MODULE 16

FOR B1 CERTIFICATION

PISTON ENGINE

Aviation Maintenance Technician Certification Series

COMPLIANT WITH EASA European Aviation Safety Agency EASA PART 66/147

AIRCRAFT TECHNICAL BOOK COMPANY

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REVISION LOG

VERSION	EFFECTIVE DATE	DESCRIPTION OF CHANGE
001	2016 01	Module Creation and Release
002	2017 02	Format Update
003	2020 06	Realignment to Part-66 Appendices. Enhanced figures throughout entire textbook.

PISTON ENGINE

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ENGINE STORAGE AND PRESERVATION

The mounting arrangement supports the entire power plant including the propeller, and therefore is designed to provide ample strength for rapid maneuvers or other loadings. Because of the elongation and contraction of the cylinders, the intake pipes which carry the mixture from the diffuser chamber through the intake valve ports are arranged to provide a slip joint which must be leak proof. The atmospheric pressure on the outside of the induction system of an unsupercharged engine is higher than on the inside, especially when the engine is operating at idling speed. If the engine is equipped with a supercharger and operated at full throttle, the pressure is considerably higher on the inside than on the outside of the induction system. If the slip joint connection has a slight leakage, the engine may idle fast due to a slight leaning of the mixture. If the leak is quite large, it may not idle at all. At open throttle, a small leak probably would not be noticeable in the operation of the engine, but the slight leaning of the fuel/air mixture might cause detonation or damage to the valves and valve seats. On some radial engines, the intake pipe has considerable length and on some inline engines, the intake pipe is at right angles to the cylinders. In these cases, flexibility of the intake pipe or its arrangement eliminates the need for a slip joint. In any case, the engine induction system must be arranged so that it does not leak air and change the desired fuel/air ratio.

CRANKSHAFTS

The crankshaft is carried in a position parallel to the longitudinal axis of the crankcase and is generally supported by a main bearing between each throw. The crankshaft main bearings must be supported rigidly in the crankcase. This usually is accomplished by means of transverse webs in the crankcase, one for each main bearing. The webs form an integral part of the structure and, in addition to supporting the main bearings, add to the strength of the entire case. The crankcase is divided into two sections along a longitudinal plane. This division may be in the plane of the crankshaft so that one-half of the main bearing (and sometimes camshaft bearings) are carried in one section of the case and the other half in the opposite section. Refer to ***Figure 3-3***. Another method is to divide the case in such a manner that the main bearings are secured to only one section of the case on which the cylinders are

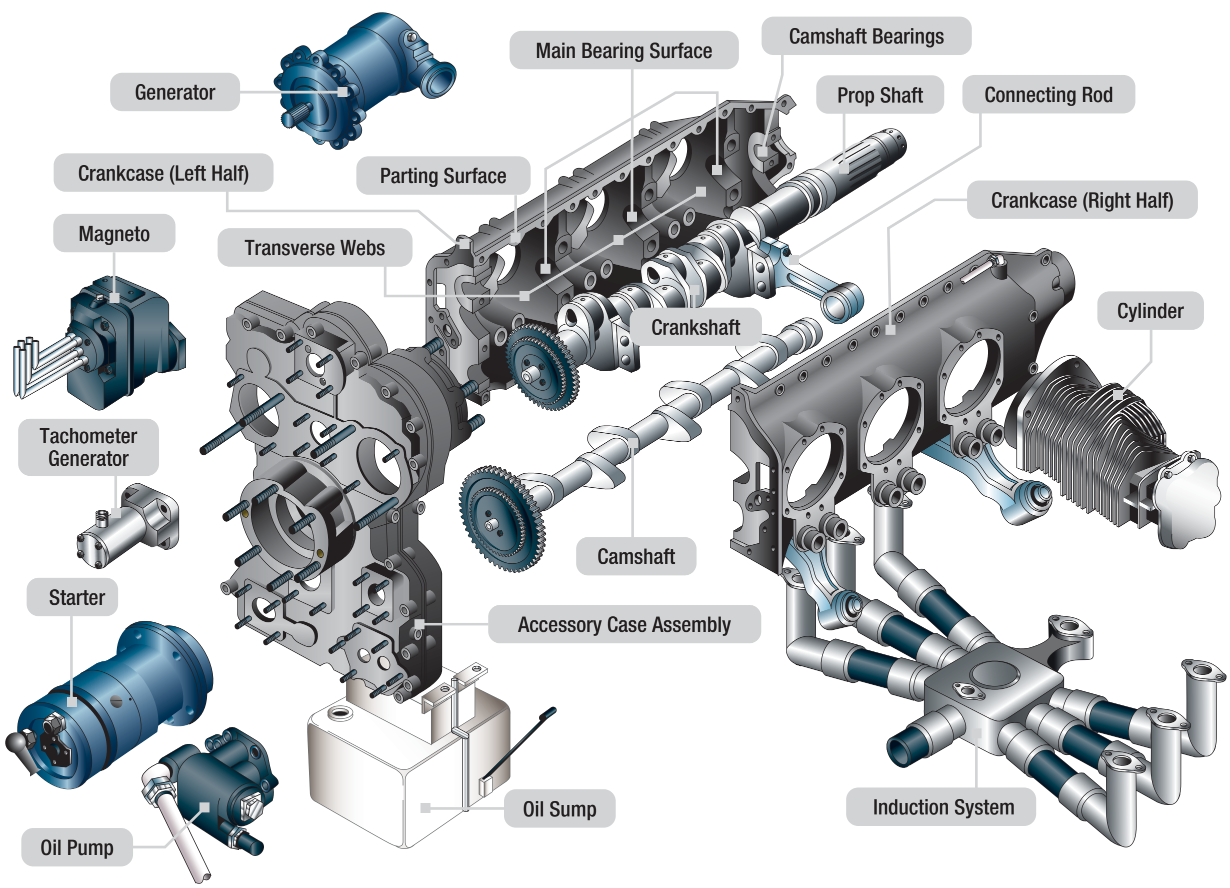

Figure 3-3. Exploded view of an aircraft engine.

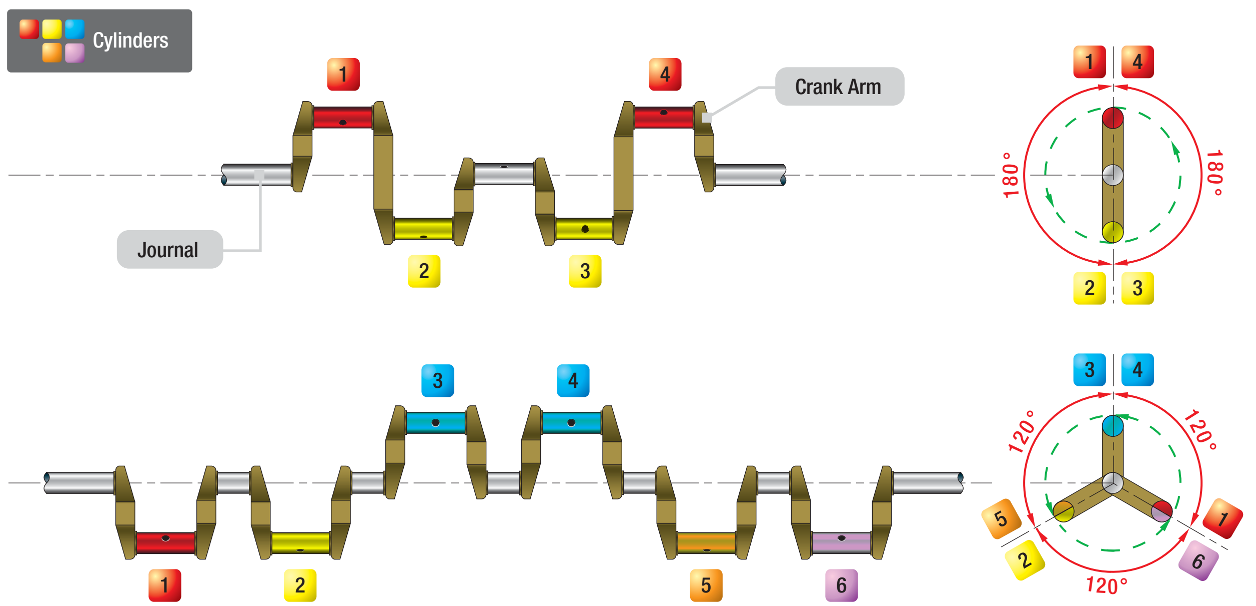

Figure 3-4. Four and six cylinder solid crankshafts.

attached, thereby providing means of removing a section of the crankcase for inspection without disturbing the bearing adjustment.

The crankshaft is the backbone of the reciprocating engine. It is subjected to most of the forces developed by the engine. Its main purpose is to transform the reciprocating motion of the piston and connecting rod into rotary motion for rotation of the propeller or helicopter transmission. The crankshaft, as the name implies, is a shaft composed of one or more cranks located at specified points along its length. The cranks, or throws, are formed by forging offsets into a shaft before it is machined. Since crankshafts must be very strong, they generally are forged from a very strong alloy, such as chromium-nickel-molybdenum steel.

A crankshaft may be of single-piece or multi-piece construction. ***Figure 3-4*** shows two representative types of solid crankshafts used in aircraft engines. The four-throw construction may be used either on four-cylinder horizontal opposed or four-cylinder inline engines. The six-throw shaft is used on six-cylinder inline engines, 12-cylinder V-type engines, and six-cylinder opposed engines. Crankshafts of radial engines may be the single-throw, two-throw, or four-throw type, depending on whether the engine is the single-row, twin-row, or four-row type. A single-throw radial engine crankshaft is shown in ***Figure 3-5***. No matter how many throws it may have, each crankshaft has three main parts—a journal, crankpin, and crank cheek.

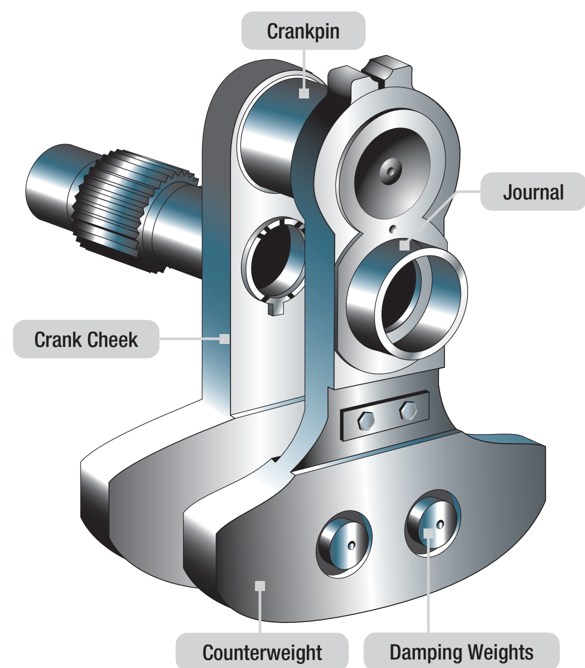

Figure 3-5. Single-throw radial engine crankshaft.

Counterweights and dampers, although not a true part of a crankshaft, are usually attached to it to reduce engine vibration.

The journal is supported by, and rotates in, a main bearing. It serves as the center of rotation of the crankshaft. It is surface-hardened to reduce wear. The crankpin is the section to which the connecting rod is attached. It is off-center from the main journals and is often called the throw. Two crank cheeks and a crankpin make a throw. When a force is applied to the crankpin in any direction other than parallel or perpendicular to and through the center line of the crankshaft, it causes the crankshaft to rotate. The outer surface is hardened by nitriding to increase its resistance to wear and to provide the required bearing surface. The crankpin is usually hollow. This reduces the total weight of the crankshaft and provides a passage for the transfer of lubricating oil.

On early engines, the hollow crankpin also served as a chamber for collecting sludge, carbon deposits, and other foreign material. Centrifugal force threw these substances to the outside of the chamber and kept them from reaching the connecting-rod bearing surface. Due to the use of ashless dispersant oils, newer engines no longer use sludge chambers. On some engines, a passage is drilled in the crank cheek to allow oil from the hollow crankshaft to be sprayed on the cylinder walls. The crank cheek connects the crankpin to the main journal. In some designs, the cheek extends beyond the journal and carries a counterweight to balance the crankshaft. The crank cheek must be of sturdy construction to obtain the required rigidity between the crankpin and the journal.

In all cases, the type of crankshaft and the number of crankpins must correspond with the cylinder arrangement of the engine. The position of the cranks on the crankshaft in relation to the other cranks of the same shaft is expressed in degrees.

The simplest crankshaft is the single-throw or 360° type. This type is used in a single-row radial engine. It can be constructed in one or two pieces. Two main bearings (one on each end) are provided when this type of crankshaft is used. The double-throw or 180° crankshaft is used on double-row radial engines. In the radial-type engine, one throw is provided for each row of cylinders.

CAMSHAFT

The valve mechanism of an opposed engine is operated by a camshaft. The camshaft is driven by a gear that meshes with another gear attached to the crankshaft as shown in ***Figure 3-6***. The camshaft always rotates at one-half the crankshaft speed. As the camshaft revolves, the lobes cause the tappet assembly to rise in the tappet guide, transmitting the force through the push rod and rocker arm to open the valve as illustrated in ***Figure 3-7***, ***Figure 3-8*** and ***Figure 3-9***.

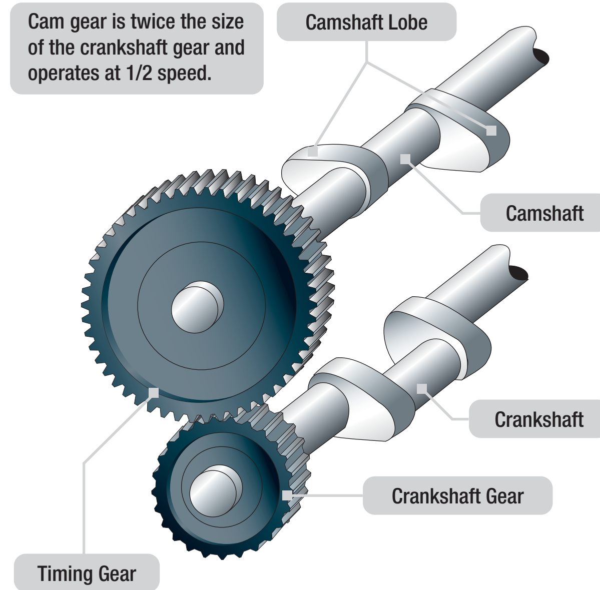

Figure 3-6. Cam drive mechanism opposed-type aircraft engine.

SUMPS

Reciprocating aircraft engines have sumps that are used as part of the oil system. The sumps are located at the low point of the engine and are used to collect oil circulating through the engine after the oil has completed its tasks. Depending on where the lubricating oil for the engine is stored will determine whether the engine is a wet sump or a dry sump.

Wet sump engines use the sump as the storage tank for the oil. Oil departs the oil sump, passes through the engine, and returns to the oil sump beneath the engine. Because the oil remains in the engine, with the exception that it may travel to a remote oil cooler, the engine is classified as a wet sump design. (***Figure 3-10***)

By contrast, dry sump engines store their oil in a remote tank. Generally speaking, dry sump engines have oil quantities that are comparatively large. For example, an airplane equipped with a 9-cylinder radial engine may have an oil capacity of 8 gallons. A 14-cylinder radial engine typically has an oil tank with a 30 gallon capacity. In such instances, it would not be practical to keep those quantities of oil within the engine. Consequently, the oil sump is used to collect the oil that has passed through the engine and return the oil to the oil tank. A scavenge oil pump is used to transfer the oil from the dry sump to the oil tank. Normally, the oil returning to the oil tank from the sump passes through an oil cooler. An example of a dry sump is presented in ***Figure 3-11***.

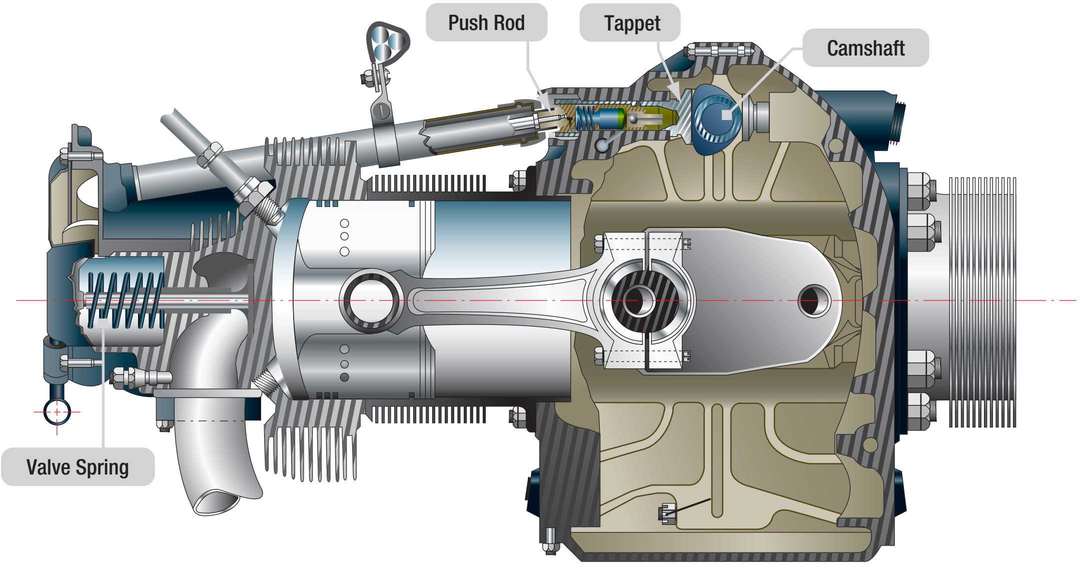

Figure 3-7. Valve-operating mechanism (opposed engine).

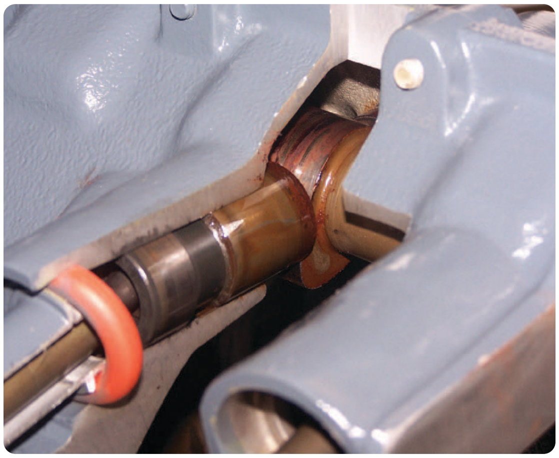

Figure 3-8. Cam load on lifter body.

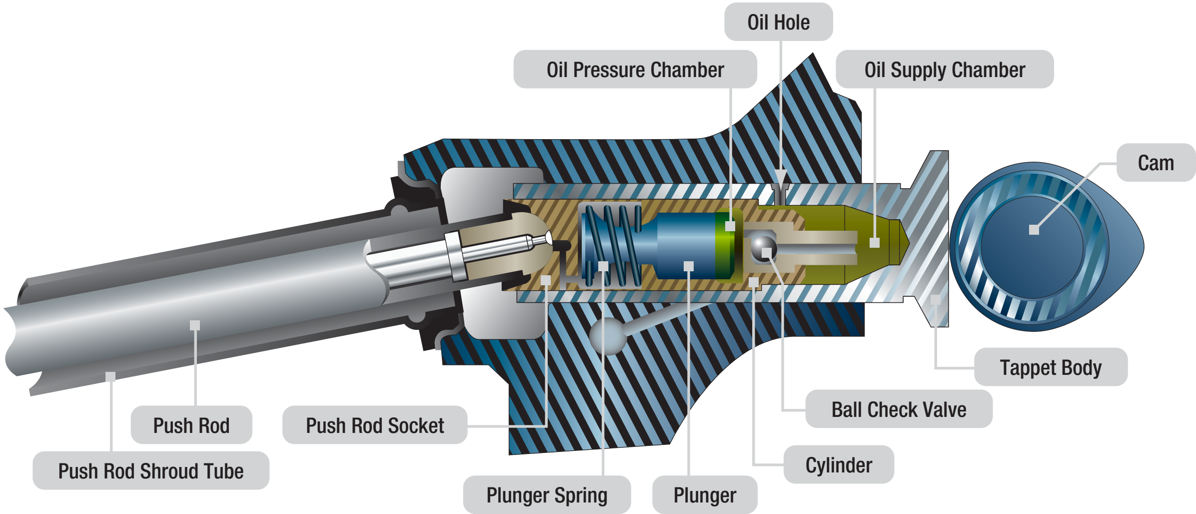

Figure 3-9. Illustration of zero-lash hydraulic lifter.

Figure 3-10. Wet sump engine.

Figure 3-11. Dry sump on a radial engine located between the two lowest cylinders.

ACCESSORY SECTION

The accessory (rear) section usually is of cast construction and the material may be either aluminum alloy, which is used most widely, or magnesium, which has been used to some extent. On some engines, it is cast in one piece and provided with means for mounting the accessories, such as magnetos, carburetors, fuel, oil, vacuum pumps, starter, generator, tachometer drive, etc., in the various locations required to facilitate accessibility. Other adaptations consist of an aluminum alloy casting and a separate cast magnesium cover plate on which the accessory mounts are arranged. Accessory drive shafts are mounted in suitable drive arrangements that are carried out to the accessory mounting pads. In this manner, the various gear ratios can be arranged to give the proper drive speed to magnetos, pumps, and other accessories to obtain correct timing or functioning.

ACCESSORY GEAR TRAINS

Gear trains, containing both spur- and bevel-type gears, are used in the different types of engines for driving engine components and accessories. Spur-type gears are generally used to drive the heavier loaded accessories or those requiring the least play or backlash in the gear train. Bevel gears permit angular location of short stub shafts leading to the various accessory mounting pads. On opposed, reciprocating engines, the accessory gear trains are usually simple arrangements. Many of these engines use simple gear trains to drive the engine's accessories at the proper speeds.

CYLINDER AND PISTON ASSEMBLIES

CYLINDERS

The portion of the engine in which the power is developed is called the cylinder. The cylinder provides a combustion chamber where the burning and expansion of gases take place, and it houses the piston and the connecting rod. There are four major factors that need to be considered in the design and construction of the cylinder assembly. It must:

1. Be strong enough to withstand the internal pressures developed during engine operation.
2. Be constructed of a lightweight metal to keep down engine weight.
3. Have good heat-conducting properties for efficient cooling.
4. Be comparatively easy and inexpensive to manufacture, inspect, and maintain.

The cylinder head of an air-cooled engine is generally made of aluminum alloy because aluminum alloy is a good conductor of heat and its light weight reduces the overall engine weight. Cylinder heads are forged or die-cast for greater strength. The inner shape of a cylinder head is generally semispherical. The semispherical shape is generally stronger than other designs and aids in a more rapid and thorough scavenging of the exhaust gases. The cylinder used in the air-cooled engine is the overhead valve type. As illustrated in ***Figure 3-15***, each cylinder is an assembly of two major parts: cylinder head and cylinder barrel. At assembly, the cylinder head is expanded by heating and then screwed down on the cylinder barrel, which has been chilled. When the head cools and contracts and the barrel warms up and expands, a gas-tight joint results. The majority of the cylinders used are constructed in this manner using an aluminum head and a steel barrel. Review ***Figure 3-12*** for an illustration of a cylinder head.