Chapter Twenty-two

GENERAL INFORMATION

(relating to overhaul, recond itioning, repair, and salvage)

Contents

Illustrations

THIS CHAPTER which is applicable to both the Ghost 48 Mk. 1 and the Ghost 48 Mk. 2, contains general information relating to overhaul, reconditioning, repair, and salvage, and should be read in conjunction with chapters 23 to 52.

DISMANTLING THE ENGINE

The following information should be read in conjunction with chapters 23 and 24 which respectively contain instructions for dismantling the engine and dismantling the sub-assemblies.

It is assumed that the engine will be received without the air compressor, generator, tachometer generator, hydraulic pump, and turbo starter, or that they are removed from the engine before dismantling commences. The exhaust cone and fireguard will be received separately.

As the engine is dismantled, each sub-assembly should be treated as a complete unit and care must be taken that small components do not become mixed or placed with the wrong assembly.

Locking devices

Where the removal of split pins and tab washers is not specified, it is assumed that these and any other locking devices will be released by the operator before proceeding with dismantling. To avoid damage to the hole in union nuts and locking tabs, etc., it is important that locking wire is cut and then removed from the locking locations. The wire must not be broken by twisting or stretching either with pliers or by unscrewing the nut or part concerned. All tab washers, split pins, locking washers and joint washers should be discarded immediately after removal.

Shims

Distance washers and shims should be tied to their associated parts and subjected to inspection. Retaining shims with their associated parts will save time during subsequent reassembly.

Component marking

Before a component is removed, ensure that it is clearly marked to indicate its position on the engine, unless the design is such as to ensure refitment in the correct position. This is of particular importance with components which can be turned through 90 or 180 deg. Unless the operator is familiar with the particular engine he is concerned with, it is sound practice to make written notes of the location of, or to label, all small parts so that each part can be refitted with absolute certainty in its original position during reassembly.

Where temporary marking is necessary, as, for instance, when it is required to draw the inspector's attention to a crack, or other defect, either with a view to determining its rate of increase or to indicate the area where a more thorough examination is considered necessary, chalk, soapstone, or some other similar substance which will not leave any carbon deposit should be used. Marking media such as lead pencil, wax crayons and grease pencils

should not be used to mark the position of items, or defects, as instances of failure have occurred on items subject to high temperature, due to carburisation and subsequent hardening or embrittlement of the immediate area surrounding the carbon deposit when subjected to intense heat. Chalk and soapstone will not leave any carbon deposit.

Evidence

Filters, and the oil which drains from the engine should be examined for evidence of scoring or wear in the form of metallic particles ; similarly, an indication of the condition of components can be obtained if they are examined whilst burnt oil and signs of running are still visible.

Use of tools

When components are difficult to remove or to separate, due to the adhesion of jointing compound between the mating faces, or the close fitting of dowels or studs, light tapping with a rubber or raw-hide mallet around the periphery of the component should be sufficient to break the joint. In no circumstances should any form of wedge be inserted between the mating faces in an endeavour to part them.

The method of dismantling described, assumes that the extractors provided in the tool kit will be used. In some instances, however, the fit of mating parts may render a tool unnecessary as the operation can be effected by hand.

Where, in the following chapters, reference is made to " pressing off " or " pressing out " a component, i.e., ball bearing, bearing housing, shaft, etc., it is assumed that a suitable press will be utilised when necessary, although certain pressing operations may possibly be effected by hand without any mechanical assistance.

Blanking

All apertures, pipes, etc., should be blanked off on both the engine casing and accessories directly they are exposed, unless the component in question is being completely dismantled immediately. In the absence of proper blanking plates, caps or plugs, cavities should be blanked off with improvised plates of metal or plywood ; pipes and similar openings may be blanked off with rubber caps. Cotton waste, rags, etc., must never be used for these purposes, as small particles may enter the oil-ways or the fuel system with disastrous results.

Certain obvious operations, such as the removal of blanking plugs, pipe union bodies, etc., have been omitted. Such items must be removed for cleaning, and unless definite instructions to the contrary are given, the necessity for their removal must be assumed.

Miscellaneous

As each sub-assembly is dismantled the respective components should be placed in a box allocated to the particular sub-assembly, and the box marked with the engine number. Ball and roller bearings should be wrapped in greaseproof paper for protection, and when the parts of a bearing are separated the outer and inner races should be tied to the centre cage before wrapping. Re-usable washers, distance pieces, spacers, etc., should be tied to their respective main component, so that upon reassembly time will not be lost in checking components to obtain the correct washer thickness.

Where reference is made to turning or bending down the locking tabs of tab washers, a small chisel-pointed punch in conjunction with a light hammer should be used. Similarly, a cup locking washer is best opened with a small flat-nosed punch and a light hammer.

Seeger circlips should be removed with a pair of Seeger circlip pliers. The use of a screwdriver or pointed tool for this purpose is liable to damage the circlip groove as well as the circlip.

Where jointing compound has been employed, all traces of the previous coating must be removed and the mating surfaces thoroughly cleaned before reassembly. When the joint faces are perfectly clean, ensure that there are no nicks, burrs, scratches or other damage which might prevent the components seating correctly.

REASSEMBLING THE ENGINE

The following information should be read in conjunction with chapters 33 and 34 which respectively contain instructions for reassembling the sub-assemblies and reassembling the complete engine.

Scrupulous cleanliness, the proper use of the correct tools, and attention to detail are vital at every stage of the rebuilding operations. Ball and roller bearings must be treated with particular care.

Application of blanks

Any loose parts, small tools, or foreign bodies left within, or entering the engine after assembly might result in extensive damage when the engine is started and run. Even a microscopic particle can cause failure of a fuel system component. Therefore, blanks and covers should not be removed until the aperture they protect can be closed by the assembly of the related parts, and as assembly proceeds all unconnected unions and apertures should be blanked off.

Splined and serrated drives

Splined and serrated drives should be lubricated with Shell grease Rhodina No. 2 or a grease such as British Specification D.T.D. 825. If, however, these are not available some other lubricant may be used—e.g. engine oil. On no account should these drives be assembled dry.

Lubrication of moving parts

All moving parts should be oiled with clean engine oil during assembly to ensure adequate lubrication during the few seconds immediately after the first start when the normal pressure lubrication may not have reached the bearing surfaces. Plain

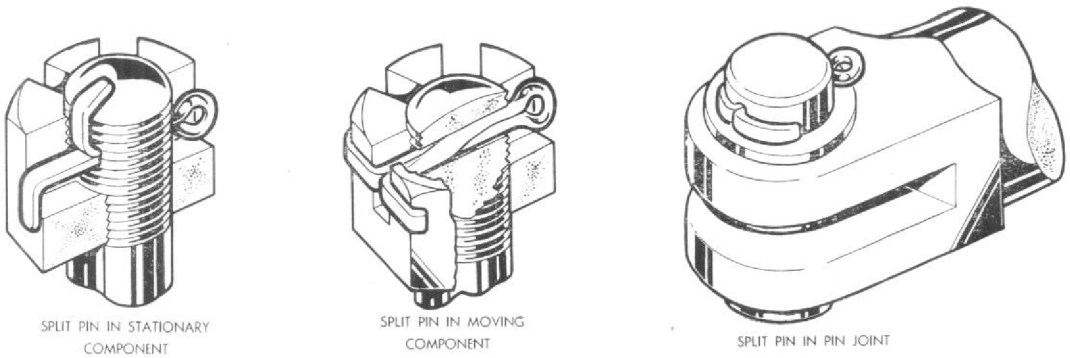

Fig. 1. Correct method of fitting split pins.

bearings, such as the bushes in the bottom wheelcase of the 48 Mk. 1, should be lubricated with anti-scuffing paste (British specification D.T.D. 900/4284) or Ragosine L.M. grease (D.T.D. 900/4424) immediately prior to assembly.

Joint faces and application of compound

Ensure that all joint faces are clean and that there are no burrs, nicks, or other damage which might prevent the components seating properly or an oil-tight joint being obtained. Where jointing compound has been employed, all traces of the previous coating must be removed. Where the use of jointing compound is specified in this section, apply a thin even film of Wellseal jointing compound to each joint face.

Anti-seize compound on screw threads

To reduce the risk of seizure, all screw threads which are subjected to high temperature should be coated with an anti-seize compound. Because of the critical torque loading which must be applied when tightening the nuts and bolts which secure the turbine disc to the hub shaft, the threads of these nuts and bolts must be lubricated with either Ragosine L.M. grease (British specification D.T.D. 900/4424) or anti-scuffing paste to British specification D.T.D.900/4284. For all other screw threads which are subjected to heat, anti-seize grease to British specification D.T.D.392 is recommended, but any other reputable graphite anti-seize grease may be used as an alternative.

Screw threads which are not subjected to heat should be coated with a mixture of engine oil and a reputable graphite anti-seize grease.

Locking devices

New locking devices, tab washers, split pins, etc., and new circlips, joint washers, oil seals, and similar parts must be used ; each chapter includes a list of consumable parts essential to the rebuild described in that chapter.

Split pins

The normal recommended practice for stationary components is for the head of the split pin to be fitted into the slot in the nut and for one leg of the split pin to be bent up over the end of the bolt and the other down over the nut as illustrated in Fig. 1.

For moving components the split pin must be carefully twisted through 90 degrees before insertion, so that with the head fitting correctly in the slot in the nut, the legs of the split pin can be wrapped round the hexagon of the nut as illustrated in Fig. 1. To reduce the possibility of fretting due to split pin slackness, the split pins for all moving components are a very close fit in their holes and must be of the correct length. Split pins fitted in pin joints are to be fitted as indicated in Fig. 1. Except in the case of pin joints, the head of the split pin must not protrude beyond the slot of the nut. Split pins should be inserted and the legs bent over with pliers and not by hitting with a hammer, as use of the latter tool may cause fracture of the legs at the point of bending or at the base of the head on the sharp edges of the nut or of the hole. After locking, the bends of all split pins should be examined for cracks, especially in highly stressed components.

Tab washers

After tightening a bolt or nut which is locked by a tab washer, examine the washer to ensure that the initially fixed limb has not sheared whilst tightening the bolt or nut. The locking limb should be turned up to a flat on the hexagon and not on a corner. Finally, examine the bend for cracking.

Angular contact thrust bearings

If an angular contact thrust bearing is fitted the wrong way round, so that the thrust is taken in the wrong direction, premature failure of the bearing and the gears which it locates can be anticipated. Before fitting an angular contact thrust bearing therefore, it is essential to determine the direction of thrust of the individual shaft and to fit the bearing with the " closed end " to the front in relation to the direction of thrust to the shaft as shown in Fig. 2.

Fig. 2 shows that the inner diameter of the outer race tapers from the balls towards one end to form a narrow end face (A in Fig. 2), and that the balls between the cage and the narrow face of the outer race can be readily seen. This is referred to as the " open end ". At the " closed end " (B in Fig. 2) the balls cannot be seen as the end face of the outer race is approximately the same width as the space between the cage and the outside diameter of the complete bearing. These bearings are marked " THRUST " on the face of the outer race at the " closed end ".

Rigid pipes

Sharp edges at the end of the conical seat of unions can cause deep grooves in the belled end of

The angular contact thrust bearings fitted to these engines are tabulated below.

Sub-assembly	*Engine*	*Location*	*Fitment*	*Chapter Ref.*
Centre housing	48 Mk. 1 48 Mk. 2	Upper, for upper vertical drive	"Closed end" nearest the ring-nut on the upper vertical drive	33C
	48 Mk. 1 48 Mk. 2	Front ball bearing, for horizontal drive shaft (Pre-mod. 1148)	"Open end" nearest the ring-nut at the front end of the horizontal drive shaft	33C
Oil sump	48 Mk. 2	Bearing, for the pump drive assembly	"Closed end" nearest the ring-nut on the fuel pump driving gear	33F
	48 Mk. 2	Bearing, for accessory drive	"Closed end" nearest the ring-nut on the accessory drive bevel gear spindle	33F

rigid pipes and this may result in complete fracture of the pipe at that point. Before fitting any rigid pipe therefore, each union should be examined to ensure that there is neither a sharp edge nor a burr which might damage the pipe when the union nut

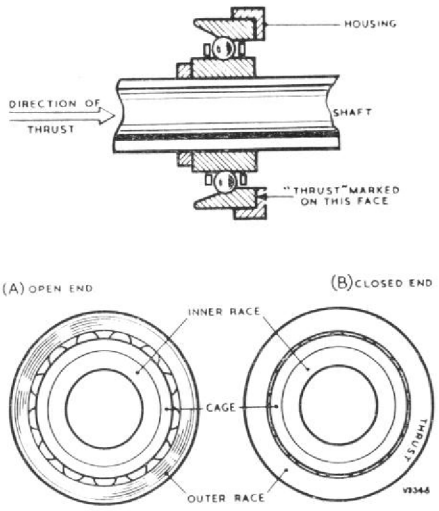

Fig. 2. Correct method of fitting angular contact thrust bearing.

is tightened. Burrs found should be carefully removed and any sharp edge radiused very slightly.

Similarly, examine the belled end of each pipe for evidence of circumferential ridging in the belled mouth. If a ridge has been formed it should be removed with a small hand scraper and the belling lightly polished with metal polish; finally, wash away all traces of abrasive. After polishing, visually examine the pipe for cracks. Cracks in any form are not acceptable, and defective pipes must be replaced by new pipes.

Rigid pipes must never be forced into position against their natural spring. If this appears to be necessary, verify that the pipe is the correct one for the position, and if this is confirmed, check that the run is correct. If the foregoing points are assured, carefully set the pipe to a correct fit. When the pipe has a flanged end fitting secured by studs and nuts, ensure that malalignment is not caused by the holes in the flange binding on the studs.

Bundy pipes

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

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

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

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

It must be fully understood that no attempt must be made to continue tightening these nuts until appreciable resistance is felt. The check for sufficient tightening, having complied with the foregoing instructions, is freedom from leaks during engine test. If it is necessary to tighten a union nut

further to correct slight leakage, this must be done to the least possible extent that will cure the leak, tighten the nut a few degrees at a time only. If excessive necking of the pipe, or excessive distortion of the olive has occurred, a new pipe assembly should be fitted.

Flexible pipes

Reference should be made to chapter 51 for the special requirements applicable in the treatment and handling of flexible pipes.

Accessories

New or reconditioned fuel system components and engine-driven accessories will have received protective treatment, and before fitment to the engine the necessary blanks must be removed and all inhibiting fluid drained off. If engine-driven accessories are not to be connected to the test bench immediately, the connections must be blanked with air-tight caps immediately after draining.

Torque loading

The bolts and nuts listed in the following table must be tightened to the torque loading specified.

BALL AND ROLLER BEARINGS

It should be noted that manufacturers of ball and roller bearings build their bearings to two standards "Commercial" and "Aircraft". The Aircraft standard bearings are manufactured from

Sub-assembly	*Engine*	*Torque load lb. in.*	*Chapter Ref.*
Front bearing nut on impeller front pivot	48 Mk. 1 48 Mk. 2	1920–2450	33A
Nuts, for front pivot studs	48 Mk. 1 48 Mk. 2	500–600	33A
Nuts, for impeller to centre shaft studs	48 Mk. 1 48 Mk. 2	500–600	33A
Nuts, for centre shaft to extension shaft bolts	48 Mk. 1 48 Mk. 2	190–230	33A and 34
Nuts, for turbine disc to hub shaft bolts	48 Mk. 1 48 Mk. 2	850–950	33A and 34
Bolts, for turbine disc to hub shaft	48 Mk. 1 48 Mk. 2	850–950	33A and 34
Nut, for hub shaft	48 Mk. 1 48 Mk. 2	8000–8500	33A
Nut, for starter dog	48 Mk. 1 48 Mk. 2	2040–2400	33D
Ring nut on accessory drive gear (vertical)	48 Mk. 2	450–500	33F
Ring nut on front end of centre housing horizontal shaft	48 Mk. 1 48 Mk. 2	500–550	33C
Ring nut on lower drive gear	48 Mk. 1	500	33F
Diffuser bolts	48 Mk. 1 48 Mk. 2	800–850	33G and 34
Lucas burner	48 Mk. 1	700–750	33J
Igniter plug screen tube (pre-mod. 966) or igniter plug (mod. 966) to adapter in combustion chamber	48 Mk. 1	240–300	34
Screen tube, or igniter plug, to torch igniter body	48 Mk. 2	Pre-mod. 1199 240–300 Mod. 1199 336–396	—
Fuel jet to torch igniter body	48 Mk. 2	336–396	—
Banjo pillar nut to torch igniter fuel jet	48 Mk. 2	216–240	—
Ignition cable union nuts to igniter plug and to high energy ignition unit	48 Mk. 1 48 Mk. 2	150–160	34
Welded nuts (sheet metal)	48 Mk. 1 48 Mk. 2	360	33K and 34

specially selected materials and have more rigid inspection standards than the Commercial standard bearings and, although the bearings may have the same type number and may look absolutely identical, the aircraft standard bearings are obviously of a much higher quality than the commercial standard.

In view of the serious consequences which may result from fitting commercial standard bearings in place of those to aircraft standard, the practice of obtaining these bearings from the local agent of the manufacturers is not advised, as no responsibility will be accepted for damage to engines which result from the failure of bearings obtained other than through The de Havilland Engine Company Ltd.

FUEL SYSTEM COMPONENTS

The following information should be read in conjunction with these chapters dealing with fuel system components.

The importance attached to cleanliness cannot be over-emphasized and extreme precautions must be taken in every instance to ensure that all details are thoroughly clean.

Box or ring spanners must be used for nuts and bolts whenever possible to ensure that damage is not caused to nuts, bolts, etc., by rounding off the flats and corners. Slave nuts, washers, etc., should be used in those instances where components are assembled temporarily, to enable sound parts to be fitted on final assembly.

Dismantling

Before attempting to dismantle any unit, study any complaints reported and examine the exterior for any visible signs of damage or interference (e.g. broken locking wire), and check that all exposed connections have been securely covered to prevent the entry of any foreign matter into the interior of the unit while off the engine. Examine all exposed threads to ensure that no damage has been caused in transit.

The special tools required for dismantling and assembling each unit are listed at the beginning of each " Dismantling " section of each chapter and illustrated in the appropriate portions of the text. It is assumed that hide hammers and a wide range of punches and drifts are available.

It is advisable to have close at hand small receptacles or boxes in which such small items as nuts, washers, bolts, springs, screws, etc., may be stored for safety until required for inspection and subsequently for rebuild.

It is recommended that only one set of components at a time be in use on the bench, in order to prevent the accidental inclusion in the assembly of small items, such as washers, etc., from other sets. If one set only is in use at a time, the possibility of shortages or interchanging of parts will be considerably reduced.

Cleaning

It is important that the bench upon which work is to be effected be scrupulously cleaned and kept free from all dirt, swarf, etc. It is recommended that the bench be covered with zinc sheeting or other material to facilitate cleaning, and that several clean containers be available in which to keep the various parts removed.

Prior to complete washing and cleaning, remove all gaskets except where stated to the contrary. All parts must be thoroughly washed and cleaned before reassembling, for which purpose a paraffin bath and spray gun with adequate filtering facilities are recommended. Hard brushes or abrasives of any kind should on no account be employed. Use of rags is not recommended since this may result in clogging.

Inspection

The inspection and viewing checks are all contained in the " Inspection " portions of each chapter, but they do not contain dimensional and clearance checks. The latter can be carried out by reference to the Schedules of Fits, Clearances and Repair Tolerances at the end of each chapter.

Each detail should receive close scrutiny for any signs of damage or wear, and, if necessary, discarded and a replacement fitted.

The detail components are grouped as nearly as possible into sub-assemblies. Separate details which do not form part of a sub-assembly are dealt with nearest to their associated group, and the viewing and inspection checks are listed to correspond with the normal dismantling sequence of operations.

All paper joints or gaskets, banjo washers, etc., must be replaced by new ones whenever the seal is disturbed, and new split pins and locking wire must always be used. Details of those parts which are not interchangeable are given under " Replacements " in each instance.

It is usual during inspection to reject all parts rendered redundant by the embodiment of essential modifications and the inspector must thus have complete information concerning modifications so that redundant parts can be rejected. Tab washers, split pins, gaskets and other consumable parts will be rejected during dismantling.

Scores and surface damage. The standard of acceptance when dealing with scores and other forms of surface damage may vary according to the number of hours the unit is to run, the purpose and region of operation, accessibility of spares and the issue of up-to-date instructions.

In general, scores on moving parts or joint faces will impair the operational efficiency of the unit, and may cause leakage, hence the parts concerned must be replaced.

Where the region of operation is an outlying one and spares are not readily accessible, very slight surface scoring insufficient to seriously affect the efficiency and safety of the unit, may be permissible at the discretion of the appropriate inspecting authority.

ALPHABETICAL INDEX OF COMPONENTS SHOWING APPLICABLE REPAIR SCHEMES

For the titles of the repair schemes which are listed beside each component, reference should be made to the relevant T.R. No. in the Numerical Index which follows this index. For further details reference should be made to the relevant chapter.

Component	*T.R. No.*	*Chapter*
Air-intake	123, 124, 213, 260, 284, 320	28D
Air compressor housing	See wheelcases	28D
Bottom wheelcase	See wheelcases	28D
Centre casing	312, 389	28F
Rear bearing housing	327	28B
Centre housing	123, 270, 399	28D
Centre shaft	See main shaft	28B
Combustion chambers		30
Expansion chamber	272, 273, 287, 289, 300, 305, 314, 339, 373, 418	30
Flame tube	344, 345, 346, 347, 352, 353, 354, 388, 397, 412	30
Diffuser casing and rear cover	227, 234, 250, 268, 275, 277, 279, 281, 308, 313, 315, 338, 366, 384, 387, 401, 402, 408, 415	28E
Deflector assembly	322, 351, 371, 410	28E
Sealing plate	299, 374, 380, 406	28E
Discharge nozzles	See nozzle ring	28F
Exhaust system		31
Fairings	241, 311, 381	31
Fireguard	375, 379, 409	31
Inner cone	226, 242, 297, 382	31
Outer cone	333, 378, 385, 405, 413, 414	31
Propelling nozzle	304	31
Support tubes	217	31
Expansion chamber	See combustion chambers	30
Extension shaft	See main shaft	28B
Fairings	See exhaust system	31
Fireguard	See exhaust system	31
Flame tube	See combustion chambers	30
Generator drive	See wheelcases	28D
Hub shaft	See main shaft	28B
Impeller	See main shaft	28A
Inner exhaust cone	See exhaust system	31
J		
K		
L		
Main shaft		28A, B, C
Centre shaft	111, 204, 221, 403	28B
Extension shaft	221, 403	28B
Hub shaft	215, 225, 266	28B
Impeller	111, 133, 134, 201, 222, 253 254, 357, 396	28A
Rear bearing housing	See centre casing	28B
Turbine blades	151	28C
Turbine disc	215, 225, 252, 266, 340	28C

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NUMERICAL INDEX OF TURBINE REPAIR SCHEMES

This index contains a complete sequence of T.R. numbers but titles are given only where the repair is applicable to the engines dealt with in this handbook. The chapter and page listed against a repair indicates where working instructions, or other information, will be found. Where modifications are referred to further information will be found in the Modification News Sheets issued by The Service Department of The de Havilland Engine Company. "Not issued by D.O. (Drawing Office)" is self-explanatory, "Not issued" in the "Refer to" column indicates that drawings have been issued by the D.O. but instructions have not yet been compiled for publication in this handbook.

T.R. No.	Title	Refer to Chapter	Page
1 to 110	————	Goblin	
111	Impeller, oversize centre shaft dowels	28A	18
112 to 118	————	Goblin	
119 & 120	Not issued by D.O.	—	
121	————	Goblin	
122	Cancelled by T.R.274	—	
123	Air-intake, centre-housing dowel	28D	5
124	Air-intake, top wheel-case dowel	28D	8
125	Not issued by D.O.	—	
126 to 132	————	Goblin	
133	Impeller, oversize centre-shaft studs	28A	21
134	Impeller, oversize pivot studs	28A	21
135 to 141	————	Goblin	
142	————	Ghost Fifty	
143	Cancelled by T.R.275	—	
144	————	Ghost Fifty	
145 to 150	————	Goblin	
151	Turbine blades, repair	28C	21
152	Nozzle blades, repair	28F	11
153 to 180	————	Goblin	
181 & 182	Cancelled by mod. 1018†	—	
183 to 200	————	Goblin	
201	Impeller, undersize centre-shaft spigot	28A	26
202	Cancelled by T.R.222	—	
203	Cancelled by T.R.269	—	
204	Centre shaft, damaged impeller-spigot recess	28B	8
205	Cancelled by T.R.254	—	
206	Cancelled by T.R.253	—	
207	Cancelled by T.R.277	—	
208	Cancelled by T.R.278	—	
209	Cancelled by T.R.279	—	
210	Cancelled by T.R.280	—	
211	Cancelled by T.R.281	—	
212	Cancelled by T.R.282	—	
213	Air-intake, bearing housing bore	28D	12
214	————	Ghost Fifty	
215	Turbine disc, hub shaft spigot	28C	30
216	————	Ghost Fifty	
217	Support tubes, wear	31	2
218 & 219	Cancelled by mod. 1018†	—	
220	Cancelled by T.R.221	—	
221	Centre and extension shafts, oversize bolts	28B	10
222	Impeller bore, wear or damage	28A	20
223	Cancelled by T.R.270	—	
224	————	Ghost Fifty	
225	Turbine disc, oversize bolts	28C	25
226	Inner exhaust cone, cracks	31	3
227	Diffuser casing, oversize diffuser-bolt dowels	28E	6
228 & 229	Not issued by D.O.	—	
230	Cancelled by T.R. 227	—	
231 & 232	Cancelled by T.R.338	—	
233	Cancelled by T.R.376	—	

† *Mod . 1018 cancelled repair schemes for type 4 flame tubes*

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T.R. No.	Title	Refer to Chapter	Page
234	Diffuser casing, oversize cooling-ring insert	28E	13
235	Cancelled by T.R.234	—	
236	Cancelled by T.R.307	—	
237	Cancelled by mod. 1018†	—	
238	Not issued by D.O.	—	
239	Cancelled by T.R.283	—	
240	Cancelled by T.R.284	—	
241	Exhaust cone fairings No. 1 and 2, cracks	31	3
242	Inner exhaust cone, front diaphragm, renewal	31	5
243	Cancelled by T.R.267	—	
244	Cancelled by T.R.268	—	
245 & 246	Cancelled by mod. 1018†	—	
247	Nozzle ring, discharge nozzle, cracks	28F	4
248	Not issued by D.O.	—	
249	————	Ghost Fifty	
250	Diffuser casing, rear cover, securing and mounting bolts	28E	4
251	Not issued by D.O.	—	
252	Turbine disc, eccentric nut holes	28C	27
253	Impeller, oversize centre-shaft studs	28A	23
254	Impeller, oversize pivot studs	28A	24
255	Cancelled by T.R.274	—	
256	Cancelled by T.R.275	—	
257	Cancelled by T.R.271	—	
258	Cancelled by T.R.272	—	
259	Cancelled by T.R.273	—	
260	Air-intake, centre housing bore	28D	13
261 & 262	————	Ghost Fifty	
263	Cancelled by mod. 1018†	—	
264	Cancelled by T.R.357	—	
265	Cancelled. Applicable to pre-mod. 794 rear covers only	—	
266	Turbine disc, oversize bolts	28C	26
267	Cancelled by T.R.268	—	
268	Diffuser casing, rear cover, damaged stud holes	28E	2
269	————	Ghost Fifty	
270	Centre housing, damaged stud holes	28D	4
271	————	Ghost Fifty	
272	Expansion chamber, drain-boss stud holes	30	12
273	Expansion chamber locating plug stud holes	30	12
274	Cancelled by T.R.275	—	
275	Diffuser casing, deflector ports, damaged stud holes	28E	9
276	Cancelled by mod. 1018†	—	
277	Diffuser casing, rear cover, damaged stud holes	28E	10
278	Cancelled by T.R.277	—	
279	Diffuser casing, rear cover, damaged stud holes	28E	10
280	Cancelled by T.R.279	—	
281	Diffuser casing, damaged stud holes	28E	16
282	Cancelled by T.R.281	—	
283	————	Ghost Fifty	
284	Air-intake, damaged ¼ in. B.S.F. stud holes	28D	3
285	Not issued by D.O.	—	
286	Cancelled by T.R.287	—	
287	Expansion chamber, loose interconnector bush	30	13
288	Cancelled by T.R.289	—	
289	Expansion chamber outlet-flange stud holes	30	13
290	————	Ghost Fifty	
291	Cancelled by mod. 1018†	—	

† *See page 9*

T.R. No.	Title	Refer to Chapter	Page
292 & 293	————	Ghost Fifty	
294	Cancelled by T.R.263	—	
295	Cancelled by T.R.330	—	
296	————	Ghost Fifty	
297	Inner exhaust cone, front flange	31	8
298	Cancelled by T.R.391	—	
299	Diffuser casing, sealing plate, inspection cover stud holes	28E	14
300	Expansion chamber, pressure connection	30	14
301	Cancelled by T.R.300	—	
302 & 303	————	Ghost Fifty	
304	Propelling nozzle spacer-strips	31	3
305	Expansion chamber, igniter plug stud holes	30	14
306	Cancelled by T.R.305	—	
307	Oil sump, rear bearing connection	29	2
308	Diffuser casing and rear cover mounting and securing bolts	28E	5
309	Cancelled by T.R.233	—	
310	Cancelled by T.R.312	—	
311	Exhaust cone fairings, bosses	31	4
312	Centre casing, front and rear cones, rear flange	28F	12
313	Diffuser casing, rear cover, air annulus cover studs	28E	11
314	Expansion chamber, inlet flange face	30	23
315	Diffuser casing, deflector ports	28E	8
316 & 317	Cancelled by mod. 1018†	—	
318 & 319	————	Ghost Fifty	
320	Fitment of protection plates to anti-resonance holes introduced by mod. 336 Part 2.	28D	13
321	Not issued by D.O.	—	
322	Diffuser casing, deflector assemblies, damaged threads	28E	7
323 to 326	————	Ghost Fifty	
327	Rear bearing housing, damaged threads	28B	9
328 to 332		Ghost Fifty	
333	Outer exhaust cone, bosses	31	7
334	Oil sump, dowels	29	2
335 to 337	————	Ghost Fifty	
338	Diffuser vane tips, repair	28E	12
339	Type 4 and 5 expansion chamber, locating plates	30	15
340	Turbine disc, corrosion	28C	28
341	Discharge nozzle assembly, joint ring replacement	28F	10
342	Oil pump cover, stud holes	29	3
343	Inner nozzle ring, diaphragm recess	28F	13
344	Type 5 flame tube and head, cracks	30	6
345	Type 5 flame tube and head, worn inter-connector sleeve	30	16
346	Type 5 flame tube and head, loose or damaged rivets	30	18
347	Type 5 flame tube head, replacement	30	11
348	————	Ghost Fifty	
349	Not issued by D.O.	—	
350	Alternator and generator gear drive shaft (Pre-mod. 776), wear	28D	3
351	Deflector assemblies, corrosion	28E	7
352	Type 5 flame tube and head, rear section, replacement	30	10
353	Type 5 flame tube and head, locating ring, wear	30	18
354	Type 5 flame tube and head, mounting pads, wear	*Not issued*	

† *See page 9*

T.R. No.	Title	Refer to Chapter	Page
355 & 356	————	Ghost Fifty	
357	Impeller, damaged vanes	28A	2
358 to 363	————	Ghost Fifty	
364	Air compressor housing, oil feed hole	28D	12
365	————	Ghost Fifty	
366	Diffuser casing or rear cover, renewal of either component	28E	17
367	Oil pump, spindle bores	*Not issued*	
368	Not issued by D.O.	—	
369*	Expansion chamber, loose interconnector bush (Mod. 1019)	30	20
370*	Type 5 flame tube and head, worn inter-connector sleeve (Mod. 1019)	30	20
371	Deflector assemblies, radii of side plates (Pre-mod. 843)	28E	17
372	Cancelled by mod. 1147	30	22
373	Expansion chamber, pressure connection, threads or ferrules stripped or damaged	30	22
374	Diffuser casing, sealing plate, damaged face	28E	16
375	Fireguard, damaged drain trough pipe	31	13
376	Turbine shroud, distorted bore	28F	8
377	————	Ghost Fifty	
378	Outer exhaust cone, stripped or damaged bosses	31	9
379	Fireguard, repair to thermocouple flange and cracks in front flange	31	12
380	Sealing plate, cracked bore	28E	15
381	Exhaust cone assembly, fairings, damaged thread in bosses	31	11
382	Front baffle assembly, cracked stiffeners	31	10
383	Generator drive casing, oil feed union ferrule (Pre-mod. 860)	*Not issued*	
384	Diffuser casing vane, damaged stud holes	28E	15
385	Outer exhaust cone, cracked holes in front flange	*Not issued*	
386	Cancelled by T.R.393	—	
387	Diffuser casing, damaged vane tips (Mod. 1105)	*Not issued*	
388	Flame tube and head	30	23
389	Centre casing	28F	14
390	Planet gear carrier cover, oversize dowel	*Not issued*	
391	Cancelled by T.R.413	—	
392	Not issued by D.O.	—	
393	Bottom wheelcase, oversize bearing bushes	*Not issued*	
394	Oil sump, union for priming connection, damaged threads	29	9
395	Cancelled by T.R.414	—	
396	Impeller, local application of cold setting lacquer	28A	25
397	Type 5 flame tube and head, damaged suspension sleeve	*Not issued*	
398	Starter gear casing, damaged threads	28D	2
399	Centre housing, worn or damaged sleeve	*Not issued*	
400*	Bottom wheelcase, oversize bearing bushes	—	
401	Diffuser casing and rear cover, damaged holes for mounting and securing bolts	*Not issued*	
402	Diffuser casing, damaged vane tips	*Not issued*	
403	Centre and extension shafts, oversize bolts	28B	10

* *Limited to certain licensees only*

T.R. No.	Title	Refer to Chapter	Page
404	Top wheelcase, bottom bearing friction ring cover assembly, mod. 1132, worn or damaged friction ring	*Not issued*	
405	Outer exhaust cone, damaged fireguard supports	*Not issued*	
406	Sealing plate, pre-mod. 897, oversize dowels	*Not issued*	
407	Diffuser casing, damaged identification-plate securing holes	Not applicable to civil engines	
408	Diffuser casing, damaged threads	*Not issued*	
409	Fireguard, worn locating holes	*Not issued*	
410	Deflector, damaged vanes	*Not issued*	
411	Sightglass housing, taper pin	*Not issued*	
412	Flame tubes, worn mounting pads	*Not issued*	
413	Outer cone, cracked or damaged front flange (Pre-mod. 1140)	*Not issued*	
414	Outer cone, cracked or damaged front flange (mod. 1140)	*Not issued*	
415	Diffuser casing	28E	17
416	Nozzle shroud, distorted bore	28F	9
417	Turbine shroud, front flange, enlarged or elongated bolt holes	28F	13
418	Expansion chamber	30	24
419	Not issued by D.O.	—	
420	Combustion chamber, foul with centre casing	*Not issued*	
421	Oil pump, spindle bores	29	4
501 to 602	————	Goblin	
71500 to 98935	————	For incorporation of modifications only	

MISCELLANEOUS REPAIRS AND PROCESSES

INTERPRETATION OF WORKING DRAWINGS AND SYMBOLS

The repair schemes contained in chapters 28 to 31 include reproductions of the engine manufacturers' gas turbine repair (T.R.) drawings. These drawings conform to the manufacturers' standard drawing office practice, and, consequently, include symbols and other data with which the users of this handbook may not be familiar. Whilst these repair drawings, and similar drawings elsewhere in this handbook, conform closely to British Standard (B.S.) 308, correct interpretation of the drawings will be obtained only by reference to the following paragraphs which describe the manufacturers' drawing office practice, so far as it affects these drawings.

1. TRIANGLE INDICATING A MACHINED SURFACE

2. TRIANGLE INDICATING SURFACE FINISH IN MICRO-INCHES (FIGURE) AND TYPE OF MACHINING (LETTER)

Fig. 3. Machining symbols.

Machining symbols

When the symbols illustrated in Fig. 3 are found on working drawings, they should be interpreted as follows.

1 on Fig. 3. A triangle of this type denotes that the surface to which it is adjacent, or which is indicated by a leader line from the triangle, is a machined surface.

2 on Fig. 3. A figure outside the triangle (in this instance 16) expresses the surface finish in micro-inches. A letter, or group of letters, within the triangle (in this instance G) indicates the type of machining.

Below is a list of the letters used to denote types of machining, and their interpretation.

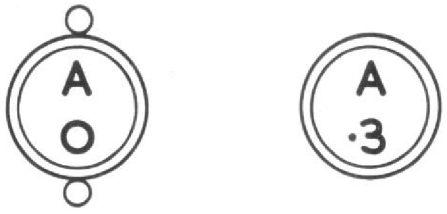
BF = Buff	BU = Burnish
D = Drill	DB = Diamond Bore
DT = Diamond Turn	G = Grind
H = Hone	LP = Lap
LI = Linnish	PO = Polish
R = Ream	SP = Spot Face

Positional symbols

The symbols illustrated in Fig. 4 refer to the limits for position, concentricity, or symmetry.

1 on Fig. 4. This symbol indicates a datum surface, and the letter (in this case A) indicates the group to which all other positional symbols containing the same letter belong. It will be appreciated that more than one datum surface may be found on a single working drawing, and each additional datum surface will be indicated by the basic symbol, but each individual datum surface will have a different identification letter. Below the identification letter in a datum symbol is the figure "O", which is constant in all datum symbols and serves to emphasise that the surface indicated is the datum to which all symbols with the same identification letter must be related, see following sub-paragraph.

2 on Fig. 4. This symbol indicates a machined surface whose position, concentricity, or symmetry, is governed by a datum surface. The letter within the symbol (in this case A) indicates the letter group to which the symbol belongs, and thereby the datum surface to which the machined surface is related. The figure within the symbol (in this case ·3) which is below the group letter, expresses in thousandths (0·001) of an inch the degree of accuracy required, between the actual position of a surface, and its theoretical position, relative to the datum surface in that letter group. An example of the application of this tolerance is illustrated in Fig. 5. It is essential that these tolerances on position, concentricity or symmetry are not confused with dimensional tolerances. The first are concerned with relative position of planes, or curved surfaces one to the other, whilst the



1. SYMBOL INDICATING A DATUM SURFACE, OR LOCATION

2. SYMBOL INDICATING A SURFACE, OR LOCATION, WHICH MUST BEAR A CERTAIN RELATIONSHIP TO THE DATUM BEARING THE SAME IDENTIFICATION LETTER. THE FIGURE INDICATES THE REQUIRED DEGREE OF ACCURACY IN THIS RELATIONSHIP

Fig. 4. Positional symbols.

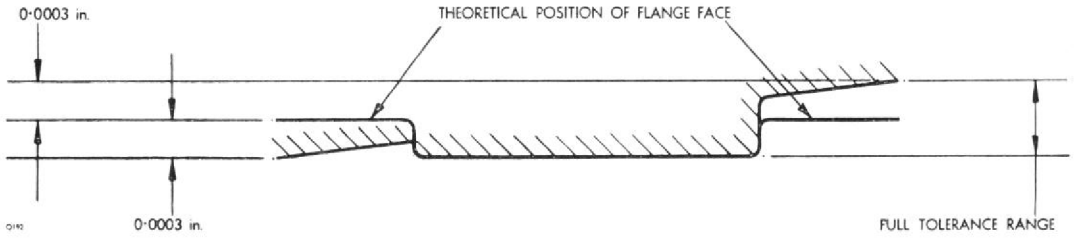


Fig. 5. Diagram showing tolerance between actual and theoretical position of a surface.

B.A. FORM SCREW THREAD, STANDARDS FOR INTERNAL THREADS

B.A. Designation Number	*Pitch*	*Major (Full) Dia.*			*Effective Dia.*			*Minor (Core) Dia.*		
		Min.	*Tol.*	*Max.*	*Min.*	*Tol.*	*Max.*	*Min.*	*Tol.*	*Max.*
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
2	*0,810*	*4,700*	*0,170*	*4,870*	*4,215*	*0,085*	*4,300*	*3,730*	*0,285*	*4,015*
4	*0,660*	*3,600*	*0,145*	*3,745*	*3,205*	*0,075*	*3,280*	*2,810*	*0,230*	*3,040*
6	*0,530*	*2,800*	*0,125*	*2,925*	*2,480*	*0,060*	*2,540*	*2,160*	*0,185*	*2,345*

Approximate Inch Equivalents

B.A. Designation Number	*Threads per inch*	*Major (Full) Dia.*			*Effective Dia.*			*Minor (Core) Dia.*		
		Min.	*Tol.*	*Max.*	*Min.*	*Tol.*	*Max.*	*Min.*	*Tol.*	*Max.*
2	31·4	0·1850	0·0067	0·1917	0·1659	0·0033	0·1692	0·1468	0·0112	0·1580
4	38·5	0·1417	0·0057	0·1474	0·1262	0·0030	0·1292	0·1106	0·0091	0·1197
6	47·9	0·1102	0·0049	0·1151	0·0976	0·0024	0·1000	0·0850	0·0073	0·0923

B.A. FORM SCREW THREAD, STANDARDS FOR EXTERNAL THREADS

B.A. Designation Number	*Pitch*	*Major (Full) Dia.*			*Effective Dia.*			*Minor Dia.*		
		Max.	*Tol.*	*Min.*	*Max.*	*Tol.*	*Min.*	*Max.*	*Tol.*	*Min.*
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
2	*0,810*	*4,700*	*0,120*	*4,580*	*4,215*	*0,085*	*4,130*	*3,730*	*0,170*	*3,560*
4	*0,660*	*3,600*	*0,100*	*3,500*	*3,205*	*0,075*	*3,130*	*2,810*	*0,145*	*2,665*
6	*0,530*	*2,800*	*0,080*	*2,720*	*2,480*	*0,060*	*2,420*	*2,160*	*0,125*	*2,035*

Approximate Inch Equivalents

B.A. Designation Number	*Threads per inch*	*Major (Full) Dia.*			*Effective Dia.*			*Minor Dia.*		
		Max.	*Tol.*	*Min.*	*Max.*	*Tol.*	*Min.*	*Max.*	*Tol.*	*Min.*
2	31·4	0·1850	0·0047	0·1803	0·1659	0·0033	0·1626	0·1468	0·0067	0·1401
4	38·5	0·1417	0·0039	0·1378	0·1262	0·0030	0·1232	0·1106	0·0057	0·1049
6	47·9	0·1102	0·0031	0·1071	0·0976	0·0024	0·0952	0·0850	0·0049	0·0801

latter (the dimensional tolerances) are concerned with the distance between surfaces or points.

Fig. 6 illustrates various applications of the symbol system for indicating limits on position, concentricity, or symmetry. In the cross section (the left-hand view), the symbol "AO" (which has been marked with an asterisk*) indicates that the 1·0000 + ·0006 inch diameter bore is the primary datum, to which all symbols containing the same letter are related. The symbol "AO" (which has been marked with a dagger†) indicates that the 1·500 + ·0012 inch diameter counterbore must be perfectly concentric with the 1·0000 inch diameter bore, the figure "O" in this instance indicating that there is no tolerance. The symbol "A1" indicates that the $1\frac{1}{8}$ inch thread must be concentric with the 1·0000 inch bore within 0·001 inch, and the symbol "A5" indicates that the 1·4369 – ·0006 inch diameter spigot must be concentric with the datum bore within 0·005 inch. Similarly, the symbol "A·3" indicates that the under surface of the flange must be square to the datum bore within 0·0003 inch. In addition to its relationship to the datum bore, the 1·4369 inch spigot is itself a datum surface, as indicated by the symbol "BO". The symbol "B6" in the right-hand view, indicates that the 2·3125 inch diameter circle on which the centres of the $\frac{11}{32}$ inch clearance holes lie, must be concentric to within ·006 inch of the centre of the 1·4369 inch spigot. Also, the centres of these $\frac{11}{32}$ inch holes are limited to within a circle of 0·006 inch radius, the centre of which is the theoretical position of the $\frac{11}{32}$ inch holes on the 2·3125 inch diameter.

Screw threads

Where screw threads are indicated on working drawings, the thread notes will have a standard form, giving the following particulars.

1. In all cases of medium fit standard threads, only the basic size and thread form will be given. In these instances, the tolerances permitted are those laid down for medium fit threads in British Standard 84.

2. In cases where a close fit tolerance is required, the thread notes will state the basic size and thread form, followed by a note in brackets (B.S. 84 close fit). This does not apply to B.A. form threads for which see the following sub-paragraph.

3. For B.A. form threads the manufacturer has laid down standards (refer to facing page) which must be adhered to strictly.

4. Where special threads are used, the following particulars will be given in the thread notes.

   Basic Thread Size
   Threads per inch (T.P.I.)
   Thread Form
   Effective Diameter
   Full Diameter (Truncated) for external threads
   Minor Diameter (Truncated) for internal threads

Dimensional tolerances

Where specific tolerances are not given on a working drawing, the following general tolerances apply.

(1) Linear	..	± ·010 inch
(2) Angular	..	± 2 degrees
(3) Drilled Holes		+ ·010 inch – ·002 inch
(4) Screw threads		see previous paragraph

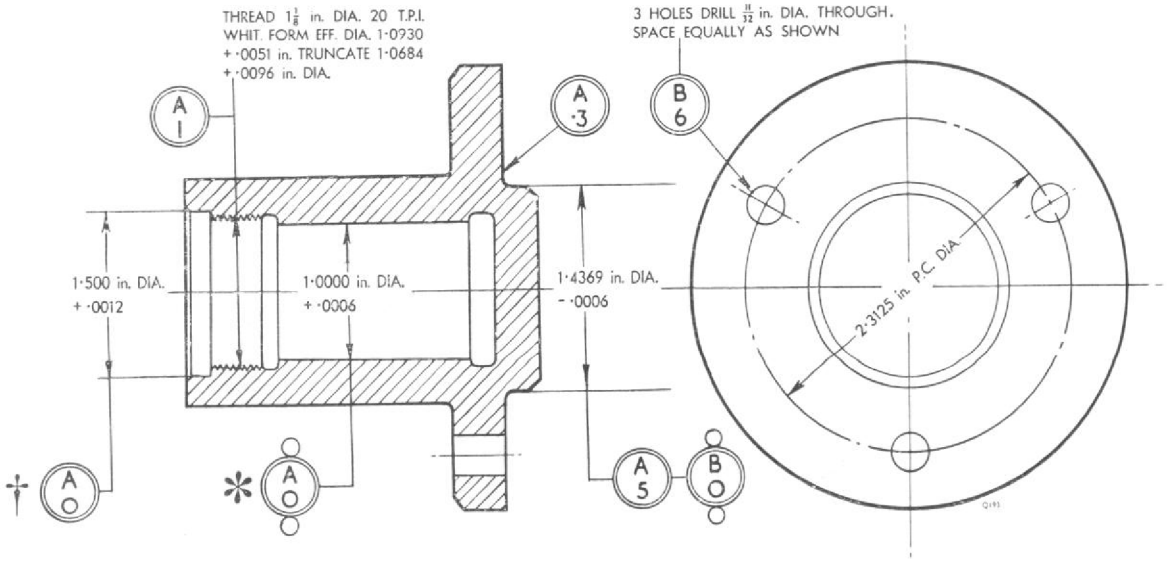


Fig. 6. Diagram showing various applications of the symbol system.

REPAIRS FOR WHICH WORKING INSTRUCTIONS ARE NOT PROVIDED

There are a number of repairs for which detailed working instructions have not been provided. Broadly speaking these repairs can be classified as coming within one of the following categories.

1. The tooling is of such a nature that, normally, it is available in the engine manufacturer's works only.
2. The tools are not available for sale.
3. The repair is intended for the salvage of new parts damaged during initial manufacture.

Although these repairs cannot, normally, be carried out by operators, knowledge of their existence and general effect on the components concerned can be invaluable for the following reasons.

1. To enable an operator to know what has been done to a component on which a repair (T.R.) number is marked, or in respect of which such information is contained in the relevant documents.
2. To inform an operator that such repair is possible, and so avoid the needless destruction of repairable components (even though they may be repairable only by the manufacturers), or the pointless retention of components which are beyond repair.
3. To enable the correct mating replacement components to be obtained where one result of the repair is loss of interchangeability ; e.g., where repair to a damaged spigot results in an undersize spigot which necessitates a corresponding undersize counterbore in the mating component.
4. To enable an operator, in an emergency, on his own responsibility, to carry out the repair.

Chapters 28 to 32 contain brief descriptive information covering repairs in the foregoing categories. These brief descriptions do not pretend to provide complete working instructions and are identified by the words ' For Information Only ' immediately below the heading.