HILL AEROSPACE MUSEUM

HILL AIR FORCE BASE, UTAH

Aircraft Engines

There are two main types of aircraft engines: jet and reciprocating. There are many different kinds of each.

Jet Engines

A jet engine is simply a reaction engine that develops thrust by the rapid discharge of a gas. Jet engines depend on the surrounding atmosphere for oxygen to support combustion and therefore can only operate in regions where an atmosphere exists. There are several types of jet engines: turbojet, turboprop, turbofan, ramjet, pulsejet, and scramjet.

Turbojet

A *turbojet* engine is a jet engine that incorporates a turbine-driven compressor to take in and compress air for the combustion of fuel. The exhaust from the combustion drives the turbine and creates the thrust-producing jet.

The USAF T-43 trainer operates with turbojet engines.

Turboprop

A *turboprop* engine is a turbojet engine in which a portion of the exhaust energy is used to drive a propeller. The engine's thrust is therefore generated by a combination of the propeller's thrust and the jet exhaust from the engine.

The USAF C-130 transport operates with turboprop engines.

Turbofan

A *turbofan* engine is a turbojet engine in which additional thrust is gained by extending a portion of the compressor or turbine blades outside the inner engine casing. These extended blades propel bypass air around the engine core, between the inner and outer engine casings. This air is not combusted but does provide additional thrust since it is compressed by the blades.

The USAF C-17 transport operates with turbofan engines.

Ramjet

A *ramjet* engine is the simplest type of jet engine since it has no moving parts. The engine is basically a specially-shaped duct open at both ends, with the air necessary for combustion being compressed by the forward motion of the engine. Fuel is sprayed into the air stream and the mixture is ignited. The high-pressure air coming into the combustion chamber keeps the reaction from going back toward the inlet.

Ramjet engines cannot operate under static conditions. In order to function, they have to already be traveling through the air at slightly over the speed of sound (somewhat over 740 miles per hour at sea level). This means that the aircraft using them must first get up to the required speed using some other type of propulsion, then start the ramjets. They can operate at up to five times the speed of sound.

The USAF Bomarc missile cruised with ramjet engines.

Pulsejet

A *pulsejet* engine uses the principle of "intermittent combustion." The inlet duct has a series of shutters which are spring-loaded to the open position. Air is drawn in through these open shutters and fuel is injected and ignited inside the combustion chamber. The increased pressure caused by

this combustion forces the inlet shutters to close, forcing all the combustion gases to be expelled through the outlet duct at the rear of the engine. When the exhaust gases are expelled, the internal pressure subsides, allowing the inlet shutters to spring open again and the cycle repeats itself.

The German V-1 operated with a pulsejet engine.

Scramjet

A *scramjet*, or "supersonic combustion ramjet," engine is similar to a ramjet, but is designed to operate at well over five times the speed of sound, or at *hypersonic* velocities. As with ramjets, aircraft powered by scramjets must first be brought up to required speed by some other means of propulsion. Unlike ramjets, which slow the supersonic air stream entering the inlet to subsonic speeds before combustion, a scramjet combusts the supersonic air stream without slowing it.

The National Aerospace Plane (NASP) will operate with scramjet engines.

Afterburner

Modern turbine engines are extremely efficient, but there is still a lot of oxygen available in the exhaust stream. An apparatus called an *afterburner* can be built onto a turbine engine to inject fuel directly into the exhaust stream and burn it using up the remaining oxygen. This heats and expands the exhaust gases further, and can increase the thrust of a jet engine by 50% or more.

The big advantage of an afterburner is that you can significantly increase the thrust of an engine without adding much weight or complexity to it. An afterburner is nothing but a set of fuel injectors, a tube and flame holder that the fuel burns in, and an adjustable exhaust nozzle. A jet engine with an afterburner needs an adjustable nozzle so that it can work both with the afterburners on and with them off.

The big disadvantage of an afterburner is that it uses a LOT of fuel for the power it generates. Therefore, most planes use afterburners sparingly. For example, a military jet would use its afterburners when taking off from a short runway or from an aircraft carrier's deck, or during a high-speed maneuver in a dogfight.

US Navy F/A-18 fighter with afterburning turbofan engines.

Reciprocating Engines

Reciprocating engines, or "piston" engines, are internal combustion engines that depend on moving pistons to turn a shaft with a propeller mounted on it to generate the thrust to propel the aircraft. A mixture of fuel and air is compressed by the pistons; an electric spark causes the mixture to explode, driving the pistons downward. This motion is transferred to the crankshaft by connecting rods. The rotating crankshaft turns the propeller.

A *propeller* is a type of airfoil (similar to a wing) that turns and accelerates air. As the blades of the propeller rotate they create lifting forces just as a wing does, only working in the horizontal plane instead of the vertical as with wings. Thus, the propeller creates a propulsive force perpendicular to its plane of rotation that moves the aircraft forward as a reaction. Propellers, or "props," can either "pull" the aircraft from their position on the front of the fuselage or wings, or "push" it from behind, or both.

USAF T-6 trainer with four-bladed propeller

USAF O-2 with both "pusher" and "puller" propellers

There are two basic types of reciprocating engines: radial and in-line. These refer to the arrangement of the cylinders in the engine. *Radial* engines have their cylinders arranged in a circle around the crankshaft. *Inline* engines have their cylinders arranged in straight lines.

The USAAF P-47 fighter operated with a radial engine.

The USAAF P-51 fighter operated with an inline engine.