INTRODUCTION

1. Engine Change Units are complete power unit replacements, designed to facilitate rapid 'turn round' of the aircraft and maximum economy in manhours. Each Mark of engine change unit in these series consists of the basic aero-engine, together with a number of additional items. These additional items will vary according to the installational requirements of the aircraft concerned and are listed in the engine change unit specification.

2. The basic engine for these e.c.u.'s consists of the following main components:—

(1) A twelve-stage, axial-flow compressor fitted with an air-bleed system to control air flow and prevent surge within the compressor.

(2) Eight straight-flow combustion chambers to heat and direct the flow of gas.

(3) A nozzle box to direct the flow from the combustion chambers on to the turbine.

(4) A two-stage axial-flow turbine which converts part of the gas energy into rotating motion to drive the compressor.

(5) An exhaust unit which directs the gases into a jet pipe and propelling nozzle where the gases are accelerated still further in their passage to atmosphere.

(6) An internal and an external wheelcase to house the gears which drive the engine components and remotely situated accessory gearbox.

3. The engine systems consist of:—

(1) A starter system comprising a turbo-starter to turn the engine, and high-energy igniter plugs to initiate combustion of the fuel burner spray during the starting cycle.

(2) A high pressure fuel system to deliver the correct quantity of fuel to the burners under all operating conditions.

(3) A self-contained, single-pressure lubrication system incorporating a fuel-cooled oil cooler.

(4) An internal cooling system using air tapped from the compressor.

(5) An electrically operated hot air anti-icing system, serving the air intake and intake guide vanes.

(6) An electrically operated gun-firing system consisting of a fuel and air dip unit which controls the fuel and air flow to prevent surge when the guns are fired at high altitudes *(Mk. 121 and 122 only)*.

(7) A fire extinguishing system consisting of spray pipes fitted around the engine, and a fireproof bulkhead to screen the fuel system components from the combustion chambers.

Compressor

4. The rotating assembly of the axial-flow compressor is formed by a hollow cone-shaped shaft, splined to receive steel rings, to which are pinned twelve rows of matched and graded rotor blades. The stator assembly consists of an initial row of variable-pitch intake guide vanes carried in the intake casing, followed by eleven rows of stator blades secured radially in a two-piece outer casing; a row of outlet guide vanes is provided at the compressor exit.

5. The compressor shaft is flexibly coupled to the turbine shaft and the complete rotating assembly is supported in roller bearings at the front and rear ends and a ball thrust bearing at the centre. A spring drive at the forward end of the shaft transmits the torque derived from the turbo-starter when turning the engine for starting.

6. Labyrinth-type seals are fitted at the front end of the compressor shaft, to control the flow of cooling air to the front bearing, and at the rear end to restrict the air leakage from the last stage of the compressor into the hub area, which is vented to atmosphere. By these means the forward thrust of delivery pressure on the rear of the compressor, and consequently the loading on the centre bearing is reduced.

7. Control of the air flow through the compressor is effected by an air bleed control unit, operated by seventh and twelfth-stage air pressure, which actuates air bleed valves to minimize compressor surge at low engine speeds. The variable-pitch intake guide vanes *(para. 4)*, which assist air flow by imparting the necessary swirl to the incoming air, are controlled by a ram operated hydraulically by fuel from an engine-driven governor pump and the h.p. fuel pump.

8. Air is tapped from the compressor for various aircraft services such as cabin pressurizing, aircraft anti-icing, gun heating and fuel tank pressurizing.

Wheelcases

9. A single gear mounted on the rear of the compressor shaft transmits the drive to four spur gears housed in an internal wheelcase behind the compressor. The top spur gear drives a centrifugal breather and the others drive the triple oil pumps, an accessory gearbox driveshaft and the external wheelcase.

10. The external wheelcase is secured to the starboard wall of the compressor outlet casing and houses the driveshafts and gears for the fuel pump, tachometer generator, governor pump for the intake guide vane ram, and an alternative drive coupling for a remote accessory gearbox.

Fuel system

11. Fuel from the aircraft supply is delivered at low pressure through a felt filter situated on the underside of the engine, to the engine-driven h.p. fuel pump. The high pressure pump output is fed through a fuel-cooled oil cooler to the throttle valve, pressurizing valve, burner manifolds, and so to the burners in the combustion chambers.

12. To satisfy fuel flow requirements the engine is fitted with a twin pump, which comprises two complete pumping mechanisms sharing a common housing. The pumping mechanisms are of positive displacement, multi-plunger, variable-stroke type, a parallel-connected servo control system limits the total output and a centrifugal or hydro-mechanical governor limits the overspeed. Provision is made for external adjustment of the governor.

13. Fuel flow is controlled by a main control unit and an altitude-sensitive acceleration control and metering valve. The control unit comprises :—

(1) A manually operated throttle valve to meter fuel to the burners.

(2) A fuel-operated pressurizing valve to proportion fuel flow between primary and main burners in accordance with engine requirements.

(3) A barometric pressure control which varies pump output in relation to throttle position and barometric pressure.

(4) A manually operated high pressure shut-off cock.

(5) A l.p. filter and, on Mk. 122 engines, a fuel de-icing switch.

14. The acceleration control unit, which works in conjunction with the metering valve unit, is fitted to prevent an excess supply of fuel during acceleration, which could cause excessive jet pipe temperature, surge or flame extinction. It operates by utilizing the pressure difference created across the metering valve unit to measure and restrict the fuel flow according to compressor delivery pressure. An evacuated capsule in the atmospheric chamber ensures sensitive operation at all altitudes.

15. The throttle valve is a rack and pinion operated plunger which works through a fixed range to control engine speed by metering fuel to the burners. With the throttle closed, idling speed is maintained and adjusted by a variable fuel by-pass valve. Mk. 115, 121 and 122 engines incorporate a top temperature control which automatically trims the throttle valve to prevent maximum j.p.t. being exceeded.

16. A solenoid-operated isolating valve is provided on single engined aircraft as a safety device to ensure that fuel delivery equal to at least the maximum output of one pump is available in the event of a fuel pump failure or a fault within the servo system.

17. A drain system is fitted to prevent accumulation of fuel in the combustion chambers when the engine is shut down and so prevent 'torching' from the jet pipe when restarting the engine.

Oil system

18. The self-contained oil system uses a low-viscosity anti-freezing oil circulated by a single pressure pump and two scavenge pumps, driven by a common shaft from the internal wheelcase and mounted in a reservoir-type sump situated beneath the compressor outlet casing. Each pump is provided with a filter on the inlet side.

19. Oil is drawn from the sump by the pressure pump and passed through a fuel-cooled oil cooler to a pressure filter, after which it is distributed throughout the engine by pipes and drillings in the casings. A relief valve fitted in the delivery line from the high pressure filter regulates the oil pressure and spills excess oil to the sump, and a pressure-operated valve allows oil to by-pass the cooler under conditions of high viscosity.

20. The compressor and turbine shaft bearings are lubricated by pressure oil directed through spray jets which are fitted with thread-type filters. Leakage of oil past the main bearings is prevented by continuous groove seals pressurized by third-stage air from the compressor. The gears in the wheelcases are lubricated through spray jets or by splash. The ball and roller bearings in the wheelcases are lubricated by splash oil from the gears and the plain bearings of the oil pump drive and tachometer drive are pressure fed.

21. Scavenge oil from the front and rear bearings is returned, through the scavenge pumps and a de-aerator funnel, to the sump. Surplus oil from the centre bearing and internal wheelcase gravitates to the sump through the oil pump drive shaft shroud, and oil from the external wheelcase returns through a pipe from the base of the wheelcase. The sump is vented to the external wheelcase and the internal wheelcase and thus to atmosphere, through a centrifugal breather at the top of the engine. The centrifugal breather separates the oil from the outgoing air and allows the oil to return to the sump.

22. Provision for transmitting oil pressure to an instrument in the aircraft cockpit is made by a tapping in the high-pressure line before the relief valve; the oil operates an oil pressure transmitter mounted on the left - hand side of the oil sump.

Combustion chambers

23. The combustion chambers are designed to facilitate stable burning of the fuel/air mixture and to enable the heat so generated to expand the gases and accelerate them rearwards. Each combustion chamber consists of a cast expansion chamber secured to an outer casing, inside which a flame tube is centrally mounted. The flame tube is separated from the outer casing by an annular air space. To ensure even pressure distribution and allow the flame to spread during starting, the flame tubes and air casings of adjacent combustion chambers are interconnected.

24. Air entering the combustion chambers is used to combine with the fuel to promote efficient combustion, and to cool the flame tubes and outer casings. The apportioning of air between the flame tubes and the annular spaces is accomplished by perforations and flutes in the flame tube walls. The air flowing in the annular spaces is progressively admitted into the flame tubes to mix with the burning gases and cool them to the temperature required at the turbine inlet.

25. A Duple burner is provided in each expansion chamber, the burner head projecting into the snout of the flame tube.

Internal cooling

26. Internal cooling of the main bearings, turbine and nozzle box is by air bled from various stages of the compressor and directed throughout the engine by pipes, ducts and transfer holes. The flow between rotating and static parts is controlled by labyrinth type seals.

27. The front and rear bearings are cooled by third-stage air which is led through the hollow compressor shaft to a labyrinth seal at the front bearing, and rearwards, by transfer holes in the hollow shaft, to the intermediate casing and the rear bearing. Outlets for the rear bearing cooling air are provided on the nozzle box, and air from the front bearing escapes into the compressor inlet.

28. The turbine discs are cooled by air tapped from the compressor eleventh stage and by restricted twelfth-stage air. The eleventh-stage air is directed through the hollow turbine shaft to cool the space between both turbine discs and the rear face of the second-stage turbine disc. The restricted twelfth-stage air is directed by transfer pipes to the front face of the first-stage turbine disc. After cooling the discs the air joins the main gas stream at the roots of the turbine blades. Labyrinth type seals are fitted between the rotating and static parts of the turbine to prevent leakage of hot gas from the main stream.

Starting

29. Starting is effected by a turbo-starter which accelerates the engine until it becomes self-sustaining; a high-energy igniter system ignites the fuel injected into the combustion chambers by the main burners. The sequence and period of the starting cycle is controlled by a time switch in the aircraft starter panel.

30. The turbo-starter is actuated by an electrically ignited cartridge containing a slow burning charge, the gases from which impinge on the starter turbine blades to produce a very high torque. This torque is transmitted through reduction gearing and a spring drive assembly fitted in the front of the compressor shaft. An engaging and disengaging mechanism is incorporated.

31. The high-energy igniter system comprises dual high energy units and two igniter plugs. A booster coil in each unit transforms the normal aircraft electrical supply to a higher voltage which passes through a rectifier to a storage condenser. When the potential across the condenser reaches a predetermined value the stored energy is discharged by a flashover at the sparking plug.

32. When the turbo-starter and high-energy igniter system are operated, the engine is turned, fuel is sprayed into the combustion chambers and is ignited by the igniter plugs. When 'light-up' occurs, the flame spreads rapidly to all combustion chambers through the interconnectors *(para. 23)* and sufficient energy is obtained to drive the turbine and thus allow the engine to become self-sustaining. At this stage the time switch *(para. 29)* cuts out the igniter system.

33. Starting the engine in flight is accomplished by a relight switch in the aircraft electrical system which operates the igniters. Operation of the turbo-starter for this purpose is unnecessary since the compressor normally rotates due to the forward speed of the aircraft.

Anti-icing

34. Ice formation on the air intake, which would be likely to affect engine performance, is prevented by an anti-icing system initially operated by a three-way cockpit switch. The system is fed by hot air from the compressor twelfth stage via an electrically operated valve. A feed pipe from the valve carries the hot air to a manifold surrounding the front bearing housing, it then passes down the hollow support struts and guide vanes to the starter fairing and finally into the main air stream passing through the engine.

Fire extinguisher

35. To combat fire should it occur, the engine is fitted with interconnected spray rings, one around the rear end of the compressor casing and the other around the nozzle box; these are connected to bottles of extinguisher fluid in the aircraft.

Installation and handling

36. Provision for mounting the engine in an aircraft is by trunnion mountings, one on each side of the nozzle box at the rear end, and a flexible framework with vibration-insulated eye fittings at the front end. To facilitate interchangeability in multi-engined aircraft, the accessory gearbox drive, the fuel inlet, and the fire extinguisher connections are duplicated, and the throttle valve and high-pressure shut-off cock levers can be moved on their hubs to accommodate the aircraft linkwork.

37. Slinging eyes are provided for lifting the engine, one on top of the front end of the compressor, and two fitted to the nozzle box flange. With the exception of the Mk. 109, the engines have mounting rollers fitted to the nozzle box and compressor casing which, in conjunction with a system of mounting rails on the aircraft structure, support the engine for installation purposes and permit the complete unit to be rolled into position from the rear of the engine compartment.