D. 900/4424, to reduce risk of seizure and to facilitate dismantling at a later date.

20. Lower the nozzle ring into the nozzle shroud, aligning the offset hole in the inner flange of the nozzle ring with the chiselled line marked TOP on the nozzle shroud. Coat the studs on the inner flange with anti-seize grease and assemble the twenty-four double tab-washers and forty-eight nuts to secure the junction pipe assembly to the nozzle ring. Tighten and lock the nuts.

21. *Mk. 2 only.* Assemble the insulating washer, insulating plate and packing plate to the loose flange of the diaphragm in that order. These are assembled so that the two countersunk holes in the loose flange are blanked off and the parts held together by slave bolts. Check with feeler gauges that

there is a clearance between the outer edges of the diaphragm and insulating plate.

22. *Mk. 3 only.* Assemble the insulating washer to the loose flange of the diaphragm so that the two countersunk holes in the loose flange are blanked off, and secure it in position with two slave bolts.

23. Lay the support cylinder with its rear flange uppermost on a low table. Place the diaphragm, curved side downwards, on the support cylinder flange and align the offset holes. Reverse the nozzle and junction pipe assembly and lay it on the diaphragm, again aligning the offset holes. Apply anti-seize grease to the threads of the thirty bolts, and secure the support cylinder and diaphragm to the inner flange of the nozzle ring with the bolts, nuts and tab-washers.

24. *Mk. 2 only.* Ensure that the four stiffening segments are assembled under the bolt heads on the support cylinder flange and that the insulating-plate retaining plates are located under twenty of the nuts. Square-up the retaining plates before tightening the nuts. The thirty nuts are locked by fifteen double tab-washers each of which locks two nuts. The tab-washer for the offset bolt is therefore shorter than the others and should be assembled first. Similarly, as this bolt is not used for the insulating-plate retaining plates, the retaining plates each side of the offset bolt should be assembled first.

25. *Mk. 3 only.* Ensure that the four stiffening segments are assembled under the bolt heads on the support cylinder flange and that the insulating-plate support ring is located under the nuts. Twelve of these nuts and bolts also secure the rear portions of the six nozzle-ring cooling pipes which should be refitted at this stage. Remove the slave bolts from the diaphragm inner flange and position the insulating plate in the insulating-plate support ring, rotating it sufficiently to engage the claws. Align the holes in the inner flange of the insulating plate with those in the diaphragm and assemble the packing plate to the flange, again aligning the holes. Refit the slave bolts.

Refitting

26. Assemble the lifting tackle T70252 by attaching the bridge pieces with two pairs of

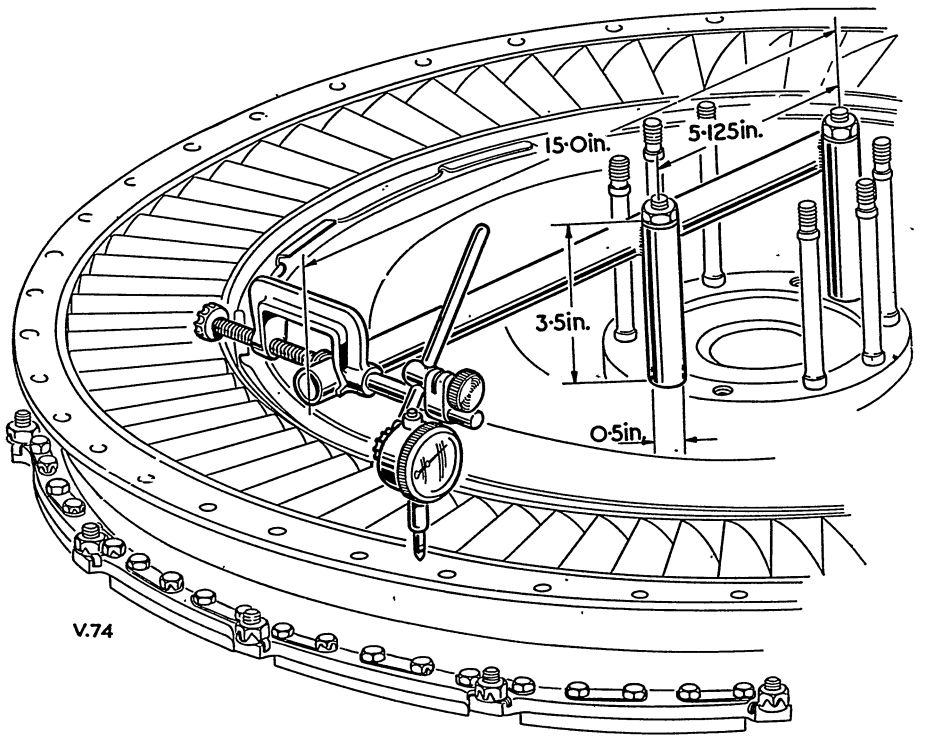


Fig. 5. Using locally-made tool to check the alignment of the nozzle ring assembly

Note . . .
When Mod. No. 398 is embodied the turbine disc securing bolts are shorter and, therefore, the two locating tubes should be 3·25 in. length.

bolts to the nozzle shroud flange and hoist the nozzle ring assembly into position over the engine. Remove the slave bolts from the diaphragm and insulating plate inner flange; align the holes in the flange with the offset holes in the rear bearing housing rear flange, and carefully lower the nozzle ring assembly on to the rear bearing housing flange. When the assembly is being lowered over the rear bearing, the rear bearing thermocouple lead (if fitted) must be threaded through the slot in the support cylinder.

27. Assemble two combustion chambers in diametrically opposite positions by sliding each into a nozzle junction pipe and bolting the front casing flange to the diffuser rear cover. Adjust the nozzle ring assembly to obtain freedom of the combustion chamber sealing rings. Apply anti-seize grease to the threads of the twenty-eight bolts, and secure the nozzle ring assembly to the rear bearing housing flange with the bolts and double tab-washers, using the special tab-washer for the offset holes. Tighten the bolts evenly to prevent distortion, but do not lock them. Remove the two combustion chambers. Apply anti-seize grease to the threads of the thirty-two bolts, and secure the support cylinder to the centre casing with the bolts and plain washers.

28. The alignment of the nozzle ring assembly must now be checked, for which purpose a tool similar to that shown being used in fig. 5 will be necessary. Assemble the tool to the hub shaft bolts and secure it with two nuts. Clamp a dial test indicator to the arm of the tool and locate the stylus on the rear flange of the nozzle shroud. Rotate the mainshaft and check the alignment which should be within 0·040 in. If the correct alignment is not obtained the support cylinder bolts must be slackened and the position of the nozzle ring assembly adjusted accordingly. The support cylinder bolts must be tightened before the alignment is checked again. When the alignment is satisfactory, remove the tool from the hub shaft.

29. Lower the turbine disc on to the hub shaft as described in Chapter 2, and secure it with two nuts; the nuts must be tightened sufficiently to locate the turbine disc on the hub shaft, but it is not necessary to torque-load them. Check with feeler gauges that the axial clearance between the edge of the inner nozzle ring and the leading edge of the turbine blades is within the limits of 0·25 to 0·35 in., measured at each of four positions.

30. Remove the two nuts which secure the turbine disc to the hub shaft, and lift off the turbine disc as described in Chapter 2. Check the tightness of the rear bearing housing flange bolts and bend up the locking tabs. Assemble the turbine disc to the hub shaft as described in Chapter 2.

31. Apply anti-seize grease to the threads of the forty-five bolts and assemble the turbine shroud, the lifting eye, and the two halves of the fireguard support ring to the nozzle shroud. Pre-mod. 987 one of the bolts was a dowel bolt and was a close fit in the shrouds and the lifting eye. Where Mod. No. 987 has been embodied, the dowel bolt is replaced by a standard bolt (Part No. N.8242) and the hole in the shroud flanges and in the lifting eye are opened out to $\frac{13}{32}$ inch. Where Mod. No. 987 has not been embodied, to facilitate assembly and to simplify adjustment of the turbine shroud/turbine blade tip clearance, it is permissible to open the hole in the turbine shroud only to a clearance size, retaining the original bolt.

32. If a new pre-mod. 987 turbine shroud is fitted, the undersize dowel-bolt hole in the turbine shroud should be opened up to a standard clearance hole.

33. Assemble a nozzle shroud strut to each of the sixteen nozzle shroud eyebolts with a shackle pin, and connect the lower end of each strut to the support cylinder with a shackle pin. Check the pins for freedom and if necessary adjust the shims fitted to the eyebolts to obtain this. Secure the shackle pins with split pins. *Mk. 3 only.* Screw in the gland nut and connect the two sections of each of the six nozzle ring cooling pipes; wire-lock the joints.

34. Refit the combustion chambers as described in Part 3, Sect. 3, Chap. 1.

Turbine shroud ring adjustment

35. If the turbine shroud has become distorted and the tip clearance cannot be obtained by adjustment as described in Part 3, Sect. 3, Chap. 1, an attempt should be made to restore circularity by the use of a cramp as shown in fig. 6. Ovality of the shroud may be corrected "in service" by slackening all but a few of the bolts fastening the turbine shroud to the nozzle shroud,

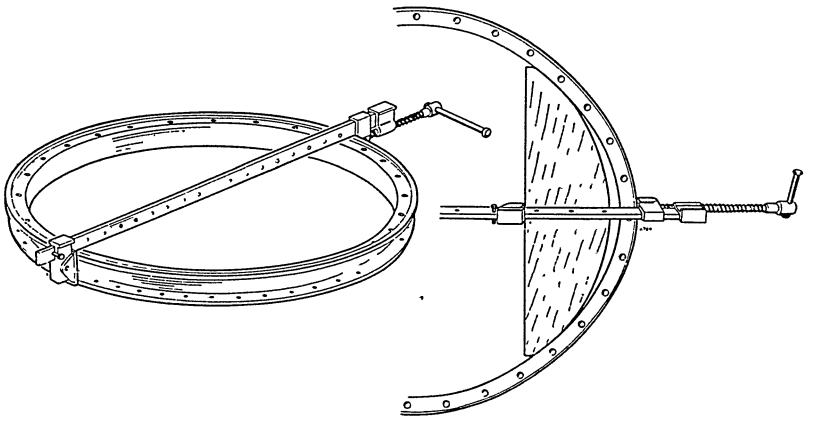


Fig. 6. Turbine shroud ring adjustment

tightening a cramp across the shroud until it is once more circular, and retightening the bolts. When the turbine shroud is removed from the engine the cramp may be used with a shaped block, as illustrated in fig. 6, to correct local distortion. Frequent dimensional checks should be carried out during this operation until it is considered that the maximum restoration has been effected. When assembling the trued turbine shroud to the nozzle shroud, a further turbine blade tip clearance check should be made before finally tightening the securing bolts. When satisfactory conditions have been attained, tighten the securing nuts and re-check the blade tip clearance to ensure that the turbine

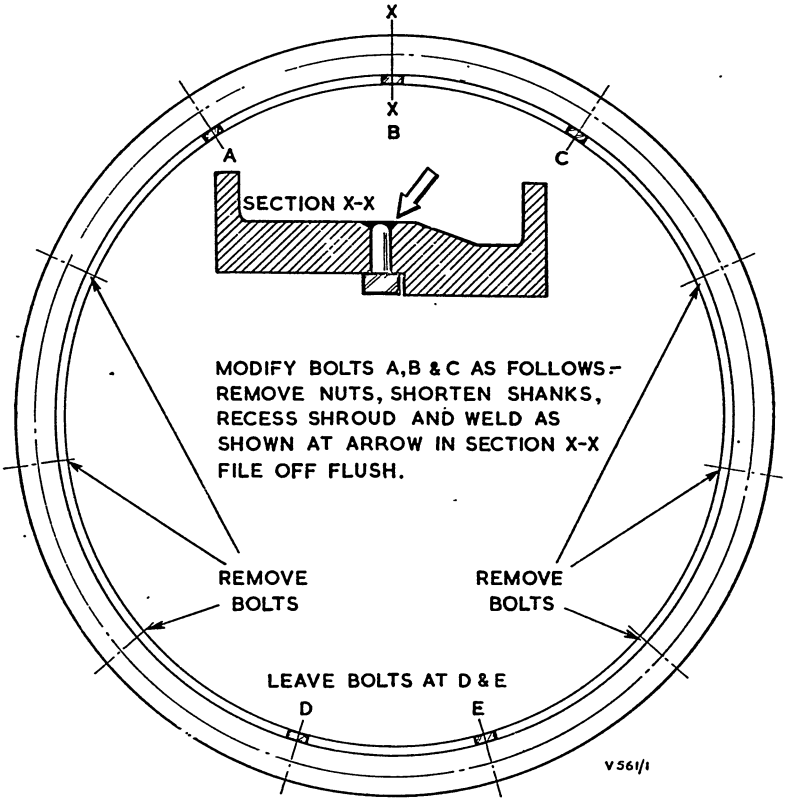


Fig. 7. Modification of a scrap nozzle shroud for use when fitting new nozzle blades

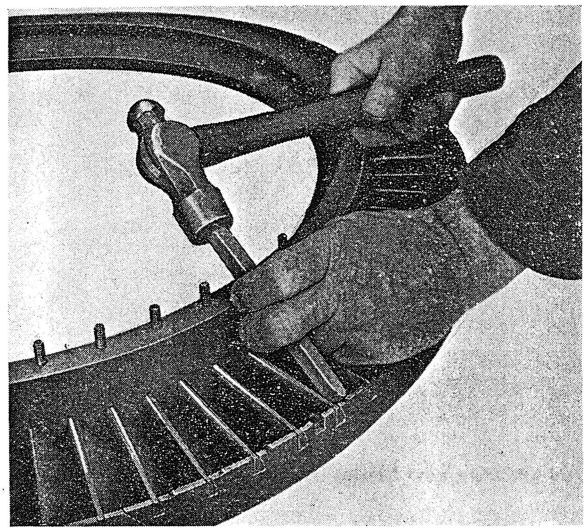


Fig. 8. Detaching a ring segment from the blade lugs

shroud has not been displaced during the tightening operation.

Changing damaged nozzle blades

36. Nozzle blades which have become damaged or bowed beyond the limits given in Part 3, Sect. 3, Chap. 1, may be replaced by new blades in accordance with these instructions. Individual blades, groups of blades, or a complete segment of seven blades may be replaced, although it has generally been found that only a group of three or four require replacing. Nozzle blades manufactured of different materials cannot be indiscriminately mixed in a nozzle ring assembly, because of the different rates of expansion. Where it is desired to mix blades of different materials in a nozzle ring assembly, it must be ensured that only blades of the same material are fitted in any one outer ring segment.

37. Scrap turbine and nozzle shrouds will be required, and the nozzle shroud must be modified as follows (*fig.* 7). Remove all but five of the nozzle shroud locating bolts from the shroud, leaving the five bolts at the positions shown in fig. 7. Remove the nuts from the bolts in the group of three indicated as A, B and C, and cut off the portions of shanks which protrude on the outside of the shroud. Recess the shroud and weld each bolt in position as indicated in Section X–X (*fig.* 7), finally filing flush with the outer surface of the shroud so that there is no obstruction to the metal dolly block when peening the new blades.

38. To remove damaged blades and fit replacements, the nozzle ring must be removed from the engine and the following procedure adopted. Using a wooden or light-alloy drift, carefully and progressively force the ring segment off the blade lugs, applying the drift to the side of the ring segment which locates on the nozzle shroud locating bolt, as indicated in fig. 8. With a metal block held hard up against the outer ends of the blades, and using a drill slightly smaller in diameter than that of the peened lugs on the inner end of the blades, drill off the heads of the lugs and punch out the blades (*fig.* 9).

39. Fit the new blades in position to the inner ring (*fig.* 10); the lugs will be an easy fit in the inner ring. Replace the ring segment over the blades; if necessary, file out the segment slots slightly to enable them to fit over the new blades. Tap the segment down until it fits flush with the blades and the rear of the outer ring. Fit the modified scrap nozzle shroud to the nozzle ring, using the middle bolt of the three welded locating bolts to locate the segment which contains the new blades (*fig.* 11); the opposite locating bolts will assist in aligning the assembly. Fit the scrap turbine shroud to the nozzle shroud, and before final tightening of the securing bolts fit two G-clamps, as shown in fig. 12, to hold the nozzle ring hard up against the nozzle shroud. With the metal dolly block held hard up against the nozzle shroud, peen the lugs of the new blades, using a suitable flat-headed punch, until, in appearance, they

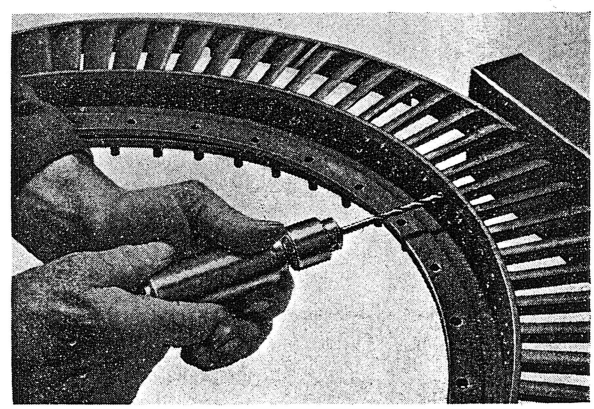


Fig. 9. Drilling off the heads of the blade pips
(A.L.78, June 56)

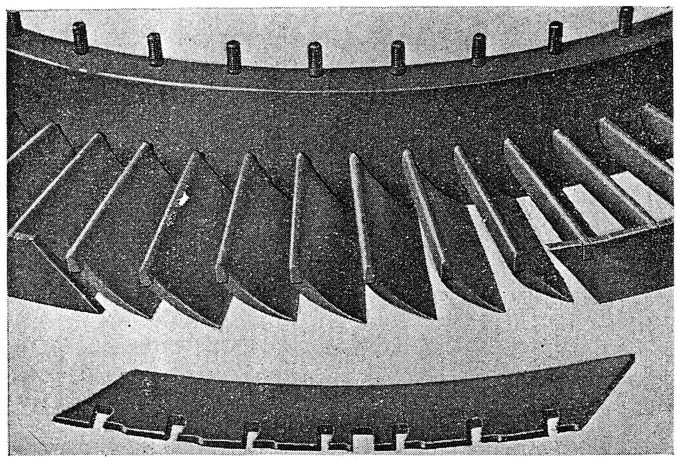
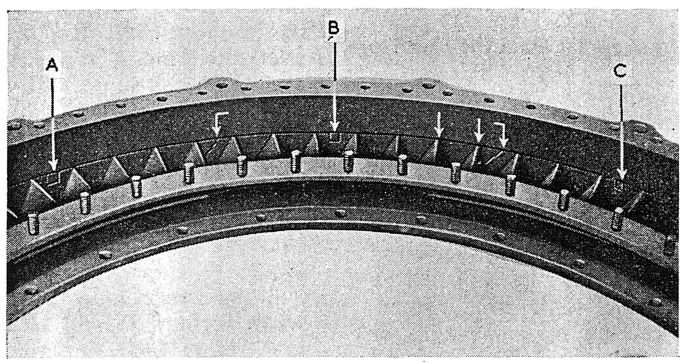


Fig. 10. Ring segment removed and two new blades fitted



Arrows indicate locating bolts A, B and C on scrap nozzle, and the segment and two new blades shown in fig. 9.

Fig. 11. Nozzle ring fitted to the scrap nozzle and turbine shrouds for peening the pips of the new blades

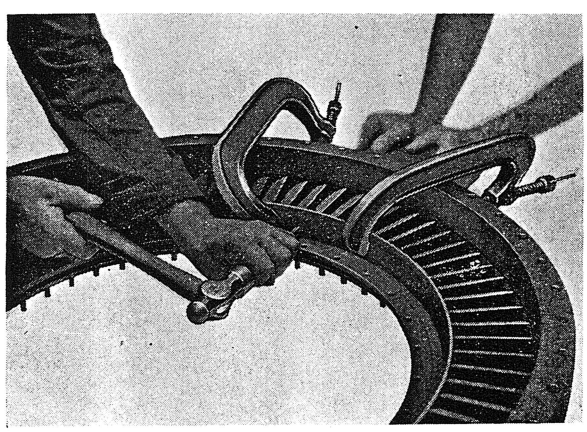


Fig. 12. Nozzle ring clamped to the shrouds by two G. clamps when peening the pips of new blades

closely resemble the peened lugs of the existing blades. On completion of satisfactory peening, remove the modified turbine and nozzle shrouds. It may be necessary to tighten the peening of the outer segment on to the blades; this must be done carefully to avoid cracking, and the segment must be supported.

40. If the lugs of the new blades project beyond the segment ring when the latter has been tightened, the excess metal must be filed off before the assembly is refitted to the engine. Similarly, if the trailing edges of the tips of the blades project beyond the segment ring, metal must be filed off until they conform to the line of the existing blades, so that the new blades do not become jammed under the turbine shroud and cause distortion when the latter is fitted.

List of tools and consumable parts

41. Table 1 lists the consumable parts and Table 2 the tools which are required to change the complete nozzle ring assembly. The actual tools and spare items which will be needed will depend upon the particular component being replaced.

TABLE 1

List of consumable parts

Ref. No.	Part No.	Description	Qty.
36KK/4938	N.1458	Washer-tab, junction pipe nuts	24
36KK/390	N.1603	Washer-tab, rear end diaphragm bolt	24
36KK/5030	N.2967	Washer-tab, support cylinder (Mk. 3 only)	36
36KK/4531	N.3730	Washer-tab, support cylinder (Mk. 2 only)	14
36KK/4532	N.3733	Washer-tab, support cylinder (Mk. 2 only)	1
36KK/4530	N.3732	Washer-tab, support cylinder (Mk. 2 only)	30
36KK/4861	N.3771	Washer-tab, turbine disc nuts (Mod. No. 398)	2
36KK/4860	N.3769	Washer-tab, turbine disc nuts (Mod. No. 398)	2
36KK/5138	N.4507	Washer-tab, turbine disc nuts (required in lieu of N.3769 when Mod. No. 704 is embodied)	2
—	N.1601	Washer-tab, turbine disc nuts (pre-Mod. No. 398)	4
36KK/386	N.1588	Washer-tab, bearing housing flange bolt	1
36KK/384	N.1587	Washer-tab, bearing housing flange bolt	13
36KK/5029	24054	Joint washer, flexible connection pipes to inner nozzle ring (Mk. 3 only)	6
28P/5032	A.G.S.784–3	Pin, split, nozzle shroud locating bolt	11
28P/5037	A.G.S.784–10	Pin, split, nozzle shroud strut shackle pin	32
36KK/371	N.3224	Stud (A.S.509) nozzle blade assembly	48
28M/7674	A16Z–EC	Nut, castle, nozzle shroud bolts	11
36KK/4619	24195	Bolt, nozzle shroud	11
36KK/125	15302	Gasket, diffuser casing combustion chamber	16
36KK/814	20099	Gasket, burner (Mk. 2)	32
36KK/5037	22709	Gasket, burner (Mk. 3)	32

TABLE 2

List of tools

Stores Ref. No.	Tool No.	Description
64KK/655	T70988	Nozzle ring stud peening tool
64KK/566	T70989	Nozzle ring stud peening fixture
64KK/784	T70252	Nozzle assembly lifting tackle
64KK/780	T70186	Lifting eye (Pre-Mod. 398)
64KK/966	T74332	Lifting eye (Mod. No. 398)
IL/156		Torque spanner 5 to 50 lb./ft.

(A.L. 78, July, 56)

P26210 136789/6942 8/56 1500 C & P Gp. 1

ADMIRALTY
AIR MINISTRY

GOBLIN Mk. 2 & 3 AERO-ENGINES

This is Amendment List No. 35 to Air Publication 4121B & C, Volume 2, Parts 3 and 4

Part 4, Section 2. List of Chapters: *Delete* "*(To be issued later)*" after the titles of Chapters 4 and 5 and *write* "(A.L.35)" in the outer margin against each deletion. *Insert* these Chapters 4 and 5 to follow Chapter 3. *Record* the incorporation of this A.L. in the Amendment Record Sheet.

ENGINEER

Chapter 4

COMBUSTION CHAMBERS

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

LIST OF CONTENTS

	Para.		Para.
General	1	*Rectification leaflets*	3

General

1. This chapter contains leaflets detailing the method of carrying out rectification of combustion chamber components which have been rejected as being outside the permissible acceptance standard.

2. Instructions for dismantling, examining, and reassembling the combustion chambers are contained in Part 3, Section 3.

Rectification leaflets

3. These leaflets will be issued as they become available and are prepared from Turbine Repair Schemes used by the engine manufacturer. To enable each leaflet to be identified with its relevant repair scheme, the T.R. (Turbine Repair) number and the issue number of the scheme from which the leaflet was prepared, are retained as part of the leaflet reference.

INDEX OF LEAFLETS

SPECIAL NOTE

The Turbine Repair Schemes listed in this index are limited to those for which tools and equipment will normally be available "in the field". Further approved schemes in respect of the combustion system are contained in Vol.6, Part 2, but their applicability is precluded by the requirement for argon arc or electric welding and other process considerations.

Leaflet Ref. No.	Title
F.1 (TR 34)	Scheme ~~for reforming~~ TO RECTIFY WORN locating pips A.L.54
F.3 (TR 170)	Scheme to weld cracks under the flange of the interconnecting stub
F.4 (TR 105)	Scheme to repair rear section cracks
F.6 (TR 506)	Welding repair of cracks in vicinity of locating pin sleeve ~~and~~ dilution ports, & AIR HOLES A.L.54
B.1	Cleaning prior to examination and repair by welding
B.2	Oxy-acetylene process

FLAME TUBE, COMBUSTION CHAMBER

Scheme to rectify worn locating pips

1. Provided that the flame tube locating pip dimensions are satisfactory at the commencement of the flame tube life, and that the correct clearance exists between the flame tube and the outer casing joint ring, the pips may be expected to endure approximately 150 hours running before rectification is required. Wear at the rear end of the combustion chamber outer casing, caused by indentation of the joint ring, is also rectified by forming new pips in the flame tube, re-positioned to bear on fresh locations in the outer casing, between the indentations worn by the original pips.

2. This scheme consists of five separate, but basically identical, stages of repair, each stage being normally applied at consecutive servicing periods when the flame tube is removed from the engine for examination.

3. To ensure that the maximum life is obtained from the flame tube, the five stages of repair given below should preferably be applied in the order given.

TR 34/1 - Reform the original pips

TR 34/2 - Form pips at new locations in accordance with the dimensions given in fig.1

TR 34/3 - Reform the pips previously formed by the application of TR 34/2

TR 34/4 - Form pips at new locations in accordance with the dimensions given in fig.1

TR 34/5 - Reform the pips previously formed by the application of TR 34/4

4. The material of pips that are to be reformed should not be badly fretted and must not be less than 0.025 in. thick.

5. Under no circumstances may a pip be formed on the longitudinal seam.

6. Formed or reformed pips must be free from sharp edges along the boundaries of the formed portion.

7. The repair consists of either reforming the existing pips, or, alternatively, removing the worn pips by hammering, and forming new pips at fresh positions.

8. This scheme may be applied to combustion chamber flame tubes Part No. 23022, 23023, 70337, 70359, 76692 and 76693.

9. No new parts are required.

10. Before commencing this repair, check by reference to the marking etched adjacent to the part number, i.e., TR 34/1, /2, /3, /4 or /5, which stage of repair was last applied to the flame tube, then proceed to carry out the next stage in accordance with the appropriate instructions detailed below.

11. TR 34/1

(1) Check that the material is free from excessive fretting and that the thickness of each pip is not less than 0.025 in.
(2) Position the flame tube on the pip-forming tool T74245 as shown in fig.1, carefully locate the first pip in position and then strike the forming punch with a heavy hammer; repeat this operation to the remaining pips.
(3) Using ring gauge T70452, check the diameter over the pips.

12. TR 34/2

(1) Support the flame tube on form block T70802, which should be bolted to a stout bench, or on a bar which is slightly smaller in diameter than the internal diameter of the flame tube; remove the worn pips by hammering.
(2) Using ring gauge T70451, check the diameter and circularity of the flame tube.
(3) Position the flame tube on pip-forming tool T74245 so that the first new pip will be formed approximately one third of the distance between the two original pips, on either side of the seam, but not on the seam, as shown in fig.1.
(4) Using a heavy hammer, strike the forming punch so that a new pip is formed on the flame tube between the punch and the forming die of the tool.
(5) Rotate the flame tube until the new pip is opposite the index mark (arrow marked 60 deg.) on the tool.
(6) Repeat Op.4 and 5 until six new pips have been formed.
(7) Using ring gauge T70452, check the diameter over the new pips.

13. TR 34/3

(1) Repeat the operations described in para.11, on the existing pips formed during the application of TR 34/2.

14. TR 34/4
(1) Repeat the operations described in para.12, forming each new pip in the centre of the larger space between the old pips.

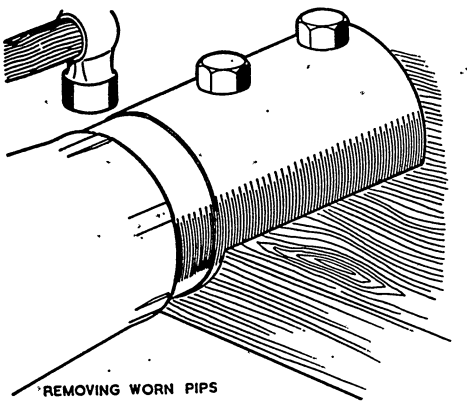
15. TR 34/5
(1) Repeat the operations described in para.11 on the existing pips formed during the application of TR 34/4.

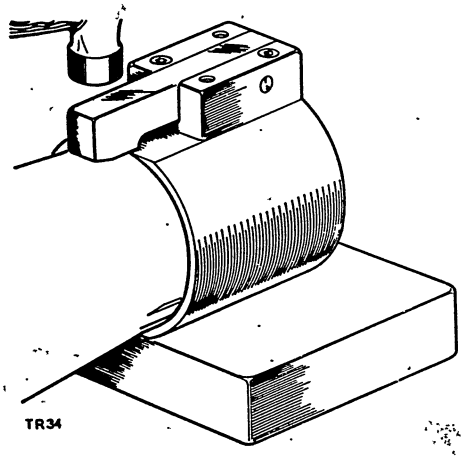
16. Lightly etch TR 34/1, /2, /3, /4, or /5, as appropriate, adjacent to the existing part number or previous repair number.

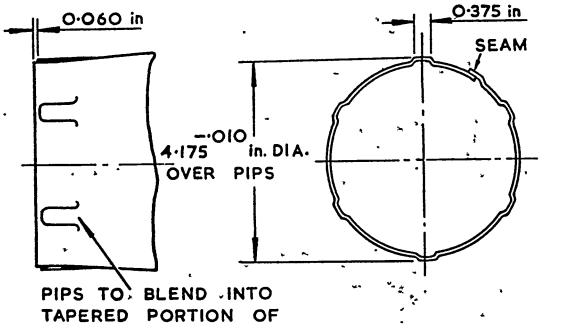
17. The following tools are required to carry out this scheme.

Description	Part No.	No. off
Ring gauge	T70451	1
Form block	T70802	1
Pip-forming tool	T74245	1
Ring gauge	T70452	1

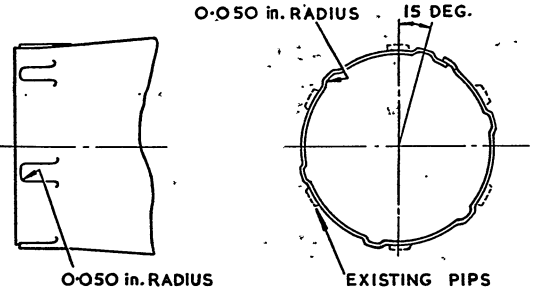
Fig. 1 overleaf



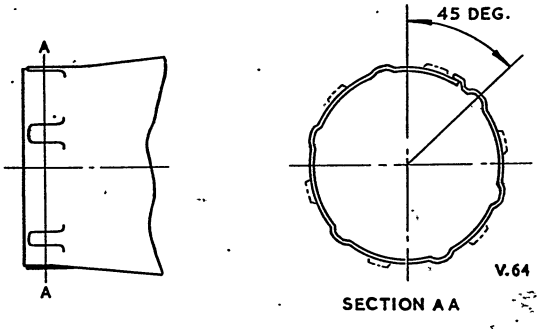




TR 34/1 RE-FORM OF ORIGINAL PIPS



TR 34/2 FORMING OF PIPS IN NEW POSITION.
TR 34/3 RE-FORM OF THESE PIPS
(SEE FIRST REPAIR)



TR 34/4. FORMING OF PIPS IN SECOND NEW POSITION
TR 34/5 RE FORM OF THESE PIPS
(SEE FIRST REPAIR)

Fig.1 Reforming locating pips

LEAFLET F.3 (TR 170 Issue 3)

FLAME TUBE, COMBUSTION CHAMBER

Scheme to weld cracks under the flange of the interconnecting stub

1. Cracks that occur around the flame tube lip, under the interconnecting flange as shown in fig.1, can be repaired by oxy-acetylene welding. This scheme can be applied to flame tubes Part No.21666, 21678, 23022, 23023, 70337, 70359, 76692 and 76693, where the length of the crack does not exceed 0.500 in. The maximum permissible number of cracks per hole permitted to be repaired is six. If the number of cracks exceed this allowance the flame tube must be rejected.

2. Flame tubes which have been repaired under this scheme can be identified by "TR 170" etched adjacent to the part number. No new parts are required.

3. To carry out this repair proceed as follows:-

(1) Remove the carbon deposit by the cleaning process described in the leaflet entitled "Cleaning prior to examination and repair by welding", contained in this chapter.
(2) Immerse the flame tube in the acid pickling solution described in the same leaflet to remove the products of corrosion.
(3) Using a junior hack saw blade, saw down the crack.
(4) Clean up both sides of the slot with a rotary wire brush.
(5) Build up the slot with oxy-acetylene welding on the inside, using filler rod NC 82 (H. Wiggin & Co.) and a boron free flux (i.e., not containing borax, or boric acid).
(6) Remove any excess weld to bring the hole back to shape, especially the ridge that may have formed on the flame tube lip in the interconnecting hole.
(7) To remove surplus flux, pickle the flame tube in the acid solution referred to in Op.2.
(8) Lightly etch the marking "TR 170" adjacent to the existing part number.

Fig.1 overleaf.

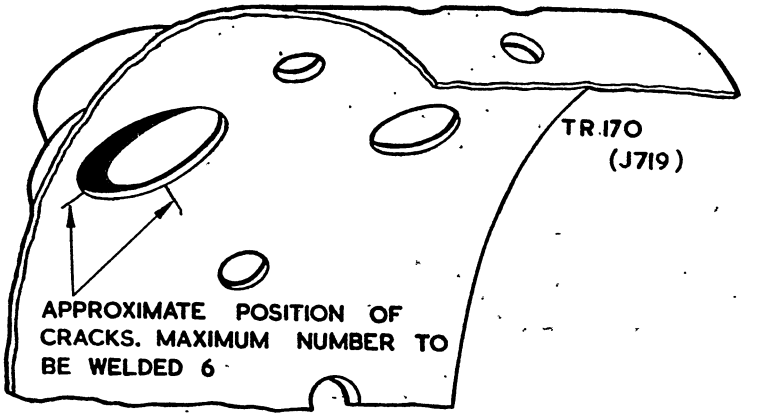


Fig.1. Example of cracks around the flame tube lip under the interconnecting flange

FLAME TUBE, COMBUSTION CHAMBER

Scheme to repair rear section cracks

1. Cracks that occur in the rear section of the flame tube as indicated in fig.1, can be repaired by argon arc welding; if this equipment is not available oxy-acetylene welding may be used. This scheme can be applied to flame tubes Part No.70337, 70359, 21666, 21678, 23022 and 23023, where the crack does not exceed 2.0 in. in length. If the crack exceeds this allowance the flame tube must be rejected.

2. Flame tubes which have been repaired under this scheme can be identified by "TR 105" etched adjacent to the part number. No new parts are required.

3. To carry out this repair proceed as follows:-

(1) Remove the carbon deposit by the initial cleaning process described in the leaflet entitled "Cleaning prior to examination and repair by welding", contained in this chapter.

(2) Immerse the flame tube in the acid pickling solution described in the same leaflet to remove the products of corrosion.

(3) Clean by wire brushing, in and around the crack, sufficiently to expose bright metal.

(4) Weld up the crack by the argon arc process, using filler rod NC 82 (H. Wiggin & Co.). The same filler rod with a boron free flux (i.e., not containing borax, or boric acid) should be used in the case of oxy-acetylene welding.

(5) To remove surplus flux when oxy-acetylene welding is used, pickle the flame tube in the acid solution referred to in Op.2.

(6) On completion of welding, check that the clearance between the pips and the flame tube's rear outer casing, falls within the permitted tolerance.

(7) Lightly etch the marking "TR 105" adjacent to the existing part number.

Fig.1 overleaf.

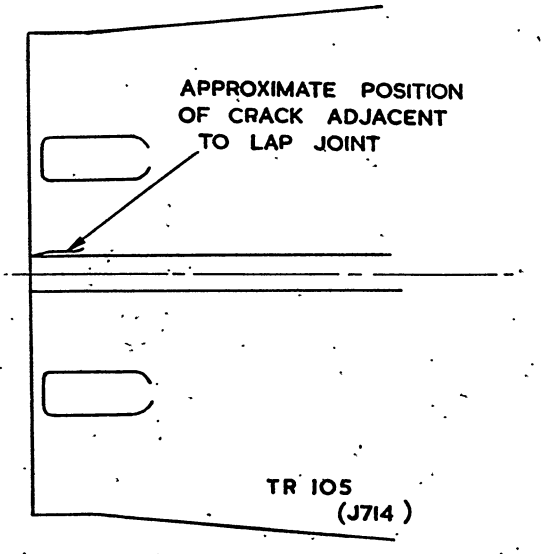


Fig.1. Example of crack in rear section of flame tube

FLAME TUBE, COMBUSTION CHAMBER

Welding repair of cracks in vicinity of locating pin sleeve ~~and~~ dilution ports, AIR HOLES

Note.- See Section Index for engine Marks affected.

1. Cracks that occur in the flame tube at points marked A, B, C, D and E in fig.1, may be repaired by argon arc or oxy-acetylene welding. Fig.2 to 11 inclusive illustrate typical cracks before and after rectification. This scheme can be applied to flame tubes Part No.23022, 23023, 70337, 70359, 76692 and 76693. Cracks at the points specified must not exceed the following limits:

A. 1.250 in. length

B. 1.250 in. length

C. 0.375 in. length

D. 0.500 in. length

E. 0.375 in. length

2. Flame tubes which have been repaired by this scheme can be identified by "TR 506" etched adjacent to the part number. No new parts are required.

3. Prior to welding cracks, the flame tube must be positioned on a suitably shaped anvil and the distortion which normally occurs in the area of the locating pin sleeve, removed by tapping with a wooden mallet.

4. If any of the three locating pin sleeves are elongated beyond the permissible limit the application of TR 96 (fitting a new locating pin sleeve) must also be carried out prior to welding cracks at A and B in fig.1. One of the initial operations of TR 96 consists of blanking out the defective locating pin sleeve and the operation will, in certain cases, completely or partially, remove the smaller cracks at this point.

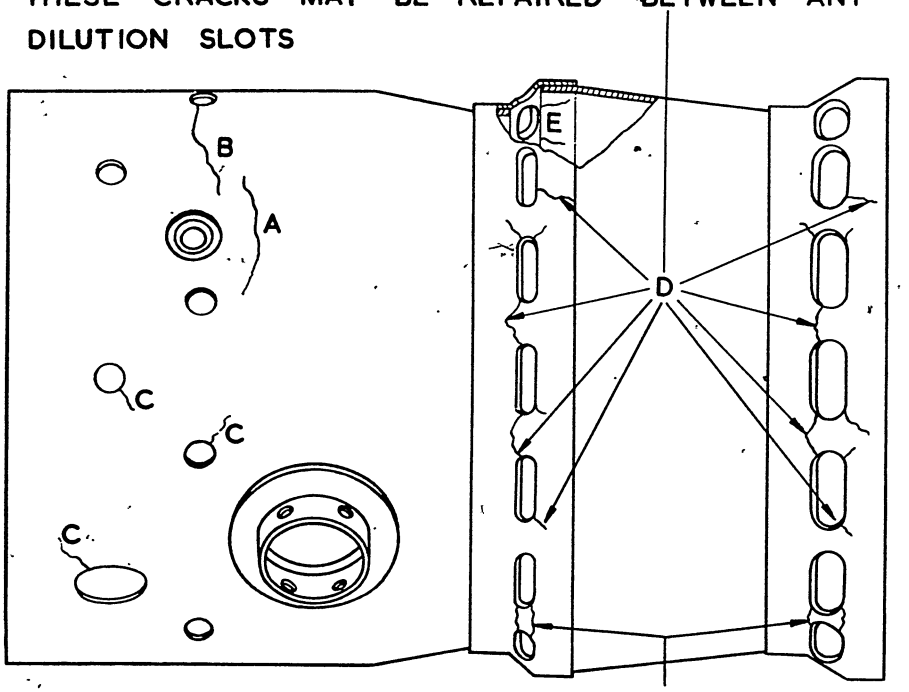


Fig.1. Permissible repair of cracks in flame tube

5. Use filler rod NC 82 (H. Wiggin & Co.) with either welding process and a flux which does not contain boron compounds (i.e., borax or boric acid) with oxy-acetylene welding.

6. To carry out this repair proceed as follows:-

(1) Remove the carbon deposit in accordance with the initial cleaning process described in the leaflet entitled, "Cleaning prior to examination and repair by welding", contained in this chapter.

(2) Remove any local distortion as described in para.3.

(3) Carry out the acid pickling process described in the leaflet referred to in sub-para.1, to remove the products of corrosion.

(4) Clean by wire brushing, in and around all cracks and on both sides if possible, sufficiently to expose bright metal.

Note.- It is not permissible to dress the weld by filing or grinding, except when specified, therefore, care must be taken when welding cracks in the vicinity of the locating pin sleeve to ensure that excess filler rod is not deposited in this area, otherwise fouling may occur during assembly of the scoop and colander and the flame tube.

(5) To prevent a crack at A in fig.1 from extending during welding, drill a 1/16 in. dia. hole right through one end. Commencing approximately $\frac{1}{4}$ in. before the opposite end, weld towards and just over the drilled end of the crack.

(6) Drill a 1/16 in. dia. hole at the end of a crack originating on the periphery of an air hole, similar to B and C in fig.1, and if the shape permits, cut into the crack with a junior hack-saw blade.

(7) Commencing just before the drilled hole, and working towards the air hole periphery, weld the crack.

(8) Using the same drill, lightly countersink at intervals, a crack similar to any of those at D in fig.1, sufficiently to remove the original outline of the crack. Commencing just before the end of the crack, and working towards the open end on the periphery of the dilution slot, weld the crack.

(9) Cracks at E in fig.1 can only be seen from inside the flame tube; if possible, they should be prepared for welding as described in sub-para.8, if this is impracticable, use a small file to groove the crack sufficiently to ensure efficient penetration of filler rod.

(10) On completion of welding, use a smooth round file to restore the shape, and radius the periphery of all air holes and dilution slots affected; finish with smooth emery cloth.

Note.- Blending a finished weld either by filing or grinding, is not permissible except at the locations specified above; but to facilitate inspection of the repair it may be cleaned by wire brushing.

(11) If oxy-acetylene welding has been used, pickle the flame tube in the acid solution referred to in sub-para.3, to remove surplus flux.

(12) To minimise the risk of the cracks recurring in the region of the weld repair, if facilities are available, the flame tube should be normalised by heating for 10 minutes in a high temperature furnace at 1.050 deg.C, followed by cooling in air at room temperature.

(13) Lightly etch TR 506 adjacent to the existing part number.

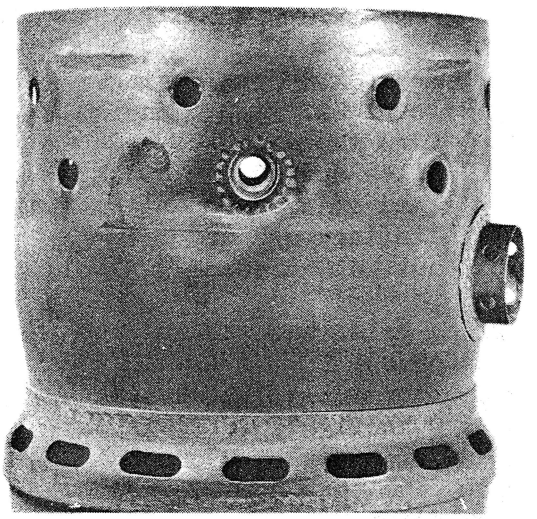


Fig.2. Typical crack and distortion in area of locating pin sleeve.

Fig.4. Crack shown in fig.2 welded by argon-arc process.

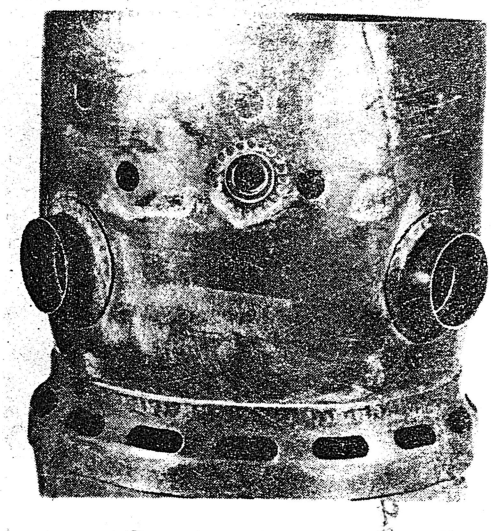


Fig.3 Typical crack and distortion in area of locating pin sleeve

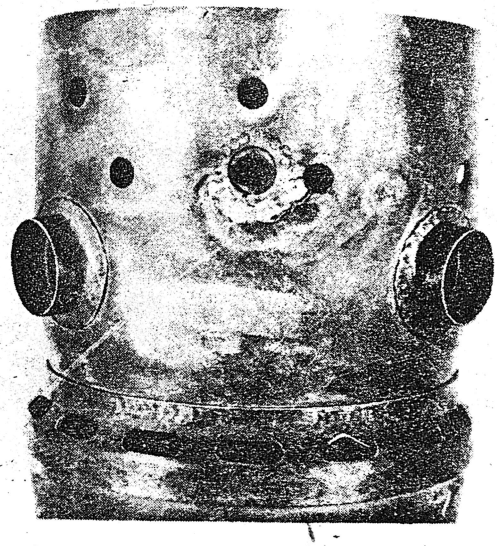


Fig.5 Crack shown in fig.3 welded by oxy-acetylene process

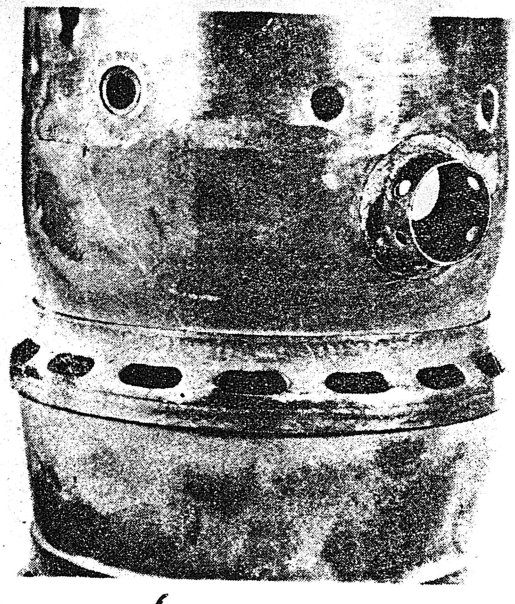


Fig.6 Typical cracks originating from the dilution ports

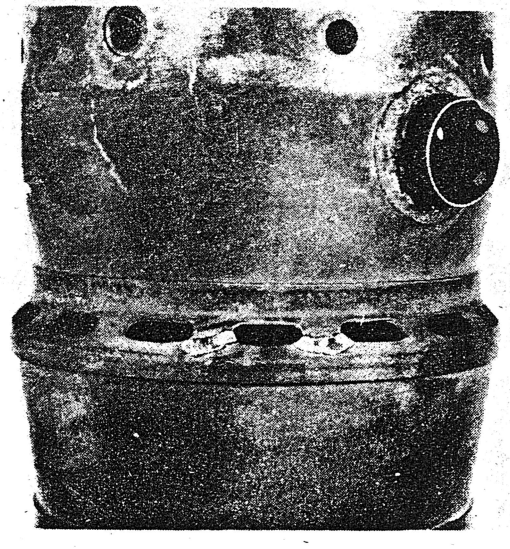


Fig.8 Cracks shown in fig.6 welded by argon-arc process

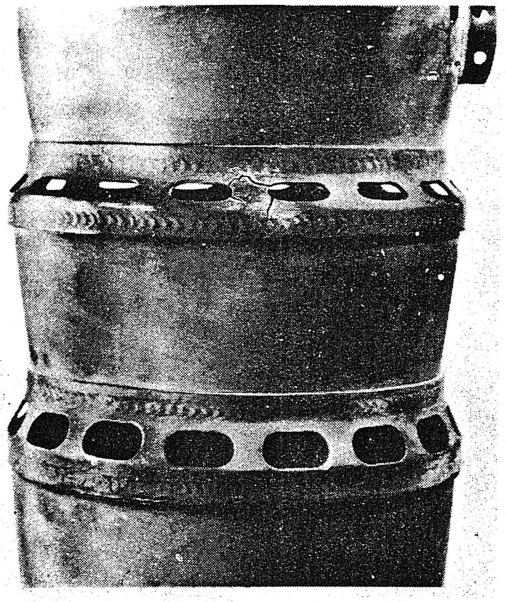


Fig. 7. Typical cracks originating from the dilution ports

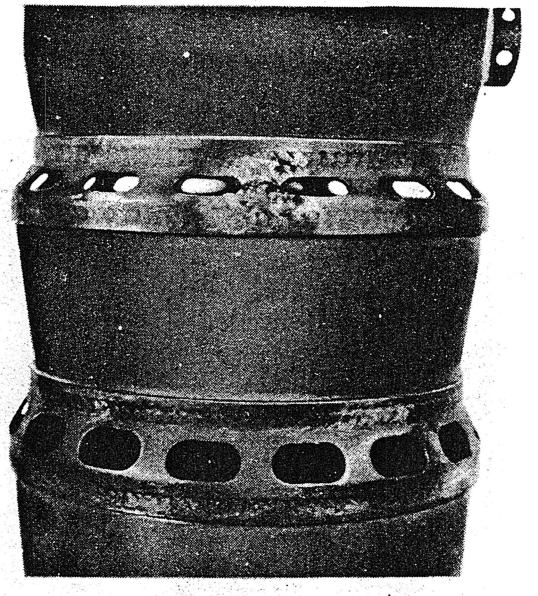


Fig. 9. Cracks shown in fig. 7 welded by oxy-acetylene process

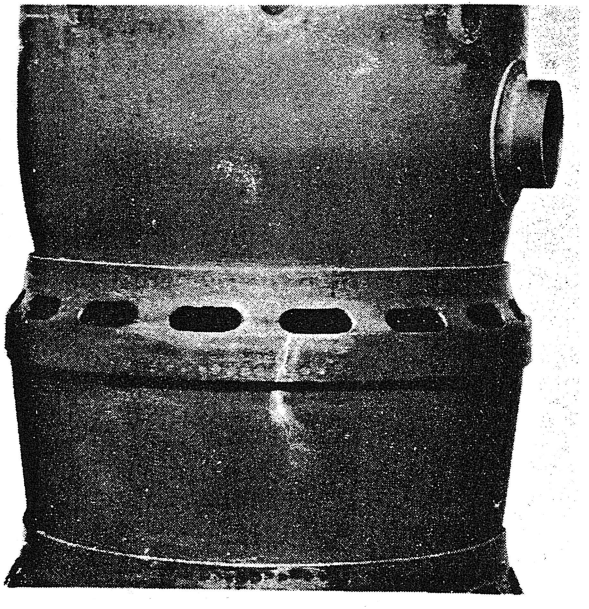


Fig. 10. Typical crack originating from the dilution ports and extending beyond the window piece

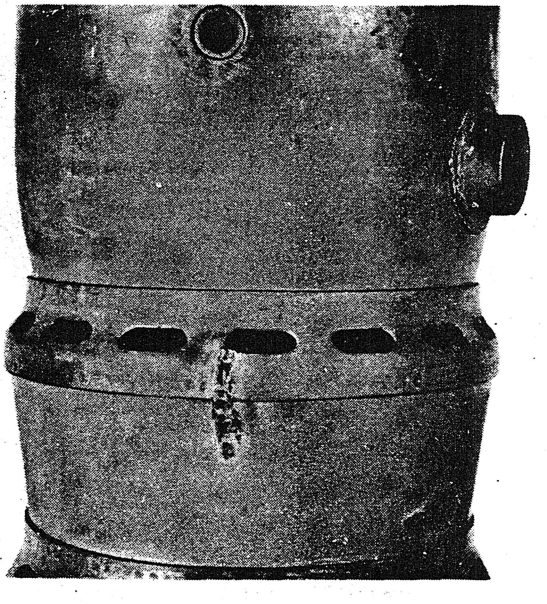


Fig. 11. Crack shown in fig. 10 welded by oxy-acetylene process

LEAFLET B.1

FLAME TUBE, COMBUSTION CHAMBER

Cleaning prior to examination and repair by welding

1. The normal method of removing carbon deposit prior to examination, is to heat the flame tube for twenty to thirty minutes in an air circulating constant temperature furnace at 550 deg.C., or alternatively, by steeping the component for about 1½ hours at 70 deg.C. in a solution of 7 per cent. caustic soda, 0·1 - 0·5 per cent. liquid soap, and water to 100 per cent. Where however doubt exists with regard to the extent of poorly defined or suspected defects, the additional acid pickling process described below, must be applied to the flame tube. This process is also an essential treatment for flame tubes that are to be rectified by welding, as the corrosive products on the surface of the flame tube, especially in the edges of any cracks or in the vicinity of weld failure, will have an embrittling effect on a finished weld.

ACID PICKLING

APPARATUS

2. A lead-lined tank fitted with lead steam coils is required and fume extraction is necessary. The heating should preferably be thermostatically controlled and a temperature recording gauge provided. Rinsing and scouring facilities are also required.

COMPOSITION OF SOLUTION

3. The pickling solution should be maintained at a temperature of 75 ± 5 deg.C. and consist of hydrofluouric acid (technical, 50-55 W/V) and ferric sulphate solution (14-16% Iron) in the following proportions:-

Hydrofluouric acid	8 Per cent
Ferric Sulphate	27 Per cent
Tapwater	65 Per cent

METHOD OF PROCESSING

4. Ensure that the flame tube is free from all traces of grease and paint then immerse the component in the solution for approximately 1½ to 2 hours. A clean silvery surface should be obtained by light swabbing or brushing.

AFTER TREATMENT

5. After removal from the pickling solution, the flame tube should be drained, rinsed in cold water and washed or lightly scoured to loosen any smut. It should then be rinsed clean and dried.

DEFECTS IN WORKING

6. The correctly constituted pickling solution will produce a smooth silvery surface. The appearance of a uniform reddish-brown layer on the flame tube after pickling, or the presence of slight etching, is an indication of unbalance or exhaustion of the solution. The reddish-brown layer is not detrimental, and is readily removed by swabbing.

7. Immediately prior to repair of a flame tube by welding, it is imperative that clean, bright parent metal is exposed over an area extending 2 to 3 in. from the proposed line of welding and on the inner and outer surface. This can be obtained by the use of a rotary wire brush or light smooth file, depending on the accessibility of the damaged area. Where fusion welding is to be applied, the use of a fine wheel, disc grinder or emery cloth is not advisable as the minute particles of abrasive compound tend to adhere to the parent metal, even after thorough cleaning. Sub-surface porosity with subsequent weld decay will probably result.

REPAIR OF COMPONENTS BY WELDING

Oxy-acetylene process

1. Repair of components by oxy-acetylene welding is not permissible unless it is approved by the relevant Turbine Repair Leaflet. Experience has shown that when applied to the repair of components having cracks which exceed a specific length, shrinkage and distortion of the material will occur. Only the filler rod specified and a vigorous boron free flux may be used. Flux containing boron compounds (i.e., borax, boric acid) is not permitted, owing to the adverse affect on the finished weld and the liability for cracks to develop.

2. During welding, weaving or puddling is to be avoided, as agitation of the molten metal either by manipulation of the blowpipe or by stirring with the filler rod results in two undesirable effects.

(1) Deoxidizers which are present in small quantities in the parent metal become burnt out and their removal leaves the metal in a brittle and unsound condition.

(2) Agitation of the molten pool will produce porosity in the weld caused by gas pockets forming when the metal solidifies.

3. The appearance of the finished weld should be smooth and not rough or burnt and with no evidence of porosity or undercutting. After all traces of flux residue have been removed, the weld may be cleaned by wire brushing but not dressed by grinding unless specifically stated in the relevant repair leaflet.

Chapter 5

EXHAUST SYSTEM

(This chapter supersedes that issued with A.L. No. 35)

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

LIST OF CONTENTS

	Para.		Para.
General	1	*Propelling nozzles*	4
Rectification leaflets	3		

General

1. This chapter contains leaflets detailing the method of carrying out rectification of exhaust system components which have been rejected as being outside the permissible acceptance standard.

2. Instructions for dismantling, examining, and reassembling the exhaust system components are contained in Part 3, Section 3.

Rectification leaflets

3. These leaflets will be issued as they become available and are prepared from Turbine Repair Schemes used by the engine manufacturer. To enable each leaflet to be identified with its relevant repair scheme, the T.R. (Turbine Repair) number and the issue number of the scheme from which the leaflet was prepared, are retained as part of the leaflet reference.

Propelling nozzles

4. The size of propelling nozzle fitted is decided while the engine is being bench tested, the larger, alternative nozzles being selected to correct excessive jet pipe temperature. A different size of propelling nozzle must not be fitted to engines in service, except as a result of subsequent bench testing. Where Mod. 938 is embodied, when the engine is tested, the size of the nozzle and the radial position and number of trimming strips required to give the specified performance are recorded in the engine log book. If an adjustable propelling nozzle is changed in the field, the exact position may be disregarded provided that the correct number of trimming strips are fitted in a propelling nozzle of the correct diameter. If an adjustable nozzle is not available and it is necessary to fit a fixed nozzle, or if an engine previously fitted with a fixed nozzle is to be fitted with an adjustable nozzle, reference should be made to the table which shows the equivalent fixed nozzle sizes in relation to the number of trimming strips removed.

Number of trimming strip segments in position	Equivalent fixed nozzle diameter
No equivalent adjustable nozzle	16 in. 16⅛ in. 16¼ in.
8	16⅜ in.
4	16½ in.
Nil	16⅝ in.

5. Each detachable trimming strip takes the form of a segment one eighth of the circumference of the propelling nozzle in length, and is secured by four 2 B.A. counter-

(A.L. 67, July, 54)

sunk socket screws, plain washers, and plain nuts, the screws being fitted so that the heads are inside the propelling nozzle. Each trimming strip must be fitted so that its radiused edge faces the front of the engine. After calibration on a test bench, or after adjusting a replacement nozzle to match the original nozzle in the field, the screws should be locked by peening. Where all eight trimming strips are not fitted, the redundant screw holes should be blanked off by fitting blanking screw AGS.967/14.

6. By observing the modification numbers etched on the nozzle modification plate, or from the nozzle Part No., the size of the propelling nozzle fitted to an engine can be determined from the table which follows.

PROPELLING NOZZLE ASSEMBLIES

Part No.	Standard	Dia. inches
	Goblin Mk. 2	
20884	Pre-Mod. 396	16
72656	Mod. No. 396	16
72907	,, 628 & 860	16
77372	,, 936	$16\frac{1}{8}$
71538	,, 936 PT. 2	$16\frac{1}{8}$
	Goblin Mk. 3	
72676	Basic	$16\frac{1}{2}$
74324	Mod. No. 820	$16\frac{3}{8}$
74509 } Alternatives	,, 628 & 860	$16\frac{3}{8}$
74500 }	,, 851 & 860	$16\frac{1}{2}$
77984	,, 938	Adjustable

Note . . .

There is no change to the above Part numbers when Mod. 860 *is embodied. Although alternative propelling nozzle sizes are quoted, on no account must an alternative size be fitted different to the nozzle installed.*

INDEX OF LEAFLETS

SPECIAL NOTE

The Turbine Repair Schemes listed in this index are limited to those for which tools and equipment will normally be available "in the field". Further approved schemes in respect of the exhaust system are contained in Vol.6, Part 2, but their applicability is precluded by the requirement for argon arc or electric welding and other process considerations.

Leaflet Ref. No.	Title
G.9 (TR 174)	Scheme to repair a cracked heater muff
G.10 (TR 171)	Scheme to replace a damaged flange and sole plate
G.12 (TR 168)	Scheme to repair cracked fairings
G.14 (TR 48)	Scheme to rectify damaged or stripped $\frac{1}{4}$ in. B.S.F. threaded holes in the heater muff flange
G.15 (TR 173 part)	Scheme to repair a cracked heater muff

LEAFLET G.9 (TR 174 issue 2)

FRONT OUTER CONE, TAIL PIPE

Scheme to repair a cracked heater muff

1. A cracked heater muff situated on the front outer cone, can be rectified by welding a suitably sized patch over the crack with argon arc or any other approved fusion welding process.

2. This scheme can be applied to outer cone Part No.23629 where the crack does not exceed 5.00 in. length. If the crack exceeds this allowance the outer cone is to be rejected.

3. Outer cones which have been repaired under this scheme can be identified by 'TR 174' etched adjacent to the Part No.

4. Material required to form the patch plate will be D.T.D.171B No.24 S.W.G. (0.022 in.).

5. To carry out this repair proceed as follows:-

(1) Open out the crack so that the length of the cut out is the same as the length of the crack and the width is equal to half the length of the crack. Radius the corners of the cut out to 0.250 in.

(2) Cut out a patch from D.T.D.171B, the size to be such, that when in position on the heater muff, the patch will overlap 0.500 in. all round the edge of the cut out. Fig.1 shows the maximum permissible size patch that can be fitted.

(3) Remove any oil or grease from the welding area and clean, by wire brushing, the two surfaces to be welded.

(4) Fit the patch plate over the heater muff and weld in position by argon arc or any other approved fusion welding process, using filler rod D.T.D.549 or D.T.D.571. An applicable flux will be required if argon arc welding is not used and cleaning to remove flux after welding will be necessary.

(5) Lightly etch TR 174 adjacent to the existing Part No.

(Fig.1 appears overleaf)

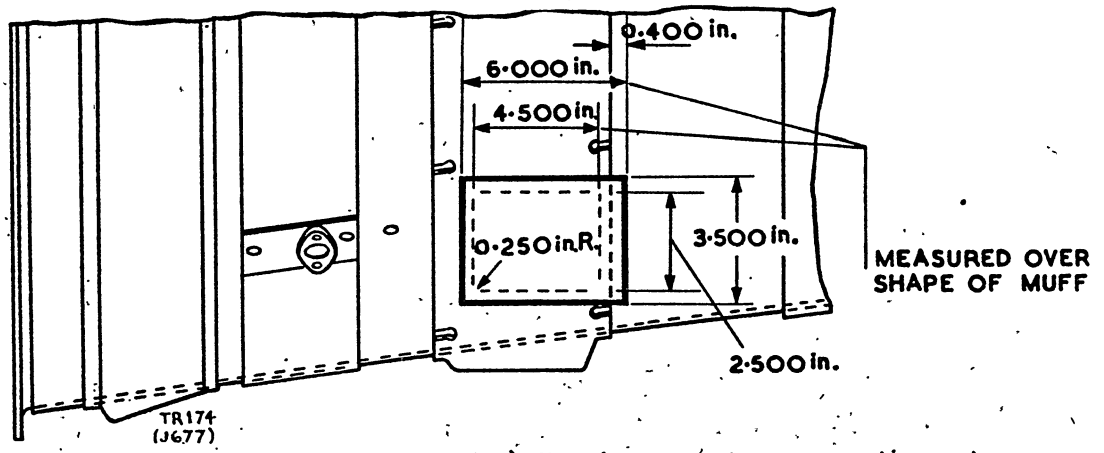


Fig. 1. Patch (maximum size) fitted over cut away portion of heater muff

RESTRICTED

HEATER MUFF, FRONT OUTER CONE, TAIL PIPE

Scheme to replace a damaged flange and sole plate

1. Weld failure or cracking at the junction of the flange and sole plate, or sole plate and heater muff, can be rectified by cutting out the damaged flange and sole plate and welding a patch plate and flange in position by argon arc or any other approved fusion welding process.

2. This scheme can be applied to front outer cone Part No.23629.

3. Outer cones which have been repaired under this scheme can be identified by 'TR 171' etched adjacent to the Part No.

4. Material required to form the patch plate will be D.T.D.171B No.24 S.W.G. (0.022 in.). A new flange and sole plate Part No.21846 (standard part) will be required, unless the original flange and sole plate can be rectified and utilized.

5. To carry out this repair scheme proceed as follows:-

(1) Remove damaged flange and sole plate by cutting along the edge of the flange (A) as shown in fig.1.

(2) Cut out a patch plate from D.T.D.171B No.24 S.W.G. (0.022 in.) 6 in. wide and sufficiently long enough to leave a 0.400 in. flange extending either side of the heater muff when the patch plate is in position.

(3) Remove any oil or grease from the welding area and clean, by wire brushing, the two surfaces to be welded.

(4) Fit the patch plate over the muff and cone and weld in position by argon arc or any other approved fusion welding process, using filler rod D.T.D.549 or D.T.D.571. An applicable flux will be required if argon arc welding is not used and cleaning to remove flux after welding will be necessary.

(5) Cut a hole 2.750 in. diameter in the patch plate, diametrically opposite to the other flange hole.

(6) Position flange and sole plate Part No.21846 central to the hole and the cone and mark the four holes on to the patch plate.

(7) Remove the flange and sole plate and drill the four holes 0.3750 in. diameter.

(8) Reposition the flange and sole plate on the patch plate and weld all round.
(9) Lightly etch TR 171 adjacent to the existing Part No.

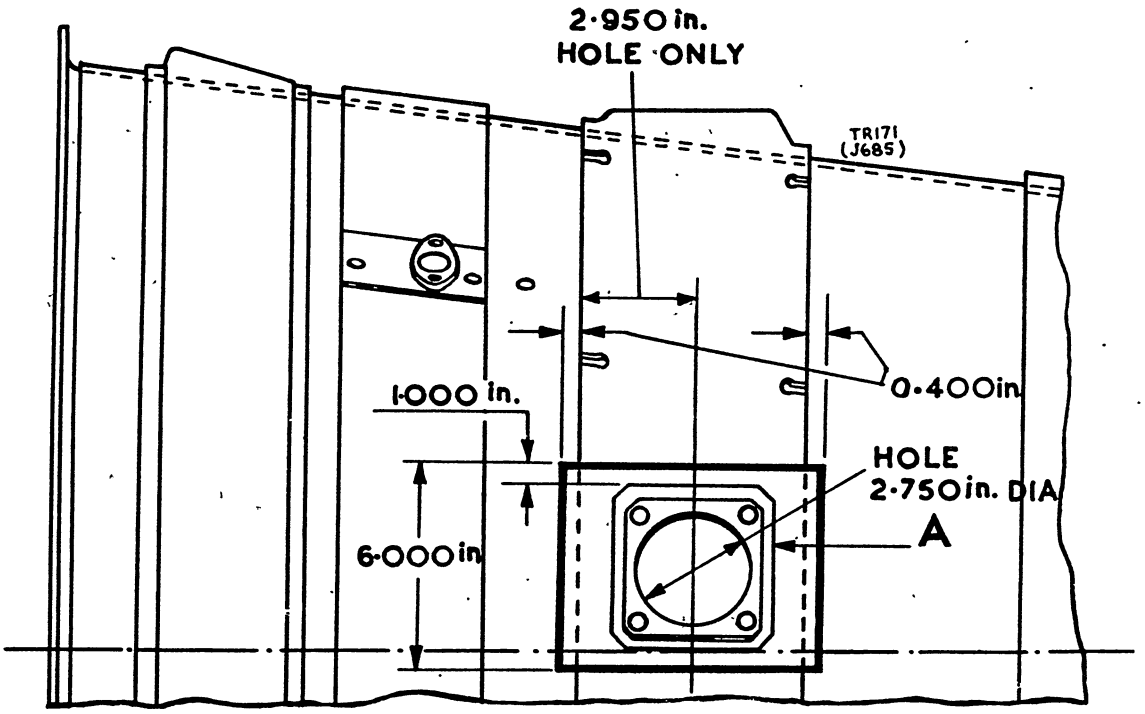


Fig.1. Method of cutting away damaged flange and sole plate from heater muff

A.T.P./7544/1100/2/52

RESTRICTED

This leaf issued with A.L. No.50 February, 1953

A.P.4121B & C, Vol.2, Part 4 Sect.2, Chap.5

LEAFLET G.12 (TR 168 issue 3)

FAIRINGS, FRONT AND REAR, TAIL PIPE

Scheme to repair cracked fairings

Note.- See Section Index for engine Marks affected

1. Small cracks that occur in the front and rear fairings, as indicated in fig.1 can be repaired by argon arc or oxy-acetylene welding.

2. This scheme can be applied to fairings, front and rear Part No.19289, 19304, 19309, 19322, 70544, 70545, 70552 and 70553, where the cracks do not exceed one in. length at A and 0.625 at B. Fairings with cracks exceeding this allowance are to be rejected.

3. Fairings which have been repaired under this scheme can be identified by "TR 168" etched adjacent to the part number.

4. No new parts are required to carry out this repair.

5. To carry out this repair proceed as follows:-

(1) Remove any oil or grease present and clean, by wire brushing, sufficiently to expose bright metal in and around the crack.

(2) Weld up the crack by the argon arc or oxy-acetylene process using filler rod D.T.D.549 or D.T.D.571. A suitable flux must be used in the case of oxy-acetylene.

(3) To remove surplus flux if oxy-acetylene welding has been used, immerse the fairing in a bath of boiling water for 30 minutes.

(4) Grind down the weld to give a smooth finish ensuring that the point of fusion of the weld is not removed.

(5) Lightly etch TR 168 adjacent to the existing part number.

Fig.1 overleaf.

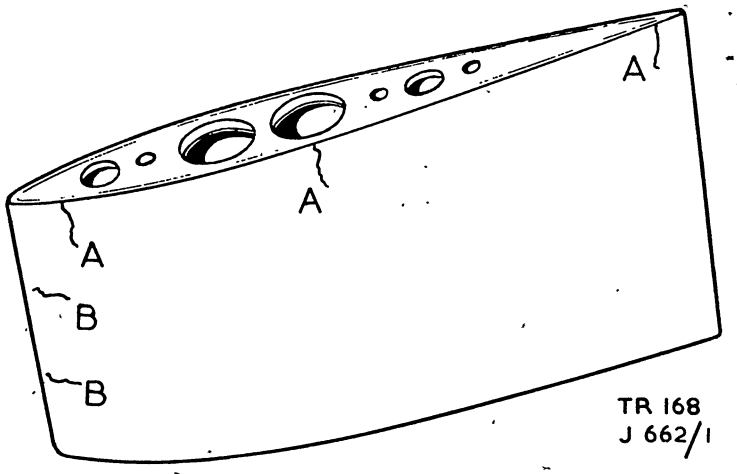


Fig.1. Location of repairable cracks in tail pipe fairing

JUNCTION PIPES, NOZZLE RING

Scheme to repair cracked junction pipes

Note.- See Section Index for engine Marks affected

1. Cracks that occur in the area indicated in fig.1, can be repaired by welding with the argon arc or oxy-acetylene process.

2. This scheme can be applied to junction pipe assembly Part No.22118 if the cracks do not exceed 1.500 in. in length. Where the length of any crack exceeds this allowance the junction pipe is to be rejected.

3. Junction pipes which have been repaired under this scheme can be identified by 'TR 169' etched adjacent to the Part No.

4. No new parts are required to carry out this repair.

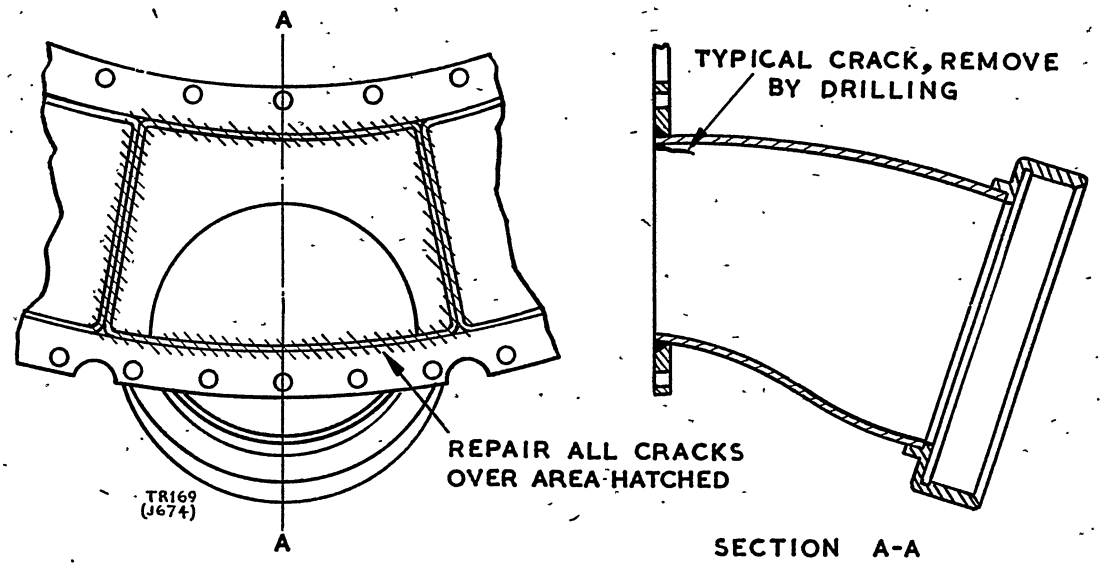


Fig.1. Area of repairable cracks in nozzle ring junction pipe assembly

5. To carry out this repair proceed as follows:-

(1) Remove metal along the line of the crack by drilling 1/16 in. diameter holes to the depth and length required, sufficient to remove the original outline of the crack.

(2) Remove any oil or grease present and clean, by wire brushing, to expose bright metal above and below the crack.

(3) Weld by the argon arc or oxy-acetylene process using filler rod NC 82 (WIGGIN).

(4) File the weld where it protrudes on the jointing face of the flange.

(5) Lightly etch TR 169 adjacent to the existing Part No.

A.T.P.8662/1100/8/52

FRONT OUTER CONE, TAIL PIPE

Scheme to rectify damaged or stripped $\frac{1}{4}$ in. B.S.F. threaded holes in the heater muff flange

1. Stripped threads or other damage to any of the four $\frac{1}{4}$ in. B.S.F. threaded holes in the heater muff flange, may be rectified as detailed below.

2. The repair consists of drilling and tapping the defective flange holes and fitting a threaded ferrule into each modified hole. The ferrule is locked in position by drilling an adjacent hole in the flange and fitting a dowel pin. The pin is secured by peening metal into the top of each hole.

3. This scheme can be applied to front outer cones Part No. 22760, 23450, 23629 and 75808.

4. Front outer cones which have been repaired under this scheme can be identified by "TR 48" etched adjacent to the part number.

The following new parts will be required

Description	Part No.	No. off
Ferrule	N.2546	as required
Dowel pin	N.2497	as required

5. To carry out this repair proceed as follows:-

Note.- The operations refer to one hole only but may be applied at the same time to more than one hole as required.

(1) Set up the front outer cone in position under a radial drilling machine, so that the flange face will be at right angles to the drill.
(2) Drill out the defective $\frac{1}{4}$ in. B.S.F. tapped flange hole to 11/32 in. dia.
(3) Tap out the hole to $\frac{1}{8}$ in. B.S.P. using a taper and plug tap, ensuring that they enter the hole at right angles to the flange face.
(4) Blow out the hole with compressed air.
(5) Screw in the ferrule Part No. N.2546 flush with the outer face of the flange.

(6) Position the drill jig T70813 with its locating pin in the modified flange hole aligning the dowel pin guide hole as shown in fig. 1.
(7) Using a radial drilling machine offer up the 1/16 in. dia. drill to the guide hole of the jig, check for free running through the hole, then drill to a depth of 0·120 in. into the flange.
(8) Remove the jig and blow out the drilled hole with a compressed air jet.
(9) Check that all swarf is removed, failure to do this will cause the dowel pin to project proud of the flange face when it is tapped into position.
(10) Tap the dowel pin Part No. 2497 down to the bottom of the dowel hole; peen metal into the top of the hole to lock the dowel pin.
(11) Clean up the flange face to remove any burrs.
(12) Lightly etch the marking "TR 48" adjacent to existing part number.

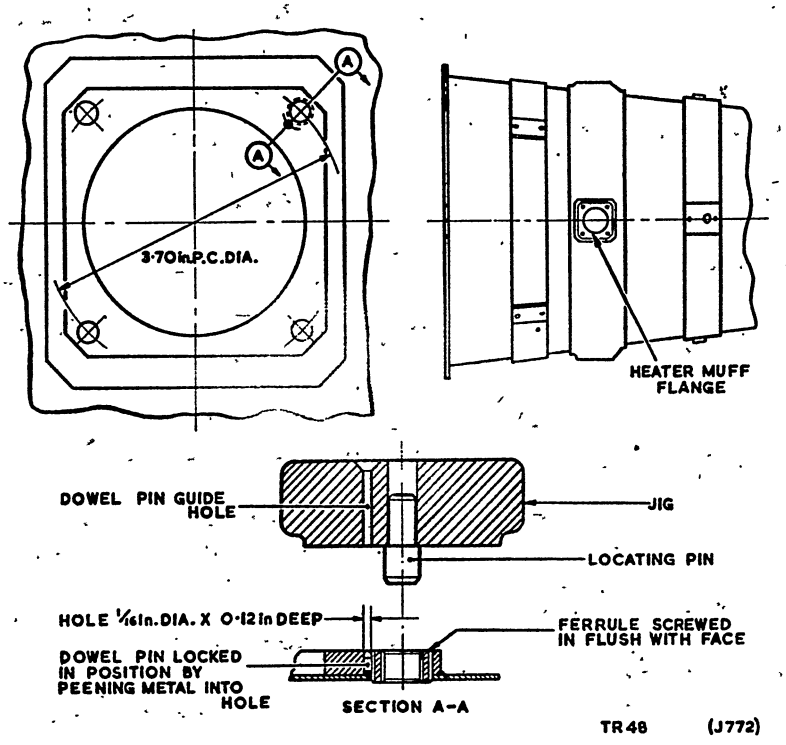


Fig. 1. Method of rectifying stripped thread in heater muff flange

The following tools are required to carry out this scheme.

Description	Part No.	No. off
Drill, twist 11/32 in. H.S.S.	Standard	1
Tap, taper, thread $\frac{1}{8}$ in. B.S.P.	Standard	1
Tap, plug, thread $\frac{1}{8}$ in. B.S.P.	Standard	1
Drill, twist 1/16 in. H.S.S.	Standard	1
Drill jig	T70813	1

ATP/7844/1100/4/52

LEAFLET G.15 (TR.173 Issue 2) part

FRONT OUTER CONE, TAIL PIPE

Scheme to repair a cracked heater muff

1. Cracks and failure of welded joints that occur in the rear heater muff, situated on the tail pipe outer cone, indicated at "A" and "B" in fig.1, can be repaired by argon arc or oxy-acetylene welding.

2. This scheme can be applied to outer cones Part No.22760, 23450, 23629 and 71509. If the cracks at "A" exceed 2·0 in. length, a suitable patch can be welded over the crack, as described in Leaflet G.9 (TR.174) contained in this chapter. If the cracks at "B" are excessive and difficult to repair by welding, a new section of heater muff may be inserted as described in the full application of this repair scheme (TR.173) contained in Vol.6, Part 2, of this Air Publication; if necessary, the complete diameter of the end sections may be renewed.

3. Outer cones previously repaired by this scheme may be identified by "TR.173" etched adjacent to the part number. No new parts are required.

4. To carry out this repair proceed as follows:-

(1) Clean by wire brushing to expose bright metal in and around the cracks.

(2) Using a filler rod to specification D.T.D.549 or D.T.D.571, weld all cracks at position "A" by the argon arc or oxy-acetylene process; extend the weld just past each end of the crack. An applicable flux will be required if oxy-acetylene welding is used and cleaning to remove surplus flux after welding will be necessary.

(3) Press together the edges of cracks or detached sections at position "B" and weld by either process.

(4) If oxy-acetylene welding is used, immerse the tail pipe for 30 minutes in a bath of boiling water to remove any residual flux that may be trapped inside the heater muff.

(5) To facilitate inspection, clean by wire brushing all finished welds, but do not attempt to dress by filing or grinding.

(6) Etch "TR.173" in a position adjacent to the part number.

Fig.1 overleaf

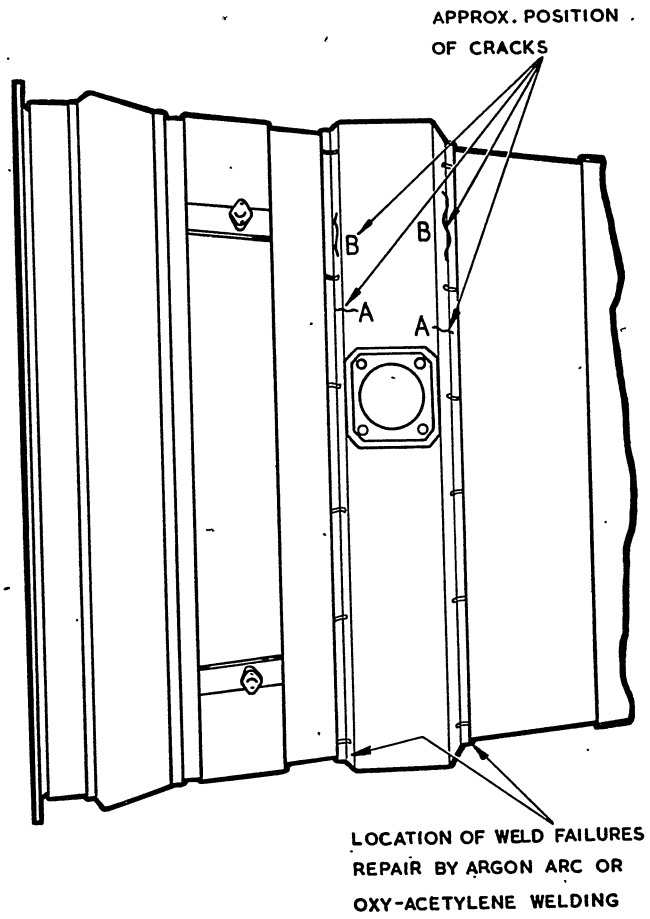


Fig.1. Probable position of cracks and weld failures occurring in tail pipe heater muff

Chapter 6

FUEL SYSTEM COMPONENTS

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

(This chapter supersedes that issued with A.L. No. 31 and 48)

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1. This chapter contains instructions for removing and refitting the fuel system components which are not dealt with in Part 3, Sect. 3, together with instructions for making adjustments and minor repairs. The general information contained in Chapter 1 of this section should be referred to as necessary.

Fuel pump and adapter (Mk. 2)

Removal

2. To remove the fuel pump from the bottom accessory box, disconnect the fuel supply pipe from the pump inlet and remove the L.P. fuel filter bowl. Disconnect the fuel pump to H.P. fuel filter pipe at the union nut adjacent to the fuel pump. Disconnect the fuel pump to control box pipe at the union nut adjacent to the fuel pump, and the anti-hammer pipe at the junction union on the fuel pump inlet. Using the special spanner T70258, remove the four nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) which secure the fuel pump to its adapter and remove the fuel pump. Instructions for dismantling, reconditioning, and reassembling the fuel pump are contained in A.P.4282.

3. The two top rear studs, which partly secure the fuel pump adapter to the bottom accessory box, pass right through the accessory box and form part of the fixing for the overspeed governor and its adapter. If, therefore, it is required to remove the fuel pump adapter, it is first necessary to remove the overspeed governor complete with its adapter, as described in para. 30 and 31; the fuel pump adapter can then be removed as follows. Remove the four $\frac{1}{4}$ in. B.S.F. plain nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) which secure the adapter to the accessory box. Withdraw the adapter by tapping the starboard ends of the two top rear studs which project through the overspeed governor adapter mounting face.

Refitting

4. Ensure that the two long studs which are attached to the fuel pump adapter are secure, and that the mating faces of the adapter and the fuel pump drive housing in the accessory box, are clean and undamaged. Apply a thin film of jointing compound to the mating faces, and fit the adapter by pushing the long studs through the appropriate holes in

the bottom accessory box, from the port side. Refit the overspeed governor complete with its adapter, as described in para. 32. Secure the fuel pump adapter by refitting the four spring washers (also plain washers when Mod. No. 755 has been embodied) and plain nuts.

4A. Care must be taken to ensure that the drive shaft of the fuel pump does not receive an endwise blow. Such a blow could be the result of careless handling of the pump during transit, whilst in store, or during removal or refitment of the pump on the engine. A severe endwise blow can cause the drive shaft to be driven through the pump ball bearing with the result that the end float on the pump rotor assembly is taken up, the rotor comes into contact with the pump casing, and the consequent increased loading of the drive shaft ultimately causes failure.

5. Before refitting the fuel pump, ensure that the splines in the drive within the accessory box, and those on the fuel pump quill shaft, are clean and undamaged. Check the mating faces of the fuel pump adapter and the fuel pump for condition and apply a thin film of jointing compound to each face. Align the splines on the fuel pump quillshaft with the splines in the engine, and push the fuel pump into position; if necessary, turn the impeller by hand to facilitate engagement. Secure the fuel pump with the four spring washers (also plain washers when Mod. No. 755 has been embodied) and nuts. Reconnect the pipes detailed in para. 2, and prime the fuel system as described in Part 3, Sect. 2, Chap. 1.

Fuel pump and adapter (Mk. 3)

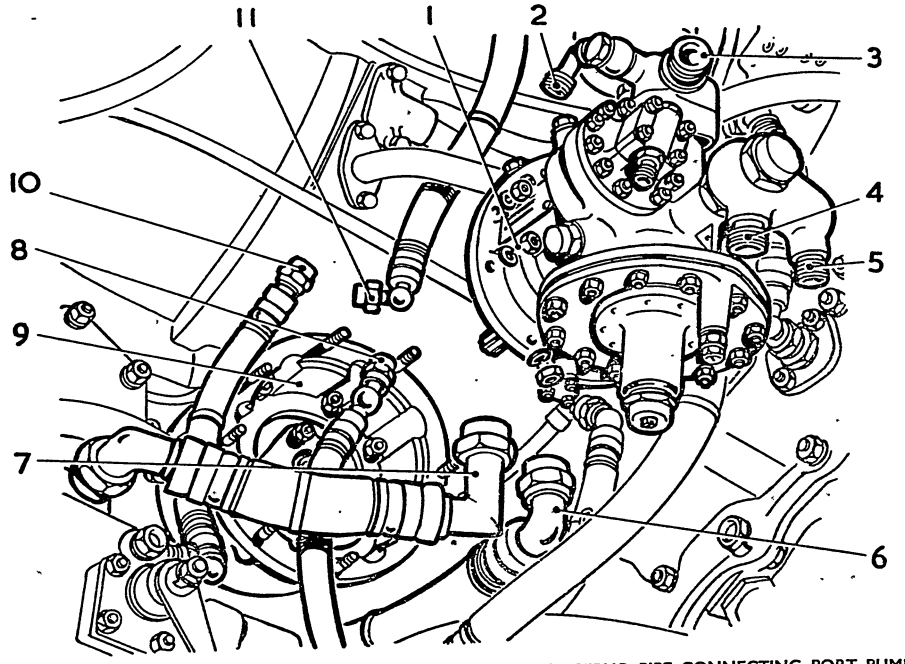
Removal

6. There are slight differences between the connections to the Lucas fuel pump depending on whether it is a single pump system, or the port or starboard fuel pump of a dual pump system. The following lists detail the connections which it will be necessary to unscrew, according to which pump it is required to remove. Fig. 1 shows a fuel pump removed from a dual pump system.

Port pump, dual pump system.

(1) Pump delivery pipe from pump to control box.

(2) Inter-pump delivery pipe.



1 EIGHT PLAIN NUTS AND SPRING WASHERS
2 ANTI-HAMMER PIPE CONNECTION
3 FUEL SUPPLY PIPE CONNECTION
4 PUMP DELIVERY PIPE CONNECTION
5 INTER-PUMP DELIVERY PIPE CONNECTION
6 INTER-PUMP DELIVERY PIPE
7 PUMP DELIVERY PIPE TO CONTROL BOX
8 SERVO PIPE CONNECTING PORT PUMP TO STARBOARD PUMP
9 FUEL PUMP ADAPTER ON BOTTOM ACCESSORY BOX
10 ANTI-HAMMER PIPE FROM CONTROL BOX TO PUMP INLET
11 REMOTE BLEED PIPE

Fig. 1. Lucas fuel pump removed

(3) Servo pipe connecting port pump to starboard pump.
(4) Anti-hammer pipe from control box to pump inlet.
(5) Remote bleed pipe.
(6) Fuel supply pipe (engine installed in aircraft).
(7) Pump delivery pressure pipe from pump to B.P.C.
(8) Servo pipe from pump to B.P.C.
(9) Pipe from B.P.C. to pump inlet

(Engines with air-fuel ratio control)

Starboard pump, dual pump system

(1) Inter-pump delivery pipe.
(2) Servo pipe connecting port pump to starboard pump.
(3) Servo pipe from pump to B.P.C.
(4) Pipe from B.P.C. to pump inlet
(5) Pump delivery pipe from pump to B.P.C.

(Engines without air-fuel ratio control)

(6) Fuel supply pipe.
(7) Electric leads from terminals on fuel pump (engine installed in aircraft).

Single pump system

(1) Pump delivery pipe from pump to control box.
(2) Servo pipe from pump to B.P.C.
(3) Pipe from B.P.C. to pump inlet.
(4) Pump delivery pipe from pump to B.P.C.
(5) Anti-hammer pipe from control box to pump inlet.
(6) Fuel supply pipe (engine installed in aircraft).
(7) Remote bleed pipe
(8) Electric leads from terminals on fuel pump (engine installed in aircraft).

7. Remove the eight nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) which secure the fuel pump to its adapter and remove the pump; do not disturb the castellated nuts. If it is required to remove the adapter, unscrew the six nuts and tab-washers which secure it to the accessory box.

Refitting

8. The procedure for refitting a fuel pump is largely a reversal of the instructions given for removal. The fuel system must be primed, as described in Part 3, Sect. 2, Chap. 1 before starting the engine.

Single pump check (dual pump installation)

9. On the test bed, when the maximum permissible engine speed cannot be obtained on one pump alone due to low ambient temperature, the single pump delivery is established by applying a formula. Since when making this check in the field the actual delivery cannot be measured, the results obtained can be checked only by comparison, as the maximum r.p.m. obtained on each pump should be approximately the same, subject to allowance being made for the difference in governor setting described in para. 34. Speed variations of approximately 100 to 150 r.p.m. are acceptable but any wide difference obtaining in these circumstances would be an indication that one pump is faulty.

10. To check the port fuel pump, disconnect the servo pipe between the fuel pumps at the solenoid valve on the starboard fuel pump, and blank off the open end of the pipe, leaving the connection on the pump open. Move the fuel pump isolating switch to the ON position, to close the solenoid valve. Start the engine, and move the fuel pump isolating switch to the OFF position, to open the solenoid valve. Increase the engine speed, and establish the maximum r.p.m. obtainable.

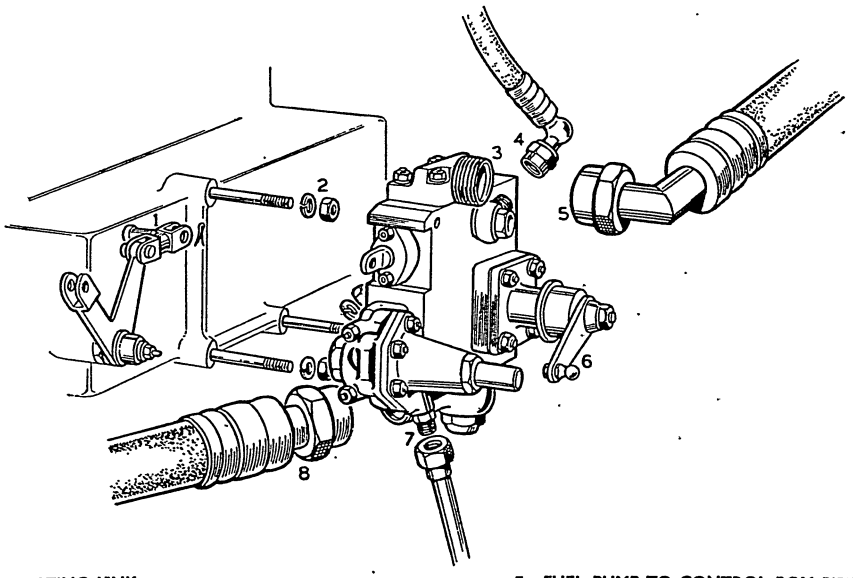
11. To check the starboard fuel pump, return the fuel pump isolating switch to the ON position to close the solenoid valve, and remove the blank from the servo pipe. Start the engine, and increase the engine speed until the maximum r.p.m. obtainable is established. Stop the engine and reconnect the servo pipe to the starboard fuel pump.

Control box and dump valve

Removal

12. The control box, illustrated in fig. 2, and dump valve (Mk. 2 only), must be treated as a single unit and, when removed from the engine, must be stored with the control valve plunger in the closed (slow-running) position, i.e., pushed fully into the control box to avoid damage to the plunger by bending. If the control box is being removed only for the purpose of removing the pressure limiting valve, the associated flexible fuel pipes need not be disconnected. To remove the control box, disconnect the drain pipe from the union on the pressure limiting valve, and the control rod from the H.P. cut-off valve lever on the control box.

(A.L. 67, July, 54)



1 CONNECTING LINK
2 THREE PLAIN NUTS AND SPRING WASHERS
3 CONTROL BOX INLET CONNECTION
4 ANTI-HAMMER PIPE, CONTROL BOX TO PUMP INLET
5 FUEL PUMP TO CONTROL BOX PIPE
6 H.P. CUT-OFF VALVE LEVER
7 PRESSURE LIMITING VALVE DRAIN
8 CONTROL BOX TO GOVERNOR PIPE (Mk. 2)
8 CONTROL BOX TO STARTING VALVE PIPE (Mk. 3)

Fig. 2. Control box removed

Disconnect the following flexible pipes; unscrew the union nut at the control box end of the pipe in each case. (Mk. 2 only), the fuel pump to control box pipe, the control box to overspeed governor pipe, and the anti-hammer pipe from control box to fuel pump. (Mk. 3 without air-fuel ratio control only), the fuel pump to control box pipe, the control box to starting valve pipe, and the anti-hammer pipe from control box to fuel pump. (Mk. 3, with air-fuel control only), the fuel pump to control box pipe, the pressurizing valve to starting valve pipe, the pressurizing valve to air-fuel ratio control pipe, the pressurizing valve to control box pipe, and the anti-hammer pipe from control box to fuel pump. Completely remove the following rigid pipes. (Mk. 2 and Mk. 3, Mod. 713 only), the starting valve to dump valve pipe. (Mk. 3, with air-fuel ratio control only), the shut-off valve to starting valve pipe. Extract the split pin and remove the shackle pin which couples the connecting link to the control valve plunger. Push the control valve plunger into the control box as far as possible. Remove the three nuts and spring washers (also plain washers when Mod. 755 has been embodied) which secure the control box to the sump, and draw the control box off the studs.

Renewing the control valve plunger seals

13. The only minor repair permitted is the renewal of the control valve plunger seals to rectify leakage of fuel. Instructions for dismantling, reconditioning, reassembling, and testing the control box are contained in A.P.4282.

14. The importance of cleanliness and the exercise of every care to avoid damage while carrying out the following operations cannot be too highly stressed; irreparable damage can be caused by dropping the control box or by the incorrect use of tools.

15. To fit new seals proceed as follows. Remove the two nuts and spring washers which secure the control valve plunger cover; remove the cover and the control valve seal cover plate. Insert a small tommy bar through the eye of the plunger to prevent it turning, unlock and unscrew the 2 B.A. bolt from the rear of the plunger, and remove the collar which forms the plunger stop. Lightly stone any burrs which may be present on the plunger; grip the eye end and withdraw the plunger from the control box. Remove the control valve seal and collar. Remove the two nuts and spring washers which secure the control valve dust seal cover to the front of the control box, and remove the cover, felt washer, and control valve

seal cover plate. Remove the other control valve seal and collar.

16. Examine the control valve plunger for evidence of scoring and, using a straight edge or by rolling the plunger on a surface plate, check its length for straightness. Minor scores or scratches may be lightly polished out using well worn emery paper of the finest grade. Polishing should be localised to the area of the scratch, so that as far as possible the original matt lapped finish is preserved.

17. Before refitting the parts at the rear end of the control valve plunger bore, ensure that the circlip which retains the control valve seal bush is tight in its location, and that it has not moved and blanked off the small bleed hole in the body of the control box. The control valve seal collars, which are at each end of the plunger bore, should be fitted with the slots innermost, and it is important that the slot in the collar at the rear end fits over the leg of the circlip.

18. Using insertion tool T70038, fit new seals (Part No. 21026) at each end of the plunger bore so that their grooves are located inwards over the collars. Ensure that the seals do not project beyond the face of the control box at the rear, or beyond the control valve flange at the front; if necessary, the length of the collars may be reduced to obtain this condition. Refit the two cover plates and temporarily secure the rear plate by fitting one of the nuts. Fit a new felt washer and secure the dust seal cover at the front finger-tight only with the two spring washers and nuts.

19. Lubricate the control valve plunger and, using the special guide plug T70063, insert the plunger, care being taken that the seals are not damaged in the process. The plunger will ensure correct alignment of the felt washer at the front end and the two nuts securing the dust cover should now be tightened. Insert a small tommy bar through the eye of the plunger to prevent it turning, refit the control valve collar, or plunger stop, and a new tab-washer (Part No. N3766); tighten and lock the 2 B.A. bolt. Remove the nut which secures the rear plate and refit the control valve plunger cover, and secure it with the two spring washers and nuts.

Refitting

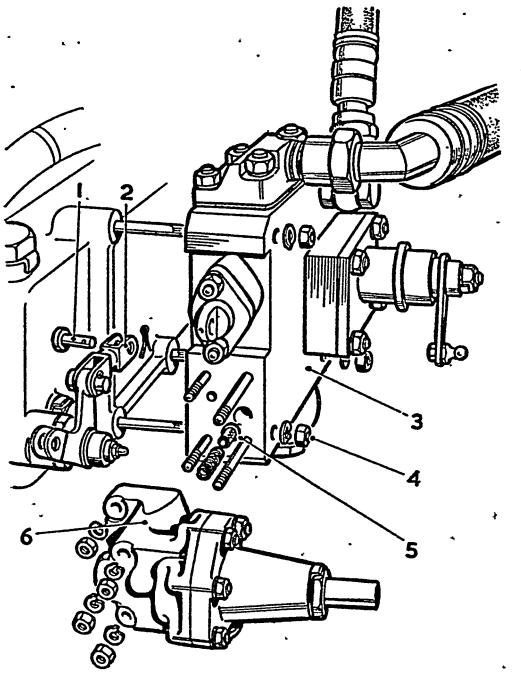
20. Mount the control box on the oil sump, and secure it by refitting the three spring washers (also plain washers when Mod. No. 755 has been embodied) and plain nuts. Lubricate the shackle pin with a smear of anti-freeze grease and couple the connecting link to the control valve plunger, inserting the shackle pin so that its head is towards the sump. Secure the shackle pin by fitting a new split pin. Reconnect the pipes detailed in para. 12. If the engine is installed in an aircraft, reconnect the pressure limiting valve drain pipe, and the H.P. cut-off valve control.

Note . . .

Mk. 2 only. It is important that whenever the H.P. *cut-off valve control has been disconnected from the engine, or has been readjusted, the check recommended in Part 3, Sect. 2, Chap. 1, should be made during the next ground run.*

Pressure limiting valve

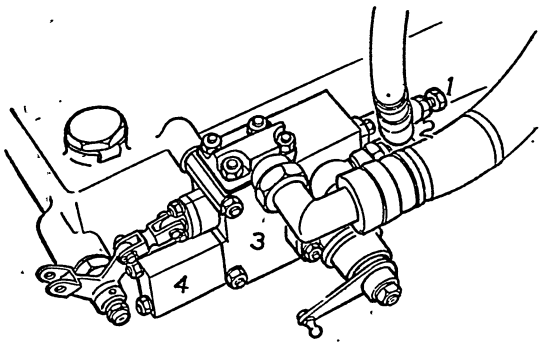
21. To remove the pressure limiting valve (*fig.* 3), disconnect the drain pipe from the union on the P.L.V. Remove the rigid pipe which connects the starting valve to the dump valve (Mk. 2 only), or the rigid pipe which connects the shut-off valve to the



1 SHACKLE PIN
2 CONNECTING LINK
3 CONTROL BOX
4 THREE PLAIN NUTS AND SPRING WASHERS
5 FILTER AND SPRING (Pre-mod- 754 only)
6 PRESSURE LIMITING VALVE

Fig. 3. Pressure limiting valve removed

(A.L. 67, July, 54)



1 SLOW-RUNNING ADJUSTING SCREW
2 LOCK-NUT
3 CONTROL BOX
4 BLANK ON P.L.V. MOUNTING FACE

Fig. 4. Slow-running adjustment

starting valve (Mk. 3, with air-fuel ratio control only). Extract the split pin, remove the shackle pin which couples the connecting link to the control valve plunger, and push the control valve plunger into the control box as far as possible. Remove the three nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) which secure the control box to the sump, and draw the control box away from the sump just enough to permit the four nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) which secure the P.L.V. to the front face of the control box to be removed, and the P.L.V. drawn off the studs. Blank off the P.L.V. mounting face on the control box, use blanking cover T75065 or make reference to fig. 3, Part 3, Sect. 3, Chap. 1 for particulars of a suitable blanking arrangement.

Checking the pressure limiting valve

22. Whenever the P.L.V. is removed, a check should be made by running the engine with a blanking plate fitted to the P.L.V. mounting face on the control box, to compare the slow-running speed obtained under these conditions with that obtained after the P.L.V. has been refitted. Use blanking cover T74065 or the locally-made blank illustrated in Part 3, Sect. 3, Chap. 1, Fig. 3. Should the slow-running speed be higher, with the P.L.V. fitted, it probably indicates a faulty P.L.V., which must be changed for a serviceable unit. Readjustment of the slow-running stop on the control box, to compensate for leakage past the P.L.V., is *NOT* permitted.

Refitting

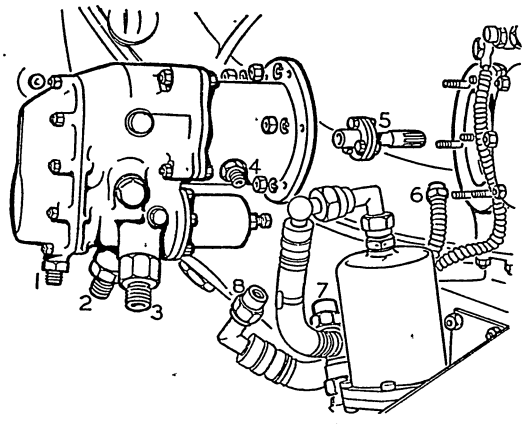
23. When refitting a P.L.V. which has Mod. No. 754 embodied, ensure that the two seal rings (Part No. CH.65163 and CH.65164) are undamaged and are correctly positioned in the P.L.V. joint face. If Mod. No. 754 has not been embodied, fit the joint washer (Part No. 21772A) to the P.L.V. mounting face on the control box and ensure that the small filter and spring are in position. Mount the P.L.V. on the control box and secure with the four spring washers (also plain washers when Mod. No. 755 has been embodied) and nuts. Push the control box into position and secure it with the three spring washers (also plain washers when Mod. No. 755 has been embodied) and nuts. Reconnect the rigid fuel pipe between the starting valve and the dump valve (Mk. 2 only) or the rigid pipe which connects the shut-off valve to the starting valve (Mk. 3, with air-fuel ratio control only), and reconnect the P.L.V. drain. Couple the throttle control to the control valve plunger. On Mk. 3 engines it will be necessary to reprime the fuel pumps after the P.L.V. has been refitted. Start the engine and check that the slow-running speed is the same as that previously established. When the slow-running speed is satisfactory, carefully examine the joint face between the P.L.V. and the control box, and each of the fuel pipe unions that have been disturbed for evidence of fuel leakage.

Slow-running adjustment

24. 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 (*fig.* 4) at the rear of the control box, and provides adjustment for the slow-running (idling) speed. The setting obtained on the test bed, after manufacture or reconditioning is wire-locked and sealed with a lead seal by the inspection authority, and this adjustment should not normally require alteration.

25. An increase in the slow-running speed may be due to a faulty pressure limiting valve and, for this reason, it is advisable to carry out the test described in para. 22 before attempting to adjust the slow-running speed. Re-check the slow-running speed if a replacement P.L.V. is fitted. Adjustment of the slow-running stop to compensate for leakage past the P.L.V. is *NOT* permitted.

26. To adjust the slow-running speed, slacken off the lock-nut on the slow-running adjusting screw, and screw in (turn clockwise)



1 OIL DRAIN UNION
2 FUEL INLET UNION
3 FUEL OUTLET UNION
4 METERED OIL FEED UNION
5 SPLINED SHAFT ASSEMBLY
6 METERED OIL FEED PIPE
7 FUEL PIPE FROM GOVERNOR TO STARTING VALVE
8 FUEL PIPE FROM CONTROL BOX TO GOVERNOR

Fig. 5. Overspeed governor and adapter removed (Mk. 2)

the adjusting screw to increase the slow-running speed; screw out (turn anti-clockwise) to decrease the speed. While making this adjustment the control valve plunger must be pressed firmly against the adjusting screw; ensure that its travel is not limited by the stops in the aircraft portion of the control system. When a satisfactory slow-running speed has been obtained, wire-lock the adjustment.

Pressurizing valve (Mk. 3, with air-fuel ratio control only)

26A. No servicing or adjustment of the pressurizing valve, 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 follows. Disconnect the pressurizing valve to starting valve pipe, the pressurizing valve to air-fuel ratio control pipe, and the pressurizing valve to control box pipe, at the unions adjacent to the valve. Remove the six plain nuts and tab-washers which secure the pressurizing valve to the underside of the control box and lower the valve off the studs. Before refitting the pressurizing valve ensure that the sealing ring (Part No. N.4281) is undamaged and is correctly positioned in the valve joint face. Mount the pressurizing valve on the control box and secure it by fitting six new tab-washers (Part No. AGS.518/E) and the plain nuts; lock the nuts. Reconnect the pipes which were disturbed during removal of the valve. It will be necessary to reprime the fuel pump or pumps after the pressurizing valve has been refitted.

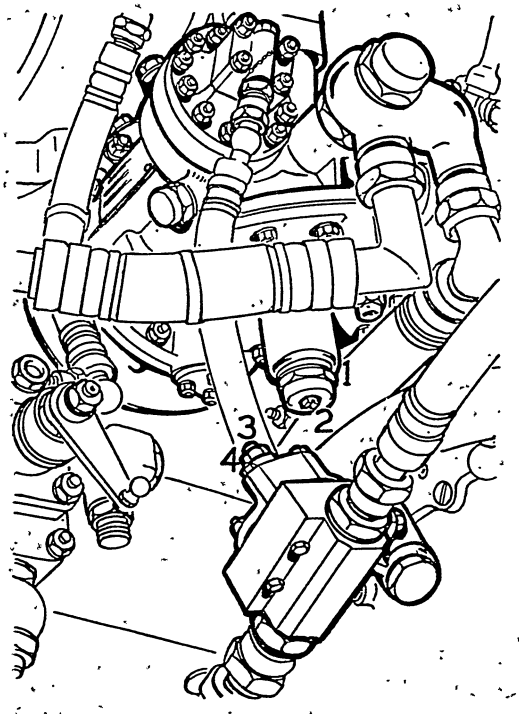
Overspeed governor (Mk. 2 only)

Adjustment

27. Deviations of the 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 bed. If attention is paid to deviations occurring 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.

28. 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 Part 3, Sect. 2, Chap. 3, and adjusted, if necessary, according to the instructions contained in the following paragraph. It is, however, recommended that the aircraft instruments are checked before any adjustments to the overspeed governor are made. When the engine is operated on Aviation Turbine Gasolene (AVTAG), governed speed variations as a result of the change in fuel density will be small, and in order to limit the exhaust gas temperature rise which will accompany any overspeed condition, it will be necessary to re-adjust governed r.p.m. in the field only in the event of 10,250 r.p.m. being exceeded.

29. Before commencing to adjust the overspeed governor, ensure that, when the pilot's lever is in the full-throttle position, the control valve plunger is hard against its stop in the control box, and that the travel is not limited by the stops in the airframe portion of the control system. To alter the overspeed governor setting, slacken off the lock-nut on the speeder spring adjusting screw, and screw in the adjusting screw (turn clockwise) to increase the governed r.p.m. and vice versa. If adjustment is being made to correct low governed speed, run the engine up to the maximum r.p.m. attainable; ensure that the throttle is in the fully



1 LOCK-NUT ON FUEL PUMP DIAPHRAGM COVER
2 GOVERNOR MECHANISM ADJUSTING SCREW
3 LOCK-NUT ON STARTING VALVE ADJUSTING PLUG
4 STARTING VALVE ADJUSTING PLUG

Fig. 6. Governor and starting valve adjustment (Mk. 3)

open position, then adjust the governor until the correct maximum r.p.m. is obtained. Alternatively, if adjustment is required to correct overspeeding, open the throttle until maximum permissible r.p.m. is obtained; hold the throttle to maintain this speed and adjust (turn adjusting screw anti-clockwise) the governor until a slight drop in r.p.m. is observed on the tachometer, then open the throttle fully and further adjust the governor until the engine speed is increased to the correct maximum permissible r.p.m., with the throttle in the fully open position.

Removal

30. To remove the overspeed governor, disconnect the following pipes; the oil drain pipe from the union at the bottom of the governor casing cover, the fuel drain pipe from the banjo on the rear of the governor casing, the fuel pipe from the control box to the governor at the inlet union on the underside of the governor casing, the fuel pipe from the governor to the starting valve at the outlet union on the underside of the governor casing, and the metered oil feed pipe from the union on the governor adapter. Remove the six nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) which secure the circular flange of the adapter to the bottom accessory box, and remove the overspeed governor complete with its adapter. If the splined shaft assembly remains in the engine, it should be removed and placed with the governor.

31. The overspeed governor and its adapter should be regarded as a unit (*fig.* 5) as, during testing after manufacture or overhaul, each governor, complete with its adapter, is submitted to a lubrication and oil seal leakage test which will be invalidated if adapters are interchanged between governors. To ensure correct assembly if a governor is separated from its adapter, two notches are cut in the periphery of the circular flange at the engine end of the adapter. These notches are to obviate a foul between the flange and two of the nuts and studs which secure the bottom accessory box. Therefore, when the adapter is attached to the overspeed governor, these two notches must be in line with the two bolts, through the square flange, which are furthest from the speeder spring housing. Correctly position the adapter on the governor casing, insert the four 2 B.A. bolts, and fit the spring washers (also plain washers when Mod. No. 755 has been embodied) and nuts.

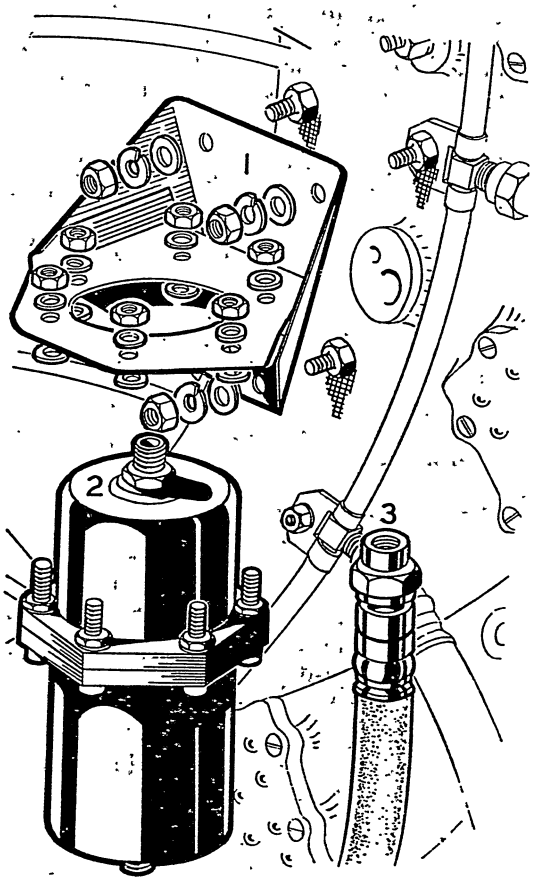
Refitting

32. Before refitting the overspeed governor and its adapter, ensure that the splines on the governor shaft, at each end of the splined shaft assembly, and in the drive within the engine, are clean and undamaged. Ensure that the three bolts in the splined shaft assembly, which fasten the coupling and extension shafts together, are secure and tight, and that the circlip is correctly positioned and secure in the groove in the coupling shaft. Ensure that the mating faces of the adapter and the bottom accessory box are clean and undamaged. Apply a thin film of jointing compound to the mating faces, and place the splined shaft assembly in position on the governor shaft. Mount the overspeed governor and its adapter on the bottom accessory box; if necessary, turn the impeller by hand to facilitate engagement of the splines. Secure the overspeed governor and its adapter to the accessory box with the six spring washers (also plain washers when Mod. No. 755 has been embodied) and plain nuts. Reconnect the pipes detailed in para. 31.

Governor mechanism (Mk. 3)

33. The overspeed governor mechanism of the Mk. 3 is integral with the fuel pumps. The general remarks given in para. 27 are equally applicable, and variations beyond the tolerance given should be investigated, as detailed in Part 3, Sect. 2, Chap. 3.

33A. When the engine is operated on Aviation Turbine Gasolene (AVTAG), it will be necessary to give careful attention to the readjustment of the governed speed when changing to this fuel for the first time, or after refuelling when AVTAG of a different specific gravity is used, as the hydraulic mechanism of the fuel pump governor is sensitive to changes in fuel density. The wide limits permitted by the fuel specification will be accompanied by considerable changes in governed speed, and it should be noted that for an increase of 0·01 in. the specific gravity of the AVTAG there will be a decrease in speed of approximately 60 r.p.m., and vice versa. After refuelling, run the engine for approximately one minute to allow the new fuel to reach the governor mechanism, then gradually increase the engine r.p.m. to check the maximum governed speed; if the maximum governed speed exceeds 10,810 r.p.m. it will be necessary to readjust the governor or governors as described in the following paragraph.



1 FUEL ACCUMULATOR BRACKET
2 FUEL ACCUMULATOR
3 PIPE FROM ACCUMULATOR TO STARTING VALVE

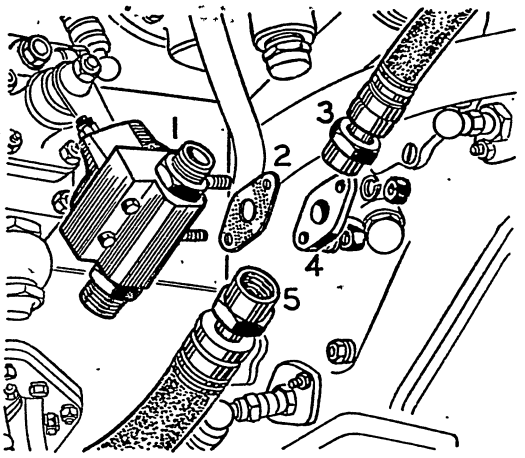
Fig. 7. Fuel accumulator and bracket (Mk. 3)

34. 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.

35. When adjusting the governor mechanism, ensure that the throttle is fully open, i.e. that the control valve plunger is hard up against its stop in the control box, and that the travel is not being limited by the stops in the aircraft portion of the control system, when the engine speed is being limited by the governor mechanism. To alter the governor setting of either fuel pump, slacken the lock-nut at the end of the diaphragm cover (*fig.* 6), and turn the adjusting screw clockwise to increase the governed r.p.m., or anti-clockwise to decrease it.

36. To obtain the required difference in governor setting, proceed as follows. Temporarily increase the governor setting of the port fuel pump to an appreciably higher value than normal, and set the starboard fuel pump to govern at 10,800 r.p.m.; as this speed exceeds the maximum permissible r.p.m., the engine must be run at this speed for the shortest time that will permit an accurate setting to be obtained. When the starboard fuel pump governor setting is satisfactory, set the port fuel pump to govern at 10,750 r.p.m.

(*A.L. 67, July, 54*)



1 STARTING VALVE
2 JOINT WASHER
3 FUEL ACCUMULATOR PIPE
4 MOUNTING FACE ON BURNER RING
5 FUEL INLET PIPE

Fig. 8. Starting valve removed (Mk. 3)

Fuel accumulator

Checking

37. To check the functioning of the fuel accumulator, remove the hollow bolt from the drain connection at the bottom of the fuel accumulator, or at the top in the case of Mk. 3 engines. Insert a suitable graduated rod, $\frac{1}{4}$ or $\frac{5}{16}$ in. diameter and not less than 7 in. long, with rounded ends, through the drain union, and lightly hold in contact with the piston in the fuel accumulator during an attempted start. The travel of the fuel accumulator piston as it fully charges and discharges during a normal starting cycle should be 40 mm. $\pm$ 1 mm. If the fuel accumulator does not charge fully, the starting valve may be at fault and should be checked as indicated in Part 3, Sect. 2, Chap. 3. Reference should also be made to para. 42 of this chapter.

Removal and refitting

38. To remove the Mk. 2 fuel accumulator, remove the hollow bolt from the bottom of the fuel accumulator, and disconnect the drain pipe. Unscrew the union nut which secures the overspeed governor to fuel accumulator pipe, from the adapter at the top of the accumulator, and remove the four plain nuts and spring washers which secure the fuel accumulator bracket to the oil sump. Remove the fuel accumulator complete with its bracket. To separate the bracket from the fuel accumulator, remove the six $\frac{1}{4}$ in. B.S.F. nuts and spring washers from the extended portion of the six bolts which fasten the accumulator cap and body together; do not disturb the six nuts and plain washers which actually clamp these two parts together. The nuts and spring washers should be reassembled to the accumulator, as they are regarded as part of that component. Reassembly of the bracket to the fuel accumulator, and refitment to the engine, are a reversal of the removal instructions.

39. Removal of the Mk. 3 fuel accumulator (*fig.* 7), which is mounted on the port side of the engine, is similar to the removal of the Mk. 2 accumulator described in para. 38, except that the support bracket is secured by three nuts and washers instead of four.

Starting valve

Checking

40. A check to determine whether the starting valve is sticking, can be made on Mk. 2 engines by disconnecting the flexible fuel pipe from the underside of the starting valve, and inserting a suitable length of metal rod to press the valve open to the full extent of its travel. The valve should close freely immediately it is released. The metal rod should be of about $\frac{1}{4}$ in. diameter by 4 in. in length, and should be rounded at the end to avoid damaging the rubber seating washers.

41. To check the Mk. 3 starting valve, remove the adjusting plug and lock-nut, and screw a two inch 4 B.A. bolt into the piston through the adjusting plug hole in the cover. This will enable the valve to be lifted. Gently move the valve up to the full extent of its travel; it should close freely immediately the valve is released. If the inner and outer valve springs were removed for the foregoing operation, refit them to the piston through the hole in the cover, and screw in the adjusting plug for approximately half its length. Readjust the starting valve, as described in the following paragraphs.

42. When it is required to check the starting valve setting, a 0–50 lb. per sq. in. pressure gauge T 72803 must be connected to the banjo union provided on No. 3 burner. This pressure gauge should be connected by the shortest pipe practicable, and it is important that the engine is not accelerated above 3,000 r.p.m. while this gauge is connected. Proceed as for a normal start, and observe the burner fuel pressure registered on the gauge just before light-up. A "flick" pressure of 19–24 lb. per sq. in. should

be observed. Too high a pressure will cause a wet start, and too low a pressure will prevent the engine starting. If the operating pressure is unsatisfactory, stop the engine, and adjust the starting valve as described in the following paragraph.

Note . . .

The need for accurate adjustment of the starting valve is described in Vol. 1, Sect. 2, Chap. 2. Readjustment is occasionally necessary as the result of ageing of the diaphragm.

43. To adjust the starting valve, slacken the lock-nut on the adjusting plug (*fig.* 6), and screw in (turn clockwise) the adjusting plug to increase the operating pressure; screw out (turn anti-clockwise) to decrease the pressure. When satisfactory conditions are obtained, tighten the lock-nut on the adjusting plug, care being taken not to alter the setting.

Removal and refitting

44. The union nut which attaches the starting valve to the fuel ring on Mk. 2 engines has a *left-hand thread.* To remove the starting valve, disconnect the fuel pipe from the overspeed governor, and remove the rigid pipe which connects the starting valve to the dump valve. Using the special claw spanner T70260, unscrew the union nut (left-hand thread) and remove the two plain nuts and spring washers which secure the starting valve bracket. Remove the starting valve and its bracket.

45. To refit the starting valve, ensure that the union on the starting valve is aligned with the thread on the fuel ring, then tighten the two nuts which secure the bracket, and the union nut.

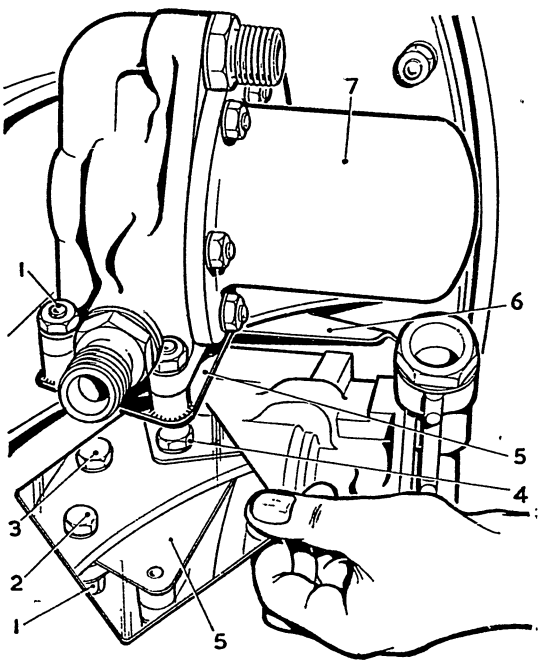
46. To remove the Mk. 3 starting valve (*fig.* 8), disconnect the fuel inlet pipe from the control box, and the pipe from the fuel accumulator, at the unions on the starting valve. Completely remove the rigid pipe which connects the shut-off valve to the starting valve (Mk. 3 with air-fuel ratio control only). Remove the two nuts which secure the starting valve to the bracket on the burner ring. Remove the spring washers and the starting valve. When refitting the Mk. 3 starting valve, a new joint washer (Part No. 19719) should be used, if necessary, between the starting valve and the burner ring.

Note . . .

When fitting a replacement starting valve, ensure that the blanking cap has been removed from the adjusting plug, and that the air vent in the end of the plug is free from obstruction.

High-pressure fuel filter (Mk. 2 only)

47. The method of dismantling the H.P. fuel filter for inspection and cleaning of the element is described in Part 3, Sect. 3, Chap. 1. To remove the complete fuel filter (*fig.* 9), disconnect the fuel pump to filter and the filter to barostat pipes, at the unions on the filter body. Remove the $\frac{1}{4}$ in. B.S.F. bolt and spring washer which secure both the barostat bracket and the H.P. fuel filter bracket to the web on the front casing. Remove the nut, spring washer (also plain washer when Mod. No. 755 has been embodied), and bolt, which passes through the bracket and base of the filter, and the short bolt and spring washer (also plain washers when Mod. No. 755 has been embodied) which passes through the web on the front casing and screws into the bracket. Remove



1 NUT AND SPRING WASHER ON BOLT 2
2 BOLT THROUGH BRACKET AND BASE OF FILTER
3 SHORT BOLT AND SPRING WASHER
4 BOLT AND SPRING WASHER WHICH SECURE BOTH BAROSTAT AND FILTER BRACKET
5 H.P. FUEL FILTER BRACKET
6 BAROSTAT BRACKET
7 H.P. FUEL FILTER COVER

Fig. 9. High-pressure fuel filter (Mk. 2)

(A.L.86, Jan. 59)

the H.P. fuel filter and its bracket. To detach the bracket, unscrew the three nuts, and remove the spring washers (also plain washers when Mod. No. 755 has been embodied) and the bracket from the filter. Reassembly of the bracket to the filter, and refitment to the engine, are a reversal of the removal instructions.

47A. When fitting new filter elements, or a replacement filter assembly, it is essential to flush through the filter, and the filter to barostat pipe, as follows. Disconnect the filter to barostat pipe at the barostat end. Simulate a start in accordance with the starting drill given in Part 3, Sect. 2, Chap. 2, 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. Reconnect the filter to barostat pipe and carry out a normal ground run, during which a check must be made for fuel leaks.

Barostat (Mk. 2 only)

48. To remove the barostat, disconnect the fuel return, or spill, pipe from the union on the forward face of the barostat, the total head pipe (standard hose clip) from the banjo adjacent to the drain connection at the bottom of the barostat, the drain pipe from the drain adapter at the bottom of the barostat, and the H.P. fuel filter to barostat pipe at the inlet adapter on the barostat, and the remote bleed pipe. Remove the bolt and spring washer which are common to the barostat and fuel filter brackets, and remove the two nuts and double coil spring washers which secure the barostat bracket to the front casing. Remove the barostat and its bracket. To detach the bracket, unscrew the four nuts, and remove the spring washers and the bracket. Reassembly of the bracket to the barostat, and refitment of the barostat to the engine, are a reversal of the removal instructions.

Note . . .

The barostat is particularly sensitive to the ingress of even minute foreign matter. Therefore, whenever this unit is removed, or any of the pipes connected to it are disconnected or changed, particular care must be taken to ensure that no foreign matter of any kind enters the pipes or the unit.

Barometric pressure control (Mk. 3 only)

49. To remove the barometric pressure control, the following pipes must be disconnected at the union nuts adjacent to the B.P.C. Servo pipe from the pump to the B.P.C., pipe from B.P.C. to starboard pump inlet, pump delivery pressure pipe from pump to B.P.C. and, in the case of an installed engine, the total head pipe. Remove the four nuts, spring washers, and bolts which secure the B.P.C. to the bracket on the port side of the front casing. Where the B.P.C. is mounted on the starboard side of the oil sump, remove the four nuts and spring washers which secure the B.P.C. bracket to the oil sump, and remove the B.P.C. complete with bracket. To detach the bracket, remove the four nuts, spring washers, bolts, and distance pieces. Reassembly of the bracket to the B.P.C., and refitment to the engine, are a reversal of the removal instructions.

Air-fuel ratio control (Mk. 3, Mod. 948 only)

50. No servicing or adjustment of the air-fuel ratio 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 follows. Disconnect the following pipes at the union nuts to A–F.R.C., servo pipe from pump to A–F.R.C., pipe from A–F.R.C. to pump inlet, and the rigid pipe from No. 5 combustion chamber to the A–F.R.C. Having disconnected three pipes, remove the four plain nuts and spring washers which secure the A–F.R.C. to the bracket on the port side of the front casing. Refitting the A–F.R.C. to the engine is a direct reversal of the foregoing instructions.

Flexible pipes

51. All flexible fuel pipes should be inspected during routine engine inspections, and great care should be taken at all times when handling these pipes. It is strongly recommended that new or replacement flexible pipes should be flushed through and pressure tested before they are fitted to the engine. Instructions for fitting, inspecting, and testing flexible pipes are contained in Chapter 10.

Chapter 7

LUBRICATION SYSTEM COMPONENTS

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

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1. This chapter contains instructions for removing and refitting the lubrication system components which are not dealt with in Part 3, Sect. 3, together with instructions for making adjustments. The general information contained in Chapter 1 of this section should be referred to as necessary.

Oil sump

Removal

2. *Mk. 2 engines.* Remove the fuel pipe which connects the control box to the overspeed governor, and the fuel pipe which connects the governor to the starting valve. *Mk. 3 engines. Pre-mod.* 700. Remove the fuel pipe which connects the control box to the starting valve, the fuel pipe which connects the two pump delivery connections together, the fuel supply pipe to the starboard pump, and the servo pipe between the two pumps. When Mod. No. 700 has been embodied, remove the fuel pipe which connects the control box to the starting valve. Disconnect the six drain pipes from the forward side of the drain box, and the main oil feed pipe and the starter oil pipe from the three-way banjo on the front of the sump.

3. Disconnect the oil metering pipes as follows—Remove the banjo bolt and washers from the upper end of the front-bearing metered oil pipe, disconnect the front section of the rear-bearing metered oil pipe at the joint under the diffuser casing, and (Mk. 2 only) disconnect the upper end of the overspeed-governor metered oil pipe from the governor adapter. Remove the control box and the fuel accumulator, complete with bracket, or in the case of Mk. 3, pre-mod. 700 engines the barometric pressure control, as described in Chapter 6. Normally the sump will be full of oil and a suitable metal tray into which the sump can be lowered should be placed under the engine. Remove the sixteen $\frac{1}{4}$ in. B.S.F. plain nuts and spring washers which secure the oil sump to the bottom accessory box, and carefully lower the sump into the metal tray. The oil pump drive shaft and coupling, which may drop down with the sump, should be removed. Empty the sump of oil.

Refitting

4. If the accessory box to oil sump joint washer (Part No. 23588) is unserviceable, a new joint washer should be fitted. Assemble the oil pump drive coupling sleeve to the splines on the oil pump driving gear, and insert the lower end of the oil pump driving shaft into the coupling. Place the joint washer over the studs on the underside of the bottom accessory box and assemble the sump to the accessory box; ensure that the upper end of the oil pump driving shaft enters the oil pump driven gear in the accessory box correctly. Place the main oil feed pipe clip over the starboard stud and secure the sump by refitting the sixteen spring washers and nuts. Refit the fuel accumulator, or barometric pressure control, and the control box. Reconnect the pipes detailed in the foregoing paragraphs.

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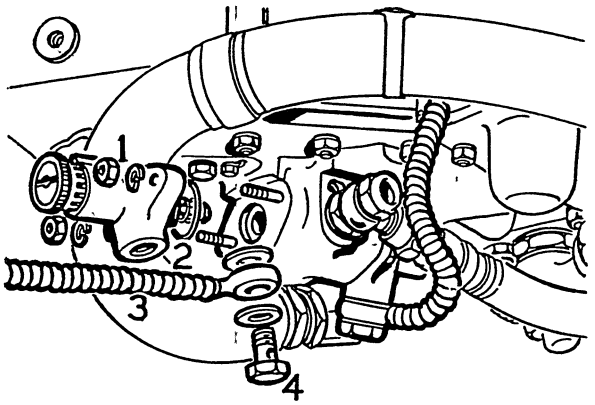


1 TWO 2 B.A. PLAIN NUTS AND SPRING WASHERS, ALSO PLAIN WASHERS WHEN MOD. No. 755 HAS BEEN EMBODIED
2 SYNTHETIC RUBBER SEALING RING
3 RIGID PIPE
4 BANJO BOLT

Fig. 1. A metering pump removed

Metering pumps

5. With the exception of its setting, each of the metering pumps is identical, therefore, instructions for removing, refitting and checking one only are given.

Removal

Remove the banjo bolt which connects the rigid pipe to the metering pump, remove the two washers, and gently ease the pipe clear of the metering pump; do not bend the rigid pipe more than is absolutely essential. Unscrew the two 2 B.A. plain nuts which secure the metering pump to the bottom casing of the main oil pump, remove the spring washers (also plain washers when Mod. No. 755 has been embodied) and carefully ease the metering pump off the studs (*fig.* 1). Should the synthetic rubber sealing ring, which forms the joint between the metering pump and the main oil pump casing remain in the latter, it should be extracted and placed on the spigot of the metering pump.

6. Do not dismantle the metering pump or alter its setting. Make a thorough visual examination of the exterior of the metering pump for signs of damage, ensure that the plunger is not bent or damaged, and that the visible spring is serviceable.

Refitting

7. Unless care is taken when refitting a metering pump and the instructions closely followed, the metering pump plunger may be displaced and bent, thus rendering the pump inoperative. If the sealing ring (Part No. 20272 pre-mod. 867, 94043 Mod. No. 867) is unserviceable it must be renewed. Place a new sealing ring on the metering pump spigot, ensuring that the sealing ring does not obstruct the oil inlet duct in the metering pump. Rotate the engine until the cam on the main oil pump spindle is at the position of no lift relative to the particular metering pump which is being refitted. Insert the metering pump spigot into the bore in the main oil pump casing, and hold it in position against the load of its spring so that the flange on the metering pump is firmly bedded against the main oil pump casing. Holding the metering pump firmly in position, screw on the two spring washers (also plain washers when Mod. No. 755 has been embodied) and plain nuts until they are finger-tight, then finally tighten the nuts.

Checking

8. The oil delivery of the metering pump(s) must be checked whenever a new metering pump is fitted, when an existing pump is removed and refitted, when defective lubrication is suspected, and (both pumps) during the initial ground running check of a newly installed engine. To check the delivery of a metering pump proceed as follows:—

(1) Disconnect the metering pump delivery pipe and prepare the engine for oil priming as described in Part 3, Sect. 2, Chap. 1, para. 17 (1) and (2), or para. 18 (1) to (4) as applicable.

(2) Prime the front or rear bearing as described in Part 3, Sect. 2, Chap. 1, para. 17 (3), or para. 18 (5), as applicable. *Do not disconnect the priming syringe at this stage*, and ensure that it is filled with clean filtered oil of the correct specification.

(3) Start the engine, and, with the engine running at 3,000 r.p.m., time the oil delivery from the metering pump into a graduated vessel. During this period of engine running the syringe should be operated gently, just sufficiently to ensure that the feed pipe to the bearing remains full of oil. If the syringe is over-operated the bearing will be over-primed and this may result in oil leakage from the bearing (in the case of the rear bearing, down the face of the turbine disc). The oil delivery from the metering pump should be:—

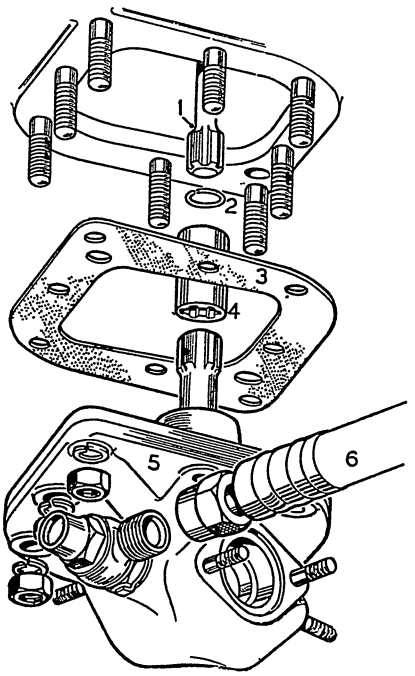
Metering pump	Engine running at 3,000 r.p.m. c.c. per hour	Engine running at 3,000 r.p.m. pints per hour
Front bearing	90	0·158
Rear bearing	90	0·158
Overspeed governor (Goblin Mk. 2 only)	14	0·025

(4) At the satisfactory conclusion of this check, stop the engine.

(5) *Front bearing oil feed, both Marks.* Fill the normal oil pipe with oil and, with as little delay as possible, to minimise the loss of oil from the duct in the front casing, disconnect the syringe and refit the normal oil pipe. Wire-lock the banjo bolts.

Rear bearing oil feed, Goblin Mk. 3. Fill the front half of the metering pump to rear bearing pipe with oil.

Rear bearing oil feed, both Marks. 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. Reconnect the drain pipe. Tighten and wire-lock the union nuts and the banjo bolt.



1 OIL PUMP DRIVING-SHAFT
2 CIRCLIP
3 JOINT WASHER
4 COUPLING SLEEVE
5 OIL PUMP
6 METERING PUMP FEED PIPE

Fig. 2. Oil pump removed

9. The metering pumps are adjusted by turning the knurled end until the locking-spring engages the lowest numbered notch which will give the delivery specified; normally notch No. 7 is the setting for the pumps lubricating the front and rear bearings and notch No. 3 is usual for the pump connected to the overspeed governor. A metering pump should not be rejected because it is necessary to employ a slightly higher setting to obtain the required delivery. The range of adjustment consists of eleven notches numbered 0 to 10, and on no account may the adjustment be turned beyond the notch marked 10 to obtain the required delivery. If the flow is insufficient at No. 10 setting, the metering pump is probably faulty and must be replaced, but before rejecting the pump, ensure that the oil supply duct is not blocked, possibly by displacement of the sealing ring. On the satisfactory completion of this check, or adjustment, the locking spring should be securely wired in position. If the pipes are of the Bundy type (Mod. 765, Pre-mod. 1051) the instructions given in Part 3, Sect. 3, Chap. 1, para. 5A to 5D must be adhered to strictly.

Oil pump

Removal

10. Drain the oil sump as described in Part 3, Sect. 3. Disconnect the metering pump feed pipe at the banjo union on the oil pump cover. Remove each metering pump as described in para. 5. Remove the eight $\frac{1}{4}$ in. B.S.F. plain nuts and spring washers (also plain washers when Mod. No. 755 has been

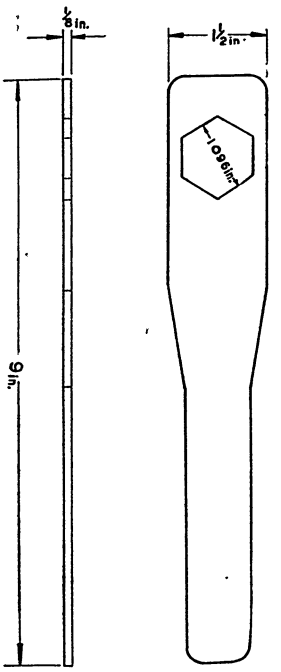


Fig. 3. Suggested ring spanner for removing the oil pressure relief valve cover

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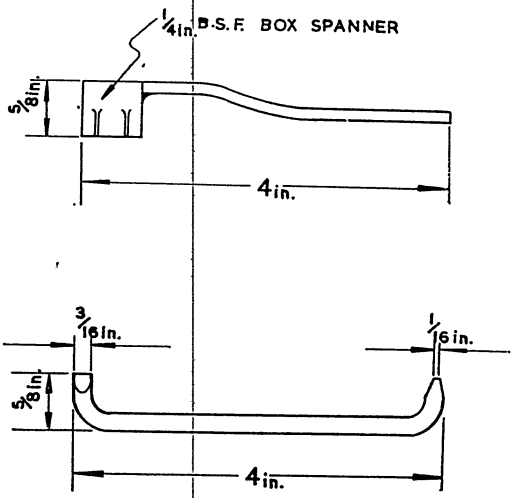
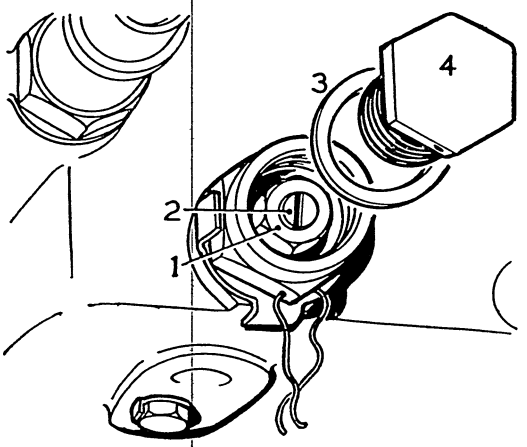


Fig. 4. Suggested box spanner and right-angled screwdriver for adjusting the oil pressure relief valve

embodied) which secure the oil pump assembly to the sump (*fig.* 2); if necessary lightly tap the pump to break the seal and remove the pump. The oil pump drive coupling sleeve and the oil pump driving shaft, which may drop down with the pump, should be removed.

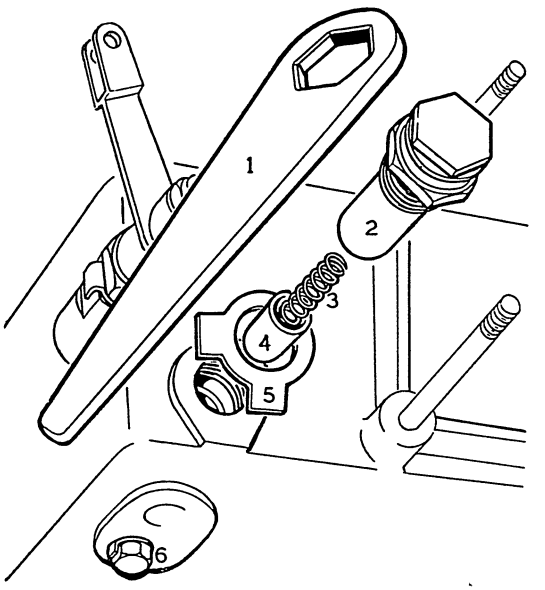
Refitting

11. Ensure that the circlip (Part No. 13613) is correctly located and secure in the coupling sleeve. Assemble the coupling to the splines of the oil pump driving gear, and insert the end of the oil pump driving shaft into the coupling. Check the oil pump for freedom of rotation. Place a new joint washer (Part No. 22344) over the studs on the oil pump mounting face on the sump. Ensuring that the upper end of the oil pump driving shaft enters the oil pump driven gear in the bottom accessory box correctly, assemble the oil pump to the sump, and secure it in position with the eight nuts and spring washers (also plain washers when Mod. No. 755 has been embodied). Refit the metering pumps, and reconnect the metering pump feed pipe. Refit the drain plug or suction filter cover as described in Part 3, Sect. 3, Chap. 1, and refill the oil sump as described in Part 3, Sect. 2, Chap. 2.



1 LOCK-NUT
2 ADJUSTING SCREW
3 COPPER WASHER
4 COVER

Fig. 5. Oil pressure relief valve adjustment



1 RING SPANNER T70149
2 RELIEF VALVE HOUSING
3 RELIEF VALVE SPRING
4 RELIEF VALVE
5 TAB-WASHER
6 RELIEF VALVE SEAT LOCKING-SCREW

Fig. 6. Oil pressure relief valve dismantled

Oil pressure relief valve

Adjustment

12. Fig. 3 and 4 illustrate tools which can be locally made to facilitate adjustment of the oil pressure relief valve. To effect adjustment, remove the cover (*fig.* 5), using a suitable ring spanner, and slacken the lock-nut which is then exposed using a small box spanner. Using a right-angled screwdriver, turn the adjusting screw clockwise (screw in) to increase the oil pressure, and vice versa. Holding the adjusting screw with the screwdriver, lock the setting by tightening the

lock-nut. The oil pressure should be checked with the engine running at 9,700 r.p.m. Mk. 2 engines or 10,250 r.p.m. Mk. 3 engines; the pressure specified in the Leading Particulars assumes an oil temperature of 40 deg. C. When the oil pressure has been proved satisfactory, refit and lock the cover.

Removal

13. If it is required to remove the oil pressure relief valve, without altering the existing setting, do not remove the cover from the end of the relief valve housing, but proceed as follows. Remove the pressure limiting valve as described in Chapter 6. Unlock the tab-washer which locks the pressure relief valve housing to the oil sump and, using ring spanner T70149, unscrew the housing from the sump (*fig.* 6). Take out the relief valve and its spring. Do not disturb the small locking screw in the bottom of the sump, which retains the relief valve seat.

14. Thoroughly wash the detail parts in clean kerosine. Carefully examine the housing, spring, and relief valve. Small scratches or scores on the valve may be blended out by light stoning. Ensure that the valve seating and the bore in the sump, which accommodates the relief valve and housing, are perfectly clean.

Refitting

15. If the oil pressure relief valve has been dismantled completely, it must be reassembled as described in this paragraph, but if the cover and adjusting screw have not been separated from the housing, certain of the operations described will be unnecessary. Screw the adjusting screw into the housing sufficiently to locate the valve spring. Insert the spring and the valve into the housing. Place a new tab-washer (Part No. N1596) on the housing, and screw the housing into the sump. Screw in the adjusting screw until it is below the top of the housing and screw on the lock-nut. Run the engine to check the relief valve setting and if necessary, adjust the valve as described in para. 12 to obtain the correct pressure. When the oil pressure is satisfactory, refit the copper washer and the cover. Bend up the tabs of the tab-washer to lock the housing to the sump, and wire-lock the cover.

Oil jets in accessory boxes

16. To obtain access to the oil jets in the top accessory box for examination and cleaning, it is necessary to remove the cover from this accessory box. Disconnect the three-core cable from the tachometer generator. Break the locking wire as necessary. Disconnect the breeze connector on the oil temperature gauge resistance bulb in the thermometer pocket on the port side of the top accessory box. Disconnect the oil pressure gauge capillary, if fitted, from the banjo union on the starboard side of the top accessory box. Disconnect the oil feed pipes from the two banjo unions on the top accessory box and from the air compressor and the vacuum pump. Remove the banjo bolt from the top end of the oil supply pipe to the top accessory box from the starboard side of the cover. Take off the thirteen 2 B.A. nuts and spring washers (also plain washers when Mod. No. 755 has been embodied) securing the cover to the accessory box and remove the cover. Turn the cover over, and unlock and remove the four plain nuts which secure the triple oil jet at the front and the single oil jet at the rear. Remove the jets and their distance pieces.

17. Clean the jets by forcing kerosine through them using a syringe, or a compressed air jet. Wire or any similar implement must not be used to probe the jets as the orifices must not be enlarged. Blow through all oil passages to ensure that they are clear.

18. Assemble the distance piece and single oil jet to the rear jet studs; the securing holes in these parts are so positioned that they cannot be assembled incorrectly. Fit new lock-washers (Part No. AGS 194/2) and secure the jet with the two nuts but do not lock the nuts until after an oil-flow check has been made. Assemble the distance piece, nipple, and triple oil jet to the front jet studs; the disposition of the securing holes ensures that these parts cannot be assembled incorrectly. Fit new lock-washers (Part No. AGS 194/2) and secure the jet with the two nuts but do not lock the nuts until after the oil-flow check.

19. If possible blank off the oil pressure gauge, vacuum pump, and air compressor oil feed banjo unions with three blanking nipples Part No. N2102, and union nuts Part No. 2510–15 and apply oil at 45 lb. per sq. in. pressure to the oil inlet at the starboard side of the cover. Ensure that there

is no leakage under the heads of the permanent blanking plugs and that there is an uninterrupted flow of oil from all four jets. Oil should also trickle from the tachometer drive bush. If the result of the test is satisfactory, lock the four nuts which secure the jet assemblies.

20. Check that the spring, thimble and rubber washer are positioned correctly on the top of the breather pipe in the top accessory box and that no foreign matter has fallen into the accessory box. Ensure that the joint faces are clean and dry; apply a thin film of jointing compound to the joint faces, and locate the cover on the two dowels and the breather pipe. Secure the cover with the thirteen spring washers (also plain washers when Mod. No. 755 has been embodied) and plain nuts, placing the two locking-wire tabs on two studs conveniently situated for the final operation. Refit the banjo bolt at the top end of the oil supply pipe to the top accessory box on the starboard side of the cover, and the remaining pipes and connections which were disturbed. Wire-lock these components and the plug adjacent to the breather, the plugs in the end and on the top of the longitudinal oil gallery, the two banjo bolts on the top of the transverse oil gallery and the oil thermometer pocket.

21. To clean the restricted orifice feeding the starter gear box, the starter, complete with gear box, must be removed as described in Chapter 9 and dismantled as described in A.P.1095C.

22. To obtain access to the oil jet on the starter coupling assembly, which is attached to the port side of the bottom accessory box, it is necessary to remove the starter and the starter coupling, then proceed in the following manner. Remove the banjo bolt and the washers from the side of the coupling housing, and ease the flexible oil pipe clear of the starter coupling. Unscrew the eight $\frac{5}{16}$ in. B.S.F. plain nuts securing the coupling housing to the bottom accessory box. Remove the eight tab-washers, and the coupling and laminated shim. Unscrew the two 2 B.A. nuts securing the oil jet to the inside of the coupling housing, remove the two tab-washers, and the oil jet. Clean the pipe and jet as described in para. 17. Reassemble the oil jet to the studs on the face of the coupling housing and secure it with two new tab-washers (Part No. AGS 194/2) and the plain nuts. Lock the nuts by turning up the washer tabs. Apply a thin film of jointing compound to the joint faces. Place the original shim pack over the studs and mount the starter coupling in position. Secure it with eight new tab-washers (Part No. AGS 195/2, pre-Mod. 912, N.3763 Mod. No. 912) and the plain nuts; lock the nuts. Refit the electric starter to the engine as described in Chapter 9 and prime the starter gearbox through the oil pipe connection as described in Section 2, Chapter 1. Reconnect the flexible oil pipe refitting the washers and the banjo bolt.

Chapter 8

IGNITION SYSTEM

(This chapter supersedes that issued with A.L. No. 67)

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

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Booster coil ignition (Mk. 2 pre-Mod. 984, Mk. 3 pre-Mod. 830)

1. Routine servicing of the igniter plugs which are the only engine items forming part of the ignition system, is described in Part 3, Sect. 3. Information in respect of the permissible replacement, adjustment or rectification is contained in A.P.4282, to which reference should be made as necessary.

2. Instructions concerning those ignition system components which are aircraft items, are contained in the relevant aircraft Air Publication and its associated Air Publications.

High energy ignition (Mk. 2 Mod. No. 984, Mk. 3 Mod. No. 830)

3. The following paragraphs contain instructions for removing and refitting the high energy ignition equipment, but reference should also be made to A.P.1374E and A.P.1374G which deals with these components for further information on their servicing, testing, and repair. Instructions for checking the system when the engine is installed in an aircraft are contained in Part 3, Sect. 3, Chap. 1.

WARNING—

The energy stored in the capacitor can, under certain circumstances, be of a lethal nature. Consequently 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. Where instructions call for the connection of the L.T. cable and checking of the discharge (sparking) at the igniter plug, for any reason, the following precautions are recommended.

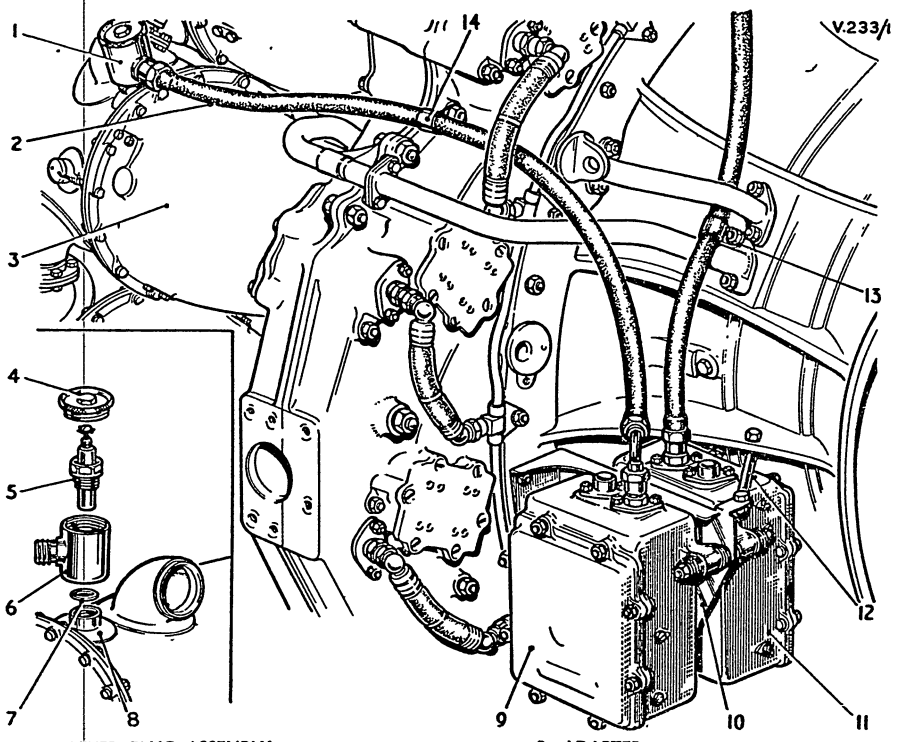
(1) Allow at least one minute to elapse after disconnecting the L.T. supply cable, before commencing to work on the condenser unit or its associated equipment.

(2) If the L.T. supply cable is re-connected, to enable the circuit and igniter plug operations to be checked, ensure that all personnel are clear of the equipment before energizing the unit.

(3) After any such test, observe the warning given above.

4. Each condenser unit, ignition cable assembly, and igniter plug is independent of the other. Assuming the low tension supply

(A.L.71, Nov. 54)



1 IGNITER PLUG ASSEMBLY
2 IGNITION CABLE
3 No. 14 COMBUSTION CHAMBER
4 SCREEN BOX LID
5 IGNITER PLUG
6 SCREEN BOX
7 SEALING WASHER
8 ADAPTER
9 OUTER IGNITION UNIT
10 BRACKET
11 INNER IGNITION UNIT
12 STAY
13 CLIP ON FRONT CASING
14 CLIP ON DIFFUSER CASING

Fig. 1. High energy ignition equipment

to the condenser units to be satisfactory, a defect in the system can be isolated by changing the components in turn, for serviceable items. The low tension supply to the condenser units is dealt with in the relevant aircraft Air Publication.

Igniter plugs

5. To remove one of the igniter plugs proceed as follows. Cut the locking-wire and unscrew the knurled lid of the screen box (*fig.* 1). Slacken off the screw which secures the ignition cable to the centre electrode of the igniter plug, unscrew the union nut which fastens the cable screening to the screen box, and withdraw the ignition cable. Using a suitable box spanner, unscrew the igniter plug, and remove the plug, screen box and sealing washers from the engine. When refitting the igniter plug, place the plug inside its screen box and ensure that the seating washer is positioned on the igniter plug between the screen box and the adapter on the combustion chamber; lightly smear the threads on the igniter plug with the recommended anti-seize compound. Tighten the igniter plug with a suitable box spanner. Insert the ignition cable into the screen box, lining up the slots in the insulator with the 'pip' in the box, and connect the ignition cable to the centre electrode of the plug. Screw the union nut of the cable onto the screen box and refit the screen box lid. Great care must be taken to avoid seizure of the screen box lid threads; ensure that they are not damaged, apply approved anti-seize compound, then tighten the lid hand-tight only and wire-lock the lid.

High energy condenser units

6. The two high energy condenser units are mounted on a common bracket on the starboard side of the front casing (*fig.* 2). To remove the outer of the two condenser units, which feeds the igniter plug in No. 14 combustion chamber, proceed as follows. If the engine is installed in an aircraft, disconnect the L.T. supply cable from the socket at the top of the condenser unit. Unscrew the union nut and withdraw the ignition cable from the top of the unit. Remove the three plain nuts, spring washers, spacers, and rubber

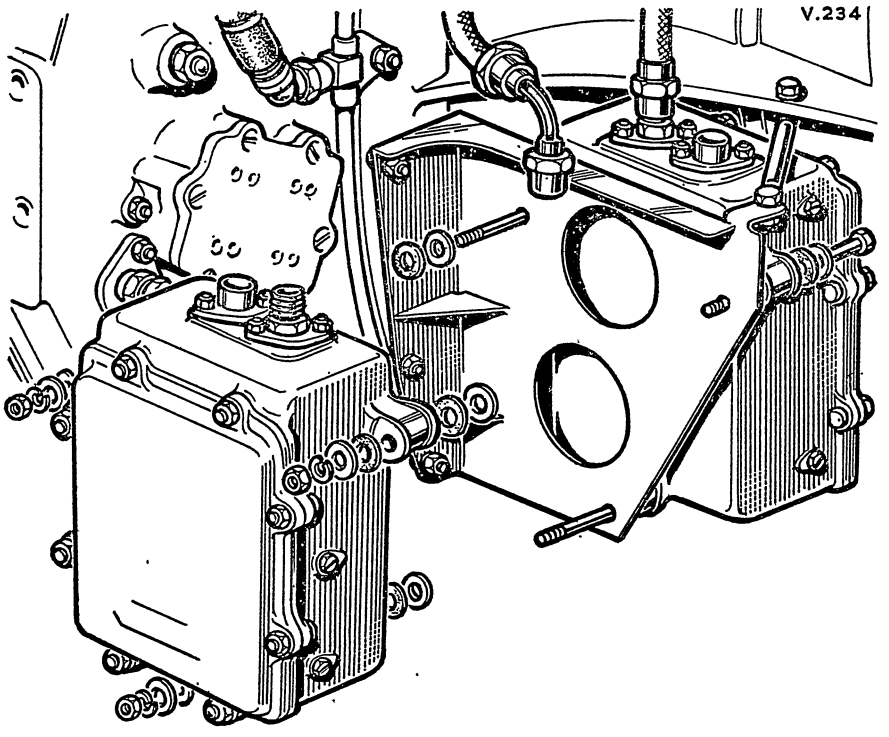


Fig. 2. High energy condenser units

washers which secure the condenser unit to the bracket, and remove the unit. Carefully note the position of the rubber washers and spacers; it is advisible to reassemble the mounting details to the bolts and temporarily secure them with the nuts so that none of the parts is mislaid. Refitment is a direct reversal of these instructions. To remove the inner condenser unit, which feeds the igniter plug in No. 2 combustion chamber, it will first be necessary to remove the outer condenser unit, as the three bolts which secure the unit to the bracket are common to both units. Having removed the outer condenser unit, as described previously, disconnect the L.T. supply cable and the ignition cable, and withdraw the inner condenser unit complete with the bolts, spacers, and rubber washers. Refitment is a direct reversal of these instructions.

Ignition cables

7. Each ignition cable is in one piece and is supported throughout its length by a number of clips. To remove either ignition cable, disconnect the cable from the condenser unit and from the igniter plug, as described previously, and remove the nuts and spring washers which secure the cable clip or clips. The ignition cable for the igniter plug in No. 2 combustion chamber is supported by three clips, and the cable for the igniter plug in No. 14 combustion chamber by one clip. Refitment is a direct reversal of these instructions.

Chapter 9

MISCELLANEOUS

(This chapter supersedes that issued with A.L. No. 38)

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

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1. This chapter contains instructions for fitting and removing the miscellaneous items including starter and the engine-driven accessories, reference should be made also to the relevant aircraft Air Publication for any instructions regarding the method of fitting aircraft items, such as cooling shrouds and ducts, and connecting up the accessories to the aircraft services. The general information contained in Chapter 1 of this Section should be referred to as necessary.

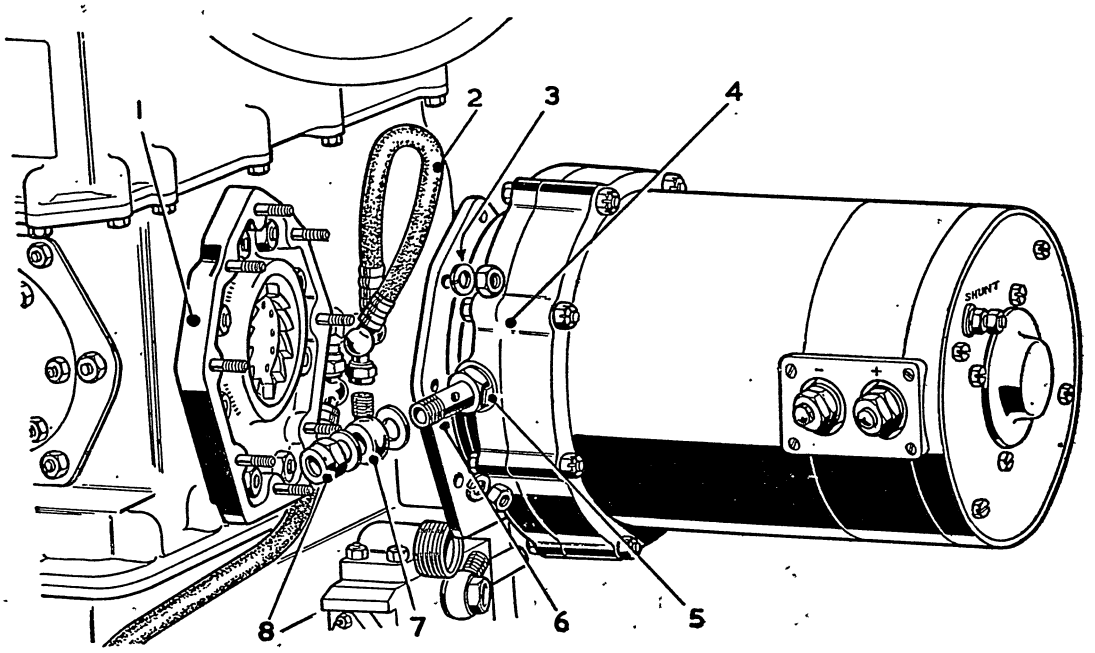
Electric starter

2. Before fitting the electric starter (*fig.* 1), check that it is the correct type for the installation and that it has not been damaged whilst in store or in transit. Unless these parts are in position already, prepare the starter for installation by fitting a new tab-washer (Part No. N1617) and banjo pillar (Part No. N2389) to the $\frac{1}{8}$ in. B.S.P. oil feed hole in the starter gearbox; lock the banjo pillar by bending up the tab-washer.

3. Remove the union nut and blanking nipple from the banjo on the rear side of the starter coupling assembly on the port side of the bottom accessory box and connect one end of the flexible oil pipe (Part No. 23572) to the banjo. Remove the eight $\frac{5}{16}$ in. B.S.F. plain nuts and spring washers and the blanking cover from the starter mounting face on the engine. The eight studs which secure the starter coupling to the bottom accessory box must be at least 0·020 in. below the level of the starter mounting face and this should be checked with a straight-edge: if necessary, file the studs down.

3A. Oil leakage at the joint between the electric starter and the engine, can be caused or aggravated by the fitment of starters with distorted flanges: For this reason, care must be taken to ensure that the starter flange is neither damaged nor deformed. Deformation of the flange could be caused, when the starter is being removed if the securing nuts at the top only were slackened off as the entire weight of the starter would then be transferred to the lower portion of the flange. Therefore, when removing the starter, the lower nuts should be slackened off first, and when fitting the starter it is essential to tighten the nuts at the top of the flange before those at the bottom.

4. Ensure that the mating faces of the starter coupling assembly and the starter gearbox, which forms part of the starter, are clean and undamaged; position a new joint washer (Part No. 75797) over the studs on the starter coupling. Mount the starter, complete with gearbox, on the starter coupling; using claw spanner (T72135) screw on and tighten the eight spring washers and plain nuts. Unless certain that the starter



1 STARTER COUPLING ASSEMBLY
2 FLEXIBLE OIL PIPE
3 EIGHT $\frac{5}{16}$ IN. B.S.F. NUTS AND SPRING WASHERS
4 STARTER COMPLETE WITH GEARBOX
5 TAB-WASHER
6 BANJO PILLAR
7 OIL FEED BANJO
8 CAP NUT

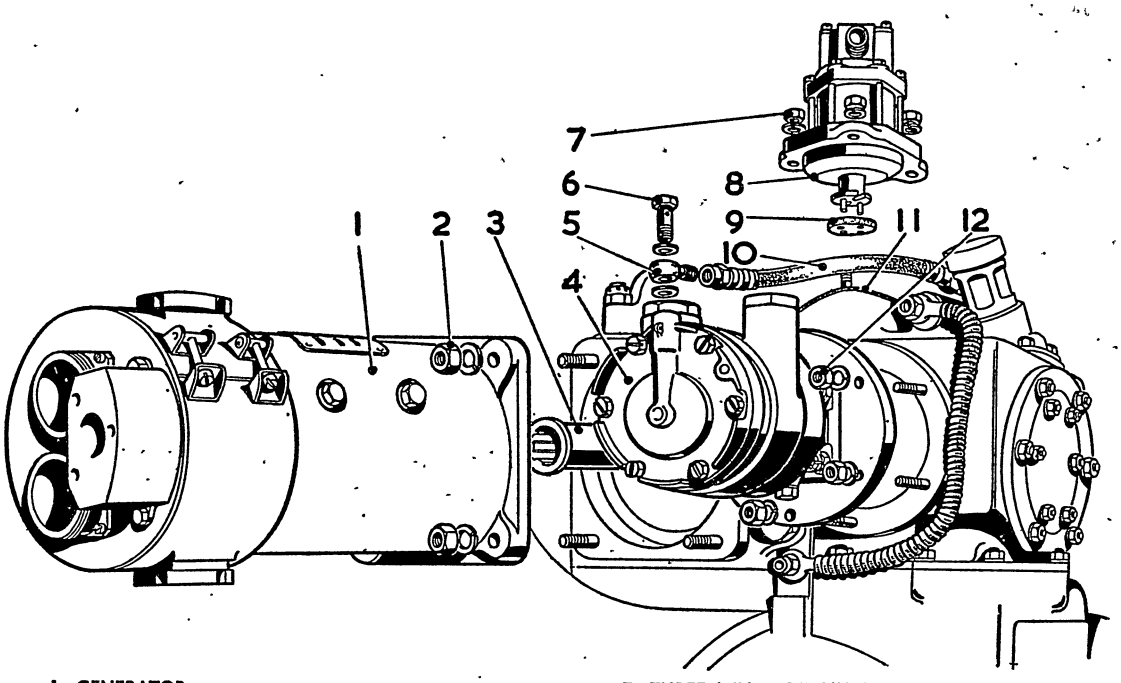
Fig. 1. Electric starter

gearbox has been primed with oil, it must be primed as described in Part 3, Sect. 2, Chap. 1. Using new sealing washers (Part No. 1406–42 or N1518), place the banjo (Part No. N2230) on the banjo pillar in the starter gearbox and screw on the cap-nut (Part No. N663). Connect the free end of the flexible oil pipe to the banjo; tighten and wire-lock the cap-nut and the union nuts at each end of the pipe.

5. If the engine is installed in an aircraft, it will be necessary to remove the low pressure fuel filter and in the case of the Vampire installation, the access panel in bulkhead 4 to obtain access to the starter motor. The procedure given in para. 3 and 4 will also differ. The flexible oil pipe (Part No. 23572) must be connected first to the banjo in the starter gearbox, as the H.P. cut-off valve linkage and bellcrank preclude access after the starter is mounted on the engine. It will also be necessary to remove the securing nuts and withdraw the fuel pump to connect the other end of the pipe to its banjo at the rear of the starter coupling. The fuel pipe connections need not be disturbed. When the connections have been made and locked, refit the fuel pump and the low pressure fuel filter; connect the three leads (positive, negative, and shunt) to the appropriate terminals on the starter, ensuring that the positive and negative leads are not crossed. On the Vampire installation, if the leads are crossed the slow engagement stage would not operate, and the engine would be initially rotated by the second stage.

Tachometer generator

6. Before fitting the tachometer generator (*fig.* 2), check that it is the correct type for the installation and that it has not been damaged whilst in store or in transit. Turn the driving dog on the spindle to check the generator for freedom of rotation. Remove the three $\frac{1}{4}$ in. B.S.F. plain nuts, spring washers and the blanking cover from the tachometer generator mounting face on the top accessory box. Verify that there is sufficient clearance to accommodate the leather coupling between the plate carrying the driving pins of the generator and the engine drive shaft assembly as the generator bearings are not designed to withstand excessive end thrust. Packing shim, Part No. 23005, must be fitted between the generator and the facing on the top accessory box.



1 GENERATOR
2 FOUR ⅜ B.S.F. NUTS AND SPRING WASHERS
3 GENERATOR DRIVING SHAFT
4 VACUUM PUMP
5 BANJO
6 BANJO BOLT
7 THREE ¼ IN. B.S.F. NUTS AND SPRING WASHERS
8 TACHOMETER GENERATOR
9 LEATHER COUPLING
10 VACUUM PUMP OIL PIPE
11 PACKING SHIM
12 SIX ¼ in. B.S.F. NUTS AND SPRING WASHERS

Fig. 2. Tachometer generator, generator, and vacuum pump

7. Ensure that the mating faces are clean and undamaged, apply a thin film of jointing compound to both faces, fit the packing shim and mount the tachometer generator with the leather coupling in position, on the top accessory box, ensuring that both sets of driving pins engage with the holes in the leather coupling. If necessary, turn the impeller by hand to assist engagement. Refit the three spring washers and plain nuts to secure the tachometer generator. If the engine is installed in an aircraft, connect the three leads to the appropriate terminals in the tachometer generator, red lead to terminal No. 1, green to No. 2, and blue to No. 3.

Generator

8. Before fitting the generator (*fig.* 2), check that it is of the correct type for the installation and that it has not been damaged while in store or in transit. Check that the generator driving shaft Part No. 24933, or 71207 if Mod. 546 is embodied, is a good fit on the armature splines. Remove the four ⅜ in. B.S.F. plain nuts, spring washers and the blanking cover from the generator mounting face at the rear of the top accessory box.

9. Ensure that the mating faces of the generator and the accessory box, and the recess into which the generator spigot fits are clean and undamaged. Apply a thin coating of graphite grease to the inside of the drive in the accessory box, internally and externally to the generator driving shaft, and to the splines on the generator armature spindle. The coating of grease, which must not be excessive otherwise it may enter the generator during subsequent running, is necessary to prevent corrosion, as the oil seal in the accessory box prevents engine oil reaching and protecting these parts. The coating should, therefore, be renewed whenever the parts are disturbed. Apply a thin film of jointing compound to one of the mating faces. Place the generator driving shaft into the engine drive in the accessory box; position the splines in the generator

spindle to align with the driving shaft and mount the generator on the accessory box; if necessary, turn the impeller by hand to assist engagement. Refit the bottom inner spring washer and plain nut first. Ensure that the generator is properly seated on its mounting face, screw on and evenly tighten the remaining spring washers and nuts using claw spanner T72143. If the engine is installed in an aircraft, connect the screened leads to the appropriate terminals on the generator. Couple the two cooling pipes to the appropriate unions on the generator, and blank off the remaining unions with the metal caps which are supplied with the generator.

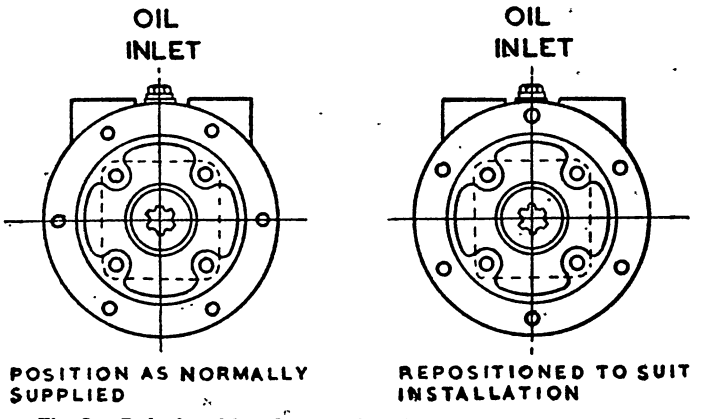


Fig. 3. Relationship of mounting flange to vacuum pump

Alternator (Mk. 3 engines only)

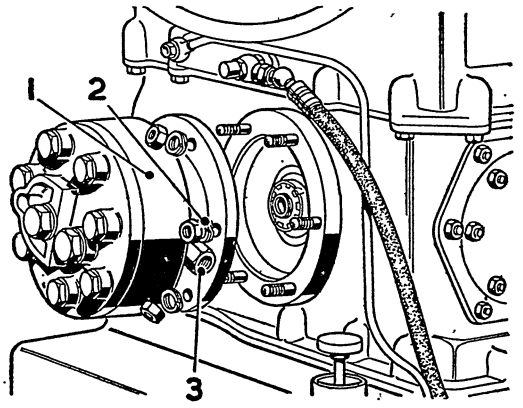
10. Before fitting the alternator, check that it is of the correct type for the installation and that it has not been damaged while in store or in transit. Check that the alternator driving shaft Part No. 24933, or 71207 if Mod. 546 is embodied, is a good fit on the splines of the alternator spindle. Remove the four $\frac{3}{8}$ in. B.S.F. plain nuts, spring washers and the blanking cover from the alternator mounting face at the rear of the top accessory box.

11. Ensure that the mating faces of the alternator and the accessory box are clean and undamaged, and the recess into which the alternator spigot fits is clean and undamaged. Apply a thin coating of graphite grease to the inside of the drive in the accessory box, internally and externally to the alternator driving shaft, and to the splines on the alternator spindle. The coating of grease, which must not be excessive or it may enter the alternator during subsequent running, is necessary to prevent corrosion, as the oil seal in the accessory box prevents engine oil from reaching and protecting these parts. The coating should, therefore, be renewed whenever the parts are disturbed. Apply a thin film of jointing compound to one of the mating faces, place the alternator driving shaft into the engine drive in the accessory box, position the splines on the alternator spindle to align with the driving shaft and mount the alternator on the accessory box; if necessary, turn the impeller by hand to assist engagement of the splines. Screw on and evenly tighten the four spring washers and plain nuts. If the engine is installed in an aircraft, connect the screened leads to the appropriate terminals on the alternator.

Vacuum pump

12. Before fitting the vacuum pump (*fig.* 2), check that it is of the correct type for the installation and that it has not been damaged while in store or in transit. If the circular mounting flange on the pump is not correctly positioned to suit the installation, extract the split pins and remove the four $\frac{1}{4}$ in. B.S.F. castle nuts from the studs which secure the mounting flange to the square flange at the driving end of the pump. Separate the mounting flange from the pump and reposition it as shown in fig. 3. Refit the four plain washers and castle nuts. Tighten the nuts and lock them with new split pins. Remove the transport blank from the vacuum pump and the dust plugs from the pump suction and exhaust ports. Rotate the drive shaft by hand to ensure that no foreign matter has entered the pump; only a moderate force should be required for rotation. Remove the six $\frac{1}{4}$ in. B.S.F. plain nuts, spring washers and the blanking cover from the starboard side of the top accessory box.

13. Ensure that the mating faces of the vacuum pump and the top accessory box are clean and undamaged, and apply a thin film of jointing compound to one of the faces. Mount the vacuum pump on the accessory box with the drive shaft aligned to engage with the engine drive; if necessary, turn the impeller by hand to assist engagement of the splines. Ensure that the pump is properly seated on the mounting face, screw on and evenly tighten the six spring washers and plain nuts. Refit the dust plugs to the



1 HYDRAULIC PUMP
2 SIX ¼ in. B.S.F. NUTS AND SPRING WASHERS
3 OIL DRAIN UNION

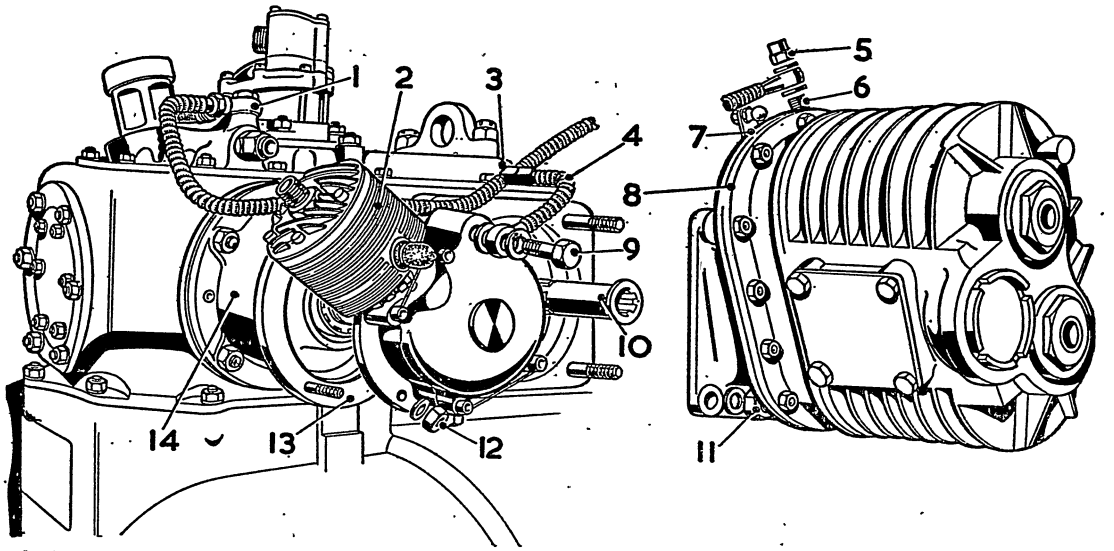
Fig. 4. Hydraulic pump

suction and exhaust ports, unless the relevant pipes are to be connected immediately. Remove the union nut and blanking nipple from one leg of the vacuum pump oil feed double banjo on the top accessory box cover, and connect one end of the flexible oil pipe Part No. 23780 to the banjo. Using new sealing washers Part No. AGS.1138–A and the banjo bolt Part No. AGS.1135–A, secure the free end of the flexible oil pipe to the oil inlet connection on the vacuum pump. Wire-lock the connections at both ends of the pipe.

Hydraulic pump

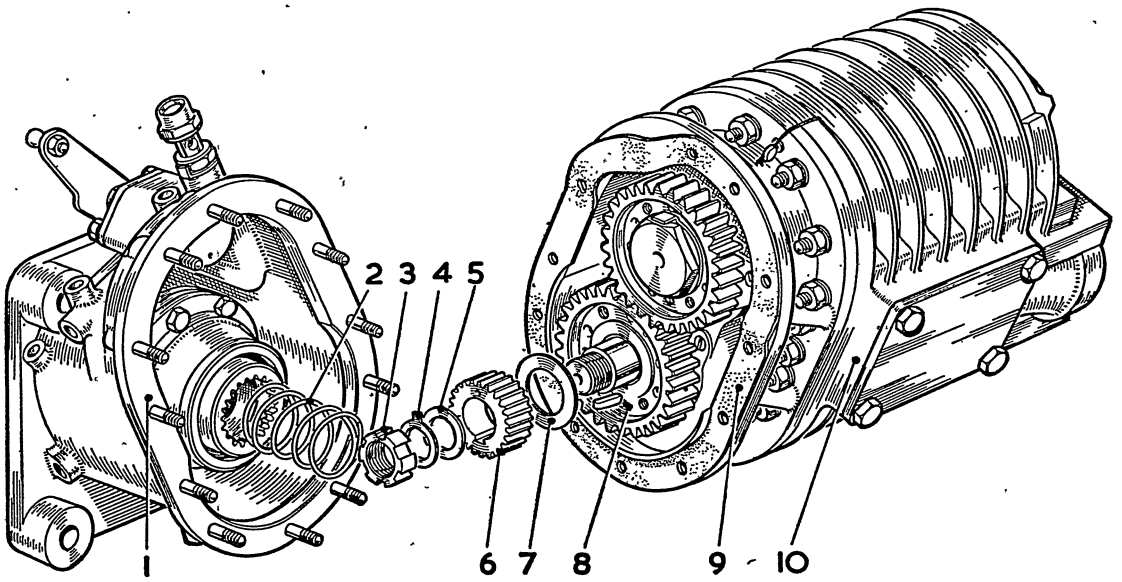
14. Before fitting the hydraulic pump (*fig.* 4), check that it is of the correct type for the installation and that it has not been damaged while in store or in transit. Check that the oil drain union Part No. N1975 is fitted to the drain hole in the pump body. Remove the six ¼ in. B.S.F. plain nuts, spring washers and the blanking cover from the front mounting face on the starboard side of the bottom accessory box.

15. Ensure that the mating faces of the hydraulic pump and the bottom accessory box are clean and undamaged, and apply a thin film of jointing compound to one of the faces. Mount the hydraulic pump on the accessory box with the drive shaft aligned to engage with the engine drive; if necessary, turn the impeller by hand to assist engagement of the splines. Screw on and evenly tighten the six spring washers and plain nuts.



1 COMPRESSOR OIL FEED BANJO
2 AIR COMPRESSOR
3 CABIN SUPERCHARGER OIL FEED PIPE
4 COMPRESSOR OIL FEED PIPE
5 CAP-NUT
6 OIL FEED BANJO PILLAR
7 CLUTCH CONTROL VALVE LEVER
8 CABIN SUPERCHARGER AND CLUTCH
9 COMPRESSOR OIL INLET FILTER SCREW
10 CABIN SUPERCHARGER DRIVING SHAFT
11 FOUR ⅜ in. B.S.F. NUTS AND SPRING WASHERS
12 SIX ¼ in. B.S.F. NUTS AND SPRING WASHERS
13 SIX ¼ in. B.S.F. BOLTS
14 COMPRESSOR DRIVE ADAPTER

Fig. 5. Air compressor, cabin supercharger and clutch



1 CLUTCH
2 SPRING
3 RING-NUT
4 TAB-WASHER
5 PACKING WASHER (N3566)
6 COUPLING
7 PACKING WASHER (N1122)
8 KEY
9 JOINT WASHER
10 CABIN SUPERCHARGER

Fig. 6. Cabin supercharger and clutch

Unless the relevant pipes are to be connected immediately, ensure that the inlet and outlet ports and the drain union are properly blanked off.

Air compressor

16. Before fitting the air compressor (*fig.* 5), check that it is of the correct type for the installation and that it has not been damaged while in store or in transit. Ensure that the spring-loaded quill shaft is correctly fitted and retained by the circlip; the large end of the quill shaft is inserted into the air compressor crankshaft, the smaller end fitting into the engine drive. Remove the six $\frac{1}{4}$ in. B.S.F. plain nuts, spring washers, and bolts, and the blanking cover from the front mounting face on the port side of the top accessory box.

17. Ensure that the mating faces of the air compressor and the drive adapter are clean and undamaged, place the joint washer Part No. 32588, or Rotol G/382 (Stores Ref. 37L/830), on the air compressor flange, aligning the holes in the gasket with those in the flange. Mount the air compressor on the drive adapter at an angle of 60 deg. forward of the vertical position when a cabin supercharger or an alternator is fitted. The vertical position is used if neither of these accessories is used. Ensure that the air compressor quill shaft splines engage correctly with the drive in the adapter on the engine; if necessary, turn the impeller by hand to assist engagement. Fit the six bolts, screw on and evenly tighten the spring washers and plain nuts.

18. Remove the blanking nipple from the oil feed banjo on the top accessory box and connect one end of the compressor oil feed pipe (Part No. 21497 pre-Mod. 777, or 75646 when Mod. No. 777 is embodied), or in the case of Mk. 3 engines (Part No. 72224). Remove the oil inlet filter screw from the compressor crankcase and, using new sealing washers, connect the free end of the pipe to the air compressor crankcase. Wire-lock the union nut and the oil inlet filter screw. When a cabin supercharger is fitted it will be necessary to remove the silencer; oil feed pipe assembly, Part No. 21461 and 20478A, will also be required and reference should be made to Para. 23. Ensure that the air-intake filter assembly is correctly assembled to the compressor, fit the cooling duct and shroud, and connect up the air delivery pipe to the delivery valve assembly.

Chapter 10

FLEXIBLE PIPES

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

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GENERAL

1. This chapter contains instructions on the installation, periodic inspection, testing, and storage, of all the flexible pipes fitted to Mk. 2 and 3 engines.

2. The pipes are approved for operation in a temperature range from minus 40 deg. C. to + 150 deg. C., but the most economical life is obtained at normal operational conditions, i.e., 70 deg. C. to 90 deg. C.

3. The service life of a flexible pipe is dependent on a number of widely varying factors such as conditions of operation, proper handling during maintenance of associated engine components, and correct conditions of storage. Air Ministry letter dated 20.2.1957, reference A.74770/C.63/Air Eng. 2 (c) states that flexible pipes may be regarded as having an unrestricted life subject to their satisfactorily meeting the routine servicing requirements specified in sub-para. 1 and 2. During complete reconditioning of an engine it is standard practice to pressure test all flexible fuel and oil pipes, as described in Vol. 2, Part 5. During reconditioning, until all burner feed pipes are fitted with the Palmer type 200 end fittings introduced by mod. 1072, any unmodified burner feed pipe which is four years old, or more, is to be rejected and replaced by either an unmodified pipe which is less than four years old, or by a modified pipe incorporating Palmer type 200 end fittings. The routine servicing requirements are:—

(1) At the specified routine servicing periods all flexible pipes fitted to a Goblin engine must be visually examined for signs of the external defects described in para. 13 to 19.

(2) In addition to the visual examination all flexible burner feed pipes, whether fitted, or held as spares, must be pressure tested on the following occasions:—

A. User Units

(*i*) *Engine in normal operational use.* At each combustion chamber bay servicing period.

(*ii*) *Spare pipes in Unit Stores.* Prior to fitment to an engine if held in store for more than six months.

(*iii*) *Uninstalled reserve engine.* Prior to installation of the engine if held in reserve for more than six months.

B. Maintenance Units

(*i*) *Spare pipes in No. 40 Group M.U.* Prior to issue from stock, if received into stock more than six months previously.

(*ii*) *Uninstalled and installed engines held in storage at No. 40 and 41 Group M.U.* Prior to issue of engine or aircraft if held in storage for more than six months.

C. Engine Contractors and Service Repair Depots

(*i*) As instructed in Vol. 2, Part 5.

IDENTIFICATION

4. The date of manufacture and initial testing is indicated on the identification tag by the letter T followed by the month and the year, for example T7/50 indicates that the pipe was manufactured and tested in July, 1950. Pipes subsequently re-tested in accordance with the instructions contained in this chapter should be marked in a similar manner.

5. A few of the Palmer flexible pipes in service may bear the following marking under a method which is now obsolete. The month of manufacture for sizes from $\frac{5}{32}$ in. to $\frac{5}{8}$ in. bore inclusive, is represented by the individual letters of the words 'BEST COUPLING', for example T–1–C–8 indicates that the pipe was manufactured and tested on 1st May, 1948. For sizes from $\frac{3}{4}$ in. bore and over, the year of manufacture is represented by a letter as follows; 1944 = A, 1945 = B, 1946 = C, 1947 = D, 1948 = E. Therefore, E/9/T indicates that the pipe was manufactured and tested in September, 1948.

6. The various types of hose used for the flexible pipes may be identified by the number and colour of the thin identification lines that are painted along their length. The following types are used.

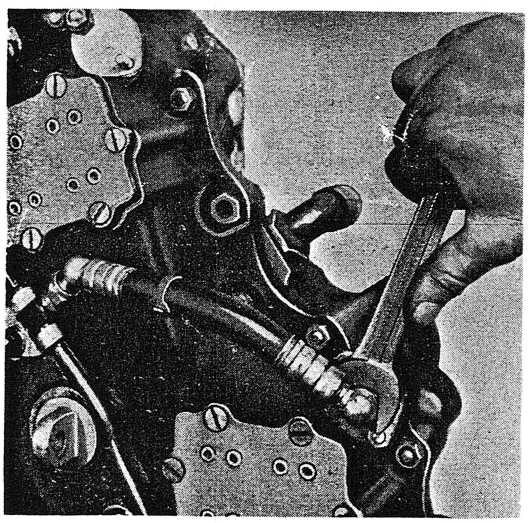


Fig. 1. Incorrect method of fitting pipe

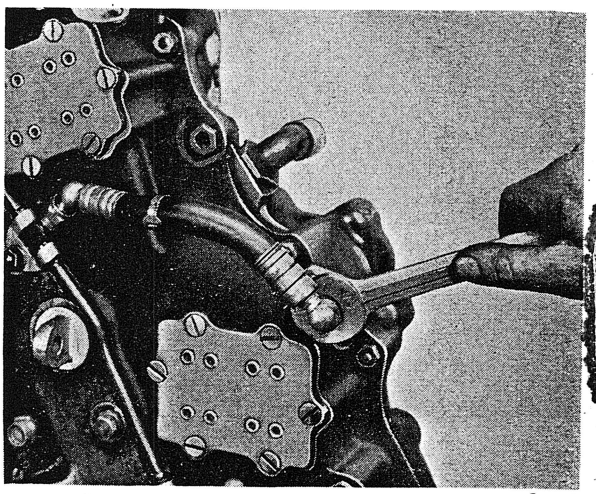


Fig. 2. Bend in pipe caused by incorrect fitting

Manufacturer's specification	Identification line(s)
Dunlop WH2/1	One brown line
Dunlop WH2/2	Two brown lines
Palmer 971	One green line
Palmer 965	Two green lines

INSTALLATION

7. Before fitting a new or replacement flexible pipe ensure that it bears the correct part number for the installation. Examine the end fittings of the pipe for corrosion or damage which may have occurred during storage or in transit. Flush through the bore of the pipe with clean kerosine, petrol or any of the fuels approved for the engine, and ensure that the end fittings, especially elbows or banjos, are clean. After flushing, oil pipes should be dried out with a clean compressed air jet to avoid fuel contamination of the lubricating oil. Flexible burner feed pipes must be pressure tested in accordance with the instructions given in para. 22 under the conditions defined in para. 3 sub-para. 2. If the pipe is not being fitted to the engine immediately, blank off the ends of the pipe with clean blanks.

8. The serviceability of flexible pipes is considerably affected by the amount they are bent when in position on the engine and the following table specifies the minimum bending radius.

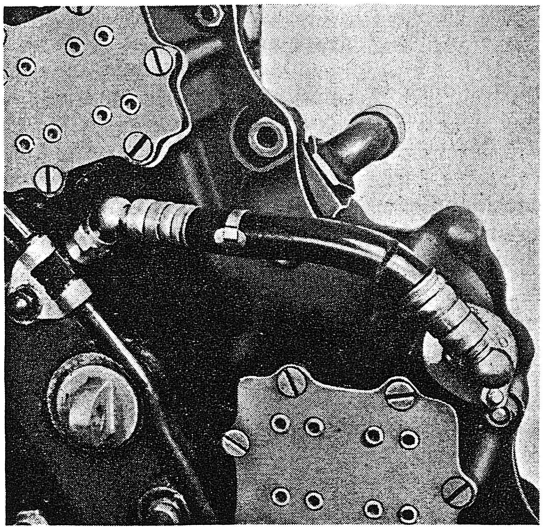


Fig. 3. Failure of pipe caused by incorrect fitting

Minimum bending radii

BORE (in.)	DUNLOP WH2/1 (1 brown) (in.)	DUNLOP WH2/2 (2 brown) (in.)	PALMER 971 (1 green) (in.)	PALMER 565 (2 green) (in.)
$\frac{5}{32}$	$1\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{2}$	—
$\frac{1}{4}$	2	3	2	2
$\frac{3}{8}$	$2\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$
$\frac{1}{2}$	3	$4\frac{1}{2}$	3	3
$\frac{5}{8}$	$3\frac{3}{4}$	$5\frac{1}{2}$	4	$3\frac{1}{2}$
$\frac{3}{4}$	$4\frac{1}{2}$	7	5	4
1	6	10	6	5

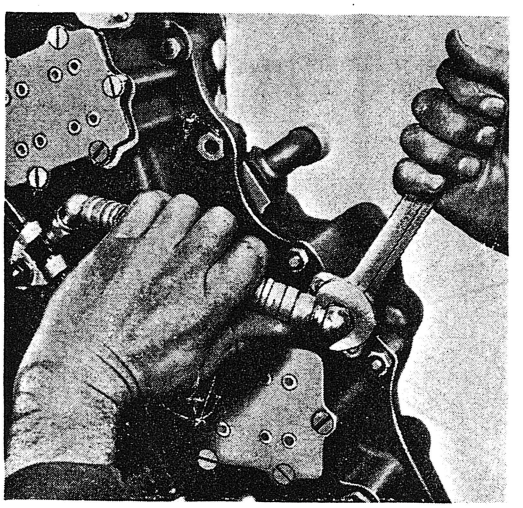


Fig. 4. Correct method of fitting flexible pipe

9. The bending radius must always be kept within the limits and a sharp bend at the point where the hose enters the end fitting must be avoided. Fig. 1 and 2 illustrate this effect in a burner feed pipe. In fig. 1 the pipe has been loosely assembled and the union nut tightened without holding the pipe in position. As the union nut begins to lock the union tends to rotate and bend the pipe as shown in fig. 2. Failure of the pipe as illustrated in fig. 3 will occur after a short period of engine running.

10. The correct method of fitting is to assemble the pipe loosely with the union nuts finger-tight and allow the pipe to take up its natural run. Where elbows or special end fittings are used it must be ensured that the assembly is fitted the correct way round and that there are no twists in the pipe; the latter can be verified from the thin identification lines marked along the length of the pipe. Hold the pipe as shown in fig. 4 and tighten the union nuts; avoid over-tightening which can cause damage to nipple faces and cone seatings. Fig. 5 shows a correctly fitted burner feed pipe. If clips are employed for support, care should be taken to avoid stressing the hose, particularly if the clips are adjacent to the end fittings. Suitable packing should be used to prevent the clips from damaging the hose cover. Wire-lock the union nuts.

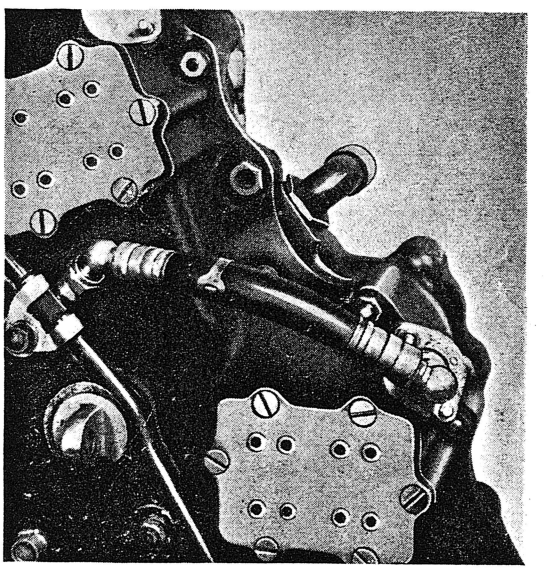


Fig. 5. Correctly fitted flexible pipe

(A.L.81, June 57)

SERVICING PERIODS

11. The following visual checks should be made on all flexible pipes during each engine servicing period. A blank should be fitted to the end of any pipe that is disconnected to facilitate a servicing operation and care must be taken to avoid excessive bending. If a pipe is removed, it should be flushed through before it is refitted.

12. Flexibility of the pipes is considerably reduced at very low temperatures and great care must be exercised in handling under severe arctic conditions. In these conditions removal should only be undertaken when a pipe is warm after engine running, or after first applying heat from an external source, i.e., a warm blanket or similar device. If neither of these methods is possible, disconnect both ends of the pipe and remove it without distortion to the installed shape. Do not bend the pipe with one end anchored whilst it is in the temporary hard state. After removal, the pipe should be kept in a warm place until it is refitted.

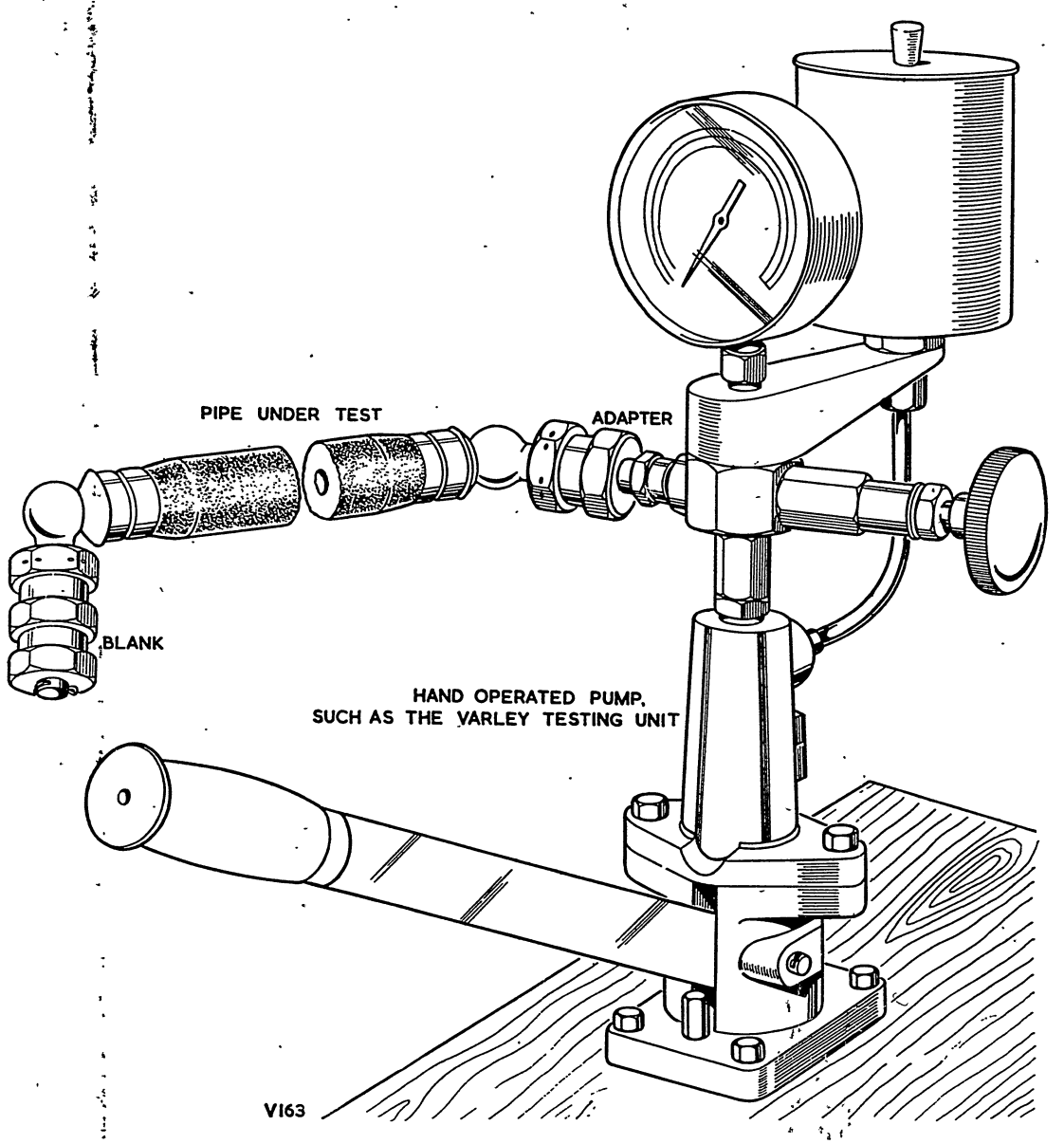


Fig. 6. Suitable pressure testing unit

13. *End fittings*—Examine for evidence of corrosion, leakage, crack or other damage. A pipe should be rejected when corrosion has caused excessive pitting, especially on the outer ferrule. If leakage at the end fittings is suspected, which is normally indicated by a liquid stain at the junction of the hose and ferrule, the pipe should be removed and pressure tested as described in para. 22. Check the general condition of the union nuts including the locking-wire holes, and the welded or brazed joints on angle end fittings. If the pipe has been disconnected, check the threads of the union nuts and the condition of the mating faces. The pipe should be rejected if the banjo faces or the spherical or conical nipples are badly scored, dented, or otherwise damaged.

14. *Kinking*—This defect is usually caused by bad installation, such as bending the pipe through a smaller radius than that specified as the minimum. If the pipe has taken up a permanent set it should be rejected.

15. *Chafed or cut covers*—The pipe run should be altered if local chafing or cutting of the hose cover has occurred. If clips are fitted, care must be taken to avoid stressing the hose, particularly adjacent to the end fittings, and suitable packing should be used to prevent the clips from damaging the cover. If the cover is worn or cut through to the wire braiding, the pipe should be rejected.

16. *Cracked covers*—Deep cracks may develop in the hose cover if the pipe is subjected to abnormal conditions such as excessive heat or local tension due to bad installation. If the cover is cracked through to the wire braiding the pipe should be rejected, but if it is not cracked to this extent, the pipe may remain in service subject to a satisfactory pressure test.

17. *Surface ageing*—Minute cracks may develop on the surface of the hose cover as a result of surface ageing. No premature failure need be anticipated, as the serviceability of the hose is unimpaired, but the cracks may tend to deepen after long periods of service.

18. *Blistered covers*—Blisters may be caused by the seepage of air or liquid through the wall of the pipe. If air emerges after the blister has been carefully punctured with a needle, the pipe should be pressure tested, but if liquid emerges the pipe should be rejected. Provided that no further leakage occurs when the pipe is pressure tested it may be regarded as serviceable.

19. *Deterioration*—External deterioration is usually denoted by surface hardening and loss of flexibility. The pipe should be removed and pressure tested if serviceability [illegible] ful.

TESTING

20. All flexible pipes must be [illegible] each reconditioning period of th[illegible] engine. During routine servicing flexible b[illegible] pipes must be pressure tested [illegible] conditions defined in para. 3, sub-[illegible]

21. Before carrying out the follo[illegible] the end fittings and hose should be inspected as detailed in para. 11 to 19.

22. *Pressure test*—The equipment [illegible] to carry out the pressure test co[illegible] hand pump with a pressure gauge a[illegible] suitable adapters and blanks. T[illegible] testing unit illustrated in fig. 6 is s[illegible]table for this test and a list of the adapters a[illegible] that will be required for individua[illegible] pipes is given in the table at the end of thi[illegible] chapter. The necessary adapter can be ma[illegible] from local resources according to t[illegible] sioned sketch given in Section 1.

23. The test fluid should be kerosi[illegible] or any of the fuels approved for t[illegible] and it should be used at the [illegible] ambient temperature. Alternativel[illegible] fluid may be water containing not less than 10 per cent and not more than 20 p[illegible] volume of Shell Dromus Oil B (solu[illegible] oil) inter-services designation ZX[illegible] Ref. 34D/243, which forms a white [illegible] in water and thus assists in the [illegible] of leaks. The fuel delivery of t[illegible] testing unit is only 0·05 cu. in. per [illegible] the pipe to be tested must be filled [illegible] by hand before connecting to the [illegible] may not be necessary with a[illegible] equipment.

24. Connect the pipe to the tes[illegible] operate the pump to ensure that [illegible] with fluid. If necessary the blank a[illegible] the loose end must be used as an air bleed. [illegible]pply the correct fluid pressure, applicab[illegible] to the particular pipe under test, specif[illegible]ed in the tables at the end of this chapter. Maintain the pressure for three minutes. D[illegible] the first two minutes of the test the pi[illegible]

retained in approximately its natural shape, including any permanent set the pipe may have assumed. During the last minute of the test the pipe must be flexed (say five complete flexings) through approximately plus and minus 15 deg. During this test careful examination must be made for leakage. No leaks are permissible.

...nding test—A continuity test should ...l between the end fittings using a ... battery, with a voltage not exceeding ... olts, or other approved means. The resistance between the end fittings should not exceed ...050 ohm., or 0·025 ohm. per foot, ... is the greater.

... test—On pipes with straight end ...low test is unnecessary, but a visual ...uld be made through the bore of the pipe for any restriction or damage to the ... slight irregularities in the bore are ...le to minor manufacturing dis... which are of no consequence. On ... with angle or banjo end fittings a ...hould be made in both directions to ... restriction in the bore. Using ...petrol, or any of the fuels approved ...gine, with a "head" of 12 in. and a ...ed, the flow should not be less than ...fied in the following table.

Bore (in.)	Flow (Gall. per min.)	Flow (Gall. per hr.)
$\frac{5}{32}$	0·18	11
$\frac{1}{4}$	0·25	15
$\frac{3}{8}$	0·40	24
$\frac{1}{2}$	0·80	48
$\frac{5}{8}$	1·42	85
$\frac{3}{4}$	1·83	110
1	3·75	225

STORAGE

27. The pipes should be stored in a dark location, preferably in boxes, where the temperature does not exceed 15 deg. C. They should not be stored in a state of stress, i.e., tightly coiled or piled in such numbers that will cause the bottom layers to be partially flattened, and care should be taken to avoid damage to hose covers by the end fittings. Blanking caps should always be fitted to the ends of the pipes, and these must remain in position until the pipes are required for service.

28. In hot climates, pipes should be stored in the coolest possible place and where the air can circulate freely around them, avoiding places close to walls of metallic construction. High temperatures will cause premature ageing with subsequent hardening of the hose outer cover.

29. To protect the end fittings in a very moist atmosphere, preservative (Stores Ref. 34A/191) should be used. Heat the preservative to 100 deg. C. and dip the end fittings into the solution. This preservative may be removed with petrol.

TABLE OF PIPES ADAPTERS BLANKS AND PRESSURES

	Pipe	Bore in.	Adapter for use with Varley testing unit	Blank	Test pressure lb. per sq. in.
...k. 2	Burner feed (16 off)	$\frac{1}{4}$	$\frac{1}{8}$ in. B.S.P. to $\frac{1}{4}$ in. B.S.P.	Union AGS.949/B Blank ~~AGS.1197/B~~ AGS.1140/B Union nut AGS.1216/B	1600
...k. 3	Burner feed (16 off)	$\frac{1}{4}$	$\frac{1}{8}$ in. B.S.P. to $\frac{1}{4}$ in. B.S.P.	Union AGS.949/B Blank ~~AGS.1197/B~~ AGS.1140/B. Union nut AGS.1216/B	2600

Cabin supercharger and clutch (Mk. 2 engines only)

19. Before fitting the cabin supercharger and clutch (*fig.* 5), check that they are of the correct type for the installation, and that they have not been damaged while in store or in transit. Ensure that the clutch has been correctly assembled to the cabin supercharger. If these components have been supplied separately, the clutch should be assembled to the cabin supercharger in the following manner.

20. Ensure that the following parts which are illustrated in fig. 6 are available. Joint washer Part No. 21940, packing washer Part No. N1122, coupling Part No. 19914, packing washer Part No. N3566, tab-washer Part No. N3735, ring-nut Part No. N748, spring Part No. 16788, and the key for the coupling which is supplied with the cabin supercharger.

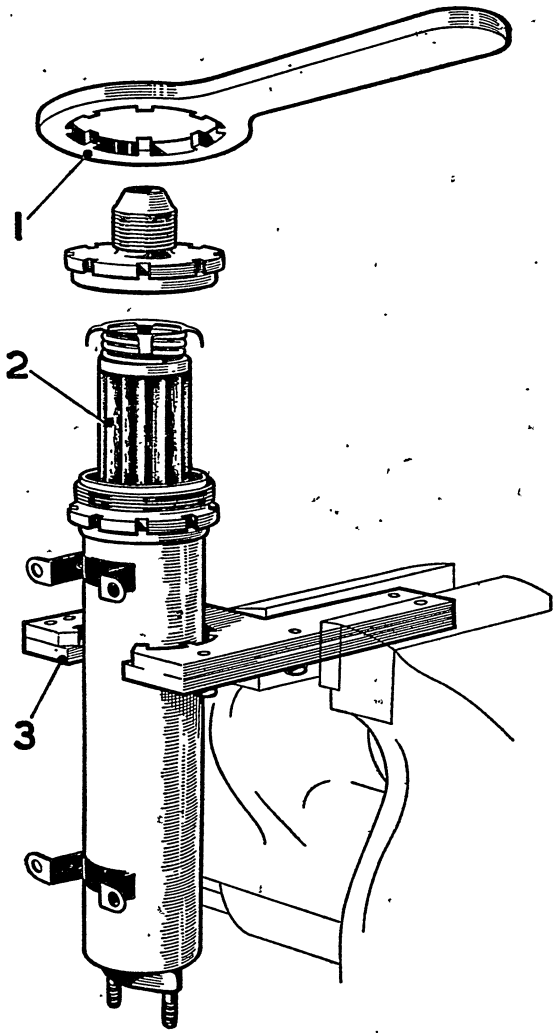
21. Remove the protective covers fitted to the cabin supercharger and, if an unserviceable accessory is being removed from the engine, transfer the covers to it. Clamp the cabin supercharger in the vice block T70167. Ensure that the driving gear is right back against the shoulder on the shaft, and lock the gears with the peg provided at the top of the vice block. Assemble the packing washer Part No. N1122 to the driving shaft, followed by the coupling, ensuring that the key is correctly fitted in its keyway, the packing washer Part No. N3566, tab-washer and ring-nut. Tighten the ring-nut with serrated spanner T70168, and lock it by turning one of the seven tabs into one of the serrations in the nut. Remove the cabin supercharger from the vice block.

Note . . .

The instructions given in Chapter 1 *regarding wear of splines are particularly applicable to the drive assembly, as "stepped" splines on the coupling, which is attached to the supercharger driving shaft, may prevent engagement of the clutch.*

22. Remove the nuts and spring washers from the studs on the face of the clutch housing and assemble the joint washer Part No. 21940 over the studs. Apply a thin film of engine oil to the coupling and the splines inside the inner cone of the clutch. Place the spring over the boss in the end of the inner cone. Position the cabin supercharger on to the studs, ensuring that the nut on the driving shaft locates correctly in the end of the spring; rotate the clutch shaft by hand to assist engagement of the splines, the friction of the sealing rings within the clutch being sufficient to rotate the inner cone under these no-load conditions. Tap the cabin supercharger right home on the studs, and assemble and tighten the twelve spring washers and nuts.

23. Before fitting the cabin supercharger and clutch to the engine, ensure that the oil feed banjo pillar Part No. N2389 is fitted to the clutch and locked with a tab-washer



1 SPLINE SPANNER (T70262)
2 AIR FILTER ASSEMBLY
3 VICE BLOCK (T73347)

Fig. 7. Air filter dismantled

(A.L. 67, July, 54)

Part No. 2305–8, and also that the clutch control valve lever Part No. 19028 is correctly fitted. Remove the union nut and blanking nipple from the oil feed banjo on the top accessory box and connect one end of the cabin supercharger oil feed pipe assembly Part No. 21461. Connect the union nut at one end of the air compressor oil feed pipe Part No. 20478A to the junction on the cabin supercharger pipe, remove the oil inlet filter screw from the compressor crankcase and connect the other end of the pipe to the air compressor. Wire-lock the union nut and the oil inlet filter screw.

24. Remove the four $\frac{3}{8}$ in. B.S.F. plain nuts, spring washers and the blanking cover, from the rear mounting face on the port side of the top accessory box. Ensure that the mating faces of the cabin supercharger clutch and the accessory box are clean and undamaged, and apply a thin film of jointing compound to one of the faces. Assemble the driving shaft Part No. 21837, or 71224 if Mod. 546 is embodied, into the drive in the accessory box. Mount the cabin supercharger and clutch on the accessory box, ensuring that the splines on the clutch shaft engage correctly with those in the driving shaft within the engine; if necessary, turn the impeller by hand to assist engagement. Ensure that the cabin supercharger is properly seated on the mounting face, screw on and evenly tighten the four spring washers and plain nuts. Using new sealing washers Part No. 1406–42 or N1518, connect the free end of the cabin supercharger oil feed pipe to the banjo pillar on the clutch, screw on and wire-lock the cap-nut Part No. N663. If the engine is installed in an aircraft, connect the control to the lever on the clutch, and connect up the inlet and outlet air pipes to the cabin supercharger.

Removing accessories

25. The operations required for removing the starter and the engine-driven accessories are largely a matter of reversing the sequence given in the foregoing paragraphs. In each case after removal, the correct transport blanks must be fitted to the mounting faces of both the engine and accessories, and in the case of the accessories, all other apertures, unions, or openings, must be blanked off. The gasket between the air compressor and the engine should remain with the air compressor. When removing the electric starter for the reasons given in para. 3A, the lower nuts should be slackened off first. In some instances it may be necessary to transfer the engine parts such as banjo pillars, etc., mentioned in this chapter, from the accessory which has been removed to the accessory which is to be fitted in its place. Attention is drawn to the remarks with regard to anti-corrosion precautions in Chapter 1.

Air filters, rear-bearing cooling

26. Before either of the rear-bearing air-cooling air filters can be removed, it will first be necessary to remove the adjacent combustion chambers as described in Part 3, Sect. 3, Chap. 1. Remove the nut and tab-washer from the short diffuser bolt between No. 14 and 15 combustion chambers, or between No. 6 and 7 combustion chambers, according to which air filter is to be removed. Remove the two $\frac{1}{4}$ in. B.S.F. plain nuts, spring washers and bolts, from the flanged joint between the front and intermediate sections of the relevant rear-bearing air-cooling pipe. Unscrew the union nut which secures the intermediate section of the air-cooling pipe to the air filter. Carefully ease the pipe out of position and remove the joint washer which is situated between the two pipe flanges. Remove the two 2 B.A. plain nuts and spring washers which secure the flange at the forward end of the rear section of the air-cooling pipe to the rear of the air filter. Remove the four bolts which secure the air filter to the centre casing and ease the filter assembly forward until the studs at the rear are clear of the pipe flange. Retain the adjusting shim which is between the two joint washers at the rear of the filter.

27. Place the air filter assembly in vice block (T73347) and unscrew the end with spline spanner (T70262) (*fig.* 7). No attempt must be made to clean the air filter element. If excessive foreign matter is present a new filter must be fitted.

28. Reassembly is a direct reversal of the removal and dismantling instructions contained in the preceding paragraphs. Tab-washer (Part No. AGS.195–12) fitted on the short diffuser bolt and joint washers (Part No. N1386 and N1224) fitted between the pipe flanges at the front, and between the pipe flange and the filter, must be renewed if necessary. Ensure that the original shim, or shims, is refitted between the pipe flange and the rear of the air filter.