



Figure 3.10 Bernoulli's Principle: The total energy of an ideal fluid is constant.

Bernoulli's Principle may be illustrated by an experiment conducted with water under pressure in a pipe. (See Figure 3.10) If we were to take a water pipe connected to the mains and closed off by a tap, and drill a small hole in the side of the pipe, we would see a jet of water of a certain length spurt out from the hole. The length of the jet would depend on the pressure in the pipe. If we were to open the tap a little so that the main water stream began to flow, we would notice that the jet of water spurting from the hole grows shorter. The more we opened the tap to increase the velocity of flow of the main jet, the shorter would become the jet of water spurting from the hole.

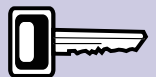
With the tap closed, there is no water flow along the pipe so the **kinetic energy** of the water is zero and all the energy in the water consists of **pressure energy**. As the tap is progressively opened, water begins to flow from the tap with increasing velocity, and the jet of water spurting from the hole gets shorter. This is because, with the tap open, the water now possesses **kinetic energy** by virtue of its velocity, or more accurately, the rate of flow of its mass. As the velocity of the water flow increases, its **kinetic energy** also increases, and so, **Bernoulli's Principle** teaches us that, the water's **pressure energy** decreases and the jet grows shorter. If the tap is closed again, the water's **kinetic energy** will decrease and its **pressure energy** rise, causing the jet from the hole to increase in length again. The **total energy** of the water **remains constant** throughout the experiment.

Aerodynamicists have discovered that **Bernoulli's Principle** of pressure variation with velocity change can accurately predict the **lift force** developed by a wing, in the same way as Newton's Laws can.

The measurement of steady, horizontal airflow around a wing, which is at a small positive angle of attack to the airflow, irrespective of whether the wing is of flat-plate or aerofoil cross-section (see Figure 3.11, overleaf), shows that, when compared to the velocity of the free airstream, the air flowing over the upper surface of a wing increases in speed while the air flowing under the lower surface of the wing decreases in speed.

In accordance with **Bernoulli's Principle**, where the **kinetic energy** of the air is highest the **pressure energy** of the air is lowest and where the **kinetic energy** is

When compared to the speed of the freestream



airflow, the air flowing over the upper surface of a wing increases in speed while the air flowing under the lower surface of the wing decreases in speed.