Aviation Maintenance Technician Series

Dale Crane

Airframe

Volume 1: Structures

Third Edition

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Basic Aerodynamics

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Basic Fixed-Wing Aerodynamics

The Beginnings of Flight

People have dreamed of taking to the air since the earliest observers watched the graceful flight of birds. It was only natural the first thoughts of flight assumed a need for flapping wings. In Greek mythology, Daedalus and his son Icarus escaped from Crete by making wings of feathers held together with wax. Icarus was so enamored of flight, he flew too close to the sun. The wax melted, and he plunged into the sea and drowned.

The earliest experimental flying machines emulated the bird, using flapping wings for propulsion. These machines, or "ornithopters," were unsuccessful. The first successful heavier-than-air flying machines were built and flown by the Chinese centuries before Christ, kites held in the air by the same aerodynamic forces that sustain modern airplanes and helicopters.

ornithopter. A heavier-than-air flying machine that produces lift by flapping its wings. No practical ornithopter has been built.

Two Types of Lift

Two types of lift raise aircraft against the force of gravity: aerostatic and aerodynamic. Aerostatic lift is produced when the weight of air displaced by the aircraft is greater than the weight of the aircraft. Aerodynamic lift is produced when movement of the aircraft through the air forces down a weight of air greater than the weight of the aircraft.

Aerostatic Lift

While the Chinese were flying kites and raising objects with the kites' aerodynamic lift, most experiments in Europe were of an aerostatic nature. In November of 1783, the Montgolfier brothers launched a manned hot-air balloon from Paris, France. Between the two world wars of the twentieth century, huge lighter-than-air flying machines carried aloft thousands of persons and transported tons of cargo, and in 1929 the German *Graf Zeppelin* made a round-the-world flight of more than 21,000 miles.

During the 1920s and 1930s, the U.S. Navy experimented with several huge lighter-than-air flying machines, using two of them, the *USS Akron* and the *USS Macon*, as flying aircraft carriers. Interest in lighter-than-air craft was dealt a serious blow on May 6, 1937, when the German airship *Hindenburg* burned as she docked at the U.S. Naval Air Station in Lakehurst, New Jersey. Strained diplomatic relations between the ruling parties in

Zeppelin. The name of large rigid lighter-than-air ships built by the Zeppelin Company in Germany prior to and during World War I.

Germany and the United States meant the Germans did not have access to helium gas (only found in commercial quantities in the United States). They used the extremely flammable hydrogen gas to lift the Hindenburg.

blimp. A cigar-shaped, nonrigid lighter-than-air flying machine.

Experimental work with large lighter-than-air machines continues today, and gas-filled blimps frequently advertise above our cities. The most common lighter-than-air aircraft, though, are hot-air balloons. Made of modern high-strength synthetic fabrics, these aircraft use propane burners to heat the air.

Figure 1-1. *The modern hot-air balloon uses the same type of aerostatic lift that carried two aeronauts aloft in France more than two centuries ago.*

Aerodynamic Lift

Most modern aircraft employ aerodynamic lift, which requires relative movement between the air and the aircraft.

To create aerodynamic lift, a specially shaped surface, called an airfoil, is moved through the air. A low pressure is produced above its surface, and a relatively high pressure is produced below it. This pressure differential deflects the air downward, and the mass of the air forced down is balanced by an equal force that pushes upward on the airfoil. This upward force is the aerodynamic lift.

aerodynamic lift. The force produced by air moving over a specially shaped surface called an airfoil. Aerodynamic lift acts in a direction perpendicular to the direction the air is moving.

airfoil. Any surface designed to obtain a useful reaction, or lift, from air passing over it.

Properties of the Atmosphere

The atmosphere is the layer of gases that surrounds the earth from its surface to a height of about 22 miles. These gases consist of a mixture of nitrogen and oxygen with a small percentage of other gases, including water vapor.

In the troposphere, the lowest layer of the atmosphere, all our weather exists. The troposphere extends from the surface to about 36,000 feet, and in this layer, the temperature and pressure decrease steadily as the altitude increases.

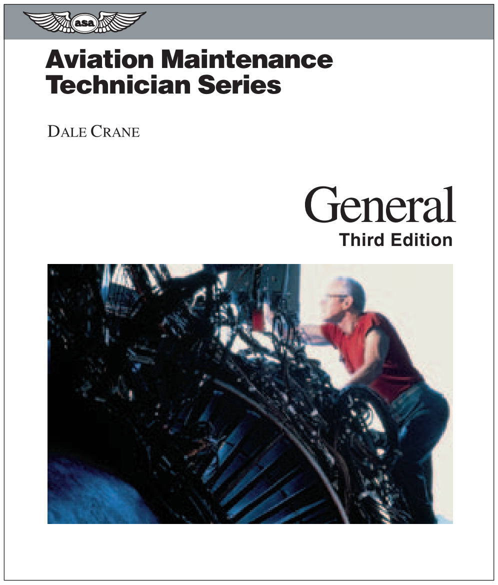
Immediately above the troposphere is the stratosphere, which extends to the upper limit of the atmosphere. The temperature in the stratosphere remains constant at -56.5°C (-69.7°F), but the pressure continues to decrease. The boundary between the troposphere and the stratosphere is called the tropopause.

Standard Atmospheric Conditions

The ICAO (International Civil Aeronautical Organization) standard atmosphere, also known as the International Standard Atmosphere (ISA), is a hypothetical condition whose parameters have been accepted by international agreement as representative of the atmosphere surrounding the earth for the purposes of aircraft design and performance calculations, and for the calibration of aircraft instruments.

ICAO Standard Atmosphere		
Parameter	**British Units**	**Metric Units**
Pressure, P_0	2116.22 lb/ft^2 29.92 in. Hg	$1.013250 \cdot 10^5$ N/m^2 760 mm Hg
Temperature, T_0	518.67°R 59.0°F	288.15°K 15.0°C
Acceleration due to gravity, g_0	32.1741 ft/sec^2	9.80665 m/sec^2
Specific weight, $g_0\rho_0$	0.76474 lb/ft^3	1.2230 kg/m^3
Density, ρ_0	0.0023769 lb-sec^2/ft^4	0.12492 kg-sec^2/m^4

Figure 1-2. *Conditions of the standard ICAO atmosphere*



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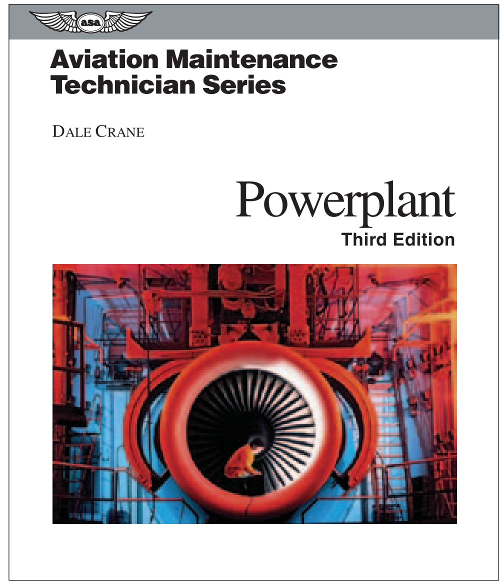

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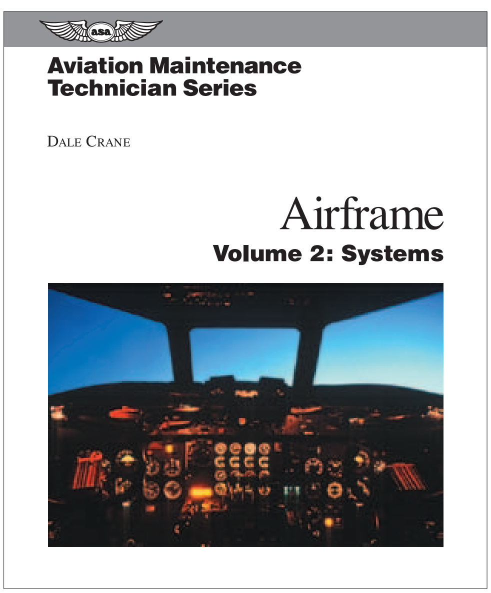

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