The Mississippi is one of the largest rivers in the world. It penetrates the heart of the most fertile portion of the United States for a distance of 2550 miles, and has 15,000 miles of navigable tributaries. Its headwaters rise amidst the pine-clad hills of northern Minnesota, where the long winters reach almost a polar cold, and winds its way through the varying conditions of climate of ten great States to the semi-tropical lowlands of southern Louisiana, finally losing itself in the Gulf of Mexico. Its drainage area, of over 1¼ million square miles, covers nearly half of the United States, and is equal to the whole of Europe exclusive of Russia. The region which it drains has no equal in any part of the world for fertility of soil and natural resources, such as vegetable products, timber, coal and minerals of various kinds. On its surface are borne immense cargoes of grain, coal and lumber gathered from the resources of a vast district and despatched across seas to all parts of the world. In its upper reaches it affords power to innumerable saw-mills and flour-mills and manufacturing industries.

The source of this great river has long been the subject of controversy. The earliest white explorers who first visited the country where the Mississippi rises were the French fur traders, but the earliest authentic account of the exploration of its source is that of William Morrison, who visited the district in 1804. The next explorer who recorded the results of his survey was R. H. Schoolcraft, in 1832, who located the headwaters in Lake Itasca. In 1872 the *New York Herald* sent a representative to visit the source of the river, with instructions to navigate the stream thence to the Gulf of Mexico. Again, in 1879, the *Louisville Courier Journal* sent an expedition to Itasca Lake. It was not, however, until 1889 that the first thorough exploration of the basin was made under the direction of the Minnesota Historical Society.

The State of Minnesota has set aside a reservation of 35 square miles, covering the basin of Lake Itasca, thus preserving for ever sacred the source of the father of rivers in the "Itasca State Park."

Unlike the origin of most large rivers which commence as mountain torrents, the Mississippi leaves its source with a width of 30 feet and a depth of 5 feet, and starts on its journey at an altitude of 1560 feet above sea-level. Commercial navigation reaches to within 25 miles of the lake, and thousands of sawn logs are floated down the stream every summer. At about 60 miles from the source the Government have constructed reservoirs, capable of holding 93,746 million cubic feet of water, for the purpose of regulating the supply of water to the channel and maintaining a navigable depth in summer. Near St. Anthony, about 500 miles from the source, are rapids which have been made use of obtaining water-power for working saw and flour mills and other manufacturing industries. Steamboat navigation commences near the junction of the Minnesota river, where the river has fallen 870 feet, 548 miles from the source.

A little above the junction with the Ohio, about 1400 miles down, the water becomes heavily charged with sediment and the country is subject to be flooded. The extreme range between high and low water at St. Louis is 37 feet. The slope of the water here falls six inches in a mile. Sand bars are numerous, and although the discharge amounts to 35,000 cubic feet a second in dry seasons there is not frequently more than four feet over the bars. Works are being carried out along this length for regulating the width of the channel and dredging away the bars so as to secure a better navigable depth. Where the banks are subject to excessive erosion they are protected by mattresses of woven willows, and the banks graded by hydraulic action. A description and illustration of this work was given in NATURE of December 19, 1896. Along this reach the river is exceedingly crooked. Between Arkansas and Greenville the distance along the river is 40 miles, the air line being only 15 miles. It also has great width, the banks, which are from 30 to 40 feet high, being in places two miles apart. The maintenance of these "levées" or banks is of vital importance to the surrounding country, as a breach would result in the inundation of 50,000 square miles of rich alluvial land.

One of the greatest difficulties which the management and the navigation has to contend with is the immense amount of drift-wood carried down in floods. This wood, if not cleared away, gets caught in the bends and accumulates, forming with the alluvial matter an effective barrier to the flow of the water and a source of danger to the banks. For the removal of this drift-wood special vessels, called snag-boats, are employed, which patrol the river and remove the snags.

Dredgers of large type, and provided with very powerful machinery, are in constant employment for removing sand bars and shoals. The type now almost universally in use for this purpose are worked by centrifugal pumps, which raise the sand and in some cases deliver it over the banks. Where the material is hard, cutters are provided at the end of the suction pipes of the pumps, which loosen the clay or hard material sufficiently to allow of its being sucked into the pipes. One of the most recent of these machines is capable of raising more than 4000 cubic yards of material an hour, and is fitted with electric light, machine shops, and all appliances necessary to repair the machinery and keep it in going order.

For the lower part of its course the river winds its way through a vast delta, twisting and turning by numerous bends until it extends its length to nearly double the point to point length of the delta. This delta is 500 miles long, and from 30 to 40 miles in width, covering an area of 400,000 square miles. It is composed of material transported by the current and deposited in the estuary, which at one time extended from the original outfall to the Gulf of Mexico. The river is still pouring solid matter into the Gulf, where it is spread out in a fan-like shape over a coast-line of 150 miles and is filling it up at the rate of 362 million tons a year. Some idea of the vastness of the silent operations of nature may be conceived when the fact is considered that this solid matter consists of the wearing away of the land through which the river flows, and that some of it must have been transported a distance of over 3000 miles; and that if the whole of it had to be carried in boats for half the total distance at the lowest rate at which heavy material is carried on the inland waterways of America, or, say, for one-tenth of a penny per ton per mile, the annual cost of transport would amount to no less a sum than 238 millions of pounds.

The channel in the lower reach is narrow, not exceeding half an mile in width, the depth in places exceeding 200 feet, and everywhere sufficient to float large sea-going craft as far as the junction of the Red river, a distance of more than 300 miles.

On this length is situated the city of New Orleans, 110 miles above the Gulf of Mexico. Ships of all nations reach this port. Its wharves extend over fifteen miles of river front, and are crowded with vessels of every description. Grain and cotton form the chief item of export.

As the river approaches the Gulf it is split up into three principal channels. The smaller of these has been improved by training walls made of mattresses and stone, which extend over the bar out into the deep water of the Gulf for more than two miles. This work was undertaken by Captain Eads, under contract with the Government to provide, for a certain sum of money, a depth of twenty-six feet at low water and to keep and maintain this depth for a period which has now expired.

The description of this mighty river above given will surely warrant its being called the "Father of Waters."

W. H. WHEELER.

HISTORY AND PROGRESS OF AERIAL LOCOMOTION.[1]

WHILE history contains no records of any past age in which men rode bicycles, the question of aërial locomotion has occupied the thoughts of man from the days of the Egyptians, to whom we are indebted for a representation of a man with wings considerably resembling the gliding machine on which Mr. Pilcher lost his life. Passing by the legend of Daedalus, whose invention of sailing ships led to the tradition that he attached wings to himself, we find in history numerous records, some such as that of Dante of Perugia or the chronicle of Busbequius, referring to gliding experiments which may not improbably have been authentic, others describing machines by which men have tried to raise themselves by their own exertions, but without success, as exemplified by Besnier, the Marquis de Bacqueville, Jacob Deghen, while a far larger number have been handed down to us of designs of fantastic machines for navigating the air, of a purely visionary character. In the latter category we must include in past times the grotesque figures

[1] Abstract of a Discourse delivered at the Royal Institution on Friday, February 8, by Prof. G. H. Bryan, F.R.S.

designed by Barthelemy Lourenco in Portugal, by the novelist Retif de la Bretonne, by Blanchard, before he became noted as a balloonist, and the prospectus of the Minerva issued by one Robertson when interest in ballooning was at its height. Even in recent times equally absurd devices have been promulgated, such as aërial tramcars supported by cigar-shaped gas vessels, not one-hundredth of the size necessary to raise such loads, and seats in such aërial tramcars with cavities filled with gas whose actual lifting power would amount to a few milligrams, and others.

The problem of aërial navigation, *i.e.* of performing *directed* journeys in the air, made no progress until Montgolfier's invention of the balloon. This rendered it possible to ascend in the air, but did not enable the motion to be directed, and from that time on aëronauts became divided into two classes: those who sought to navigate the air with balloons that rendered their apparatus lighter than air, and those who experimented with machines heavier than air but supported on structures resembling wings.

Balloons have often proved invaluable in times of war, and the war in South Africa has been no exception, thanks partly to the exertions of Major Baden-Powell. But the most practically useful application of the balloon in times of peace was inaugurated by Glaisher's ascents into the upper regions of the atmosphere for the purpose of obtaining meteorological data, and it is only recently that the balloon has been superseded for this purpose by the kite now largely used in America.

The experiments of Count von Zeppelin last summer, amounting as they did to the performance of a directed journey through the air, in some cases against a head wind, enable us to say that a solution of this problem was obtained before the end of the nineteenth century. The only previous achievement approaching von Zeppelin's was that of Messrs. Renard and Krebs in 1885 with the French war balloon, "La France." These experimenters on one occasion actually succeeded in performing a journey in the air and returning to the starting point; but as the feat was never repeated and the speed of their balloon is stated by one writer at four and by another at fourteen miles an hour, it is somewhat difficult from such conflicting evidence to estimate the amount of success achieved. The speed attained by Count Zeppelin's balloon was about eight metres per second, say seventeen and a half miles an hour, and agreed very closely with that predicted by calculation, viz., 8·12 metres per second. With lighter and more powerful motors Count Zeppelin hopes to increase the speed by 50 per cent. The chief features of this machine are (1) its division into seventeen compartments, which prevents the gas from collecting at one end or oscillating in the balloon in such a way as to increase the resistance; (2) the distribution of the load at two points instead of at the centre, which reduces the mechanical difficulty of supporting a heavy weight by a cigar-shaped balloon.

The subject of dynamical flight without the aid of balloons opens up three fields of study:—(1) experiments on the air-resistance of planes and curved surfaces, systems of such aëroplanes and aërocurves variously arranged, and propellers; (2) the construction of motors of minimum weight per horse-power, using the sources of energy of minimum weight per foot-pound; (3) experiments on the balance, stability and control of aëroplanes and aërocurves. A historic retrospect of the work done in the past century includes Captain Le Bris's gliding experiments with his "artificial albatross" in 1854; De Villeneuve's reported feat of raising himself into the air, in 1870, by a machine driven by steam supplied from a flexible hose; the experiments on air resistance conducted in 1871; Langley's confirmation, in 1891, of Duchemin's formula for the thrust of an oblique current on a plane area, and his proof of the law according to which the horse-power per unit of weight lifted decreases with the speed; and Phillips's Wealdstone experiments on the advantages of narrow superposed planes over wide planes of equal area.

Coming to the question of horse-power, the chief interest in Sir Hiram Maxim's famous experiments centred round his engine, with which he obtained 362 horse-power, the machine weighing about 8000 lbs. Langley and Hargreave are stated to have designed motors weighing 7 and 10 lbs. per horse-power respectively; while Da Pra has made theoretical calculations in connection with designs of an aërial machine from which he concludes that such a machine could be made capable of carrying a motor weighing 15 kilograms per horse-power. A more experimental treatment of the question of horse-power is afforded by estimates of the rate at which work is done by gravity in the gliding experiments of Lilienthal, Pilcher and Chanute, from which it appears that about 2 horse-power would be required to support the machines. Mr. Chanute further estimates the possible weight of the motor per horse-power in a one-man machine at 4 lbs. for screws, 8 lbs. for wings, and 14 lbs. for aërocurves.

But the most difficult question connected with the flying machine is its balance and stability under the conditions ordinarily prevailing in our atmosphere. The very fluctuations of wind velocity which may furnish a source of energy for birds in sailing flight vastly increase the danger of experiments on artificial flight. It is easy to construct a glider which when dropped in a room from any position will right itself and begin to glide before reaching the ground; but the same glider when let fall from a window will continue to roll over and over and fall to the ground. More than thirty years ago Mr. Wenham made a model which would glide well from a window, but when let fall from a balloon in one of Glaisher's ascents it overturned after descending twelve yards.

Of the three, Lilienthal, Pilcher and Chanute, who have done most to solve this question of balance and stability, the two first met with fatal accidents just when their experiments were becoming most successful, and we are naturally led to compare their methods with those adopted by Mr. Chanute.

Both Lilienthal and Pilcher used machines with broad curved wings, the former preferring two superposed aërocurves and the latter adopting a single-surfaced machine. In both machines the wings were rigidly fixed, the operator relying on the movements of his body to counteract the effects of any sudden gust of wind tending to overturn the machine. Chanute, on the other hand, experimented with narrow superposed wings, some of his machines having as many as eleven or twelve aërocurves, arranged in pairs. Instead of balancing himself by his own agility, the wings were movable about pivots and were held in position by springs in such a way that their displacements, caused by a sudden gust of wind, gave the machine a tendency to right itself. Finally, a two-surfaced machine with narrow superposed rectangular surfaces, also with automatic balancing arrangements, was devised by Mr. Herring. With this machine, gliding was possible in winds of 31½ miles an hour, the greatest wind velocity in Lilienthal's experiments having been only 22 miles an hour, and little practice was required to control the machine. Practically no motions of the body were needed when a gust of wind struck the machine in a fore and aft direction, and but little movement was needed in the case of a side gust. The longest glide was 927 feet, and was performed by "quartering," *i.e.* sailing parallel to the side of a hill up which the wind was blowing.

The experiments of Messrs. Chanute and Herring constitute a distinct advance in the construction of gliding machines, and lead us nearer to the possibility of obtaining a true flying machine propelled by a motor. The addition of such a motor, if only by increasing the weight of the apparatus, would largely add to the difficulty of controlling it in the first trials, and the action of the propeller might considerably affect the balance. It is not improbable that after the first start is once made, the motor-driven machine may prove to possess greater steadiness in flight than the present gliders. In the former the thrust of the propeller is fixed relative to the body, in the latter the only motive force, due to gravity, is fixed in space, and Mr. Herring's experiments indicate greater stability under the first-named condition. How to perform the first experiments with the motor-driven machine is the difficulty which now awaits solution. If a large motor be used, the machine becomes too heavy to be readily controllable; if the dimensions of the machine are kept down it becomes the more difficult to construct a sufficiently light and powerful motor. The automatic regulating mechanism of Messrs. Chanute and Herring, by minimising the effort required in ordinary balancing, may render it possible for a man possessing the gymnastic skill of a Lilienthal or a Pilcher to overcome by his agility the new difficulties, introduced, at least in its early stages, by the motor. But in the transition from the gliding machine to the flying machine proper a wide gap has to be bridged, and it is little wonder that experimenters hesitate before taking a step which may introduce unforeseen dangers. It is by reducing the difficulty of balancing large machines, on the one hand, and reducing the weight of motors on the other, that we must hope to arrive at an experimental demonstration of the possibility of artificial flight.