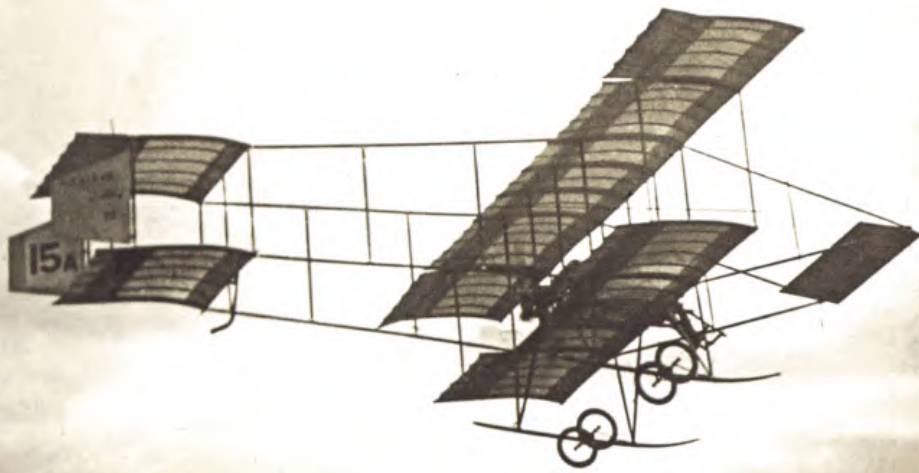


AVIATION

An historical survey from its origins
to the end of the Second World War



science
museum

Charles H Gibbs-Smith

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Introduction

This work originally appeared in 1960 as *The Aeroplane: An historical survey*. It has now been rewritten in the light of subsequent research, and brought to a close at the end of World War II, a time which saw the practical start of the jet age. As before, the intention has been to record the origin, birth and final establishment of the aeroplane in our civilisation, where it came to inaugurate – as Sir George Cayley had truly foretold – ‘a new era in society’.

Of the scope and treatment adopted, I would first say that I have again devoted what might be felt an over-preponderance of space to the origins and early days of the aeroplane; that is to say, up to World War I. But I still feel that it is the early development of ideas, then the slow technological climb from Cayley to the Wright brothers, and the final achievement of the practical powered flying machine – followed by the oddly slow progress it made in Europe during the period 1902–09 – that should be firmly established in their general features, in order properly to lay the foundations of the aviation history to come. The later periods are, in any case, well covered by others.

Regarding, almost with nostalgia, the earlier state of aeronautical history – with its amorphous personal recollections, the tentative recording of events, and its often semi-fictitious chronicles – it is nevertheless gratifying to see how the subject has now become established as an important branch of technological history, with large numbers of books appearing on every aspect of the subject. These works often cover parts of the field in the greatest detail; whole books, for example, have been written about the aircraft manufactured by one firm, or one type of machine (such as the bomber) used by a single country; and there are even books dealing with individual makes of aeroplane, along with articles in periodicals which delve ever deeper into the minutiae of construction, development and performance. But my purpose has been quite different: it has been to describe the historical origins upon which the vast industry of modern aircraft manufacture has been raised. I therefore deal with later flying more briefly, in order to keep the whole subject in historical perspective. Regarding my fuller treatment of the early periods of ideas, endeavours and achievements, I would say that I have attempted, broadly speaking, to deal with them mainly from the evolutionary standpoint, concentrating upon the main formative influences.

Expressing thanks to all those who have aided me would involve, for the second time, a very long list of names; I have already paid tribute to many of them in the original version of the book. But I would again express my sincere thanks to the Director of the Science Museum, Sir David Follett, and to his colleagues Miss Margaret Weston, Mr Brian Lacey, and Commander Walter Tuck, for all their encouragement and many kindnesses. Then I would like to express deep gratitude to my friends at the Royal Aircraft Establishment at

Farnborough, especially Dr Percy B Walker, CBE, formerly Head of the Structures Department; Dr Dietrich Küchemann, CBE, FRS, Head of the Aerodynamics Department, and John Bagley, AFRAeS, of the same department. To my colleague Mrs Beryl Edginton I owe an ever increasing debt for her many labours in connection with my books, not the least of which is the laborious task of checking and reading the proofs. Finally in Her Majesty's Stationery Office itself, there are many old and new friends to thank for their extreme good nature and ever-willing cooperation with someone who must certainly rank as one of their most demanding and most enraging authors; but particular mention should be made of Mr David Naphine, Deputy Head of the Layout Section, who has so admirably designed this book, both in its original form,¹ and as it appears today.²

Not being happy with the somewhat 'spotty' appearance of the text illustrations in the previous work, I decided greatly to increase their number, and place them in 'page groups' throughout the historical narrative.³ Most of the drawings which illustrate aircraft prior to about 1910 are taken from original documents. Mr Naphine and I then felt that it would preserve a certain essential harmony of appearance if we could continue this 'idiom of line' throughout the history. I had – in the original work – been allowed to use a number of the highly talented (sic) drawings made by Mr Douglas Rolfe in the USA; but I now required nearly double the number that I had originally used. It is therefore with especial gratitude that I here record the generous permission to use this large number of the Rolfe drawings, accorded me by The Condé Nast Publications Inc., of New York City, publishers of *Air Progress* magazine.

Every historian, no matter what his subject, must seek aid and advice from a variety of authorities within the field he explores. But every historian must also, and inevitably, make mistakes, as well as overlooking misprints. As before, I would finally appeal to readers to kindly inform me of any mistakes they find. Where it is a question of my facts being thought incorrect, I must ask to be provided with reliable documentary evidence of any alterations which they feel should be made.

Notes

- 1 *The Aeroplane: an historical survey*, published 1960.
- 2 The first edition of *Aviation: an historical survey*, published 1970.
- 3 The current edition uses almost all the line drawings from the previous editions, but most of the halftone images have been replaced with new pictures.

Preface to Second Edition

Since the stocks of the first edition of this book were exhausted there has been a continuing demand for copies, and the Science Museum decided that it should be reprinted.¹

For some time before his death in December 1981, Charles Gibbs-Smith had started preparing for a fully revised second edition. Unfortunately his own notes were too fragmentary, and the burden of completing his work too onerous, to permit of this complete revision; so the decision was taken in conjunction with the production staff of HMSO that revisions would be kept to a minimum. A significant number of minor corrections have been made, particularly in Sections 2, 3 and 10 with the help of Professor Clive Hart and of Philip Jarrett.

Beyond that, the main change has been the deletion of numerous references to the projected Volume II – tentatively entitled *Early Aviation History: Studies and Problems* – which was intended by Charles Gibbs-Smith as a compendium on miscellaneous topics which had attracted his attention. In the event, the most important parts of this work were subsumed into his study of the influence of the Wright Brothers on the European pioneers, which was published as *The Rebirth of European Aviation 1902–1908* in 1974; and other items were published separately. However, there remained a series of studies on a topic of particular concern to Charles Gibbs-Smith: various claims advanced in recent years for powered flight before the Wright Brothers. I have thought it right to add a brief summary of this work, on pages 283–7.

I know that Charles would have wished any second edition of his book to contain acknowledgement of the help received from a number of people: Tom Crouch, Tony Elsworthy, Clive Hart, Gene Husting and Philip Jarrett would certainly have been among that number.

JOHN A BAGLEY
Curator, National Aeronautical Collection
Science Museum, London
January 1984

Note

- 1 This 2003 edition omits the quotations on flying, bibliography and conversion tables featured in the 1985 edition.

Prologue



The earliest-known illustration in history of a powered aircraft: c. 1325. It is a string-pull helicopter model, shown in a Flemish manuscript in the Royal Library at Copenhagen (No. 3384.8). This type of 'toy' – called by the French a 'moulinet à noix' (see page 16) – can be clearly plotted through the succeeding centuries; from it evolved the contra-rotating model of Launoy and Bienvenue (1784), which was copied by Cayley (1796) and published by him (1809), through which it became the direct ancestor of every helicopter flying today.

The practical realisation of voyaging through air and space has been a truly international achievement, in which some ten or more great nations have taken most honourable part, each making vital contributions to the development of the balloon, the airship, and the aeroplane. Disputes, claims and counter-claims should find no place in this great company.

The birthplace of civilisation would naturally have provided the breeding ground for many of the world's basic inventions: thus the ancient Chinese made three fundamental contributions in the field of aeronautics and propulsion when they invented the kite (c. 1000 BC), gunpowder (ninth century AD), and the rocket (c. AD 1100). The kite was the archetypal aeroplane wing, as well as the world's first aerial vehicle; for man-lifting kites were certainly in use in China within a few centuries of the invention of the kite, their first application being in the service of military observation. All three of these inventions found their way along the trade routes of the ancient world, and appeared in Europe during the Middle Ages.

The ancestry of the airscrew is obscure, but although the Chinese may have evolved it, the European airscrew did not originate in China, but appeared first in the uniquely European form of post (or tower) windmill, and was in widespread use by the thirteenth century. The passive role of the windmill's sails became an active propulsive airscrew by the fourteenth century, in the form of what were at first thought of as windmill toys, but were in fact pure helicopters of the string-pull type.

So, by the end of the fourteenth century, we had in Europe the two inventions which were to form the core, so to speak, of the powered aeroplane – the rigid inclined wing of the kite, and the active propulsive airscrew – not to be combined in one structure for some five centuries, but active in separation, and ready to come together when the historical processes had reached their appropriate stages of evolution.

As might be expected, the luxuriant explosion of art, science and letters which we call the Italian Renaissance brought forth the first man of great attainments to describe the flight of birds, to speculate on aviation and to design ornithopter flying machines (Leonardo da Vinci, 1485–1510).

Meanwhile, by way of some saints and many sinners, the idea of air-mindedness was to be nourished by brave and foolhardy men who fitted themselves with wings, and jumped to death or mutilation from high places.

Visions of military destruction from the air soon followed, and were first focussed and set down by a priest of Baroque Portugal (de Lana, 1670); and it was another Portuguese priest who took the first tentative steps towards gliders and hot-air balloons in model form (Gusmão, 1709).

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As the eighteenth century was celebrated as the Age of Reason, and as France was the land of Diderot and Voltaire, it was properly in character for the French to accomplish the enclosure of a 'cloud in a bag', and for the first time to travel through the air in great gas balloons sustained by hot air or hydrogen (the Montgolfier brothers, and Charles, 1783). Soon after, came the practical parachute and the first human drop from the air (Garnerin, 1797).

As the Industrial Revolution was initiated in Britain during the same century, it was appropriate that the applied science of aerodynamics, and the first formulation of the practical flying machine – as well as the prefiguring of the aeroplanes to come – should be accomplished in the land of Isaac Newton and James Watt (Cayley, 1799–1809; Henson, 1843; Wenham, 1866).

In the meantime, France and Britain had both envisaged the elongated, powered and dirigible balloon (Meusnier, 1785; Cayley, 1809–16). Then, after a long interval, France took the lead, and brought to fulfilment the first tentative airship (Giffard, 1852), and the first near-practical airship (Renard and Krebs, 1884).

It was almost inevitable that France, with her lasting interest in aerial affairs, would also come to exploit the aeroplane products of the British 'race of shopkeepers', and to establish for some years an aeronautical ascendancy of experimentation, exploitation and panache (Du Temple, *c.* 1857; Le Bris, 1857–68, Pénaud, 1871; Tatin, 1879). It was also inevitable that the tradition of British speculative physics should again reassert itself by producing the first aeroplane model with superposed wings (Stringfellow, 1868), and by proving the superior lifting qualities – with the aerodynamic *raison d'être* – of double-surface cambered wings (Phillips, 1884, 1891).

Brave efforts to build and fly full-sized powered and piloted aeroplanes in France, Russia and Britain met with minimal success, only to the degree that, by various means, these machines were launched from the ground and into the air; but none of them could sustain themselves, and so could not fly (Du Temple, *c.* 1874; Mozhaiski, 1884; Ader, 1890; Maxim, 1894).

The all-important engines – which were later to make practical flying possible – grew from a French invention, the gas engine (Lenoir, 1866); and then took root and flourished in the atmosphere of well-patronised practicality then prevalent in the states of the German princelings, which thus saw the invention of the four-stroke petrol engine (Otto, 1876); its brilliant application to automobilisme was also brought about by Germany (Benz, 1885; Daimler, 1886).

It was the unified and emergent Germany, with her thoroughness and pertinacity, which produced the first man to mount magnificently into the air, to ride the wind on gliders, and directly to inspire the next generation of pioneers to master the craft of mechanical flight (Lilienthal, 1891–96).

Finally, the vigorous upsurge of pioneering energy, enterprise and practical experimentation, traditionally associated with the New World, made it appropriate that the ultimate triumph of achieving the

practical powered aeroplane should take place in the United States of America (the Wright brothers, 1899–1908).

To bring about this practical flying machine, a number of parallel streams of endeavour and invention had to be born, to develop, and to coalesce, before the Wright brothers could apply their creative faculties to achieve a satisfactory mechanism. These streams were: (1) the science of aerodynamics; (2) the technology of structures and aeroplane configuration; (3) fuel technology; (4) engine technology; (5) airscrew design; (6) flight control.

Thus the age-old dream that human beings would fly through the air by mechanical means was ultimately brought about by citizens of the great nations of the modern world, all working towards a common end, and for the common good of humanity; for the spur of war played little part in it.

The airship finally came to fruition in the first years of the twentieth century through the efforts of a Brazilian, a German and a group of Frenchmen (Santos-Dumont, 1899 and on; von Zeppelin, 1900 and on; the designers and builders of the Lebaudy, 1902 and on).

The first type of powered aircraft in the Western world was the helicopter toy, powered by the pull of string wound on its rotor spindle; this first appeared in the fourteenth century, in Flanders. Ever since then, a continuous history of these models can be traced in Europe, with two in particular (Launoy and Bienvenu, 1784; Cayley, 1796) being much publicised, and leading direct to the development of the modern helicopter, the first of which just to take off freely and vertically under its own power, with a man on board, was Cornu's in France (1907). It was in Germany that the first successful helicopter was flown (Focke-Achgelis, 1936), aided by the influence of the helicopter's 'halfway house', the Cierva Autogiro (1923). Then an ex-patriate Russian, working in the United States, introduced the helicopter as a practical vehicle to the world (Sikorsky, 1942), since when it has taken its place as one of the most important types of flying machine in both peace and war.

The reaction propulsion of aircraft – by jets of one kind or another – was first envisaged in France (Montgolfier, 1783); the first jet aeroplane was designed in France, but not built (De Louvrié, 1865); the first rocket-propelled and piloted aeroplane was the product of Germany (Von Opel *et al.*, 1928) which was prophetic rather than practical. Then the whole vast realm of jet propulsion, by turbo jet engines, was pioneered by Germany and Britain in the first two successful flights with such engines designed by von Ohain (1939), and Whittle (1941), the latter – because of Germany's defeat in World War II – being left to lead the world, and directly to inspire the United States.

Space travel, in the person of the artillery rocket, was born in China about AD 1100; it was first mightily employed against an adversary by Tipu Sultan's army in India (1798–99), which immediately led to the successful reinvention and exploitation of the European war rocket by Britain (Congreve, *c.* 1805; Hale, 1867).

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Powerfully stimulated en route by French science fiction (Jules Verne, 1863 and on), the rocket remained in both the armouries and the imagination of the world – but for the most part ineffectually – until an American pioneered the use of the liquid fuel rocket, which was the direct ancestor of modern space-flight (Goddard, 1926 and on). This work was then enthusiastically taken up in Germany, whose scientists (in 1944) launched a successful long-range rocket bomb which was the immediate parent of all the space vehicles of today. It was Russia – with her interest in space flight reaching back to Ziolkowsky in the nineteenth century – who achieved the first spaceship to orbit our Earth and carry its pilot (Gagarin, 1961), and who sent the first woman into space (1963). Finally, the dream of centuries came true when American astronauts first set foot on the Moon (Armstrong and Aldrin, 1969).

The conquest of space, following the conquest of the air, has been accomplished by the greatest of the world powers; not, perhaps as a League of Nations, or as the United Nations, but as member states working in amicable rivalry one with another, each of them intent on aims and objects far beyond the confines of parochial nationalism; but here it was war that set the pace.

‘Per ardua ad astra’ – ‘through hardship to the stars’ – is a fitting motto to sum up the aspirations of brave and far-sighted men from the earliest days of civilisation to the present day – and beyond.

1 Dreams, myths and devices

The idea of human flight has engaged the waking and sleeping thoughts of men from the time when they developed visual imagination and began to regard the birds with envy. With the envy came the ambition to emulate. For flying has never appeared to its devotees as a mere method of transportation, faster or more convenient than travel by land or sea; nor was it finally achieved by any pressure of economic need. Aviation has drawn its strength from an appeal to the emotions; an appeal to the longing for escape, or to the desire for exhilaration and power. Some have simply seen it as a symbol of aspiration. Desire for rapid locomotion came later.

‘O that I had wings like a dove,’ wrote the Psalmist, ‘for then I would fly away and be at rest.’ And a modern writer speaks of when ‘he closes his hands over the controls, and little by little in his bare palms he receives the gift of this power’.

In time there came prophecy to accompany desire, prophecy of achievement in both war and peace: in 1670 de Lana wrote of his proposed ‘aerial ship’: ‘Where is the man who can fail to see that no city would be proof against surprise ... houses, fortresses, and cities could thus be destroyed, with the certainty that the aerial ship could come to no harm, as the missiles could be hurled from a great height.’ And Tennyson ‘dip into the future, far as human eye could see, Saw the Vision of the world, and all the wonder that would be; Saw the heavens fill with commerce, argosies of magic sails, Pilots of the purple twilight, dropping down with costly bales’.

Realising that the prophecies were nearing fulfilment, the early pioneers were beset by more rational doubts concerning the uses that mankind might make of flying. And so both faith and hope – more technically informed – were added to prophecy, in a striving to temper the winds of Fate. In 1894 Octave Chanute was to write:

So may it be; let us hope that the advent of a successful flying machine, now only dimly foreseen and nevertheless thought to be possible, will bring nothing but good into the world; that it shall abridge distance, make all parts of the globe accessible, bring men into closer relation with each other, advance civilisation, and hasten the promised era in which there shall be nothing but peace and good-will among all men.

Even though the dream of mechanical flight had haunted its slaves over millennia, it could not be realised until modern technology had evolved a powerful and reliable prime mover of small relative weight; and until there emerged a science of aerodynamics and structures, and a technique of pilotage. As it turned out, the foundations of aerodynamics (laid in 1799–1809) preceded the prime mover by a century, and had to mark time while a host of misguided and eccentric characters ran riot over the field of aviation in the nineteenth century, while a few wise men strove to keep it on the right lines of

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development. But we should now go back for a moment to the origins of flying, and also consider some remarkable aeronautical devices which man came to invent in the early epochs of his history.

Nature has not always suggested the basic tools of civilisation – *vide* the wheel, for example – but here can be no doubt that it has been the bird which has provided the chief inspiration for men to fly. Only later came the less dynamic inspiration of the clouds, whose passive flotation was to appeal to the less adventurous spirits. Hence there arose the basic division of human flight into aviation (heavier-than-air flight) with its aviators, and aerostation (lighter-than-air flight) with its aeronauts. But even the latter, after the invention of the balloon in 1783, became irked at being at the mercy of the winds, and went on to develop the ‘navigable balloon’, or airship. It is also interesting to note that the teeming squadrons of the insect world have never played a significant part in inspiring men to fly, probably owing to their being too small to allow of any effective rapport with human beings. Nature, of course, numbers other airmen among her creatures, the most accomplished of whom is the bat, followed by such far less talented exponents as the flying fish and flying squirrels, both of which are, however, only gliders: but none of these was important in aviation until the bat came to influence a handful of workers in the nineteenth century.

Earth – and heaven – has been peopled by aerial creatures of the imagination since the earliest days of recorded time: and the makers of myth, religion and legend often invoked the power of flight to transport their heroes, gods and holy men through the sky. Sometimes the voyages were made in cars or chariots, with or without the help of birds and other beasts; sometimes the passengers were provided with wings; and occasionally the sacred aeronauts were simply invested with the power of levitation. All such celestial activity encouraged the will to fly; and from the earliest times there was no lack of prophets who arose to forestall the conquest of the air, as well as the blessings and calamities that would attend it. Thus Egypt came to have her winged deities; Assyria her winged bulls; and Arabia her flying carpet, of mysterious origin. The Far East had not only many levitated beings and bird-gods, but flying chariots, some equipped with paddle wheels. Classical Greece and Rome produced such familiar figures as the winged god Mercury, the winged horse Pegasus, and the flying chariot of Triptolemus. Then came the angels and *putti* of Christianity, the former – through countless thousands of pictures – providing a constant stimulus to air-mindedness throughout the centuries, for cleric and layman alike.

Worth their weight in gold for the creation and maintenance of air-mindedness, were also the aerial legends that grew up in Europe. And the modern airman’s legend *par excellence* is, of course, that of Daedalus and his son Icarus, which was possibly based on an early attempt at flight: Daedalus, who had constructed the Cretan labyrinth for King Minos, later incurred the King’s wrath: so Daedalus made wings for them both to escape from Crete, where they were imprisoned; but he warned Icarus not to fly near the sun:



Figure 1.1 *The classic airman's myth of Daedalus and Icarus, showing Icarus crashing; from a woodcut of 1493.*

Icarus disobeyed, and the sun melted the wax which glued together his wings, causing him to crash to his death in the sea (Figure 1.1). Daedalus made a safe landing in Sicily. Almost as picturesque was the legendary journey of Alexander the Great to view the heavens by means of gryphons harnessed to his chariot, the beasts being persuaded to fly upward by meat fixed out of reach above them (Figure 1.2). There is also our own national story which tells how the legendary King Bladud of England – founder of Bath and father of King Lear – overtaxed his powers of necromancy by trying to fly over London with artificial wings, and was killed in the attempt (c. 852 BC).



Figure 1.2 *Alexander the Great drawn through the air by gryphons; from a woodcut of 1506.*

Remaining over from the early days of civilisation, and still in use in various parts of the world, are a number of what might be called 'aeronautical devices'. First came the arrow and the boomerang, whose ages are incalculable: the arrow is, of course, only an aeronautical device by virtue of the stabilising effect of the feather(s), which are aerofoils. But the boomerang is virtually a power-launched rotating glider, and a highly remarkable aircraft at that, which returns to the man who launches it, if it misses its target: the aerodynamics of the boomerang are of considerable complexity, and it taxes the mind to imagine how such a device could have been developed by comparatively primitive tribes.

The kite – which is really a tethered glider – is a device of great antiquity in the East, being known in China for probably a thousand years BC, and becoming known in Europe certainly by the thirteenth century¹: it is the true ancestor of the aeroplane, and has played an important part in the history of flying. The kite was first to take part

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in aeroplane flight when it formed the wings of Cayley's first model glider in 1804.

How the European type of post (or tower) windmill – with its horizontal spindle and vertical sails – came into being, is still a mystery. The earliest known illustration of one is in the *Windmill Psalter* in the British Museum, and is dated *c.* 1290 (Figures 1.3 and 1.4); but, so far, it has no ancestors, although it must have come into use much earlier, and appears to be indigenous to Europe. For the Middle Eastern windmills, along the trade routes to China, seem always to have had vertical spindles and horizontally-set sails, half of which were boxed in so that the wind would strike only the blades on one side. This 'paddle' system would accord with the fact that paddle-wheel propulsion – and hence passive paddle-wheel rotation – were well known in China at an early date; and the principle, along with many other ideas and inventions, travelled westwards over the trade routes. But there is no trace of the transit, or arrival in Europe, of the upright type of mill, with its horizontal spindle. This familiar form of European windmill is the passive ancestor of the active aircraft airscrew; and it is interesting to note that certainly by the early fourteenth century, the passive 'airscrew' of the windmill had already become an active airscrew in the form of the string-pull toy helicopter. It was these toys – rather than the full-size windmills from which they were derived – which were the immediate ancestors of the modern aircraft airscrew – the first airborne use of which was on Blanchard's balloon of 1784 – and of the modern helicopter.

Notes

- 1 As the ancient Chinese are known to have used man-lifting kites, the kite is – strictly speaking – the first man-carrying aircraft of history, but without the ability to travel from place to place.

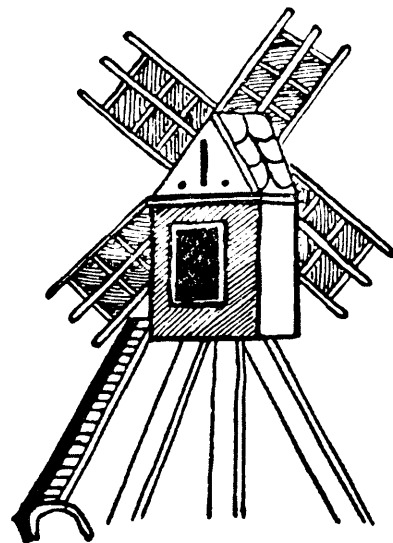


Figure 1.3 Earliest illustration of a European windmill: c. 1290.

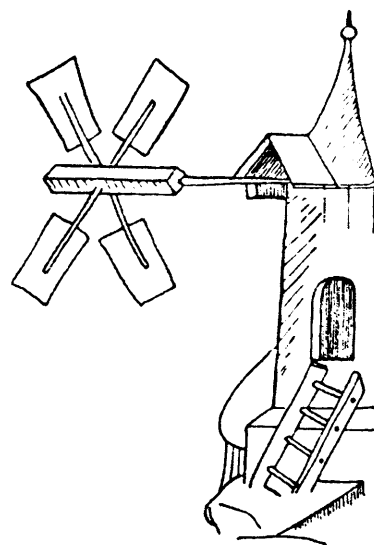


Figure 1.4 European windmill: c. 1410.

2 From classical antiquity to the end of the sixteenth century

Although classical mythology produced some intriguing figures equipped for flying, such as the winged horse Pegasus, as well as the airman's classic legend of Daedalus and Icarus, the civilisations of ancient Greece and Rome seem to have been singularly uninterested in aeronautical matters. Only the figure of Archytas of Tarentum emerges mistily about 400 BC: he is said to have made a wooden dove, which may have been propelled, when hung from a whirling arm, by a jet of steam.

There follows an astonishing interregnum of nearly 1500 years, during which time, if there were recorded events of men with wings, they do not survive, except for vague statements of an apocryphal nature.

Then emerge the historical figures of 'Abbas b. Firnas, an Arab savant who covered himself with feathers and attempted a flight in Spain, around 875; and of Eilmer,¹ a Benedictine monk who jumped off the tower of Malmesbury Abbey about 1010. He had equipped himself with wings, and is reported to have flown about 200 metres before crashing and breaking both legs: he is said to have regretted not fitting a tail surface. Then in 1162 the so-called 'Saracen of Constantinople' became famous by jumping to his death from a tower: he wore a voluminous cloak with stiffening battens forming sail-like wings. In all probability, there were many of these brave but foolhardy 'tower jumpers' who lived and died, and whose names have slowly faded out of history: they at least had the courage of their conviction that men must one day fly (Figure 2.1).

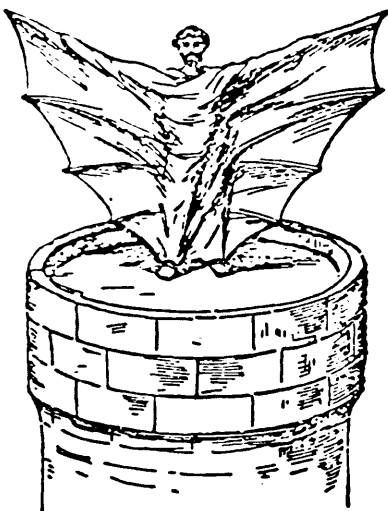


Figure 2.1 Modern illustration of one of the 'tower jumpers' of early history.

Aeronautical speculation – both on lighter- and heavier-than-air flying – was indulged in by a Franciscan monk, Roger Bacon (1214–92), whose work *De mirabili potestate artis et naturae* (written c. 1250, but first printed in Paris in 1542) contains references to hollow globes of copper filled with 'aetherial air', which would float in the atmosphere; and a flying machine in which a man would sit and propel himself by turning a mechanism of some kind: but such vague speculations must have been made by many a learned monk over the centuries but not written down; or having been committed to paper, were destroyed or lost to view, as indeed Roger Bacon's were lost for some centuries.

Then, at the end of the thirteenth century there suddenly appears, as already stated, the familiar form of the windmill with a horizontal spindle, which seems to spring into Europe fully developed, without origins or antecedents (Figures 1.3 and 1.4), but it must have been in use long before this illustration was made.

In 1326–27, there was produced a remarkable illuminated manuscript by Walter de Milemete (*De nobilitatibus, sapientiis et prudentiis regum*), now in the library of Christ Church, Oxford, which

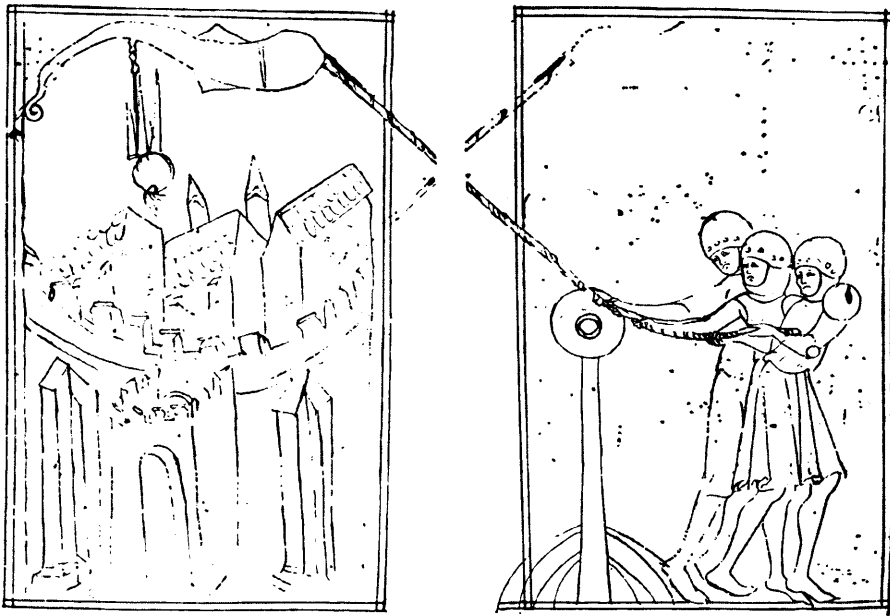


Figure 2.2 First illustration in the Western world of an aircraft (a kite), and a bomb: 1326–27.

contains an unfinished drawing of what might fairly be called the first true aircraft in the Western world (Figure 2.2); it is a kite being flown over a beleaguered city, with a finned bomb hanging from it. The kite is the first known illustration of a type which grew increasingly familiar in Europe during the fourteenth and fifteenth centuries. It has a large, rigid, plane-surface head made of parchment, and a long, flexible cloth tail. Detailed instructions about how to build and fly one are found in a manuscript in Vienna, dated about 1430. Whether such kites were ever built large enough to carry a bomb in battle is perhaps doubtful but, if so, three knights (as shown in the illustration) could well have been needed to control them.

The earliest printed illustration of a kite of the familiar diamond type (imported from the East Indies) appears in a Dutch book of 1618.

The first illustration of a helicopter toy appeared in the first quarter of the fourteenth century – say *c.* 1320–30 in a Flemish psalter now at Copenhagen (see figure on page 7), with its four-bladed rotor derived from windmill sails: this type of little model, of which the most sophisticated of the early examples is that at Le Mans came to be called by the French, ‘moulinet à noix’ (‘noix’ referring to the pulley-wheel of a spindle): it is the earliest form of the active airscrew, and the direct ancestor of every helicopter flying today. The simpler toy, with an ‘air-screw’ solely rotated by the wind, was called a ‘moulinet à vent’ (see Figure 2.3), and possibly dates back as early as the helicopter toy. Both were probably invented in the twelfth century, soon after the introduction of the classic tower type of windmill in Europe. Apart from the kite and the doll, these toys must have the longest continuous history of any plaything in history.

Then, about 1420, we find in the well-known manuscript of the engineer Giovanni da Fontana, in the Staatsbibliothek at Munich (Cod. iconogr. 242) an illustration of the first rocket ‘aeroplane’; it is a model bird with outstretched wings, and the efflux emerging from the tail (Figure 2.4): hereafter winged rockets appear at intervals.



Figure 2.3 Early representation of a simple airscrew toy (‘moulinet à vent’): *c.* 1485.

The early history of the rocket is still somewhat unclear, although it is generally believed that it originated in China and reached Europe via the Mongols and Arabs. (See Chapter 2 of *History of Rocketry and Space Travel*, W von Braun and Frederick I Ordway, 1966.)

It is impossible to judge what it was that Regiomontanus (Johann Müller) made between about 1460–75; but it was described alternatively as an artificial eagle or as an ‘iron fly’; it was probably a small model of some kind, and might easily have been a glider-model built by trial and error. There were probably a number of such models made through the years which remain unrecorded.

In 1496, an old cantor of Nuremberg broke an arm in trying to fly.

In 1498 – after some previous attempts – the Italian mathematician, G B Danti, who had attached wings to his arms, was seriously injured when he made a tower jump at Perugia. A few years later, in 1507, the Italian ‘emigrant’ John Damian, Abbot of Tunland, tried to fly with wings from the walls of Stirling Castle in Scotland; the record states that he ‘fell to the ground and brak his thee bane’, at which we would count him lucky.

Now – in the midst of the Italian Renaissance – there had just arisen the greatest all-round genius of history, to whom flying was a major obsession.

Leonardo da Vinci (1452–1519) provides an absorbing chapter in aeronautical history. He was the first man of high scientific attainments to investigate the problems of flight, and although a few of his aeronautical notes and drawings may have been lost, the bulk seem to have survived and it is fairly clear where his ambitions and achievements lay. Most of his work dealt with flapping-wing aircraft (ornithopters), based on bird and bat flight; and his concern with the human imitation of birds amounted to ‘the most obsessing, most tyrannical of his dreams’, in the words of one biographer. As a result of his emotional, rather than rational, approach to flying he did not on the whole subject it to the disciplined scrutiny he applied to other of his scientific activities. Perhaps it was the symbolic urge to escape and to conquer the air which led him to cling so tenaciously to the ornithopter idea, and neglect the idea of the fixed wing glider in all but a few of his later drawings. His obsession with the ornithopter was peculiarly fruitless owing to two factors: (a) his belief that the wings of such an aircraft ‘have to row downwards and backwards ... write of swimming in the water (he says) and you will have the flight of the bird through the air’; and (b) that human muscles could properly power a machine. A bird cannot beat its wings backwards. The tradition that Leonardo launched a full-size ornithopter is without foundation, because any flight test based on downward and backward wing movements would have immediately wrecked the machine, with serious results for its pilot. As for human muscle as a power plant, Leonardo – if he had not been subject to his overpowering ornithopter obsession – could easily have arrived at the conclusion that a man’s muscles could never have propelled even the lightest of his suggested machines, let alone the huge and cumbersome contraptions his fancy

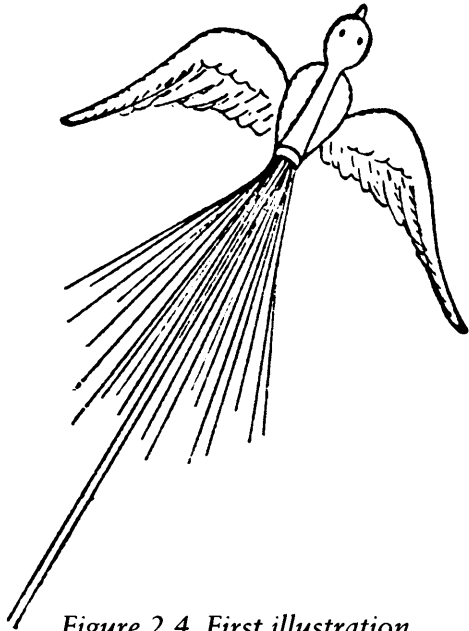


Figure 2.4 First illustration in history (by Fontana) of a rocket-propelled ‘aeroplane’ (i.e. a model bird): c. 1420.

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ultimately drove him to; only today, with the ultra-light materials now available, has it become possible to make the briefest of man-powered flights. Leonardo designed various prone-position types of ornithopter and a standing-position type, most of them to be powered by combined arm and leg movements via machinery of fascinating but misplaced ingenuity. But there were times when his acute mind seems to have tired of its emotional tyrant, and he has left sketches of two aircraft types which show a completely different approach. One is an ornithopter powered by a bow-string mechanism (to be rewound by the pilot when in flight); the other has the outer wing-panels flapping down at a greater angle than the inner – a device which under modern conditions, and with the knowledge of how a bird is propelled, might be successful. Leonardo also designed some prophetic aeronautical instruments and devices,² including a flap-valve system of wing construction for ornithopters, a head-harness working an elevator (which anticipated Lilienthal's body harness), a retractable undercarriage, and various finned projectiles. Until the discovery of medieval helicopter models, the helicopter was thought to have been the invention of Leonardo, whose machine was a helical screw operated probably by clockwork. But he did invent the parachute – in the form of a pyramidal tent – with a pole from the apex to the jointure of the shroud lines (Figure 2.5). Both Leonardo's helicopter and parachute were recorded as almost thumbnail sketches, and unfortunately he did not return to them. There was then a device, of which Leonardo may have been the inventor, for turning a roasting spit, which consisted of a properly bladed propeller on a shaft, rotated by hot air rising from the fire. If he had envisaged the blades being turned by a prime mover and displacing air, instead of the air turning the blades, he would have pioneered the proper airscrew. Leonardo also made studies of the air and its forces, which included investigations concerning the centres of gravity and pressure; and he understood the principles of streamlining, but only seems to have applied them to bodies moving in water. Curiously enough, it was after the main force of his ideas on the ornithopter were spent that he wrote his remarkable book on bird flight, *Sul Volo degli Uccelli* (1505), without, however, solving the problem of bird propulsion. Finally, late in life, he made some thumbnail sketches of a man clinging to a flat board which is seen in gliding descent like a falling leaf, a concept which might have led to vital changes in his outlook and to a mature concept of the glider. It is such glimpses of his mind working unhampered on the problems of flight that cause posterity to regret that he did not concentrate on the fixed-wing glider, a type of aircraft of which he might well have been the pioneer (Figure 2.6).

Leonardo's remarkable work in aeronautics deserved to play a major role in the centuries of experimentation that followed; but owing to the culpable stupidity of his executor Francesco Melzi, it had no direct influence on the history of flying, and was not even known to the world until the last quarter of the nineteenth century, more than 100 years after the rediscovery of the parachute and the

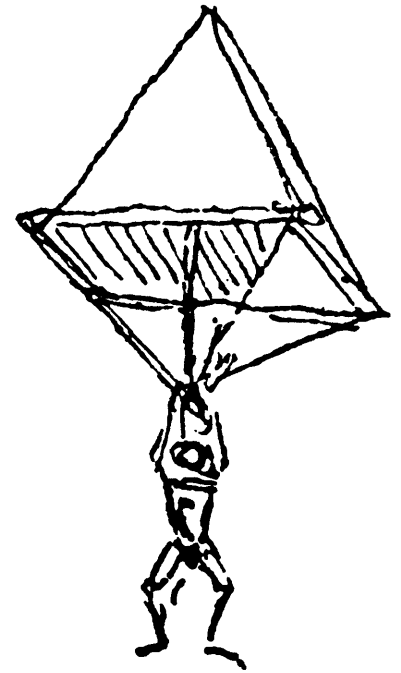
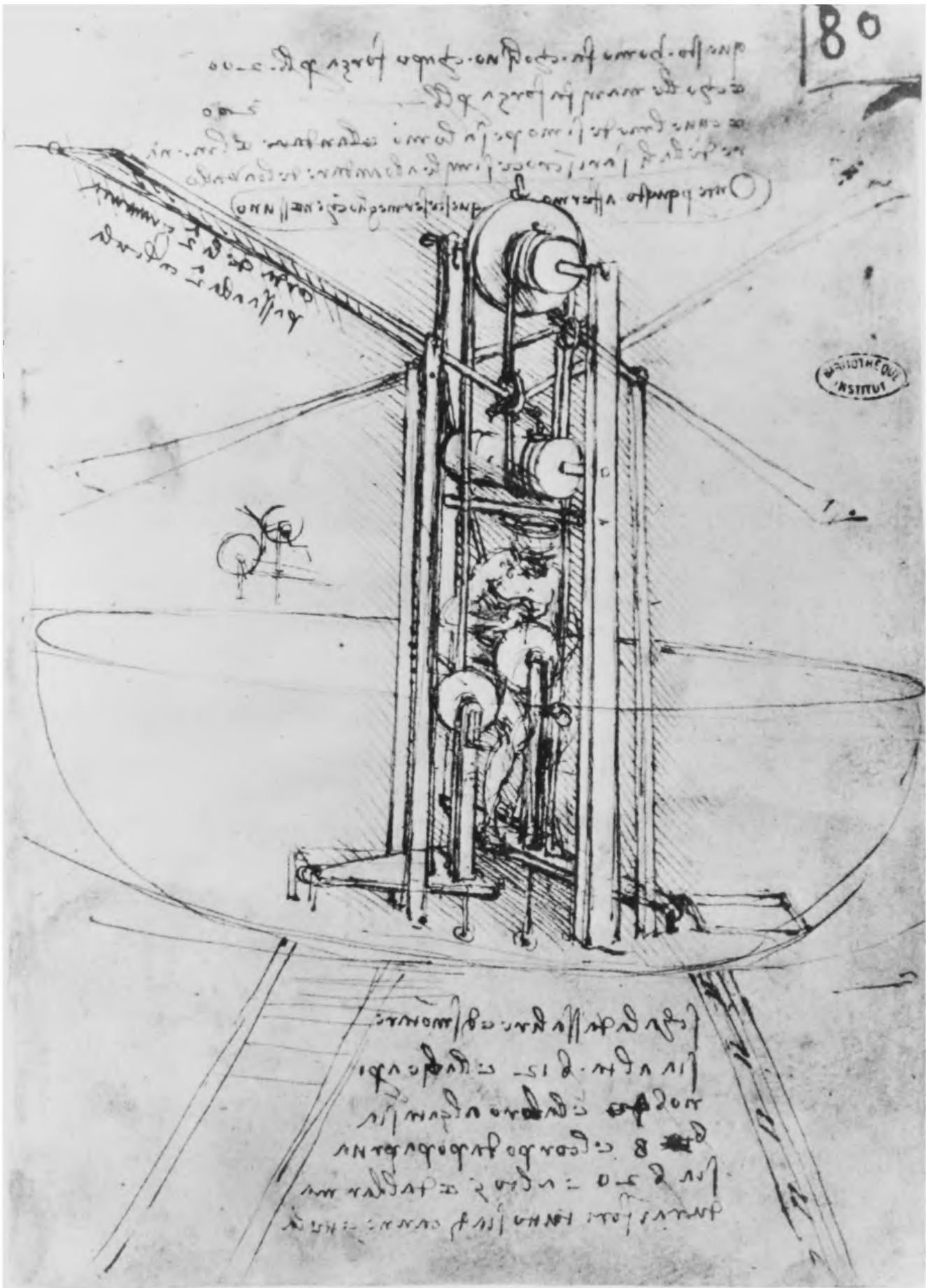


Figure 2.5 First design for a parachute, by Leonardo da Vinci: c. 1485.

Figure 2.6 Standing-type ornithopter, designed by Leonardo da Vinci: c. 1485–1500. (Science & Society Picture Library)



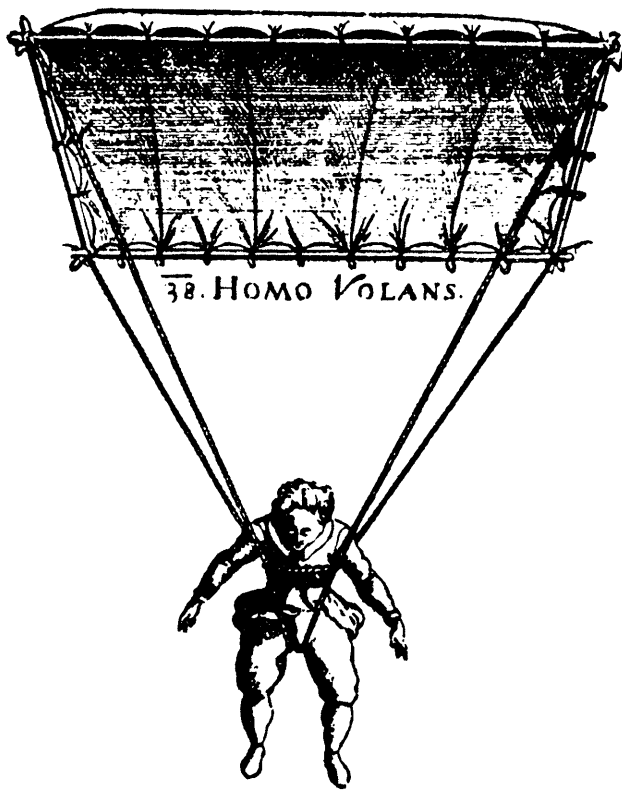


Figure 2.7 Design for a sail-derived parachute by Veranzio: c. 1595.

helicopter, and when aerodynamics was already an advanced study. If his researches had been published sooner – as he wished them to be – his achievements and mistakes would have spurred on others to experiment, correct, and develop, and his genius would have provided a powerful inspiration throughout the centuries.

With the death of Leonardo in 1519 there follows nearly a century's pause in serious aeronautical thinking.

In 1536 an Italian clock-maker, Bolori, was killed when attempting to fly from the Cathedral of Troyes in France.

About the year 1595 there was published in Venice a work entitled *Machinae novae* by Fausto Veranzio, in which he described and illustrated a 'homo volans', which provided the first published illustration of a parachute in history (Figure 2.7): unlike Leonardo's device, Veranzio's was clearly derived from a ship's sail, and it is interesting to note that the most obvious ancestors of the parachute – the sunshade or umbrella – took no part in either of the first two parachute designs to appear in the west, although they were directly to inspire the first viable parachutes which were to appear in the eighteenth century.

Notes

- 1 Owing to a mis-reading of the manuscript, Eilmer appears in earlier histories as Oliver of Malmesbury. Similarly, 'Abbas b. Firnas appears as Armen Firman in earlier books.
- 2 Tradition also credits Leonardo with the invention of the hot-air balloon, but this is not true. See my *Leonardo da Vinci's Aeronautics*.

3 The seventeenth century

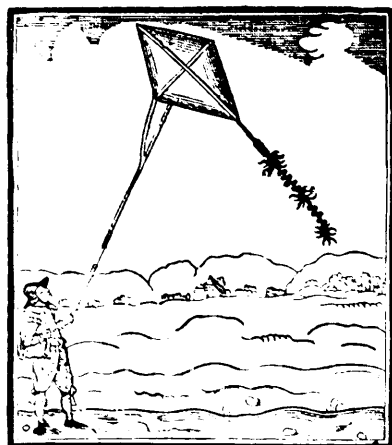


Figure 3.1 European plane-surface kite, from Bate's *Mysteries of Nature and Art*: 1634.

Before describing the chief contributors to aeronautics during this century, there is a small but important item to note in 1618, when there occurs the first illustration – in a Dutch engraving – of what we have come to think of as a standard type of diamond-shaped kite, complete with tail.¹

This enlightened century produced some interesting figures in the world of 'flying'. In 1638 two books were published in England, both works on the moon, by Francis Godwin, Bishop of Hereford (1562–1633), and by another bishop, John Wilkins, Bishop of Chester (1614–72), a founder member of the Royal Society. Godwin's book, published posthumously in 1638, was *Man in the Moone*, and told the story of the hero Gonsales who trained wild swans – tied to a framework – to transport him to the moon. Wilkins' work, *Discovery of a New World*, first published anonymously in 1638, was a speculation on the moon being inhabited. This was followed in 1640 by his *Discourse concerning Flying*, and in 1648 by *Mathematical Magick*: the former dealt with aerostation and the latter with various means of flying, i.e. with the spirits of angels, with the help of fowls, with wings fastened to the body, and with a flying chariot. These were the speculations of a shrewd man, but were not significant in history.

One of the few records of an actual model aircraft being built, concerns Tito Livio Burattini (born in Agordo, 1617), who settled in Poland about 1644. In 1647 he is said to have made working models of a flying machine, with four pairs of wings in tandem (the two middle pairs for lifting, the bow pair for propulsion, and the stern pair for propulsion and lift) with a tail unit for control: this is said to have been worked by springs, and to have raised a cat. Burattini is said also to have made a full-size version of this machine in 1648, but the account is probably untrue.

The most interesting figure in the seventeenth century, aeronautically speaking, was the great English scientist Robert Hooke (1635–1703) who, independently of Borelli, came to the conclusion that human muscles are not strong enough to provide the power for flying, and that an engine was essential. He appears to have made an ornithopter model operated by some spring device in 1655 which, as he said 'rais'd and sustain'd itself in the Air': this form of words probably, at the time, referred to travel through the air, and not helicopter flight. He then appears to have worked out designs for a man carrier. This is by far the most tantalising of 'cases', and one wonders if some sketch – as yet unrecognised – may not survive among his papers.

The German mechanic Johann Hautsch of Nuremburg, who is known mainly for his manumotive road carriage and his contribution to fire-fighting machinery, is also credited with building a flying carriage about 1660, but no details of this device are known. In 1673,

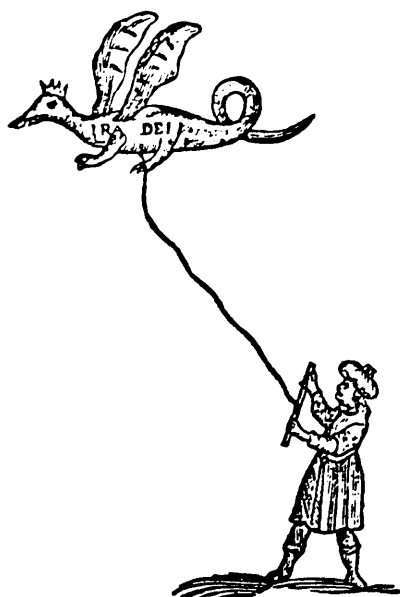


Figure 3.2 European winged dragon-form kite: 1665.

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one Charles Bernouin, a surgeon from Grenoble, is said to have flown from a tower at Regensburg in Germany using sail-like wings and rocket assistance, but to have then broken his neck flying at Frankfurt-on-Main.

Reports of attempted flights by tower jumpers occur quite regularly during the century. Among the less successful were the Italian painter Guidotti who fell through a roof at Lucca around 1600, and the anonymous Russian peasant who was severely beaten for failing to fly in 1680. On the other hand, Ahmed Hezârfen is celebrated in Turkey for a claimed flight of several kilometres to a successful landing in the marketplace at Scutari around the mid-century.

A small item of light relief occurs during this period in the Marquess of Worcester's *Century of Inventions* (1663) where, under invention number 77, one reads: 'How to make a man fly; which I have tried with a little Boy of ten years old in a Barn, from one end to the other, on a Haymow'.

Among the most constantly reproduced pictures in aviation history is that of the French locksmith Besnier (Figure 3.3), who attempted to fly at Sablé in 1678 with an apparatus working on a similar principle to that of the waterbird's webbed feet. He is said to have made many careful experiments, and finally soared over a house and landed safely; this probably means he descended from the roof of the house. The apparatus he used must clearly have been more sophisticated and many times larger than that shown, which is a concept similar to that of the flap valve. It would just be possible for a man to make a floundering glide without coming to grief, if the 'machine' parachuted him down, which would seem to be the explanation of those survivals and maimings with which fortune favoured a few.

In this connection it should be recorded that Francis Willughby, who died in 1672, unwittingly helped to perpetuate the idea of the man-powered ornithopter when, in his posthumously published *Ornithologiae libri tres* (1676), he said that it was a man's legs which

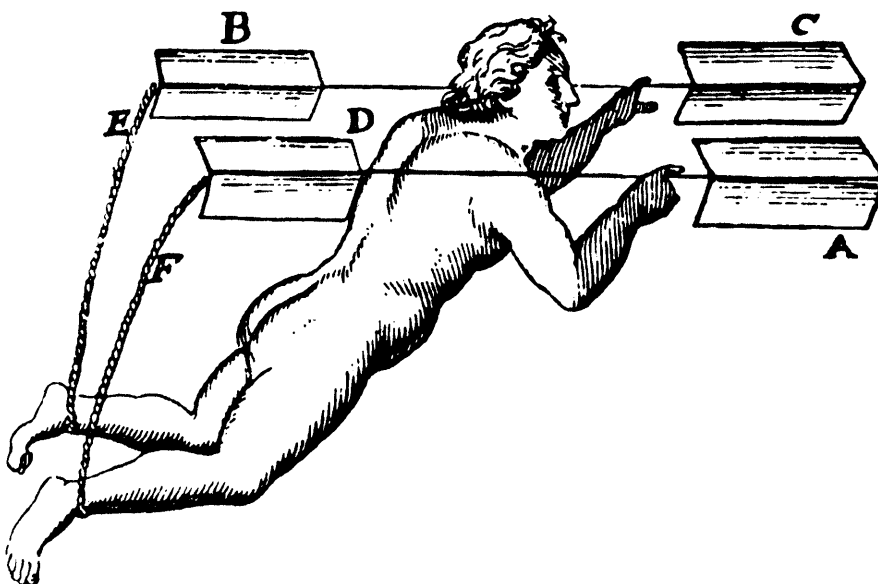


Figure 3.3 Fanciful representation of Besnier attempting to fly at Sablé: 1678.

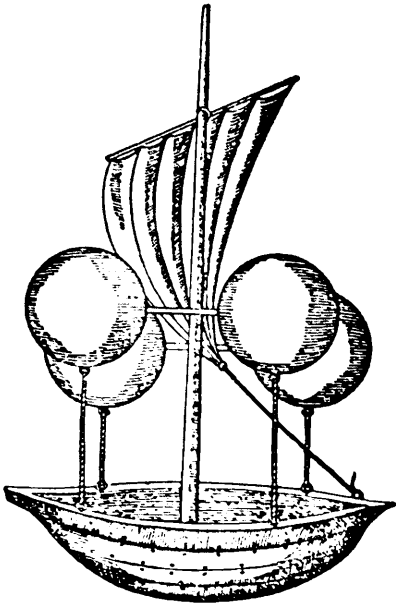


Figure 3.4 Design for an aerial ship, by de Lana: 1670.

were comparable in strength to a bird's wings, and not his arms; therefore the human makers of wings must harness leg power to them.

The man who did most to discourage the 'tower jumpers', and other experimenters with man-powered wings, was Giovanni Alphonso Borelli (1606–79), professor of mathematics at Messina, and later at Pisa. His *De motu animalium* was published posthumously at Rome in 1680, and became a major milestone in history; for in this work, Borelli proved that the musculature for a man – as compared with a bird – was inadequate for lifting himself and his apparatus, and flying. Today, with the ultra-light materials available, and the advanced knowledge of aerodynamics, man-powered flight is just physically possible; but up to a few years ago, it certainly was not; and Borelli's cold water on such schemes was badly needed. 'It is impossible', he wrote, 'that men should be able to fly craftily, by their own strength.'

In 1657–59, a Jesuit named Gaspar Schott published his *Magia universalis naturae et artis*, in which he went over the ground of speculation on aerostation, but did not contribute anything to ideas on aviation. Much more important was another book concerned with aerostation by the Jesuit Father Francesco de Lana de Terzi published in Brescia in 1670. This work – *Prodromo overo saggio* (etc.) – contained de Lana's design for, and description of, his aerial ship; this consisted of a vessel supported by four copper spheres which were to be emptied of all air, and hence rise: but de Lana did not appreciate that these spheres would be collapsed by atmospheric pressure (Figure 3.4). His descriptions of aerial bombing, and airborne invasion, by his ship, are among the classic anticipations of modern warfare.

In 1650 there had appeared the first edition of Cyrano de Bergerac's *Histoire comique, on Voyage dans la Lune*, with the first English translation appearing in 1659: Cyrano is of interest in that his fantasy methods of travel to the moon were ingeniously conceived. One of these methods was to strap round himself bottles of dew, which the sun would soak up, and take him up too: another was an inadvertent voyage in his aerial car after soldiers had fixed fireworks – presumably rockets – to it, and sent it up into space.

Notes

- 1 The first to be found in Britain is in *Bate's Mysteries of Nature and Art* (1635), shown in Figure 3.1. The fully-developed winged wind-sock type of dragon-kite is shown in Figure 3.2, which was published as late as 1665.

4 The eighteenth century

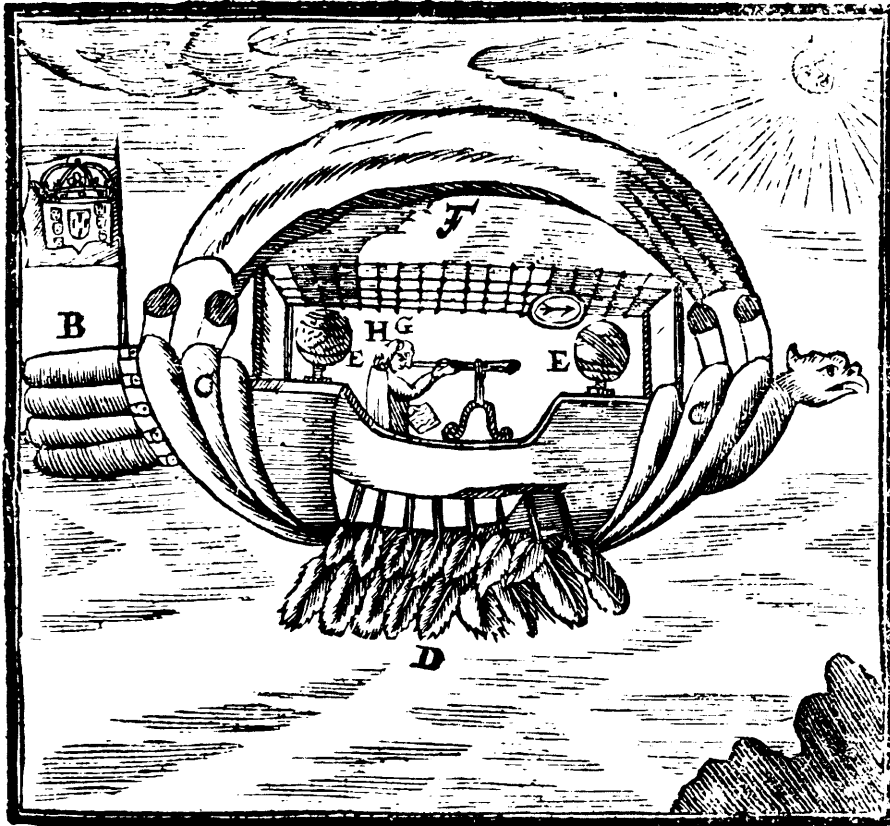


Figure 4.1 The well-known and much-ridiculed illustration of Gusmão's Passarola: 1709.

In the year 1709 there occurred a somewhat mysterious event. One of the best known of aeronautical engravings shows an apparently ridiculous contraption called the *Passarola* (Great Bird), which until recently has been treated as pure fantasy. But the evidence now suggests that some well-meaning artist drew from hearsay an actual aircraft – a small model glider in the form of a bird. It was made by a Brazilian, Father Laurenço de Gusmão (1686–1724) and launched at Lisbon, perhaps achieving a tentative flight (Figures 4.1 and 4.2). He seems first to have constructed an inevitably earthbound full-size aircraft, and then made the model to rescue his reputation: its most interesting feature was an upper hood, or ‘parachute’ cover, a device to give more lift, which rested on a frame when the machine was not flying, and would immediately have the wind catch it from the underneath when flight commenced. A similar device was to be

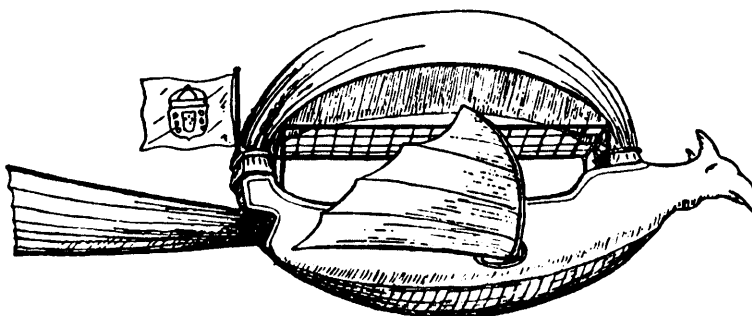


Figure 4.2 Reconstruction by the present writer of how the Passarola probably appeared.

employed by Trouvé in 1870. Gusmão also seems certain to have achieved a primitive model hot-air balloon.

In northern Europe, the Swedish mystic Emmanuel Swedenborg somewhat surprisingly suggested an aeroplane design in 1714 (it was published in *Daedalus Hyperboreas* in 1716), which consisted of a car fixed below a huge wing-canopy, which could be reefed like a sail, and propelled by flappers made on the duck's webbed-foot principle, and worked by 'a spiral spring'. There was to be a pendulum device projecting below the craft to give it automatic stability, and a sort of beetle-like shield above the wings, for no very good reason. Coming from a man of such eminence, this idea is interesting, but is – except for the pendulum stability – without much merit historically.

Despite the teachings of Borelli, the 'tower jumpers' still flourished, and perhaps the most famous of them all was the Marquis de Bacquerville, who attempted, about 1742, to fly the River Seine in Paris, with wings fixed to his arms and legs: he seems to have taken off from a riverside house and to have floundered down on to a washerwoman's barge, breaking his legs. The 'paddles' shown in the illustration are clearly some simplification, and are on far too small a scale, of the equipment used for this foolhardy but brave attempt at flight. The belief that a certain John Childs tried to fly in England, and then from a tower at Boston (USA) in 1757, is now known to be untrue, and was based on a misinterpretation of early records.

The kite first came into its own as a vehicle for scientific research – a role it was thereafter to fulfil for more than 150 years – in the year 1749 when the Professor of Astronomy at Glasgow University, Alexander Wilson, measured the temperature of clouds at about 3000 feet by means of a thermometer attached to a train of four or five paper kites; Wilson also seems to have antedated both Franklin and Jacques de Romas in the utilisation of kites for the study of atmospheric electricity. It was in 1752 that Benjamin Franklin made his celebrated experiment with a kite in a thunderstorm, in which he was nearly killed by the current.

The model helicopter – in use certainly since the fourteenth century as a toy – has recently been claimed by the Russian authorities to have been revived in 1754 with a twin contra-rotating rotor model operated by clockwork, made by the well-known scientist Michael Vasilyevitch Lomonosov, which is said to have flown successfully: but we have no documents. In 1768 the French mathematician, A J P Paucton, in his *Théorie de la Vis Archimède*, suggested a man-carrying and man-powered helicopter with two helical screws (*ptérophores*), one to sustain it and the other to propel it: it was never built. But, oddly enough, this must rank as the first specific suggestion for horizontal aerial propulsion by an airscrew.

There was discovered in 1921 in the Staatsarchiv of Thuringia, at Greiz, a collection of remarkable diagrams, giving the detailed design for an aeroplane, by Melchior Bauer, and drawn in 1764: it was to consist of a four-wheeled car for the pilot, fixed by struts to a large braced and dihedrally set low-aspect-ratio wing above it, and

Figure 4.5 Engraving of Jean-Pierre Blanchard by J Newton, after an original work by R Livesay of Blanchard: 1785. (Science & Society Picture Library)



flapping – which, in the absence of any tail or other auxiliary surfaces, would have been only tentative in the extreme, but highly creditable. Meerwein lay prone beneath the wings of his machine, and could bring about some up-and-down movements of the wings by means of a mechanism which was only briefly specified.

Jean-Pierre Blanchard (Figure 4.5) was to become of great importance in aerostation, but his first appearance in 1781 was as builder of an amphibious ‘vaisseau volant’, which looked like a huge tented houseboat, and was equipped with large manually operated flappers on rods, and a huge rear rudder: needless to say, it stayed firmly on the ground in 1782 (and later) when it was tested. In the same year Blanchard made a creditable full-size manually operated helicopter, which although ingenious, also remained earthbound.

The works of aerial fiction and satire which appeared in the eighteenth century were widely read, and they too played their part in encouraging airmindedness. Joseph Addison wrote of flying in the *Guardian* (1713), Swift in *Gulliver’s Travels* (1726), Samuel Brunt in *A Voyage to Cacklogallinia* (1727), R O Cambridge in *Scribleriad*

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(1751), Robert Paltock in *The Life and Adventures of Peter Wilkins* (1751), Ralph Morris in *The Adventures of John Daniel* (1751), Doctor Johnson in *The Rambler* (1752) and *Rasselas* (1759), *La Follie in Le Philosophe sans Préention* (1775), Hildebrand Bowman in *Travels* (1778), and Restif de la Bretonne in *La Découverte Australe* (1781). These and many others dealt with a variety of flying men, women, and machines, providing excellent reading and sometimes shrewd prophecy. Of particular interest was Restif's work, whose illustrations show winged men with what seem like parachutes above their heads, which are in fact auxiliary wings, which could be opened and closed at will; and the winged males and females (Glums and Gawries) whose expert flying is described by Paltock (Figure 4.6).

The invention of the practical balloon in 1783 was to have a profound effect on aviation, both as direct incentive and rival method of aerial navigation, and as a testing ground for various aeronautical devices such as the propeller and the parachute. Balloon flying also led to the consideration and application of aero engines to transform the



Figure 4.6 Flying Gawry, from Paltock's *Peter Wilkins*: 1751.

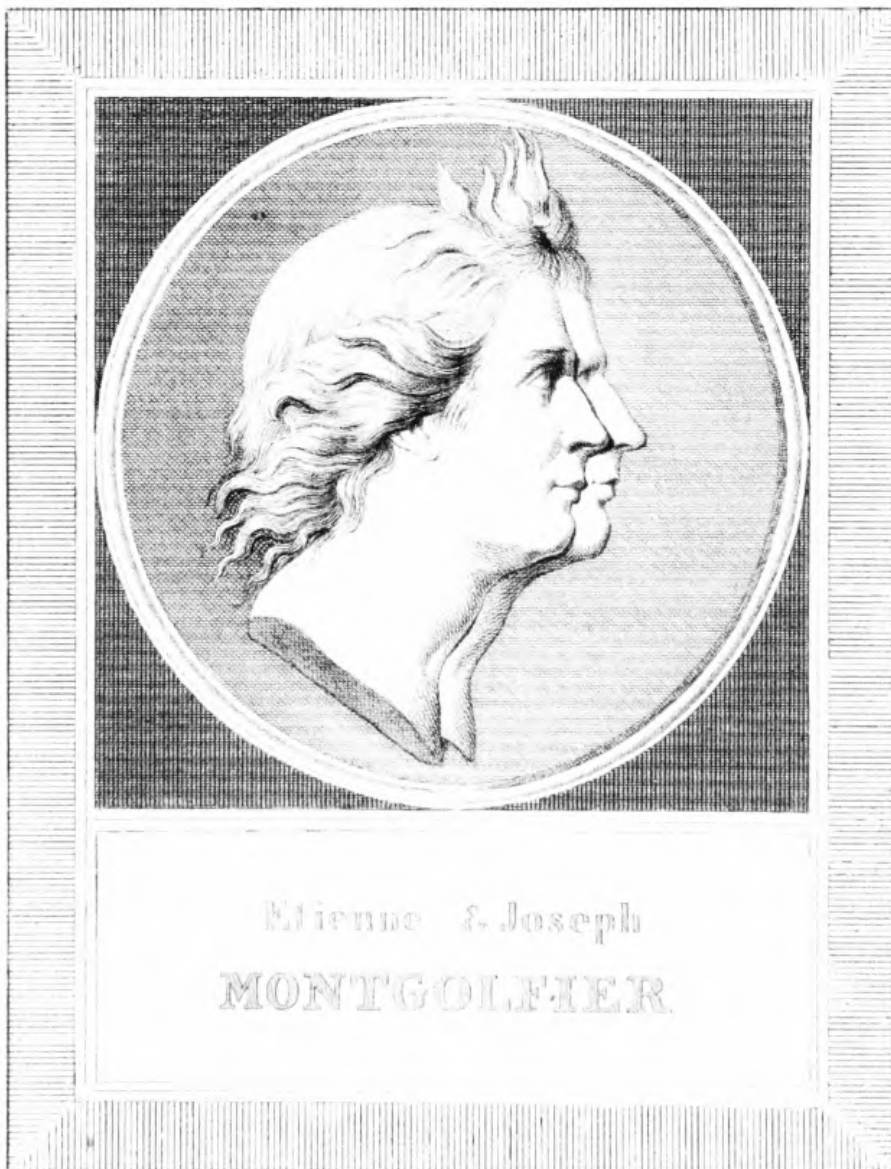


Figure 4.7 Jacques-Etienne and Joseph-Michel Montgolfier. Engraving by Robert Delaunay taken from a bas-relief by Jean Antoine Houdon in 1783. (Science & Society Picture Library)

Figure 4.8 An ascent by a Montgolfier balloon carrying a sheep, a duck and a cock at the Palace of Versailles in September 1783, depicted in an engraved plate by John Lodge for the European Magazine: 1783. (Science & Society Picture Library)



‘sphericals’ of different kinds into dirigibles; and to the building up of a wide-ranging personnel accustomed to travelling through the air.

In 1766, Henry Cavendish isolated hydrogen for the first time; described it as an element; and produced it in a sizeable quantity. He was followed by Joseph Black and Tiberius Cavallo (in England) who respectively suggested and carried out experiments to show the lifting power of hydrogen, the latter with hydrogen-filled soap bubbles. Then, working along totally different lines, the brothers Étienne and Joseph Montgolfier (Figures 4.7 and 4.8), paper-makers of Annonay, near Lyons, hit on the lifting power of hot air, without knowing why it lifted, and – after private experiments – made the

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(Compiled by Brian Riddle, Librarian of the Royal Aeronautical Society, September 2003)

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