The Illustrated Guide to Aerodynamics

2nd Edition

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What is aerodynamics?

THE HUMAN BEING IS SET APART from all other animals by an intelligent, reasoning mind. Another quality that humans seem to possess is an inherent drive to utilize that mind to achieve, to recognize challenges, and to attempt to conquer them. From the dawn of history, man has been lured to explore his world and to expand the horizons of his habitation. To accomplish this feat, chariots were devised, horses were harnessed, and sailing ships were created. In all of these endeavors, the idea of possibility surely must have been sparked by what was observed in nature. If deer and wild horses could travel great distances at high speeds, then man was tempted to try it. If fish could swim across oceans, then the possibility loomed for man to accomplish this feat.

HISTORY OF FLIGHT

It would seem obvious, then, that the sight of birds flying through the air would entice men to attempt to do the same (Fig. 1-1). It is also not too surprising that the first attempts at human flight employed the concept of flapping wings. After all, this is the way that the birds did it. In early Greek mythology, we have accounts of men flying with birdlike wings. The story of Daedalus and his son Icarus utilized flight as a means of escape from the island of Crete where they were imprisoned. They were said to have created wings of feathers held together with wax. Icarus, however, being young and impetuous, flew too close to the sun, and the heat melted the wax in his wings as shown in Fig. 1-2. He plunged to the sea and suffered one of the first fatal crashes in history—at least according to mythology. Inaccurate as the scientific facts might be, this story points out the dream of flight that pervaded the human mind far back in history.

The concept of flapping wings occupied the thoughts of practically all those who dreamed of flight for many centuries. Notable among such dreamers was Leonardo da Vinci, best known for his artistic accomplishments. He was, however, a man of many talents and made significant contributions to the scientific knowledge of his day. He was obsessed with the idea of achieving flight by somehow transforming the muscle-power of man into lift and thrust through a flap-

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Fig. 1-1. Primitive man contemplates flight by observing birds.

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Fig. 1-2. Icarus falls from the sky as the sun melts the wax from his wings.

ping wing device such as that shown in Fig. 1-3. As talented as he was, he did not recognize the futility of this approach and he contributed little to the actual achievement of flight. Such efforts, however, did serve to perpetuate—and to encourage—the idea of human flight.

Fig. 1-3. An early ornithopter conceived by Leonardo da Vinci.

The first successful aircraft of any kind relied on an entirely different principle of physical science. Early experimenters observed smoke rising and even bits of ash and other material, which normally fell to the ground, were seen to rise in heated air. Joseph and Etienne Montgolfier took advantage of this phenomenon and designed and constructed the first hot air balloon. This took place in France in June of 1783 and is illustrated in Fig. 1-4. The Montgolfier brothers did not actually realize what caused their balloon to ascend. They thought at first that burning wood released some unknown gas that mysteriously caused objects to rise. The principle of lighter-than-air flight soon became known, however, and considerable activity in both hot-air and hydrogen-filled balloons took place before the end of 1783. It is somewhat amazing that modern balloons, such as shown in Fig. 1-5, work almost exactly as those devised by the Montgolfiers.

AEROSTATICS

A balloon works on the *buoyancy principle*, the discovery of which is attributed to Archimedes. The pressure in any fluid, liquid or gas, increases with the depth. This is apparent if you dive into the sea and also if you descend from a high altitude in the air. In both cases the pressure gets greater as you go down. This is true of even small changes in height, although the change in pressure is, of course, very small also.

Figure 1-6 shows a small chunk of fluid within a larger container of the fluid. The pressure on the bottom surface is greater by an amount ΔP (Δ is pronounced *delta*, an abbreviation for difference) over the amount P on the top surface. If the

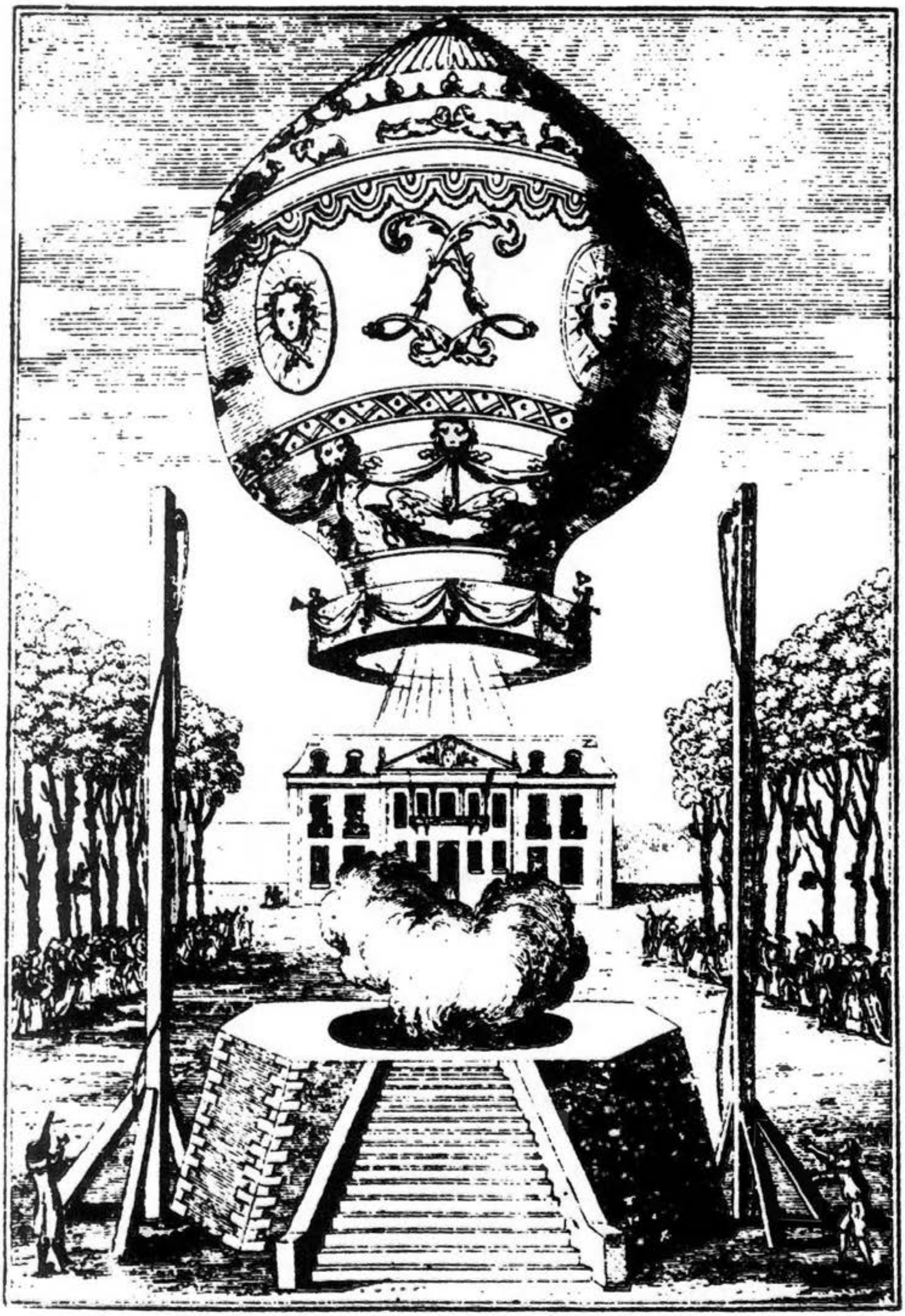

Fig. 1-4. Launching of the Montgolfier brothers' balloon in 1783.

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Fig. 1-5. Modern hot air balloons; these are quite similar to the very first balloons except that the heating device is carried along in the gondola.

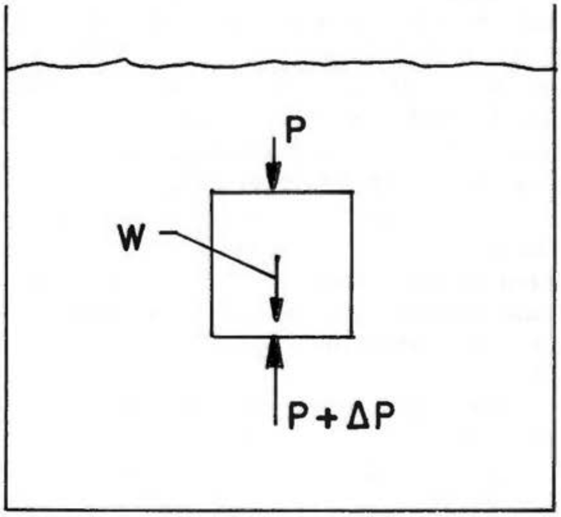

Fig. 1-6. A small chunk of fluid that tends to remain static because all forces are in balance.

chunk of fluid had no weight, it would be pushed upward by this increased pressure on the bottom; however, the weight of this chunk of fluid added to the pressure force on the top surface balances out the increased pressure on the bottom and it remains still or *static*.

Suppose now that this chunk of fluid is replaced by a container filled with a fluid lighter than the surrounding fluid. In this case, the weight is not sufficient to balance out the increased pressure on the bottom and the container rises. Actually, the total weight of the container and the fluid inside it must be consid-