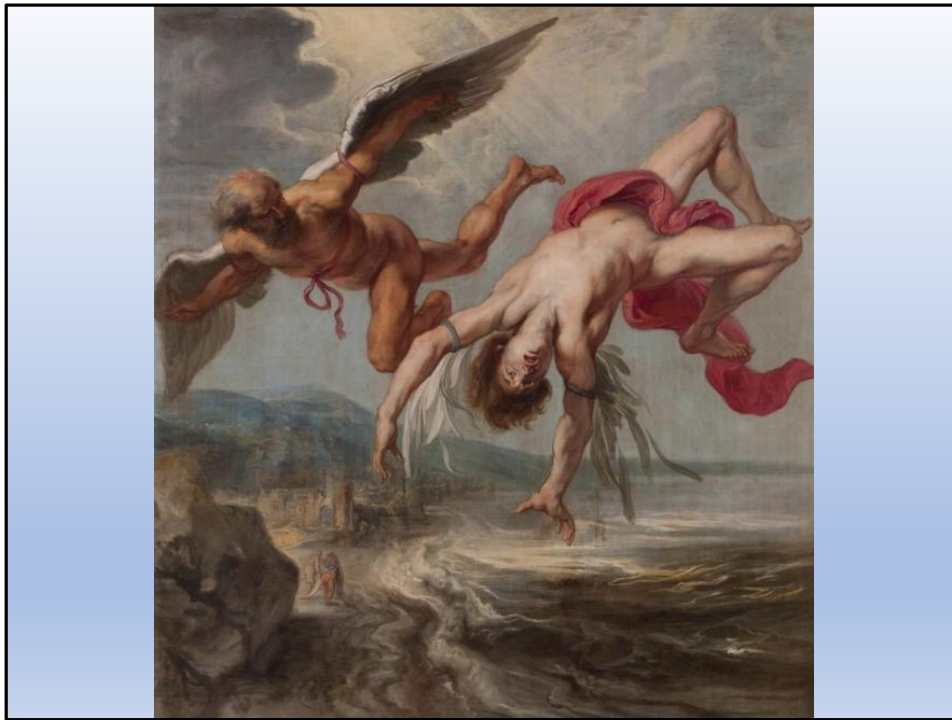


*Second Level Technologies  
Benchmark SCN 2-20a*

*Physics of Flight Pt 2*

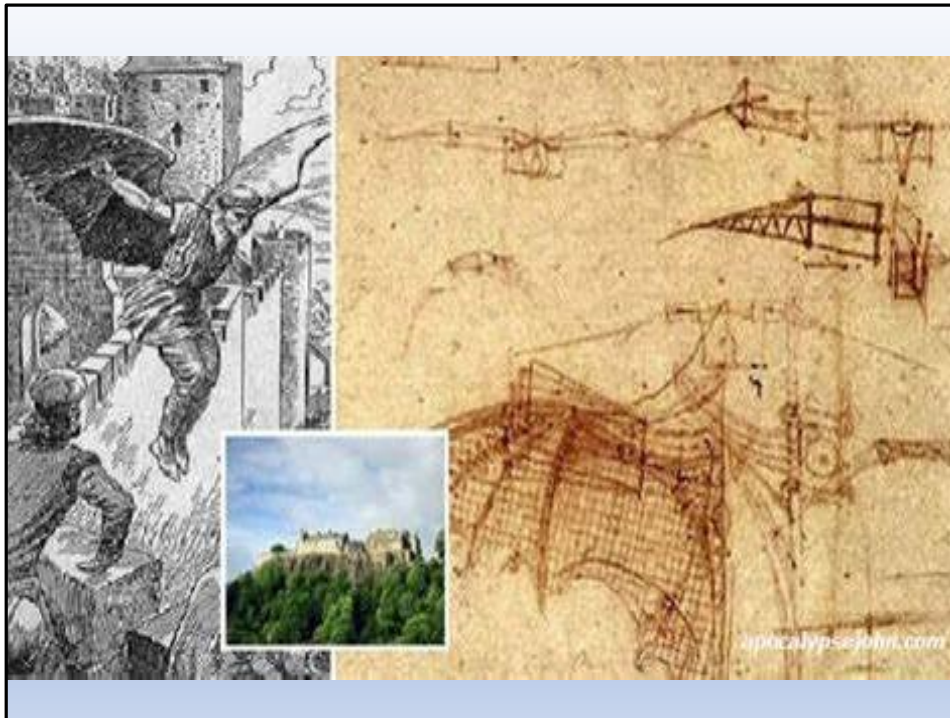
*Exploring the science  
of flight.*

*Lets see how humans  
tried to get into the air  
without  
the advantage of science.*

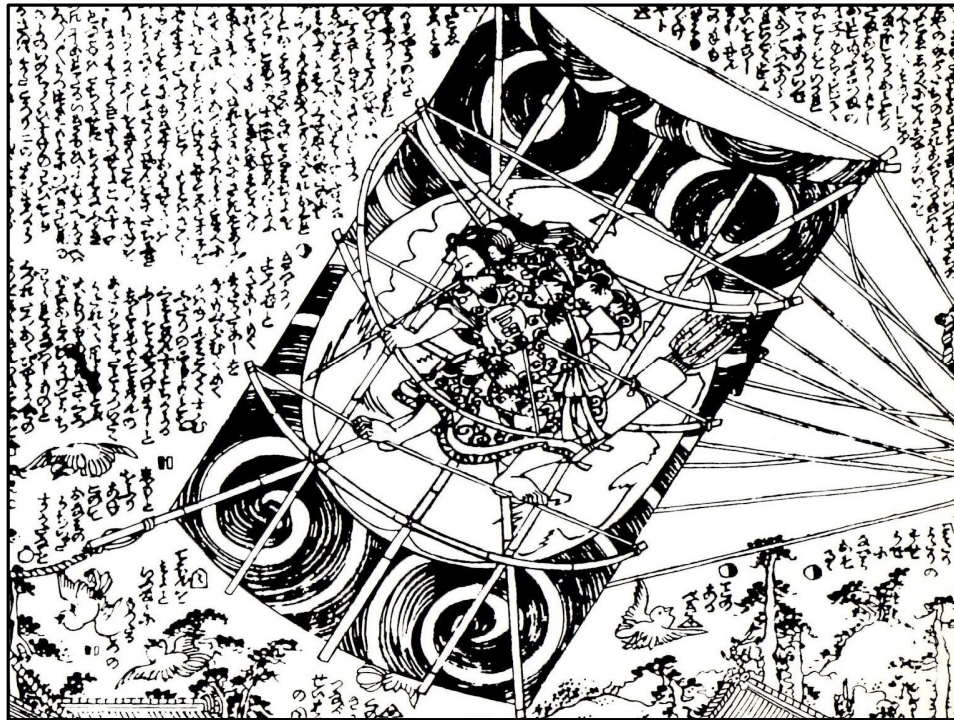


Humans wanted to fly like the birds but failed to realise that birds had been learning how to do it for about 190 million years.

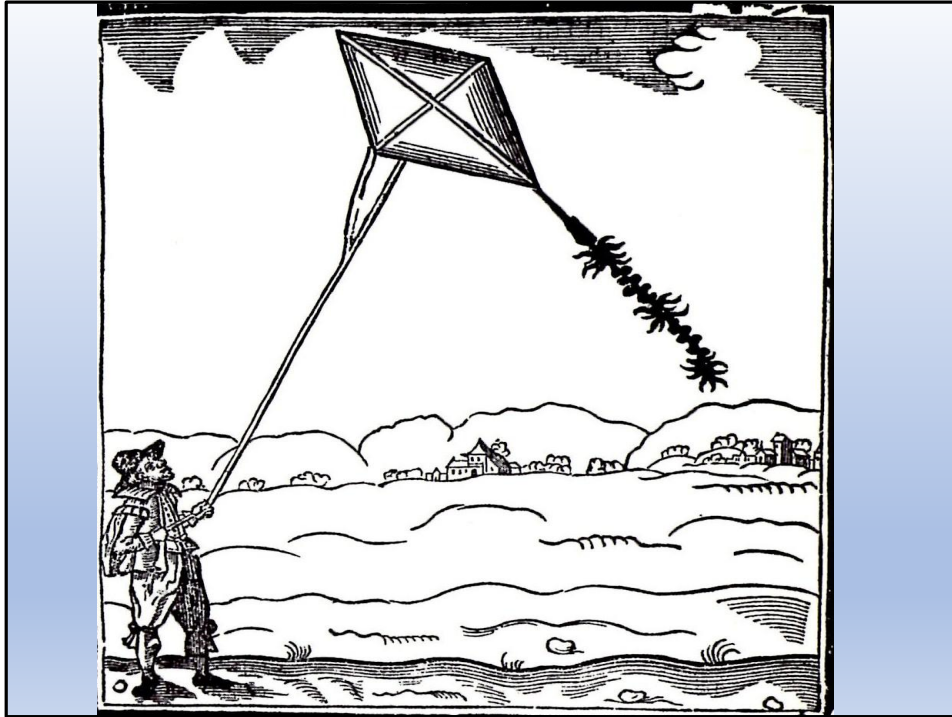
There is a story in Greek mythology about Daedalus and his son Icarus. Daedalus was an inventor but he had upset King Minos and so, to escape from Crete, he made two sets of wings covered in feathers. He warned Icarus not to fly too low or the spray from the waves would dampen the feathers and not too high or the sun would melt the wax that attached the feathers. Icarus, in the excitement of flying, ignored the warning, flew too high, the wax melted, the feathers fell off and he fell into the sea and was drowned. Daedalus flew on, not too low and not too high and arrived safely. All pilots ever since know that they must fly within the design limits of their aircraft.



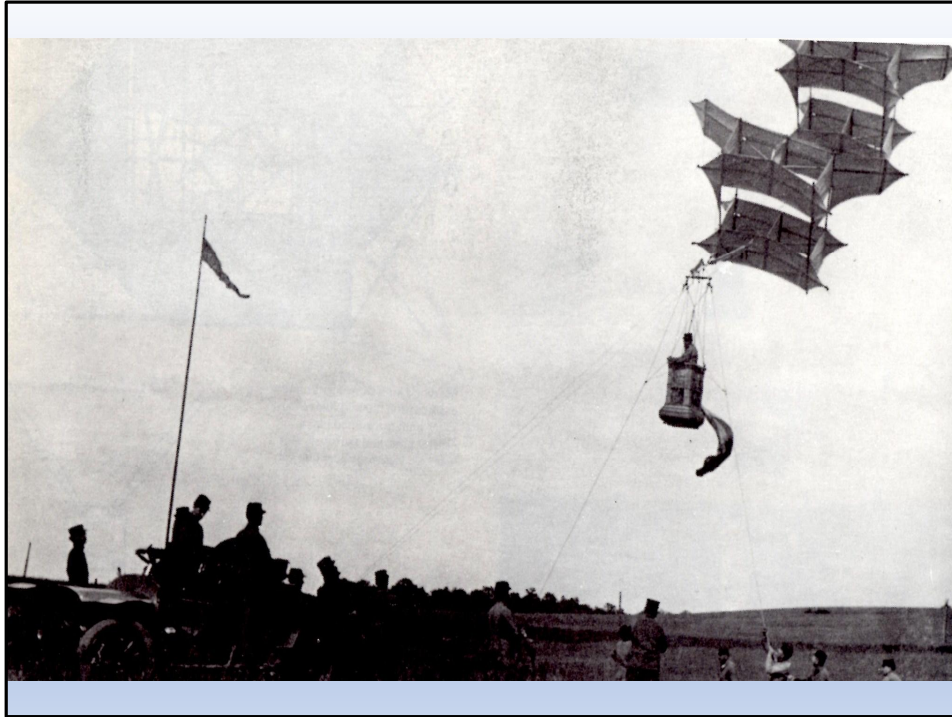
Many others tried but usually fell to their deaths. In Scotland, Giovanni Damian, an alchemist, was working for the king at Stirling Castle. In Sept 1507 he announced that he would make a pair of wings and fly to France. He covered the wings in feathers, leapt off the castle battlements and fell 70ft into a dung heap breaking his thigh bone. When he was feeling a bit better, Giovanni carried out an accident investigation. He said that his wings would have worked if someone had not swapped cheap hen's feathers for the golden eagle feathers he had ordered. Everyone knew that hens do not fly that well.



Humans have flown kites for probably 2,500 years. It seems that the first kites were made in the Far East and the size of kites gradually increased to the point where, if the old stories are to be believed, they were big enough to carry a man. In China it was said that noise making kites were flown over the battlements of besieged fortresses to frighten the enemy and in some cases carried an archer to shoot down onto the defenders. In Japan it was eventually forbidden to make a kite large enough to carry someone in case the enemy found out the secret and built his own to attack Japan from the air. In China criminals were punished by being strapped to a kite and flown from the top of a tall tower and if they survived they were set free.



This engraving from the 500 years ago, shows a Dutch man flying a kite. To make the kite more exciting he has tied fireworks to its tail.



This photo shows a French Army observer being lifted under a string of large man-lifting kites setting off on a high altitude attempt in 1910. A few years later, during the First World War, kites were again used to carry soldiers aloft over the battlefield to spy on the enemy and direct gunfire onto the enemy lines.

Kites of course cannot travel around when they are in the air because they are tethered to a point on the ground. They are not much use for going on a journey anywhere.



The Montgolfier Brothers lived in Paris from 1740 to 1810 and owned a paper factory. They made paper from straw and burned any waste straw in the boilers to heat the water needed for the manufacturing process. One fine day with no wind, one of the brothers was looking at the smoke rising up into the sky from the factory chimney and thought that if he built a large paper bag and filled it with smoke it too would rise into the air. So they did make a big paper bag, lit a fire of straw under it to make smoke, and sure enough the paper bag floated into the air.





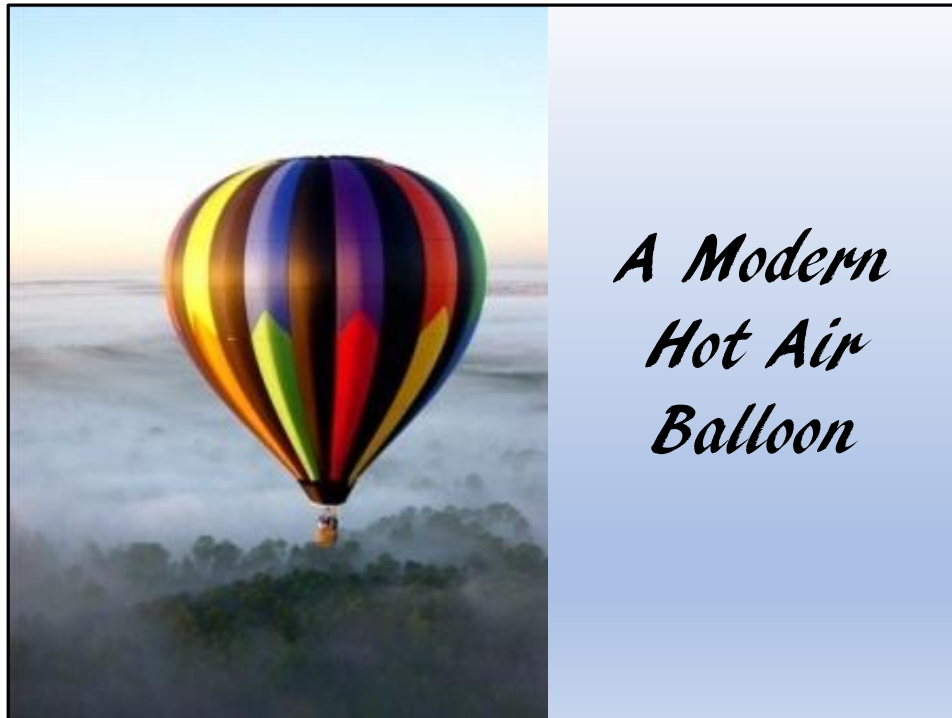
They built an even bigger paper bag and it rose into the air with three passengers, a hen, a duck and a sheep. The paper bag rose into the air and then came back down with the animals unharmed. The Montgolfier brothers still did not know that it was the hot air that caused the balloon to rise. They still thought it was the smoke.



The Montgolfier brothers were encouraged by the success of the test with the animals and decided to build a large and beautiful balloon to be able to lift human passengers. This painting shows the balloon rising into the air with two passengers in November 1783.

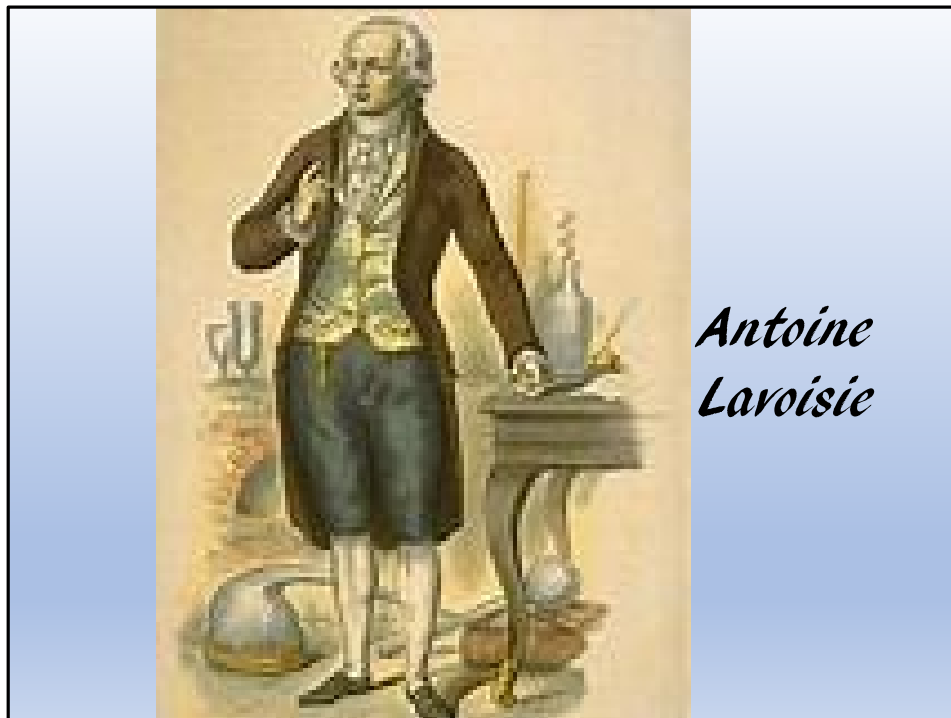


The two intrepid passengers were Pilatre de Rozier and the Marquis D'Arlande. This painting shows them waving to the crowd who had gathered to watch. They travelled nearly 10 kilometers and reached a maximum height of about 900 metres on a flight that lasted about 25 minutes. They landed unharmed, but early, because the paper of the balloon was beginning to burn and they had to put out the small fires with wet sponges.



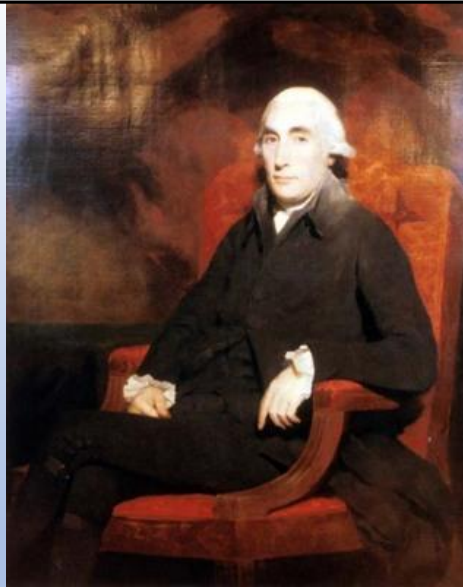
Now that we know the secret of hot air balloons it has become a popular sport and tourist flight business. This photo shows a modern hot-air balloon.

However, hot air balloons still can not fly in bad weather and have to travel in the direction of the wind. They are still not much use for everyday travel.



Around the same time that the Montgolfier brothers were flying their hot air balloons, an English millionaire and scientist Henry Cavendish was experimenting with a gas that had been found much earlier in the 14<sup>th</sup> century by Paracelcus. He found that it burned very easily but surprisingly left a residue of water. He called it “inflammable air” and also discovered that it was the lightest element known to man.

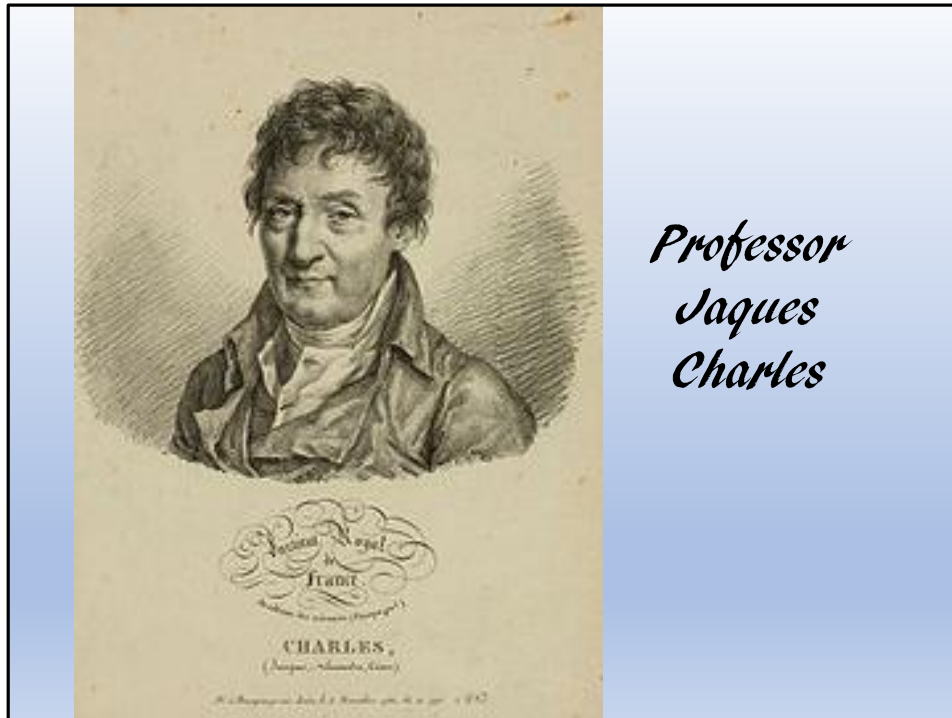
Later, the Frenchman Antoine Lavoisier repeated Cavendish’s experiments and renamed the gas Hydrogen from the Greek for water, hydro. He also discovered oxygen.



*Joseph Black 1728 -1799*

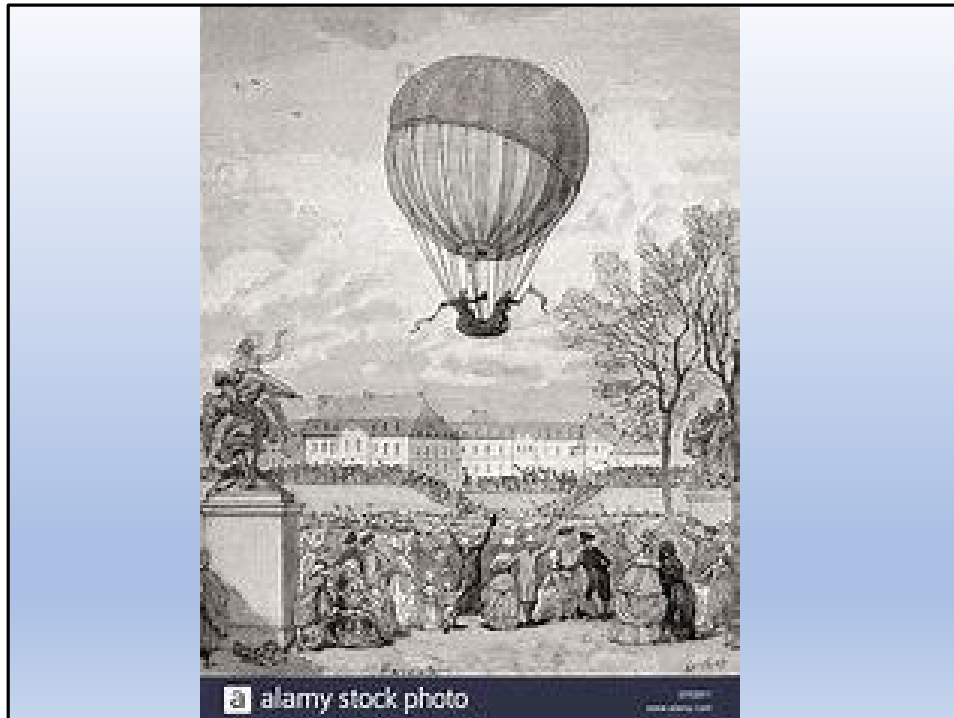
Joseph Black, the son of an Irish family living in Paris, came to Scotland to Glasgow University and became a chemist and a doctor. He knew about Hydrogen and how light it was and suggested that if a balloon was filled with hydrogen it would float in the air.

This was probably the first time that a scientific observation led directly to a design of aircraft that lifted someone into the air.



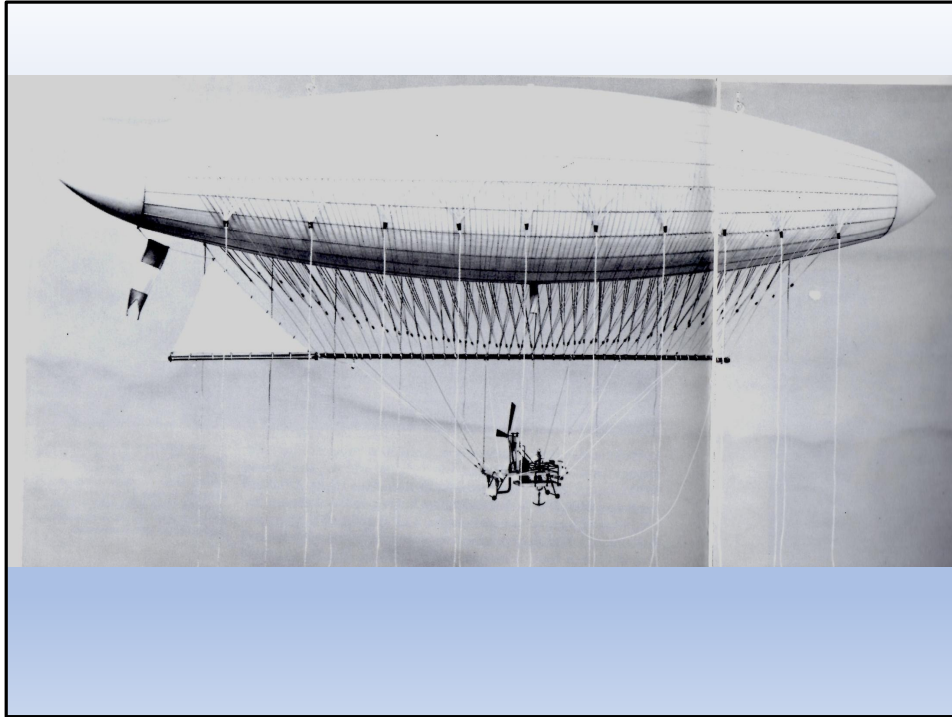
*Professor  
Jaques  
Charles*

However Joseph Black was too busy doing other things and it was left to a Frenchman, Professor Jacques Charles, to try out Joseph's idea. He built a balloon and it was a great success. On its first flight in August 1783 it flew from Paris for 2 hours and covered 27 miles and at its highest point was at an altitude of 2,000 feet.

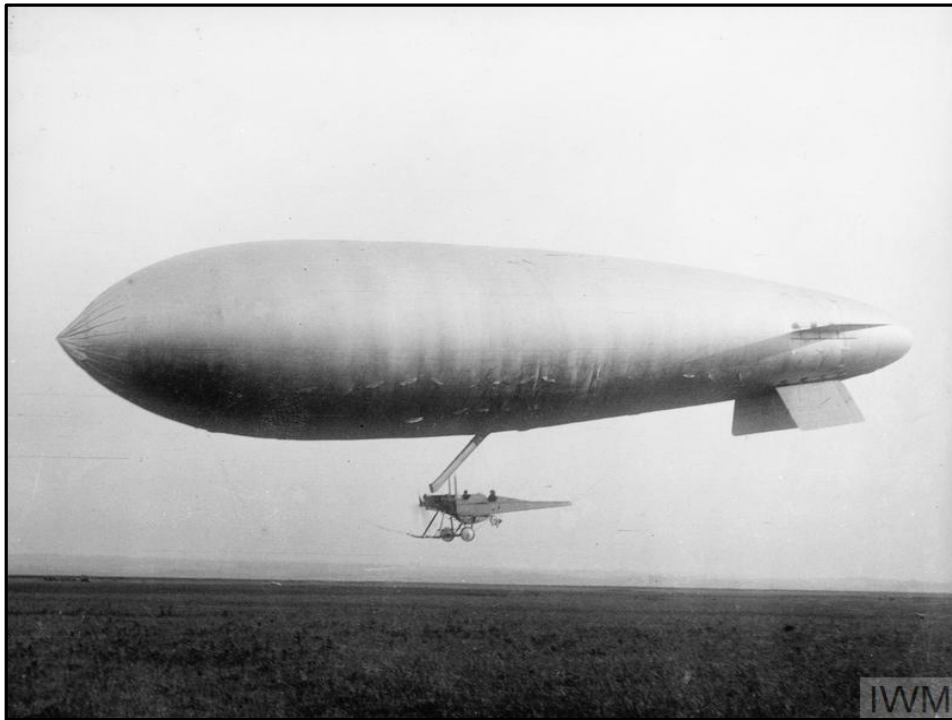


This illustration shows the first flight of the Jaques Charles hydrogen balloon.





This French airship from 1852 was filled with highly inflammable coal gas and was powered by a steam engine. A gas fired steam boiler and a gas filled balloon was not a very safe combination. It could only travel at 5 mph and so was still at the mercy of the wind. However it did show what might be possible.



About seventy years later the British Navy started to use simple non-rigid airships, these aircraft were just simple balloons but shaped to make it easier to control the direction of flight. They simply slung a fighter aircraft fuselage complete with engine underneath the gas bag and these airships were used to carry out long range patrols looking for enemy ships. These flights could be very hazardous for the crew of two who sat in open cockpits with sometimes long cold battles to make headway in strong winds.



*Count Ferdinand von Zeppelin 1838-1917*

But it was the Germans who saw the possible military use of airships during the coming First World War and it was Count Ferdinand von Zeppelin who took up the challenge to design and build a practical airship. The early Zeppelin airships explored the limits of range and altitude and they were used during the War to bomb Britain. Being filled with highly inflammable hydrogen they eventually became vulnerable to attack by fighter aircraft and many burned and crashed. This is when science was first used in a really big way to be able to design and operate these huge machines. New lightweight metals had to be devised, engines had to be designed to be more powerful and lighter, a new way of navigating had to be learned to be able to carry out long distance flights, and ways of keeping crews active at high altitude and extreme cold.



After the First World War other countries such as Italy, Britain and America also started to develop large airships with varying degrees of success. The R34, a copy of a wartime Zeppelin, was built in Scotland and was the first aircraft to do a return trip across the Atlantic. Two much larger British airships were built, the R100 which did a return trans-Atlantic trip, and R101 which crashed in France in 1930 on its maiden flight to India.



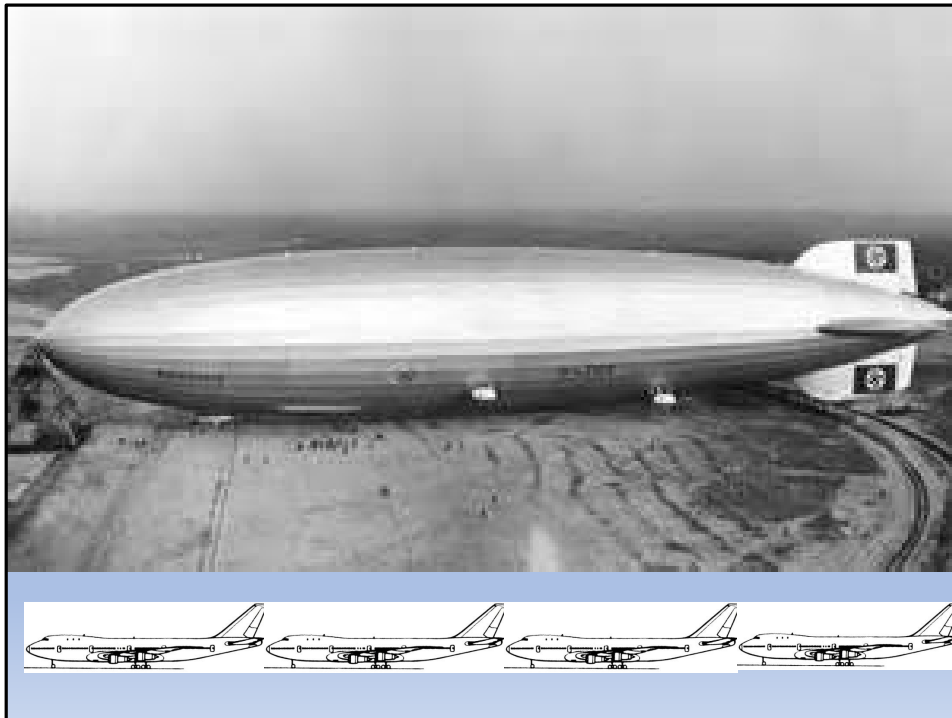
**The Hindenburg ready to take-off  
for a trans-Atlantic flight.**

However it was Germany again who took the lead and developed really large civil airships. It is difficult for us nowadays to imagine the size of these airships. Despite its huge size it carried less than 100 passengers.

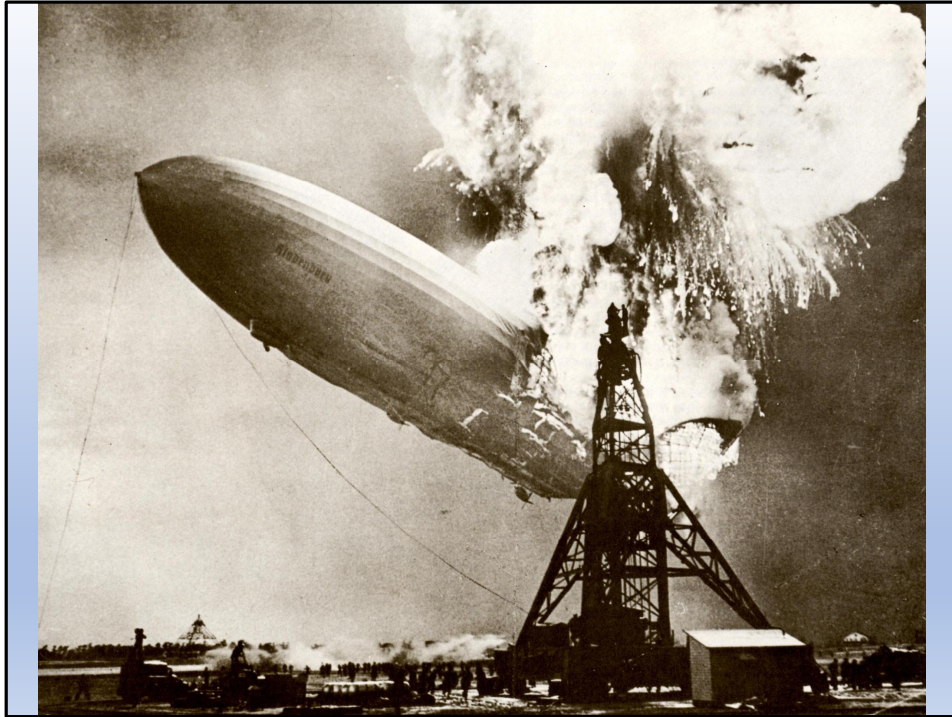


**Boeing 747 - Jumbo**

We think of the Boeing 747 as being a very large aircraft. It can carry over 400 passengers.



However compare the 747 with the size of the Hindenburg. Four 747 aircraft would just about fit inside its huge gas filled body.



But on May 6<sup>th</sup> 1937, the Hindenburg crashed in flames at the end of a trip to America and 35 of the 97 passengers and crew on board were killed. On the day of the Hindenburg disaster, passengers on another huge airship, the Graf Zeppelin, were flying back to Germany from Brazil. The captain of the Graf Zeppelin got the news of the Hindenburg crash by radio but decided not to tell his passengers. So when the passengers eventually arrived in Germany they were probably the last to hear about the fate of the Hindenburg. This very public accident only a few years after another disaster, the crash of the British Airship R101 on its way to India, effectively brought about the end of airship travel.





None of these methods of getting into the air were completely successful. The best machines were the giant airships operated by the Germans in the 1930's that carried passengers on trans-Atlantic routes but they were slow and very inefficient and, as the Hindenburg accident showed, they could be very dangerous. The travelling public needed a better method of air travel. Airships are not quite dead yet. This large modern example first flew in 2016. It is not intended for mass passenger transport. It is however filled with a non-inflammable gas, Helium, the same gas that is used for party balloons.