

2001/146

Amendment No. 138
See Overleaf

DE HAVILLAND GHOST FORTY-EIGHT

OPERATION, MAINTENANCE
AND OVERHAUL HANDBOOK



DRAFT ISSUED OCTOBER 1951

JUNE 1958 THIS COPY INCLUDES AMENDMENT No. 138

Issued by

THE DE HAVILLAND ENGINE COMPANY LIMITED, LEAVESDEN, HERTFORDSHIRE, ENGLAND
Telegrams: Gipsy, Watford *Telephone: Garston 4000*

AMENDMENT No. 138

ADDITION TO FUEL PUMP TYPE NUMBERS (MOD. 1366); REPAIR
OF TURBINE BLADES "IN THE FIELD"; REVISION OF T.R.357

BEFORE INCORPORATING THIS AMENDMENT, CHECK that the preceding amendment has been incorporated; all amendments to this handbook *must* be incorporated in strict numerical sequence.

- PRELIMINARY PAGES** REMOVE AND DESTROY one leaf bearing pages vii and viii.
INSERT one leaf bearing revised page vii, addition of mod. 1366 fuel pump type numbers.
- CHAPTER 17** INSERT, immediately after page 40, three leaves bearing new pages 41 to 46, repair of turbine blades "in the field".
- CHAPTER 28A** REMOVE AND DESTROY four leaves bearing pages 1 to 8.
INSERT four leaves bearing revised pages 1 to 5 and Fig. 1 to 9, revision of T.R.357.

Having incorporated Amendment No. 138, REPLACE the previous TITLE PAGE by this leaf.

If any of the preceding amendments have not been received please notify The de Havilland Engine Co. Ltd., Technical Publications Department, Leavesden, Hertfordshire, England. In all correspondence regarding this handbook please quote the "Reg. Copy No." which will be found at the top of the registration and change of address cards counterfoil in your copy.

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|-----|--|-------------------------|
| 122 | Renewal of turbine blades "in the field", chapter 17. | Published March, 1956 |
| 123 | Issue of chapters 28B, 28C, 28D, 28E, and 28F. | Published March, 1956 |
| 124 | Revision of preliminary pages and chapters 8, 9, 10, 16, 20A, 24, 25, 28A, 28F, and 50. | Published April, 1956 |
| 125 | Revision to chapters 9, 16, and 38 | Published July, 1956 |
| 126 | Revision to preliminary page ix, chapters 9, 12, 32, 38, 40, 41, and 42, and issue of new chapter 52 | Published August, 1956 |
| 127 | Revision of preliminary pages and chapters 5, 8, 9, 15, 22, 23, 38, 40, and 52 | Published October, 1956 |
| 128 | Addition to chapter 21 and issue of draft chapters 33B, 33C, and 33D | Published Nov., 1956 |
| 129 | Issue of draft chapters 33E, 33F, 33G, 33H, and 33K | Published Nov., 1956 |
| 130 | Revision of relighting in flight, and Fusion Welding Code | Published Jan., 1957 |
| 131 | Revision of repair instructions | Published Feb., 1957 |
| 132 | Revision of preliminary pages and chapters 11, 22, 23, 24, 25, 28, and 51 | Published April, 1957 |
| 133 | Issue of revised chapter 49. | Published May, 1957 |
| 134 | Revision of relighting in flight, and cracks in discharge nozzle; additions to general information relating to overhaul, etc.; minor revision of T.R.322 and T.R.351; issue of revised chapter 28F. | Published July, 1957 |
| 135 | Revision of impeller examination to include crack detection; addition of Ardrex 670 to cleaning of flame tubes; addition of T.R.201, T.R.213, T.R.215, T.R.260, T.R.314, T.R.320, T.R.364, T.R.366, T.R.371, T.R.375, T.R.388, T.R.415, and T.R.418; revision of T.R.376. | Published Nov., 1957 |
| 136 | Instruction school information added to foreword; generator type number altered; addition of air circulating furnace to cleaning of flame tubes; issue of contents leaf for chapter 27; issue of chapters 27A, 27B, and 27D; revision of instructions for re-anodising impeller. | Published Jan., 1958 |
| 137 | Chapter 38 revised to issue 12 for 48 Mk. 1 and to issue 11 for 48 Mk. 2 | Published April, 1958 |

THIS HANDBOOK contains (marker cards are indicated by heavy type):—

FOREWORD
SYSTEM OF AMENDMENTS
FRONTISPIECE
INTRODUCTION

LEADING PARTICULARS
LUBRICATING OILS
OPERATING LIMITATIONS
LIST OF MINOR REVISIONS

GENERAL DESCRIPTION

CHAPTERS 1 TO 4 INCLUSIVE

A complete list of the chapters contained in this group is given on the marker card.

INSTALLATION, OPERATION, SERVICING AND MAINTENANCE

CHAPTERS 5 TO 20A INCLUSIVE

A complete list of the chapters contained in this group is given on the marker card.

TOOLS AND EQUIPMENT

CHAPTER 21

OVERHAUL, RECONDITIONING, REPAIR AND SALVAGE

- CHAPTER 22. General Information.
- CHAPTER 23. Dismantling to sub-assemblies.
- CHAPTER 24A to L inclusive. Dismantling the sub-assemblies.
- CHAPTER 25. Cleaning and processing during complete overhaul.
- CHAPTER 27A to M inclusive. Detail inspection of components after dismantling the sub-assemblies.
- CHAPTER 28A to F inclusive. Compressor, Turbine, and Wheelcases ; Renewals, Reconditioning, Repair and Salvage.
- CHAPTER 29. Lubrication System Components; Renewals, Reconditioning, Repair and Salvage.
- CHAPTER 30. Combustion Chambers ; Renewals, Reconditioning, Repair and Salvage.
- CHAPTER 31. Exhaust System ; Renewals, Reconditioning, Repair and Salvage.
- CHAPTER 32. Miscellaneous; Renewals, Reconditioning, Repair and Salvage.
- CHAPTER 33A. Main Shaft Assembly, Reassembling and Dynamic Balancing.
- CHAPTER 33B. Air-intake, Reassembling.
- CHAPTER 33C. Centre housing, Reassembling.
- CHAPTER 33D. Top wheelcase, Reassembling.
- CHAPTER 33E. Bottom wheelcase, Reassembling.
- CHAPTER 33F. Oil sump, Reassembling.
- CHAPTER 33G. Diffuser casing, Reassembling.
- CHAPTER 33H. Centre casing, Reassembling.
- CHAPTER 33K. Exhaust system, Reassembling.
- CHAPTER 36C. Check Balancing After Combined Endurance/Final Test.
- CHAPTER 37. Preparing the engine for dispatch (wire-locking, packing, etc.)

A complete list of the chapters which will be contained in this group is given on the marker card.

TABLE OF FITS AND CLEARANCES

CHAPTER 38

FUEL AND IGNITION SYSTEM UNITS, AND ESSENTIAL ENGINE ACCESSORIES

CHAPTERS 39 TO 52 INCLUSIVE

A complete list of the chapters contained in this group is given on the marker card.

FOREWORD

This handbook is issued for the guidance of all concerned in the operation, maintenance and overhaul of the de Havilland Ghost Forty-eight. As a book of reference it should always be at hand, and careful attention to the information and advice it contains will do much to ensure satisfactory service. It should not be regarded as being a text-book of current general engineering and aeronautical engineering knowledge but must be interpreted against a background of such knowledge.

Basically, this handbook covers the Ghost 48 Mk. 1. The majority of the information is equally applicable to the Ghost 48 Mk. 2 and much of it is applicable to the Ghost 53 Mk. 1. In many cases, where information is applicable to certain Marks only this is indicated in the text.

Every effort is made to ensure the technical accuracy of both text and illustrations at the time of going to press, but insignificant changes may occur which will alter slightly the final product in some minor detail. Essential modifications will be dealt with by amendments as described below, so that the handbook can be kept up to date.

For the convenience of operators, Servicing

and Maintenance Courses on the Company's range of engines, are conducted in the Engine Instruction School, situated at the Leavesden Works. Overhaul Courses can also be arranged to suit operators requirements. Application for details of current Courses and reservations for Course places, should be addressed to

THE CHIEF INSTRUCTOR,
ENGINE INSTRUCTION SCHOOL,
THE DE HAVILLAND ENGINE CO., LTD.,
LEAVESDEN, HERTFORDSHIRE, ENGLAND.

Operators are strongly advised to consult the Service Department of the de Havilland Engine Company in all cases of difficulty or uncertainty, and are reminded that the Company's service engineers are always at their disposal should they require assistance. Maintenance, repair, and complete overhaul service are also available and estimates for these services will be supplied on request. All enquiries should be addressed to

DE HAVILLAND ENGINE SERVICE,
LEAVESDEN, HERTFORDSHIRE,
ENGLAND.

TELEPHONE NUMBER: GARSTON 4000
TELEGRAMS: GIPSY, WATFORD.

SYSTEM OF AMENDMENTS TO HANDBOOK

To avoid confusion with amendments to the Ghost Fifty Handbook, amendments to the Ghost Forty-eight Handbook commenced with amendment No. 101; amendment Nos. 1 to 99 being allotted to the Ghost Fifty Handbook.

REGISTRATION AND CHANGE - OF - ADDRESS CARDS are provided in this handbook. Recipients are requested to complete and post the REGISTRATION CARD immediately they receive this handbook if they wish to be included in the circulation of subsequent amendments. Unless a registration card is received no amendments can be forwarded. So that distribution records can be kept up to date please use the CHANGE-OF-ADDRESS CARD when applicable or in the event of a transfer in the ownership of this handbook.

Every effort has been made to provide an amendment system which, while being as nearly fool-proof as possible, shall cause the holder of this handbook as little clerical work as possible and enable anyone to see at a glance the amendment state of the handbook.

ALL amendments will be accompanied by a new TITLE PAGE. This will carry a statement:—

"Month, 195 . This copy includes amendment No."

ON THE BACK of the new title page will be the "Instructions" and a note of the preceding

amendments. Unless an amendment is very small, i.e., changing one or two figures or words, a new leaf or leaves (page or pages) will be issued. Each new leaf will carry a note at its bottom right-hand corner:

"Revised (or issued) by amendment No. —,
Month, 195 ."

In the case of complete new chapters this note may only appear on the first page and will read:

"Chapter issued by amendment No. —,
Month, 195 ."

Where a new leaf is not issued the "instructions" will conclude with a reminder that the holder of the handbook should make a note:

"Revised by amendment No. —, Month, 195 " at the foot of each page altered.

Before commencing to make any amendment, check to ensure that the preceding amendment has been incorporated. It is essential that all amendments be incorporated in strict numerical sequence. Failure to do this can cause considerable confusion and renders the statement on the title page "This copy includes amendment No. —" untrue, since each amendment is compiled on the assumption that it is to be incorporated into a handbook containing all the preceding amendments.

*Revised by Amendment No. 136
January, 1958*

From
Page

de Havilland
Ghost 48 Mk. 1

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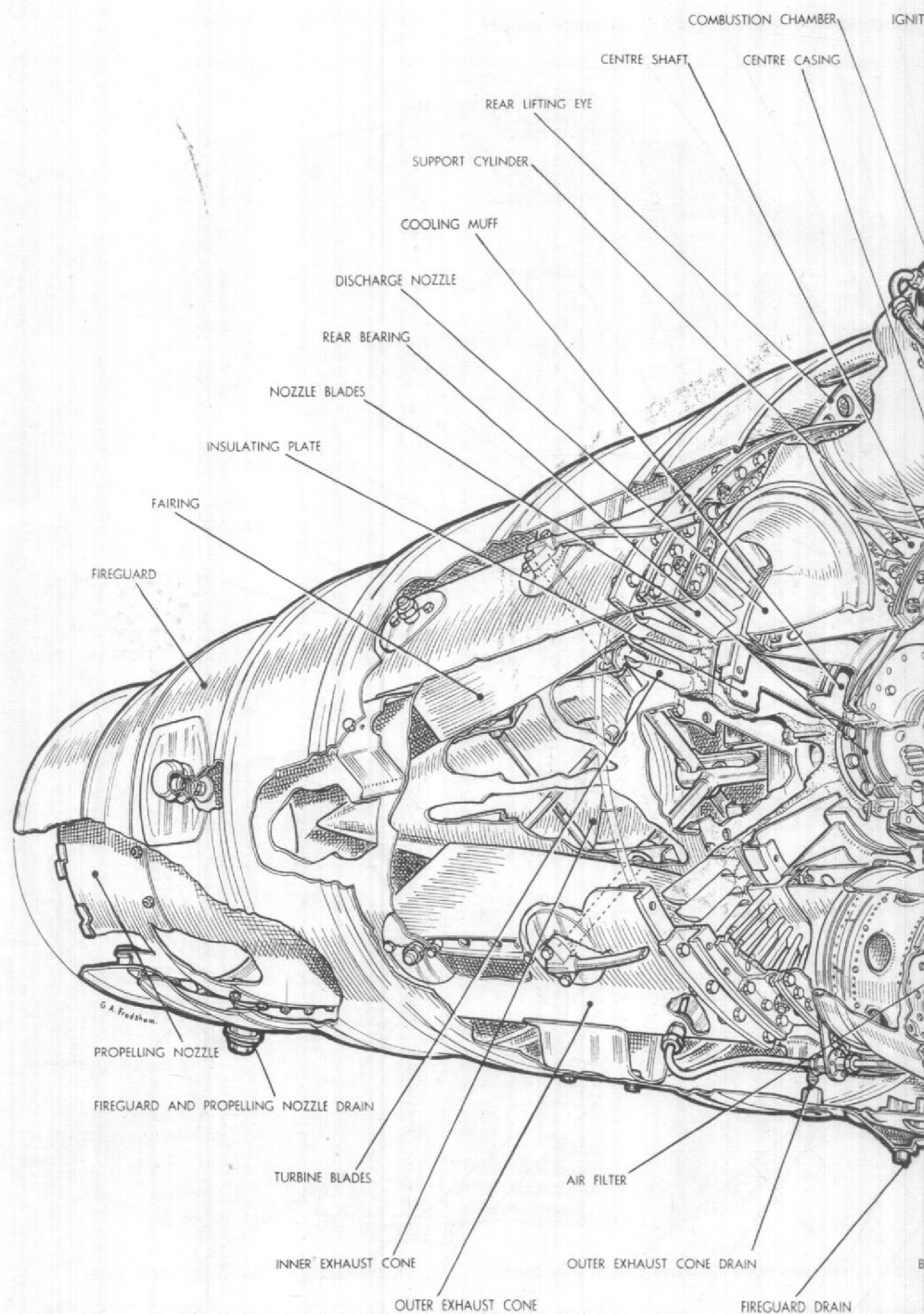
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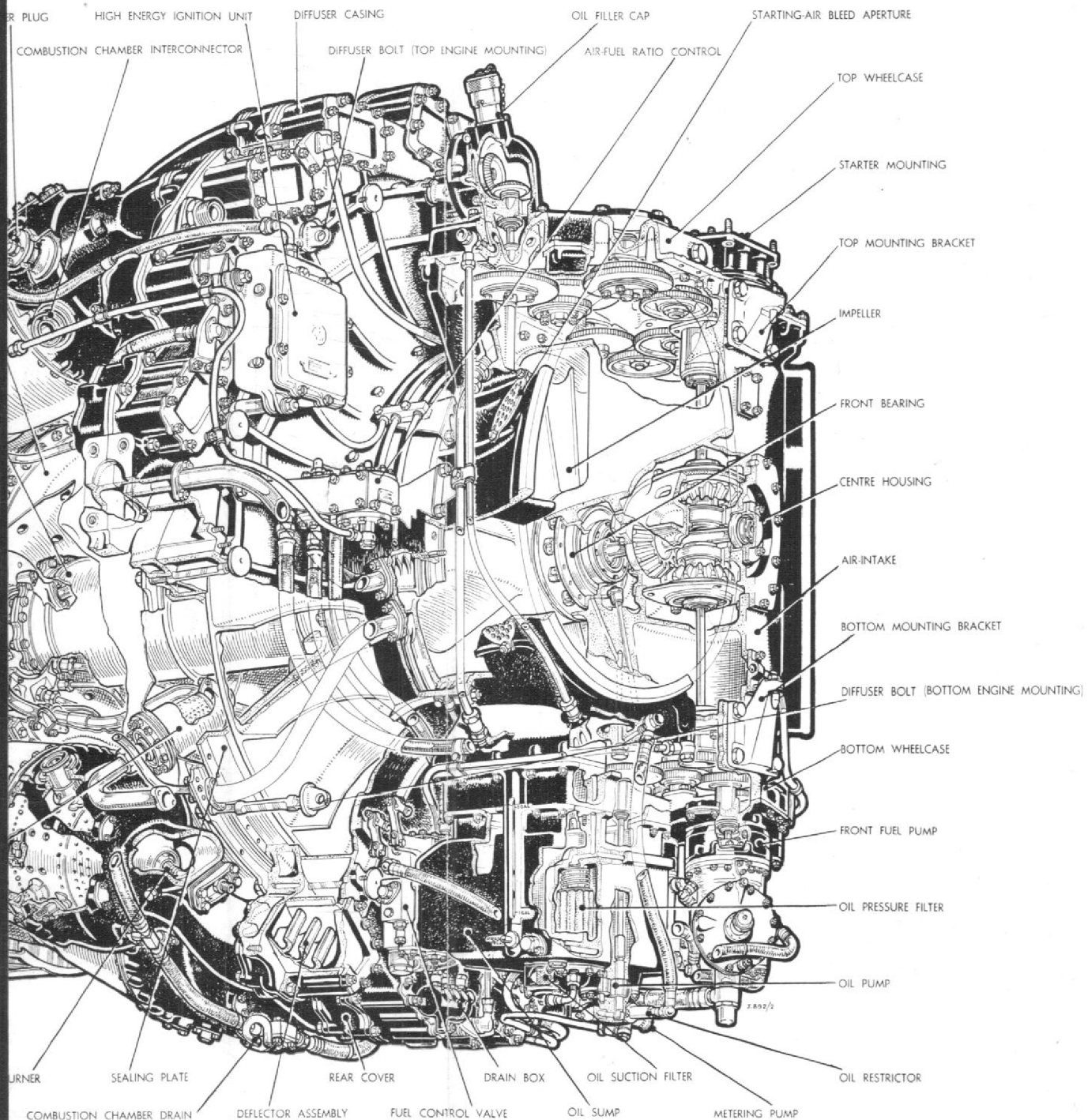
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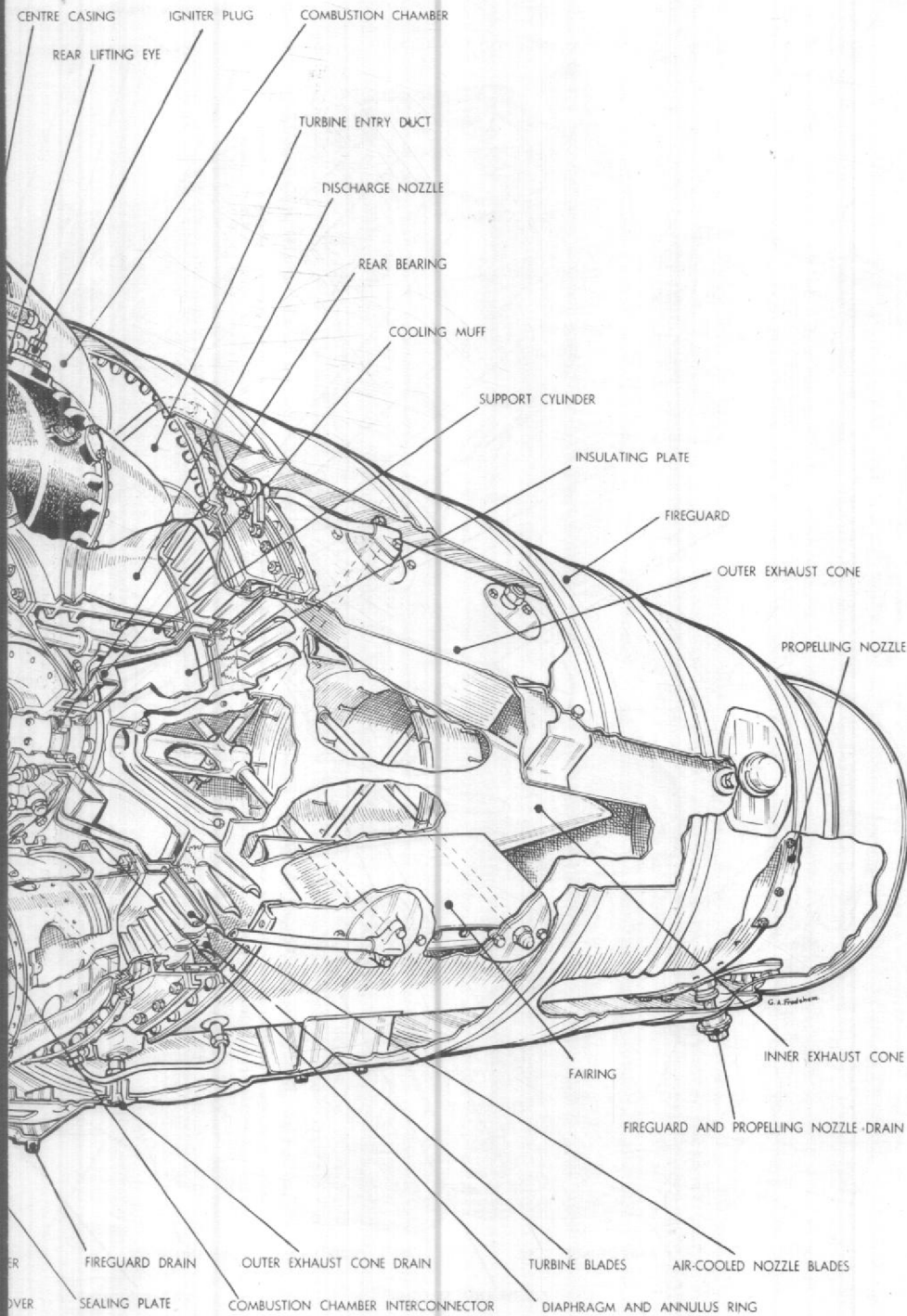
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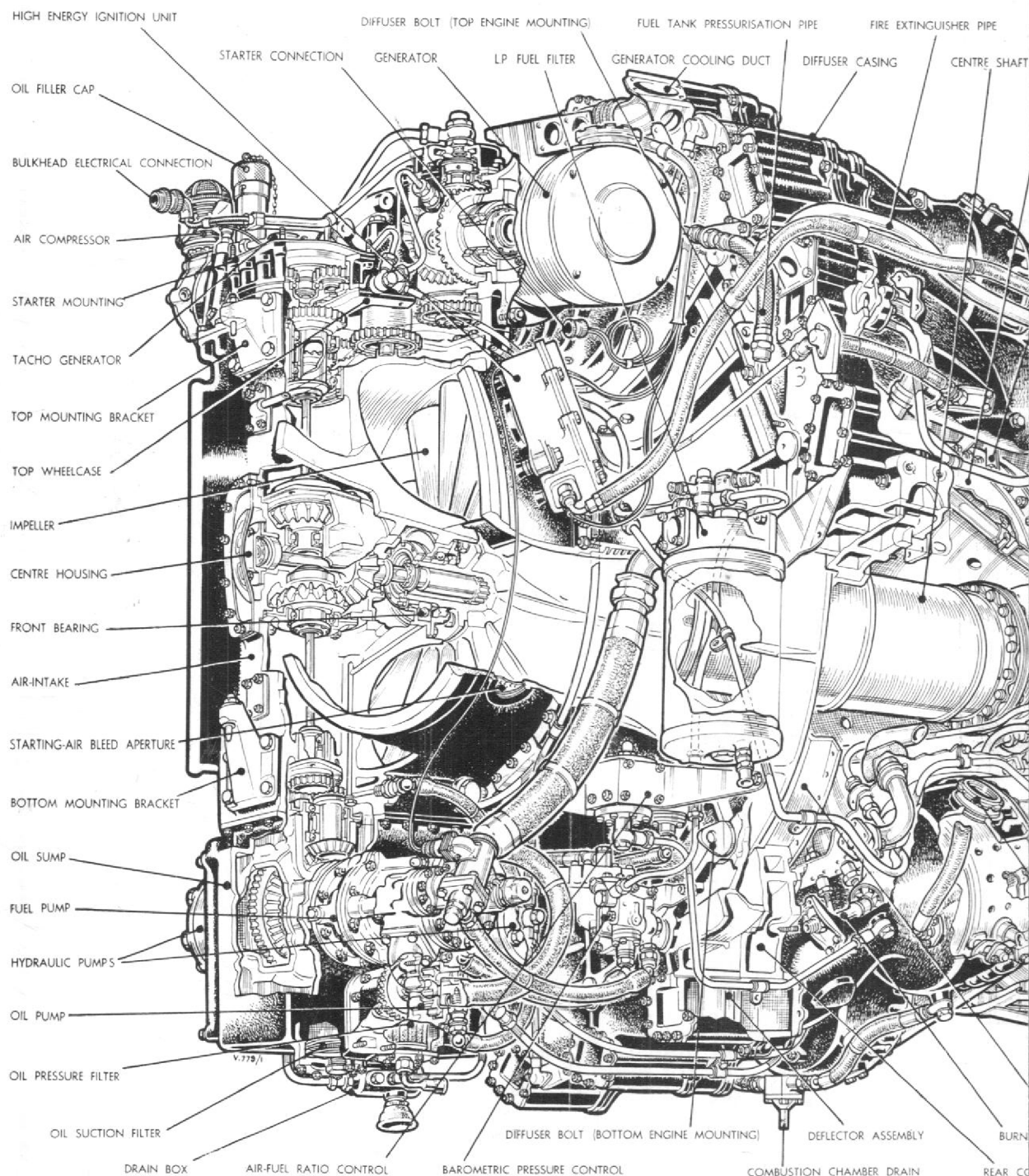




Ghost Forty-eight Mk. 1



k. 1



INTRODUCTION

THE DE HAVILLAND GHOST, production deliveries of which commenced in the summer of 1950, is a more powerful engine than the Goblin. It has been manufactured in quantity since that date and has entered service throughout the world. In addition to its extensive military application, a civil version, the Ghost Fifty, was developed and, in June, 1948, became the first turbo-jet propulsion unit to be approved for civil transport operation. This achievement complemented that of the Goblin which, in February, 1945, had become the first jet-engine to pass a military type-approval test.

The basic de Havilland design features which are responsible for the success of the Goblin have been retained in the Ghost. These concepts, comprising in essence a single-sided centrifugal compressor and a single-stage turbine which together form a single stiff rotating component, were selected when the de Havilland Engine Company embarked on gas-turbine design in 1941—the first of the established aero-engine manufacturers to do so. They yield a simple and robust engine and afford the full benefits of the effect of ram in flight, which gives progressive improvement in compression ratio as speed rises. As a result, de Havilland turbines have an exceptionally high ratio of flight thrust to static thrust, combined with unequalled performance at high speeds and altitudes.

The design thrust of the earlier Goblin engine has been increased in the case of the Ghost by 66 per cent. for an enlargement of only three inches of overall diameter (50.53 inches, 127.00-134.62 cm.). This was made possible by changes in compressor design which allowed a much larger impeller to be used without a proportionate increase in diffuser-casing diameter. By employing 20 diffuser vanes, instead of 16 as in the Goblin, a more gentle radial diffusion is obtained and this process is supplemented by some axial diffusion in the cast ducts leading to the combustion system itself.

As a result of combining two diffuser passages into one combustion chamber during the process of axial diffusion only 10 chambers are necessary.

Tests have shown that the low diameter has been obtained without loss of overall efficiency and with a reduction in the combustion pressure drop.

The frontispiece on page iii, clearly shows the air-intake leading to the centre of a single-entry compressor and also the diffuser casing, where the velocity of the air leaving the impeller is largely converted to pressure before delivery into the combustion system. The 10 straight-through combustion chambers converge in the turbine entry duct, where the gases are deflected through fixed nozzle guide vanes on to the rotating blades of a single-stage turbine. The sole function of the turbine is to extract enough power from the gases to drive the compressor; the residual energy is concentrated in the exhaust assembly, and the reaction of the gases ejected from the propelling nozzle produces the forward thrust.

Both the civil and military versions of the Ghost have achieved outstanding success in their individual fields. The performance of the Venom day, and night fighters, and the Sea Venom all-weather fighters benefits considerably from the effectiveness of the engine at extreme altitude, and the civil Ghost, which was installed in the Comet 1, contributed in no small measure to the reputation for speed, reliability and punctuality which had been established in well over 120000 hours of air line operation.

In March, 1948, a Vampire fitted with a Ghost set up a new world altitude record, for aircraft, by climbing to 59440 feet, 18119 m.

In Sweden, the Ghost is flying in the SAAB J.29 swept-wing interceptor in which, in 1954, was set up a 500 kilometre (310 miles) closed-circuit speed record of 976.916 km./hr., and, in February, 1955, the 1000 kilometre (620 miles) closed-circuit speed record of 900.65 km./hr.; the latter being a particularly striking indication of the stamina of this engine, having been set up by two Ghost-engined aircraft flying in formation. Ghost engines are being manufactured under licence agreements in both Sweden and Italy.

LEADING PARTICULARS GHOST 48 Mk. 1

Based on Engine Technical Certificate No. 1008 issue 3, and Special Certificate issue 3, dated 30th October, 1957

The Ghost 48 Mk. 1 is approved for use in civil aircraft in the Normal Category sub-divisions (a), (b), (c), (d), (e), (h), and (i), subject to compliance with the appropriate installation requirements of British Civil Airworthiness Requirements. The Normal Category is defined in British Civil Airworthiness Requirements.

GENERAL DESCRIPTION The Ghost 48 Mk. 1 is a turbo-jet engine incorporating a single-stage, single-sided, centrifugal compressor, 10 straight-flow combustion chambers, and a single-stage axial flow, turbine. This engine is similar to the Ghost 50 Mk. 1 except that it incorporates a bifurcated air-intake instead of a central intake, provision for bleeding air from the compressor for cabin pressurisation only, a modified oil system with a single wet sump in place of a dry sump with scavenge pump and double saddle oil tanks, additional accessory drives, and various other design changes of a minor nature; the ratings are slightly reduced.

DESIGNATION .. Ghost 48 Mk. 1 **TYPE OF ENGINE** .. Turbo jet
NETT DRY WEIGHT .. 2145 lb. $\pm 1\frac{1}{4}\%$ **ROTATION** .. Clockwise (viewed from rear).

NUMBERING OF COMBUSTION CHAMBERS Clockwise when viewed from the front, starting with No. 1 at the top.

NUMBER OF NOZZLE BLADES .. 80 (pre mod. 399) **NUMBER OF TURBINE BLADES** .. 97

PROPELLING NOZZLE diameter (cold) 18 $\frac{1}{2}$ inch, standard, mod. 409
 18 $\frac{5}{8}$ inch, alternative, mod. 706
 18 $\frac{3}{4}$ inch, alternative, mod. 789
 18 $\frac{5}{8}$ inch } Alternatives, adjustable by means of eight
 18 $\frac{7}{8}$ inch } detachable trimming strips, mod. 740.

The size of propelling nozzle fitted to each individual engine is decided whilst the engine is being bench tested; the larger, alternative nozzles being selected where necessary to correct excessive jet pipe temperature. Once an engine has been passed for service a different size of propelling nozzle must not be fitted, except as a result of subsequent bench testing.

PERFORMANCE .. Static under standard atmospheric conditions at sea level, with propelling nozzle only of types quoted in the engine specification.

<i>RATING</i>	<i>MAX. TAKE-OFF</i>	<i>MAX. CONTINUOUS</i>
Thrust, lb.	4660/4850	4100
Maximum r.p.m.	10250	9750
Max. Jet pipe temperature:—		
Average of four thermocouples deg. C... ..	700	600
Individual deg. C... ..	725	625
Consumption (upper Limit):—		
Oil, pints per hour	2.5	2.5
Fuel, gallons per hour (with fuel to specification D.Eng.R.D.2482)	735	595

PERFORMANCE CALIBRATION

<i>R.P.M.</i>	<i>Thrust lb.</i>
10250	4850
9750	4100
9500	3750
9000	3155
8500	2650
8000	2180
7000	1450
5000	600
3000	235

Fuel Consumption, gallons per hour (upper limit) (with fuel to specification D.Eng.R.D.2482)

735
595
535
449
382
324
241
146
90

PERFORMANCE ACCEPTANCE LIMITS will be contained in chapter 36 (Testing after Overhaul).
OPERATING LIMITATIONS .. See page ix.

FUEL Aviation kerosene to specification D. Eng. R.D. 2482 (average specific gravity at 60° F/60° F 0.80) or to specification D.Eng.R.D.2486 (average specific gravity at 60° F/60° F 0.77); or aviation gasolene to specification D.Eng.R.D.2485, or aviation carrier turbine fuel to specification D.Eng.R.D.2488 — Fuel pump governor settings must be adjusted to suit the different specific gravities of the fuels.

OIL To specification D.Eng.R.D.2479 (/0 or /1) (average specific gravity at 60° F/60° F 0.87); or to specification D.Eng.R.D.2487; see page x for proprietary brands.

NOTE. The fuel and oil specifications which are printed in italics are alternatives only when the engines are used for military purposes.

OIL TEMPERATURE AND PRESSURE .. See page ix. **OIL TANK CAPACITY** See chapter 9.
COMPRESSOR AIR BLEEDS See page ix.

Revised by Amendment No. 135
 November, 1957

<i>Accessories</i>	<i>Units type</i>	<i>Modification</i>
FUEL PUMPS—LUCAS (Solenoid fitted on front pump)	GC208/18N (front)	Basic standard.
	GC207/17N (rear)	
	Solenoid D7202	
	Solenoid D7202/M2	Mod. 403; Lucas mod. CP292.
	Solenoid D7202/MR	Mod. 521; S69 end cap, Rotax mod. 892D.
	GC208/63N (front)	Mod. 767; air bleed pipes re-positioned.
	GC207/62N (rear)	
	GC208/63AF (front)	Mod. 818; calibration code revised to differentiate between setting of Goblin and Ghost.
	GC207/62AF (rear)	
	GC208/63AF (front)	Mod. 1129 part 2; governor settings reversed.
	GC207/62AF (rear)	
	GC264/63AK (front)	Mod. 1129 part 1; incorporating bleed orifice to increase pump governor rate.
	GC263/62AK (rear)	
	GC287/63AK (front)	Mod. 1366; beryllium copper slippers.
	GC286/62AK (rear)	
BAROMETRIC PRESSURE CONTROL—LUCAS	BPC3/15N	Basic standard.
	BPC3/15V	Mod. 369; cancelled by mod. 790.
	BPC11/15V	Mod. 709; stop plate and tapered pistons to limit excessive travel of piston.
	BPC11/15N	Mod. 790; type number corrected to accord with cancellation of mod. 369.
	BPC12/15N	Mod. 865; high pressure pin hinge type lever.
AIR-FUEL RATIO CONTROL— LUCAS	AFR2/3B	Basic standard.
	AFR2/6E	Mod. 369; cancelled by mod. 790.
	AFR2/6B	Mod. 469; Bundy tubing replaces Tungum for air pressure pipe.
	AFR2/6F	Mod. 525; 120 lb. shock load test.
	AFR3/6F	Mod. 864; high pressure pin hinge type lever.
	AFR3/8F	Mod. 1031; Avica metallic hose replaces Bundy tubing.
FUEL FLOW DISTRIBUTOR— LUCAS†	FD12/14G	Basic standard.
	FD18/18G	Mod. 318; piston incorporating carbon bearings.
	FD20/22H	Mod. 368; biased flow distributor, superseded by mod. 790.
	FD18/21J	Mod. 433; restrictors in No. 4 and 9 outlet unions.
	FD20/27L	Mod. 727; recalibrated distributor.
	FD27/27L	Mod. 1008; cold test at minus 40 deg. C., letter "C" stamped on cylindrical portion of body.
	FD27/30L	Mod. 1074; non-return valve on spill.
† All new fuel flow distributors as from serial No. 1521 and all distributors overhauled since 31-8-1953 have been subjected to a cold test at minus 40 deg. C. to overcome stiction. These distributors can be identified by the letter "C" or "CC" stamped inside the weight-reducing cavity in the mounting flange; this is, of course, not visible when the distributor is mounted on an engine. Also: serial number prefixed by letter "L", or "B" if serial number is 1521 or later; see also mod. 1008 above.		
BURNERS—LUCAS	CSH28	Basic standard.
	CSH37	Mod. 228; plating on sleeve altered to nickel.
	CSH42	Mod. 326; width of slots on lock nut.
	CSH43	Mod. 369; cancelled by mod. 790.
	CSH42	Mod. 790; type number corrected to accord with cancellation of mod. 369.
	CSH53	Mod. 909; anti-carbon burners, complete sets fitted in new engines; may be mixed when servicing or reconditioning.
<i>Note.</i> —Lucas type numbers comprise: The basic type designation (AFR.2), followed by a stroke (/2) which is a code reference indicating the installation details and a final letter (B) to indicate the calibration code to which the unit is tested.		
HIGH ENERGY IGNITION UNITS	B.T.H. C.10.T.S/1	Basic standard.
	C.10.T.S/2	Mod. 573; 15 mm. flashover path and modified cables.
	C.10.T.S/3	Mod. 1190; miniature spark gap to initiate first discharge at correct breakdown voltage.
	Rotax N.B.25/2	Mod. 1051; alternative to B.T.H. units.

*Revised by Amendment No. 138
June, 1958*

<i>Accessories</i>	<i>Unit type</i>	<i>Modification</i>
SURFACE DISCHARGE IGNITER PLUGS	Lodge 277/3	Basic standard.
	Lodge 277/3RI or 277/8RI	Mod. 398; improved ceramic material.
	Lodge 277/3RI	Mod. 504; deletion of type 277/8RI.
	Lodge LH.101	Mod. 571; type number changed only.
	Lodge LH.101/1	Mod. 700; increase to wall thickness of body and hardness of semi-conductive seal.
	K.L.G. KH.102	Mod. 966; strengthened igniter plug with integral screen tube.
	Lodge LH.102	Mod. 1157; alternative to KH.102.
TURBO STARTER	Rotax CT.0101	Basic standard.
	Rotax CT.0101/1	Mod. 569; 24-blade rotor and new nozzle ring.
	Rotax CT.0101/2	Mod. 891; sintered clutch plate and rings to permit use of oil to specifications D.E.D.2479 or 2487.
	Rotax CT.0101/3	Mod. 1297; diaphragm type seal in nozzle ring assembly replaces carbon type.
OR *ELECTRIC STARTER	Rotax C.5905/2	Basic standard. Used in conjunction with the following airframe equipment: Rotax starter panel comprising two relays D.6103, time switch D.8115, overspeed relay F.1710, and resistance N.102421.

* These starters are not directly interchangeable as certain top wheelcase drive components must be changed also.

OIL METERING PUMP	Tecalemit	
	PE.7710	Basic standard.
	PE.7710/M4	Mod. 574; improved finish on cam face.
	PE.7710/M5	Mod. 819 part 1; revised locking of stop collar.
	PE.7710/M6	Mod. 819 part 2; hammer-drive screw securing setting collar.
	PE.7710/M7	AS.796; minor changes to facilitate production.
OIL PRESSURE TRANSMITTER	Smith's 480/PG/SB	
TACHOMETER GENERATOR	Kelvin Bottomley KB.156/01	
OIL THERMOMETER BULB	Sangamo Weston S.110 Form 3	Mod. 817.

ENGINE-DRIVEN AIRCRAFT ACCESSORIES

Although the following accessories may be fitted to the engine, for precise details of the accessories to be fitted for any particular installation, reference should be made to the relevant aircraft handbook or drawing.

HYDRAULIC PUMP: Lockheed Mk. 6 or 7 (two when mod. 578 is embodied), or Mk. 9 (mod. 1181 Neoprene seals replaced by silicone-treated leather seals to ensure satisfactory sealing when lubricating oil D.Eng.R.D.2487 is used).

ALTERNATOR: Newton Bros. Type U.2(1.5KVA).

AIR COMPRESSOR: Hymatic type SH6/2A.

GENERATOR: BTH. Type LG.2220 Form 1/1 (3Kw).

ACCESSORY DRIVES

Direction of rotation as seen looking on the driving spindle of the accessory, and speed of drive relative to speed of main shaft of the engine.

<i>Accessory</i>	<i>Direction of Rotation</i>	<i>Speed of Drive</i>	<i>Accessory</i>	<i>Direction of Rotation</i>	<i>Speed of Drive</i>
Fuel Pumps	Clockwise	0.369	Generator	Counter-clockwise	0.524
Hydraulic Pump	Clockwise	0.333	Tachometer Generator	Counter-clockwise	0.250
Starter (Electric)	Clockwise	5.709	Air Compressor	Clockwise	0.156
Alternator	Counter-clockwise	0.524	Spare Drive	Clockwise	0.350

Revised by Amendment No. 136
January, 1958

LEADING PARTICULARS GHOST 48 Mk. 2

Based on Special Certificate issue 2, dated 4th May, 1956.

GENERAL DESCRIPTION The Ghost 48 Mk. 2 is similar to the Ghost 48 Mk. 1 except that the oil sump and top wheelcase have been redesigned to provide mountings and drives for a pair of large capacity generators, a second hydraulic pump, and the spill-burner system components; the dual Lucas pump fuel system is replaced by a Dowty spill-burner fuel system, and there is no separate bottom wheelcase; there are also a number of detail differences. The Leading Particulars for the Ghost 48 Mk. 1, on page vi, are, in the main, applicable to the Ghost 48 Mk. 2 with the following exceptions.

DESIGNATION .. Ghost 48 Mk. 2 **NETT DRY WEIGHT** .. 2230 lb. $\pm 1\frac{1}{4}\%$
NUMBER OF NOZZLE BLADES 70

OPERATING LIMITATIONS, and **OIL TEMPERATURE AND PRESSURE**, see page xiii

PERFORMANCE .. Static under standard atmospheric conditions at sea level, with propelling nozzle only of types quoted in the engine specification and with test bed air-intakes to de Havilland drawing No. WD.9170.

RATING	MAX. TAKE-OFF and OPERATIONAL NECESSITY		MAX. CONTINUOUS
Thrust, lb.	4760/4950		4150
Maximum r.p.m.	10250		9750
Maximum single point jet pipe temperature, deg. C.	725		625
Consumption (upper limit):—			
Oil, pints per hour	2.5		2.5
Fuel, gallons per hour (with fuel to specification D.Eng.R.D. 2486)	777		626

PERFORMANCE CALIBRATION

R.P.M.	Thrust lb.	Fuel consumption, gallons per hour (upper limit) (with fuel to specification D.Eng.R.D.2486)
10250	4950	777
10000	4500	686
9750	4150	626
9250	3420	507
8750	2780	416
8000	2000	312
7000	1325	234
5000	550	139
3000	230	93

ENGINE ACCESSORIES GHOST 48 Mk. 2

FUEL SUPPLY PUMP—DOWTY 129 Mk. 33
CIRCULATING PUMP AND VALVE GROUP UNIT—DOWTY Eng.221 Mk. 5
NON-RETURN VALVE UNIT—DOWTY .. Eng.390 Mk. 1
FLOW CONTROL UNIT—DOWTY .. Eng.207 Mk. 5A

*Revised by Amendment No. 127
October, 1956*

AIR-FUEL RATIO CONTROL--DOWTY ..	Eng.268 Mk. 6
SOLENOID VALVE--DOWTY.. ..	Eng.536 Mk. 1
FUEL BURNERS--DOWTY	
Combustion chambers No. 1, 2, 3, 7, 8, and 10	Eng.310 Mk. A2
Combustion chambers No. 4, 5, 6, and 9 ..	Eng.310 Mk. C2, J2, Y2, and B2 respectively
HIGH ENERGY UNITS	B.T.H. C.10.T.S/2, or C.10.T.S/3, or Rotax N.B.25/2
TORCH IGNITERS	K.L.G. KH.103/2
STARTER	Turbo starter, Rotax CT.0104
OIL METERING PUMP	Tecalemit PE.7710/M11
TACHOMETER GENERATOR	Smith's 106RV, Mk. 8
OIL THERMOMETER BULB	Sangamo Weston S.110.G/21/111

ENGINE-DRIVEN AIRCRAFT ACCESSORIES GHOST 48 Mk. 2

Although the following accessories may be fitted to the engine, for precise details of the accessories to be fitted for any particular installation, reference should be made to the relevant aircraft handbook or drawing.

HYDRAULIC PUMPS	Two, Lockheed Mk. 6 or 7, or Mk. 9 (mod. 1181 Neoprene seals replaced by silicone-treated leather seals to ensure satisfactory sealing when lubricating oil D.Eng.R.D.2487 is used.)
AIR COMPRESSOR	Hymatic SH6/2
GENERATORS	Two, B.T.H. Type 507

ACCESSORY DRIVES

Direction of rotation as seen looking on the driving spindle of the accessory, and speed of drive relative to speed of main shaft of the engine.

<i>Accessory</i>	<i>Direction of Rotation</i>	<i>Speed of Drive</i>	<i>Accessory</i>	<i>Direction of Rotation</i>	<i>Speed of Drive</i>
Fuel supply pump	Clockwise	0.345	Generators	Clockwise	0.964
Fuel circulating pump	Clockwise	0.345	Tachometer generator	Clockwise	0.5
Hydraulic pumps	Counter-clockwise	0.345	Air compressor	Counter-clockwise	0.155

OPERATING LIMITATIONS GHOST 48 Mk. 1

Based on Engine Technical Certificate No. 1008 issue 3, and Special Certificate Issue 3, dated 30th October, 1957.

The following operating limitations must on no account be exceeded.

Limitations printed in *italics* are applicable only when the engines are used for military purposes ; if the engines are used for civil purposes these must be ignored.

FLYING CONDITIONS	R.P.M.	JET TEMPERATURE*	LIMITATIONS
Maximum take-off, and operational necessity	10250†	725 deg. C.	5 (30) mins. limit ; r.p.m. to be reduced to 10100 when climbing above 25000 ft., and in level flight above 35000 ft.
Maximum continuous	9750	625 deg. C.	—
Ground idling	3000 ± 200	Maximum 450 deg. C.	—
Minimum r.p.m. for ap- proach (as type tested)	5000	—	—
Maximum overspeed	10550	—	20 sec. limit

TURBINE BEARING

TEMPERATURE ..	Maximum 160 (195) deg. C.	FUEL	See page vi.
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DRAINAGE PERIOD

AFTER A FALSE START (as type tested)	Minimum 5 minutes	OIL	See page vi.
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OIL INLET TEMPERATURE

		<i>Oil Specification</i>	
MINIMUM FOR STARTING	Minus 10 deg. C.	<i>D.Eng.R.D.2479/0 and 2479/1</i>	<i>D.Eng.R.D.2487</i>
MINIMUM FOR OPENING UP (COLD)	Minus 10 deg. C.	<i>Minus 10 deg. C.</i>	<i>Minus 40 deg. C.</i>
MAXIMUM	Plus 80 deg. C.	<i>Plus 135 deg. C.</i>	<i>Plus 135 deg. C.</i>

OIL PRESSURE at maximum continuous r.p.m.

NORMAL at 75 deg. C. oil inlet temperature	35/45 lb. per sq. in.
MINIMUM	25 lb. per sq. in.
MINIMUM (with oil inlet temperature in excess of 105 deg. C.)	15 lb. per sq. in.

OIL TANK CAPACITY See chapter 9.

COMPRESSOR AIR BLEED

MAXIMUM R.P.M. AT WHICH AIR BLEEDS MAY BE OPERATED, 10250 r.p.m

AIR DELIVERY AT 10250 R.P.M. UNDER STANDARD ATMOSPHERIC CONDITIONS AT
SEA LEVEL

MAXIMUM FOR CABIN PRESSURISATION, 8 lb. per minute.

* Individual jet pipe temperature, with propelling nozzle only of the types quoted in the engine specification, measured in hottest position ; determined during prototype aircraft trials.

† The 50 r.p.m. overspeed, which occurs upon operation of the emergency fuel-pump-isolating switch, is acceptable when the engines are used for military purposes.

Revised by Amendment No. 135
November, 1957

LUBRICATING OIL FOR GHOST ENGINES

30-10-57

The de Havilland Ghost engines are approved for operation on lubricants complying with the following British Ministry of Supply Specification.

The proprietary brands of lubricating oil listed below and certified as complying with the requirements of the specification are, until further notice, suitable for use in the de Havilland Ghost engines under appropriate operating condition.

<i>TEMPERATURE RANGE</i>	<i>D.E.D. SPECIFICATION</i>	<i>MANUFACTURER AND DISTRIBUTOR</i>	<i>MANUFACTURER'S GRADE</i>
minus 5 to plus 85 deg. C.	D.E.D. 2479	{ Esso Petroleum Co., Ltd. Esso Aviation Oil 57 Shell Petroleum Co., Ltd. Aeroshell Turbine 9 C. C. Wakefield & Co. Castrolite Aero Anglo-Iranian Oil Co., Ltd. B.P. Aero Turbine Oil 9	
minus 10 to plus 135 deg. C.	{ <i>D.E.D. 2479/0</i> <i>D.E.D. 2479/1</i>		
minus 40 to plus 135 deg. C.	<i>D. Eng. R.D. 2487 Type R.D.E./0/463</i>	<i>Esso Petroleum Co. Ltd.</i>	<i>Esso Aviation Turbo Oil 35</i>

NOTE. British specification DTD.44D has been replaced by DEF.2001. Since these specifications are identical, oil to specification DEF.2001 may be used in lieu of oil to specification DTD.44D wherever the latter is called for in the text of this handbook. Oil to British Specification D.Eng.R.D. 2490 is an alternative to DEF.2001 and, as the difference in viscosity is only 2, is also suitable for inhibiting the fuel system of these engines.

NOTE—The temperature ranges and oil specifications which are printed in italics are alternatives only when the engines are used for military purposes.

LEADING PARTICULARS GHOST 48 Mk. 2

Based on Special Certificate issue 3, dated 30th October 1957.

GENERAL DESCRIPTION The Ghost 48 Mk. 2 is similar to the Ghost 48 Mk. 1 except that the oil sump and top wheelcase have been redesigned to provide mountings and drives for a pair of large capacity generators, a second hydraulic pump, and the spill-burner system components; the dual Lucas pump fuel system is replaced by a Dowty spill-burner fuel system, and there is no separate bottom wheelcase; there are also a number of detail differences. The Leading Particulars for the Ghost 48 Mk. 1, on page vi, are, in the main, applicable to the Ghost 48 Mk. 2 with the following exceptions.

DESIGNATION .. Ghost 48 Mk. 2 **NETT DRY WEIGHT** .. 2230 lb. $\pm 1\frac{1}{4}\%$
NUMBER OF NOZZLE BLADES 70

OPERATING LIMITATIONS, and OIL TEMPERATURE AND PRESSURE, see page xiii

PERFORMANCE .. Static under standard atmospheric conditions at sea level, with propelling nozzle only of types quoted in the engine specification and with test bed air-intakes to de Havilland drawing No. WD.9170.

RATING	MAX. TAKE-OFF and OPERATIONAL NECESSITY		MAX. CONTINUOUS
Thrust, lb.	4760/4950		4150
Maximum r.p.m.	10250		9750
Maximum single point jet pipe temperature, deg. C.	720		620
Consumption (upper limit):—			
Oil, pints per hour	2.5		2.5
Fuel, gallons per hour (with fuel to specification D.Eng.R.D. 2486)	777		626

PERFORMANCE CALIBRATION

R.P.M.	Thrust lb.	Fuel consumption, gallons per hour (upper limit) (with fuel to specification D.Eng.R.D.2486)
10250	4950	777
10000	4500	686
9750	4150	626
9250	3420	507
8750	2780	416
8000	2000	312
7000	1325	234
5000	550	139
3000	230	93

ENGINE ACCESSORIES GHOST 48 Mk. 2

FUEL SUPPLY PUMP—DOWTY 129 Mk. 33
CIRCULATING PUMP AND VALVE GROUP UNIT—DOWTY Eng.221 Mk. 5
NON-RETURN VALVE UNIT—DOWTY .. Eng.390 Mk. 1
FLOW CONTROL UNIT—DOWTY .. Eng.207 Mk. 5A

*Revised by Amendment No. 135
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AIR-FUEL RATIO CONTROL--DOWTY ..	Eng.268 Mk. 6
SOLENOID VALVE--DOWTY.. ..	Eng.536 Mk. 1
FUEL BURNERS--DOWTY	
Combustion chambers No. 1, 2, 3, 7, 8, and 10	Eng.310 Mk. A2
Combustion chambers No. 4, 5, 6, and 9 ..	Eng.310 Mk. C2, J2, Y2, and B2 respectively
HIGH ENERGY UNITS	B.T.H. C.10.T.S/2, or C.10.T.S/3, or Rotax N.B.25/2
TORCH IGNITERS	K.L.G. KH.103/2
STARTER	Turbo starter, Rotax CT.0104
OIL METERING PUMP	Tecalemit PE.7710/M11
TACHOMETER GENERATOR	Smith's 106RV, Mk. 8
OIL THERMOMETER BULB	Sangamo Weston S.110.G/21/111

ENGINE-DRIVEN AIRCRAFT ACCESSORIES GHOST 48 Mk. 2

Although the following accessories may be fitted to the engine, for precise details of the accessories to be fitted for any particular installation, reference should be made to the relevant aircraft handbook or drawing.

HYDRAULIC PUMPS	Two, Lockheed Mk. 6 or 7, or Mk. 9 (mod. 1181 Neoprene seals replaced by silicone-treated leather seals to ensure satisfactory sealing when lubricating oil D.Eng.R.D.2487 is used.)
AIR COMPRESSOR	Hymatic SH6/2
GENERATORS	Two, B.T.H. Type 507

ACCESSORY DRIVES

Direction of rotation as seen looking on the driving spindle of the accessory, and speed of drive relative to speed of main shaft of the engine.

<i>Accessory</i>	<i>Direction of Rotation</i>	<i>Speed of Drive</i>	<i>Accessory</i>	<i>Direction of Rotation</i>	<i>Speed of Drive</i>
Fuel supply pump	Clockwise	0.345	Generators	Clockwise	0.964
Fuel circulating pump	Clockwise	0.345	Tachometer generator	Clockwise	0.5
Hydraulic pumps	Counter-clockwise	0.345	Air compressor	Counter-clockwise	0.155

OPERATING LIMITATIONS GHOST 48 Mk. 2

Based on Special Certificate Issue 3, dated 30th October, 1957.

The following operating limitations must on no account be exceeded.

These Limitations are applicable only when the engine is used for military purposes.

FLYING CONDITIONS	R.P.M.	JET TEMPERATURE*	LIMITATIONS
Maximum take-off, and operational necessity	10250†*	760 deg. C.†	30 mins. limit; where mod. 1175 is not em- bodied, r.p.m. to be re- duced to 10100 when climbing above 25000 ft., and in level flight above 35000 ft.‡
Maximum continuous	9750	660 deg. C.†	—
Ground idling	3000 ± 200	Maximum 450 deg. C.	—
Minimum r.p.m. for approach	5000	—	—

TURBINE BEARING TEMPERATURE Maximum 195 deg. C.

FUEL .. See page vi OIL .. See page vi

Oil Specification

OIL INLET TEMPERATURE	D.Eng.R.D.2479/0 and 2479/1	D.Eng.R.D.2487
MINIMUM FOR STARTING	Minus 10 deg. C.	Minus 40 deg. C.
MINIMUM FOR OPENING UP (COLD)	Minus 10 deg. C.	Minus 40 deg. C.
MAXIMUM	Plus 135 deg. C.	Plus 135 deg. C.

OIL PRESSURE with any of the above-mentioned oils

NORMAL at maximum continuous r.p.m.	20/25 lb. per sq. in.
MINIMUM at max. cont. r.p.m. and above	10 lb. per sq. in.

OIL TANK CAPACITY See chapter 9

* Single point jet pipe temperature, with propelling nozzle only of the types quoted in the engine specification; measured in hottest position, determined during prototype aircraft trials.

Engine is approved for maximum average gas temperature (4 thermocouples of 720 deg. C.).

† Since, for this engine, r.p.m. is the primary operating limitation, with jet temperature a secondary, although over-riding, limitation, the engine speed indicator in the cockpit must be accurate; to attain the required degree of accuracy, an adjustable pointer, or fake scale, may have to be fitted to engine speed indicator, as these indicators may be inaccurate by as much as ± 120 r.p.m. at the upper end of their range.

* In tropical conditions, to avoid excessive rear bearing temperatures, the use of 10250 r.p.m. must be confined to 10 minutes at altitudes below 5000 feet.

‡ Mod. 1175 introduces a negative rate governor mechanism which prevents engine overspeeding at altitude and overcomes the necessity for the pilot to reduce engine r.p.m. whilst climbing, this being done automatically from about 25000 feet upwards. Where this mechanism is fitted it is, therefore, possible to carry out all maximum r.p.m. operation with the throttle in the fully open position, the full-throttle engine r.p.m. being controlled automatically as follows:—

Flying Condition	Engine r.p.m.
Take-off, static	10250 ± 50
25000 feet	10250—100
45000 feet	10050

From above this altitude the r.p.m. will be reduced automatically and progressively

Revised by Amendment No. 135
November, 1957

LIST OF MINOR REVISIONS

The following minor revisions have become necessary since the publication of the chapters concerned. When the pages affected are reprinted to embody any future amendment these revisions will, of course, be incorporated. In the meantime, operators who wish to do so may make the necessary alterations with pen and ink.

CHAPTER 6, PAGE 6 (5TH AND 6TH PARA.)

Where mod. 796 has been embodied the two front central pick-up brackets are changed and have a vertical pin which engages in redesigned pick-up points on the aircraft; as the engine is lowered into position these pins are engaged in the airframe location. There are no separate bolts and nuts to be fitted.

CHAPTER 13, PAGE 3, 6TH AND 7TH LINES

The last six words should read: should be fitted at the periods recommended in chapter 12, page 1.

CHAPTER 14, PAGE 2, PARA. 2

Where mod. 813 has been embodied, there is a bleed type drain connection at the base of the L.P. fuel filter through which the filter can be drained, without mess, as follows: Push a length of $\frac{1}{2}$ inch P.R. hose over the snout on the drain point, place the open end of the hose over a suitable receptacle and slacken the outer hexagon on the drain point about $1\frac{1}{2}$ /2 turns.

CHAPTER 14, PAGE 2, PENULTIMATE PARA., LAST LINE

The last four words should read: fitted at the periods recommended in chapter 12, page 1.

CHAPTER 14, PAGE 2, LAST PARA. 1ST SENTENCE

This sentence should be deleted as the gauze was deleted from the outer sleeve by mod. 754.

CHAPTER 17, PAGES 2 AND 18, AIR FILTERS, REAR-BEARING AIR COOLING

Add new paragraph.

Scrupulous cleanliness of the air filter element is of the utmost importance to ensure an unrestricted supply of cooling air to the rear-bearing, and care must be taken to ensure that the element (Vokes or Tecalemit) does not become impregnated with oil during handling or storage.

CHAPTER 17, PAGES 6, 8, AND 14

Mod. 593 introduced tab washers under the turbine and nozzle shroud bolt heads; the nuts being similarly locked. If, therefore, these bolts are for any reason disturbed, then new tab washers must be fitted. When fully tightened, the bolt heads and the nuts must be locked.

Tab washers for	Bolt locking		Nut locking	
	Qty.	Part No.	Qty.	Part No.
Nozzle shroud to Turbine shroud	30	N.5464	27	N.5105
Nozzle shroud to Discharge nozzle	20	N.5102	20	N.5102
	10	N.5106	10	N.5106

CHAPTER 17, PAGE 7, PARA. 4

or more than 0.010 inch fore-and-aft (axial) movement *to read* more than 0.040 in. fore-and-aft (axial) movement.

CHAPTER 17, PAGE 13, INSERT NEW PARAGRAPH IMMEDIATELY AFTER FIRST PARAGRAPH

Draw marks on the surface of the hexagonal bar from which the turbine disc securing nuts are manufactured should not be mistaken for defects and, therefore, these nuts should not be removed and rejected merely because of draw marks on their flats.

CHAPTER 17, PAGE 13, PARA. 3, 18TH LINE ET SEQ

To read: bolts to remove the turbine disc. When the disc is released from the hub shaft, 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; unscrew the inner bolts until they are clear of the hub shaft threads.

CHAPTER 17, PAGE 14, PARA. 3

If mod. 279 has not been embodied, tab washers Part No. 600542 must be used in place of 98986.

CHAPTER 17, PAGE 14 (5TH PARA.), AND FIG. 25

Special tool T.76958, which is used in conjunction with a Headland Weaver 60-ton hand-operated hydraulic press, should be used for correcting turbine shroud distortion.

CHAPTER 18, PAGE 2, REMOVAL OF EXHAUST CONE, AND PAGE 11, REFITTING

Mod. 593 introduces 30 tab washers (Part No. N.5103) to lock the turbine shroud to exhaust cone bolts and nuts. New tab washers must be fitted whenever these bolts are disturbed, and be locked after the bolts and nuts have been fully tightened.

CHAPTER 20, PAGE 5, PROTECTIVE SUBSTANCES

Add or DEF. 2001, immediately after D.T.D. 44D.

CHAPTER 20, PAGE 14, INSTALLED ENGINES

Insert new paragraph immediately after this shoulder heading

The following items of the equipment tabulated on pages 2 to 5 will be required: 7, 8, and 15.

CHAPTER 21, PAGE 14, TOOLS FOR USE ON FUEL SYSTEM

<i>Add</i>	T.77097	Male adapter	For use with T.75050 and T.75051
	$\frac{1}{8}$ in. to $\frac{1}{4}$ in. B.S.P.		
	T.77098	Female adapter	
	$\frac{1}{8}$ in. to $\frac{1}{4}$ in. B.S.P.		

CHAPTER 21, PAGE 14, TOOLS FOR USE ON BURNERS

After T.72789 Setting fixture
Add type 4 combustion chambers only.

Add new item

T.76459 Setting fixture for use with T.72788, suitable for both type 4 and type 5 combustion chambers and Dowty spill-flow burners.

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