

## LUBRICATION AND COOLING SYSTEMS

**Introduction**

1. This chapter contains information of a general nature, applicable to all types of turbo-jet and turbo-prop engines, and reference should be made to the relevant engine air publication for the details of a particular system.

**Tanks and Sumps**

2. Lubrication oil is contained in a sump or tank integral with the engine, or in a separate tank in the aircraft. Oil is drawn from the sump or tank, and delivered under pressure by an engine-driven gear-type pump through external pipes and internal passages, to the various lubricated parts of the engine (Fig. 1). An additional pump may be embodied in the main pump to supply high-pressure oil for operating a torque meter. Certain engine components, such as main bearings, have an accurately metered oil supply. Sometimes oil is sprayed under pressure onto the wheel-case driving pinions and wheel-case internal gears, or onto the anti-friction main shaft bearings.

3. **Circulation.** The high-pressure oil supply is also used to operate or lubricate various accessory units, such as the constant speed governor, the propeller brake, and feathering control of turbo-prop propellers. After use, oil is drained into the sump, and after filtration it is recirculated or, alternatively, pumped back to the tank by one or more scavenge pumps, via a filter and, if fitted, a cooler. The scavenge oil in some engines contains a considerable quantity of air. To get rid of the air it is returned to the scavenge pump over a de-aeration tray.

4. **Venting.** To prevent any pressure build-up the tanks and sumps must be vented to atmosphere. Some sumps may be vented into the wheel-case, which is itself vented through a centrifugal breather; this allows a free passage of air without loss of oil.

**Gear-Type Oil Pumps**

5. The main pressure and scavenge pumps (Fig. 2) are of the spur-gear type, the two sets of gears being arranged on a common drive

shaft with a dividing plate separating each set of gears. An additional pair of gears driven by the same shaft supplies high-pressure oil to a torque meter if fitted. A capsule element filter with a non-return valve may be incorporated in the pump to prevent oil draining from the tank into the engine when the engine is not running.

6. **Scavenge Pumps.** The scavenge pump has a greater capacity than the pressure pump to ensure rapid clearance of the sump, otherwise over-oiling of the engine would occur. One make of engine incorporates four scavenge pumps. Additional small capacity scavenge pumps may be used to supplement the main scavenge pump by collecting the surplus oil from remote parts of the engine, thereby obviating a complicated system of piping.

7. **Relief Valves.** Relief valves are fitted to prevent the build-up of excessive pressures and to compensate for variations in oil flow caused by changes in engine speed or in the viscosity of the oil. Similarly, a relief valve is embodied in the oil cooler, if fitted, to allow viscous oil to bypass the cooler and return direct to the tank whenever the pressure exceeds a preset value.

**Micro-Pumps**

8. Micro-pumps are used to lubricate high-speed rotary parts such as main bearings. These pumps are designed to meter the flow of oil within fine limits, even when the pressure on the inlet side of the pump is higher than that on the delivery side. Over a given speed range, the pump gives a delivery that is proportional to r.p.m., *i.e.* the volumetric efficiency remains constant with varying speeds. The pump, which is of a special piston type, may be operated by a cam on the end of the main pump spindle, or by any other suitable drive. The output is regulated to meet the individual engine requirements by means of an adjustable, hand-operated knurled screw.

**Reduction Gear Lubrication**

9. There are two methods of lubricating the gear chains in an engine—splash and pressure. The splash system, used at low r.p.m., depends on the splashing action of the gear teeth as they pass through an oil reservoir in the base of the

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gear-housing. At high r.p.m. pressure lubrication is obtained from the oil thrown off the gear teeth by centrifugal force. The oil leaves the gear teeth at the point where the meshing teeth are disengaging, in the form of a jet, and is fed back by special nozzles to the point where the teeth are engaging.

### Lubricating Oils

10. Several factors, such as variation in r.p.m., the material used for bearing surfaces, operating temperatures, and the profiles and dimensions of the gears, together indicate the characteristics required of an oil. The oil must therefore be chosen for each type of engine on the basis of all-round suitability. This briefly explains the reason for the variation in oil specifications for different engines. The nomenclature of the various grades of oils is given in Volume 2, Part 2 of this manual.

11. The oil used must be thin enough for circulation at low temperatures during the starting stage, but must not become too thin at high temperatures. The oil must remain stable under the worst operating conditions and so should not oxidize readily or be so volatile that excessive losses occur through evaporation. On turbo-prop engines, the propeller reduction gearing, which transmits high torques, requires an oil of high viscosity and greater load-bearing qualities. Therefore the oil used in these engines tends to be thicker and heavier than that for turbo-jet types; this accounts for the comparatively long warming-up period required by turbo-prop engines.

### Air Cooling

12. External air cooling and ventilation of the turbo-jet engine and its nacelle is effected by passing part of the free airstream over the outside of the engine. The method of cooling varies with different engines and installations. With centrifugal compressors, those parts of the engine forward of the combustion chambers do not require any special cooling arrangements, as the running temperature of the components is low. The combustion chambers and jet pipe, however, require cooling. This is done by surrounding the jet pipe with an outer cone, known as a *fire-guard*. The rear end of the fire-guard fits round a venturi cuff on the propelling nozzle, forming an annular space between the two. The

ejector action of the propulsive jet draws cold air over the combustion chambers and jet pipe while the engine is running.

13. With the turbo-prop engine, the propeller slipstream provides all the necessary cooling, the engine being cooled in such a manner as to obtain the maximum benefit from the air passing over it, but at the same time keeping the drag down to a minimum.

14. The internal components which require cooling are the main bearings, the turbine disc, and (with turbo-prop engines) the reduction gear. Fig. 3 shows a typical cooling system for a turbo-jet engine, in which the rear main bearing is partly cooled by air bled off from the compressor. The air is then passed through the annular cooling ring forming part of the air intake, and finally through an air filter to the bearing. From this point the air passes underneath the inner race of the rear bearing between the extension shaft and the hub shaft, thus forming a barrier of cold air which shields the bearing from heat conducted from the turbine disc. The air escapes from the bearing to flow over the front face of the turbine disc thus augmenting its cooling. Oil from the micropumps also helps in cooling the rear main bearing.




15. The rear face of the turbine disc is cooled by air bled off the compressor supply, the air then passing through pipes to the hollow cross-tubes which support the inner exhaust cone. A tube connected to the centre of the cross-tubes directs the air onto the rear face of the turbine disc.

16. The nozzle guide vane assembly is also cooled by air taken from the compressor, and distributed through an annular chamber onto the forward face of the assembly. The air then passes through the guide vanes and mixes with the gases passing into the turbine.

17. Further cooling of the combustion chambers and the products of primary combustion is done by the introduction of secondary and tertiary air as described in Chapter 4. The foregoing notes on the general arrangements of a cooling system can be taken as representative of many systems, but, as detail design varies between types, further information must be obtained from the relevant engine air publication.

## KEY TO FIG. I

1. Single jet, to lubricate bevel gears at the rear of the top accessory box
2. Oil supply to vacuum pump
3. Triple jet, to lubricate bevel gears at the front of the top accessory box
4. Oil pressure gauge connection
5. Oil filler cap
6. Top accessory box
7. Thermometer pocket
8. Oil supply to cabin supercharger
9. Oil supply to air compressor
10. Top accessory box, oil drain pipe
11. Jet, spraying oil on to bevel gears in centre housing
12. Front bearing
13. Oil supply to centre housing jet and to top accessory box
14. Metered oil supply to front bearing
15. Bottom accessory box
16. Oil supply to starter coupling
17. Oil supply to oil jet (not shown) which lubricates the bevel gear at the front of the bottom accessory box, and the starter coupling
18. Pressure filter
19. Oil pressure relief valve
20. Oil pump drive shaft
21. Oil pump
22. Rear bearing metering pump
23. Front bearing metering pump
24. Overspeed governor metering pump
25. Suction filter
26. Oil drain valve
27. Sump (main oil container)
28. Overspeed governor drain
29. Metered oil supply to rear bearing
30. Rear bearing supply drain
31. Rear bearing

 PRESSURE  
 METERED  
 SPLASH DRAIN AND BULK SUPPLY IN SUMP

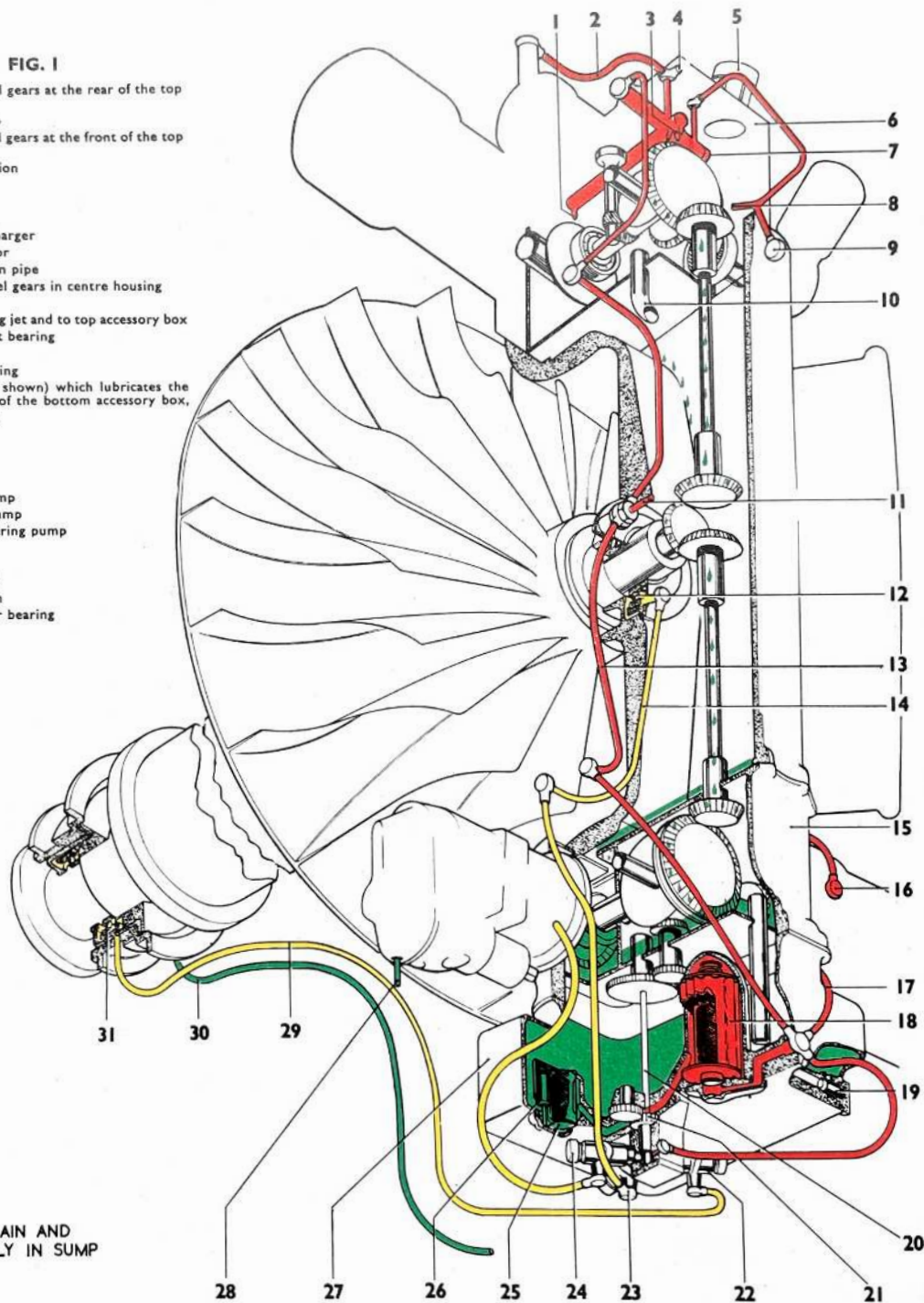


Fig. I. Typical Lubrication System

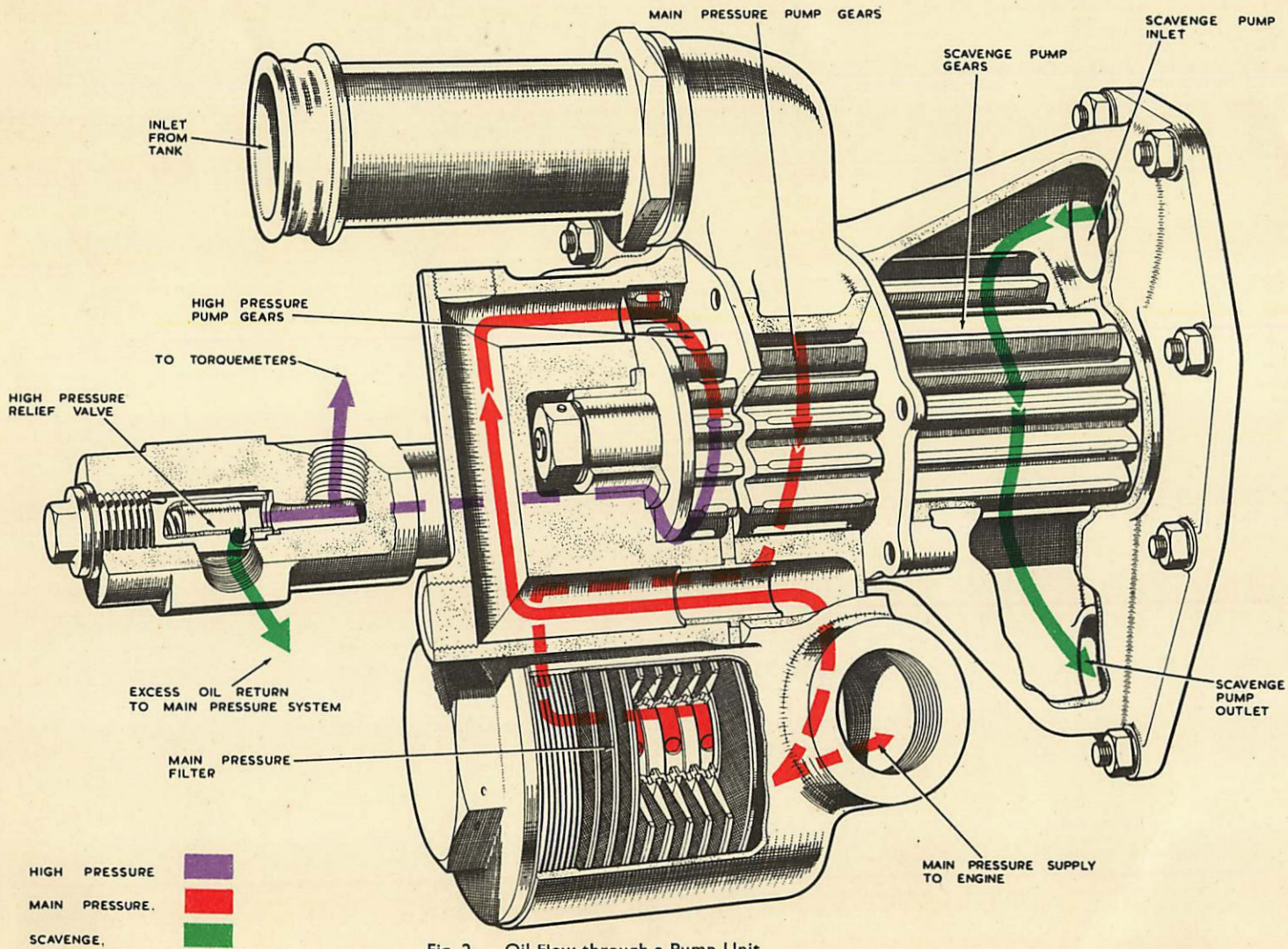


Fig. 2. Oil Flow through a Pump Unit

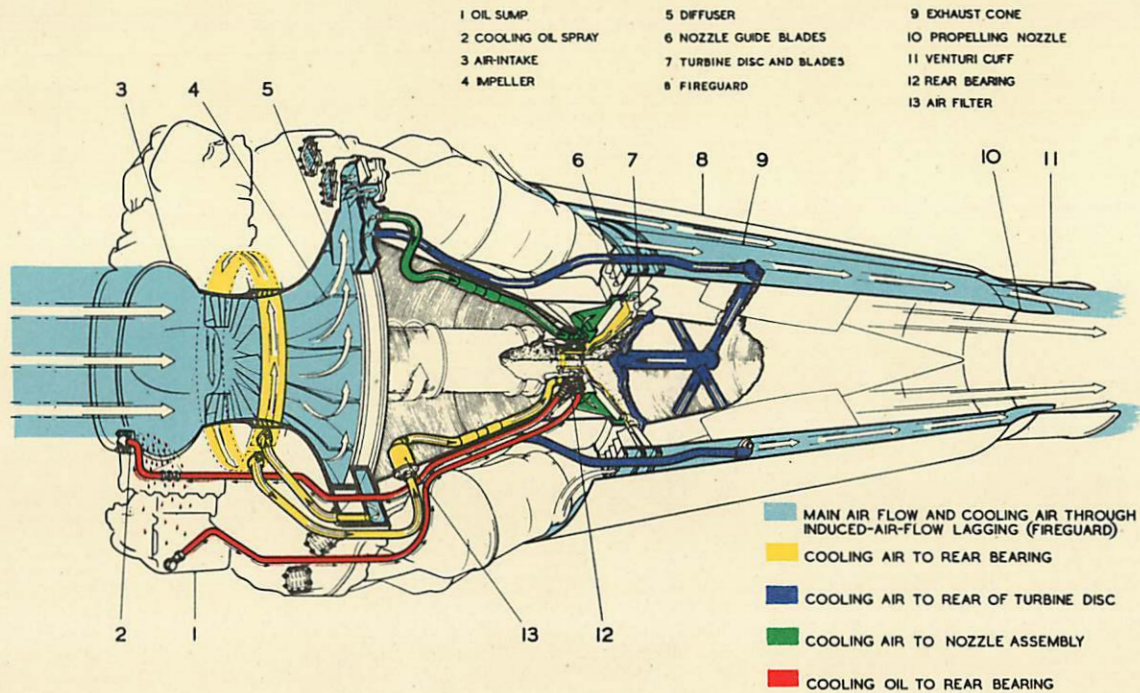


Fig. 3. Arrangement of a Typical Cooling System

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