Philosophical Magazine Series 1

ISSN: 1941-5796 (Print) 1941-580x (Online) Journal homepage: http://www.tandfonline.com/loi/tphm12

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To cite this article: Sir George Cayley Bart. (1816) XVII. On aërial navigation , Philosophical Magazine Series 1, 47:214, 81-86, DOI: 10.1080/14786441608638802

To link to this article: http://dx.doi.org/10.1080/14786441608638802

Published online: 27 Jul 2009.

XVII. *On Aërial Navigation.* By Sir George Cayley, *Bart.*

To Mr. Tilloch.

Sir,— I am glad to find that the public attention is called to aërial navigation by Mr. Evans, in your Magazine for November last. This subject is of great importance to mankind, and is worthy of more attention than is bestowed upon it. An uninterrupted navigable ocean, that comes to the threshold of every man's door, ought not to be neglected as a source of human gratification and advantage. Mr. Evans proposes the action of a large inclined plane suspended below a common balloon, as the means of making it take an oblique course in its ascent, and by means of the same plane to make the weight of the apparatus cause an oblique descent towards the same point of steerage. This principle is unquestionably capable of performing what that gentleman proposes, although the construction he has given is only adapted to effect the purpose in ascending, as the want of weight in the plane would prevent it from operating, excepting in a very limited degree, in the descent. In the small balloons used by Mr. Evans, the plane was, in fact, the whole burthen supported; and hence, under the small velocity generated, the descent was as oblique as the ascent. But in the balloon 80 feet in diameter described by that gentleman, the plane in ascending would receive, according to his estimate, above 2000 pounds of resistance from the air, and thus become efficient; whereas in descending it could only sustain a resistance equal to its weight, which of course will be as little as possible, and hence it will be nearly inefficient. The general principle, however, is perfectly true; and when applied advantageously, although it is an indirect way of gaining the proposed horizontal point, yet it will be as effectual as the process of tacking in ordinary navigation. Mr. Evans estimates that a Montgolfier balloon of 80 feet in diameter, with a plane suspended under it in an angle of 70° with a perpendicular line, the dimensions of which are as 1·4 to 1, compared with the great circle of the balloon, will be carried through the air by a power of ascent equal to 2792 pounds with a velocity of 28 feet per second, and hence that the travelling horizontal speed will be about 19 miles per hour.—If the resistance of air be taken at one pound per square foot at a velocity of 23 feet per second, which is two feet more than the common engineering estimate, the resistance of a globe to its great circle, according to Mr. Robins's experiments, as 1 to 2·27, and the resistance of the plane as the square

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of the sine of the angle of incidence,—it will require about 12450 pounds to produce this rate of conveyance in Mr. Evans's balloon; and hence the power he allows is not one-fourth part of what is required. This apparatus would, however, according to my calculation, travel with the speed of about 8¾ miles per hour*, which is quite sufficient to show the utility of the principle, whether the mistake be in Mr. Evans's figures or my own.

A few years ago I made many experiments upon the power of inclined planes, some of which exceeded 300 square feet in area: an account of these may be seen in Mr. Nicholson's Journal for November 1809, and February and March 1810. It may be affirmed with confidence from these experiments, that in obliquely descending the efficacy and steerage of the inclined plane have been completely ascertained. My object was to leave out the unwieldy bulk of balloons altogether, and to make use of the inclined plane propelled by a light first mover. Although my attention has hitherto been diverted from making further experiments, I am fully convinced that this mode of aërial navigation is practicable, and will, ere long, be accomplished. In the mean time I shall be glad to promote any promising experiments upon the steerage of balloons, and therefore offer the following observations through the medium of your Magazine.

In considering the means for obviating the relative resistance of balloons in passing swiftly through the air, the leading general principle is evidently to increase their dimensions far beyond the limits hitherto adopted. The weight of their superficial materials, and the resistance they meet with, being as the squares of their diameters; whereas their power of support being as the cubes of these diameters, it follows that their power may be made to bear any required proportion to their resistance. Thus a balloon of one yard in diameter meets with ten times more resistance, in proportion to its power, than a balloon of ten yards in diameter.

The next consideration is, that a globe is by no means the best shape for obviating resistance; a greater extension in the line of its path, with a corresponding diminution in the section perpendicular to it, may be adopted with great advantage. Keeping in view these two leading principles, the former of which places the proper scale of experiments beyond the expense that individuals choose to appropriate to such purposes, I propose that the following plan be adopted by those desirous of promoting this noble art:—First, that a subscription be entered into for

* An error in the paper of Mr. Evans was corrected in our number for December, making the velocity 10½ miles per hour.

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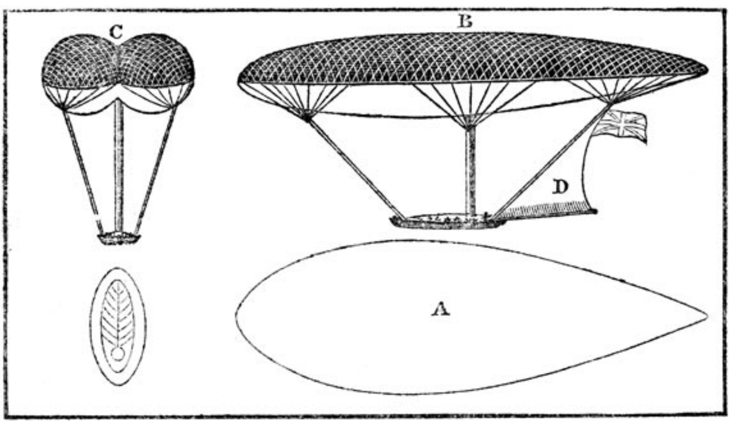
obtaining a proper fund;—and secondly, that a committee be appointed by the subscribers for the purpose of carrying such experiments as may appear eligible into effect. To such a committee I should be glad to submit the propriety of making the following experiment, which would be capable of trying all the expedients hitherto proposed for steering balloons. The principle proposed by Mr. Evans is only applicable, at present, to fire-balloons; and as these are the cheapest, and upon a large scale with proper precautions may be made safe with respect to fire, I propose that the experiments be made upon the Montgolfier balloon. The scale I propose to adopt, though as small as is compatible with the object in view, will appear to any one who has not calculated the proportions required for the success of the experiment, of stupendous magnitude.—Amazement would have been the consequence of presenting to the imagination of an ancient Briton the idea of a British hundred-gun ship, when only contemplating the principles of navigation exhibited in his humble coracle covered with a skin. From the truck of the flag-staff to the extreme of the bowsprit, a vessel of this sort will measure about 90 yards; and it is a wonderful effort of human ingenuity arising from the gradually accumulating knowledge of ages:—but the *long boat* of aërial navigation commences about the bulk where the man-of-war of common navigation has reached its full growth; and what may be the vessels, *I hope not men of war,* of this sort which a thousand years of human invention may bring to light, I am at a loss to contemplate.



Let A B C represent the plan, side and end elevation of a balloon or aërial vessel, made of woollen cloth, and kept to its

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shape by light poles attached to it, and internal cross bracings of wire or cord, opposing the tendency to become circular from the internal pressure of the heated air: this vessel to be 15 yards in elevation, 30 in width, and 100 in length. About 27 yards below this vessel must be suspended a convenient boat-shaped car, by six ropes collecting the cordage of the netting. This boat must be furnished with a light fire-grate; and an oval chimney of thin metal must descend from the balloon and cover the fire. This chimney to be furnished with three fine wire nets to prevent sparks from passing up it. A sail or rudder D must be attached to the boat from behind, which can be turned to either side by bracing the boom to which it is fixed. The cloth made use of being woollen will not be subject to take fire; but it is requisite that it should be made air-tight, and likewise impervious to rain, by some coats of paint or varnish on the outside. The machine being thus completed so far as it is necessary to try the principle of the *inclined plane*, as soon as the balloon is inflated, let the front ropes be lengthened and the hinder ones shortened, till it stands in an angle of about 30° with the horizon, when it will be found to rise in an angle of about 45°, and the horizontal velocity towards its destined *harbour* will be about 20 miles per hour*.—The power of the heated air would be about 17600 pounds: of this about 6800 pounds would be required to generate the velocity specified, and the remainder will be consumed in the weight of materials, fuel, passengers, &c.

It may seem at the first view extraordinary that I should propose to make use of so long a chimney; and this requires some explanation. The exterior resistance of the air to the anterior portion of the balloon, will amount on some parts of it to about 26 pounds per square yard at the proposed speed; and hence an internal pressure at least equal to this must be created, for the purpose of preserving the form of the balloon. This is most readily effected by force of the long column of heated air passing up such a chimney as I have described; for, were the air within it no hotter than the general temperature of the balloon, the 27 yards of chimney added to half the height of the balloon would create a pressure rather exceeding what is required; and I conceive it will, from its greater rarefaction, cre-

* This calculation is grounded upon the following data:—That in Montgolfier balloons one cubic yard of space has been found to give 11 ounces of power—that the form of the vessel will prevent it from receiving more than a third part of the resistance that its greatest cross section would receive at the same velocity; and that a velocity of twenty-three feet per second in air, creates a resistance of one pound per square foot, according to some careful experiments of my own upon a very large scale.

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ate as much pressure as will permit the prow of the balloon to be depressed to an angle of 30° with the horizon, and still enable it to resist the impression of the air in descending. It is scarcely necessary to observe that the balloon must be, as usual, furnished with a large valve at the top, and likewise with one at the bottom, to permit the escape of the hottest or coldest air as required. If the specific heat of air be to that of water as 1·79 to 1, it will require about 880 pounds of fuel to inflate this balloon, exclusive of what will be consumed to supply the waste of heat during the operation; and when a second rise is required, by having suffered the escape of air equal to the power of 6800 pounds, it will require the rapid combustion of 340 pounds of shavings, chopped straw, &c. to create a renewed ascent. Hence, including waste, probably about 100 pounds of fuel will be expended for every mile of conveyance, exclusive of the first inflation.

When this experiment has been made, it will be easy to try whether the balloon can be driven directly forward by sails wafted by the steam-engine at a less expense of fuel. In the former case the balloon had to proceed along two sides of a right-angled triangle only to gain the length of the hypothenuse: hence, as the resistance varies as the square of the velocity, the same horizontal speed of conveyance will be obtained with rather less than half the resistance in the one case than the other. The consumption of a steam horse power is about 30 pounds of water and six or seven pounds of fuel per hour. I have made several calculations relative to this subject, but it will occupy too much space for any one number of your valuable Magazine to detail them; I shall therefore close this paper, already perhaps too long, by stating, that if the dread of fire should deter any one from wishing to promote this experiment, notwithstanding the adoption of woollen cloth to prevent it, a perfect security from this accident may be obtained by using steam in lieu of heated air for inflating the balloon, or at least a great mixture of it with the heated air. The power of steam is greater than air at the usual temperature in Montgolfier balloons in the ratio of 18 to 11, although the first inflation will cost more fuel in the ratio of 2·6 to 1. The resistance to a steam-balloon will be only as 1 to 1·38, when compared with one of the same power inflated by heated air; and hence a considerable saving of power would be the result of adopting it. But several inconveniences arise upon the introduction of steam into balloons, the chief of which are the necessity of doubling the structure, so as to suspend the steam balloon within one of heated air or gas, and of the materials being incapable of absorbing water. However, I

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think it very possible that the following lines of Dr. Darwin may eventually be realized:

> "Soon shall thy arm, unconquer'd steam! afar
> Drag the slow barge or drive the rapid car;
> Or on wide waving wings expanded bear
> The flying chariot through the fields of air.
> Fair crews triumphant, leaning from above,
> Shall wave their fluttering kerchiefs as they move;
> Or warrior bands alarm the gaping crowd,
> And armies shrink beneath the shadowy cloud."

I remain, sir, your obedient servant,

GEORGE CAYLEY.

Brompton, near Malton, Yorkshire,
Dec. 24, 1815.

XVIII. *An Attempt to draw a Parallel between the Arts of Painting and Sculpture**.

THE appellation of Sister Arts is generally given to Painting and Sculpture: this mode of expression taken in a general sense is correct; but the relations and resemblances which they respectively present to the eyes of a common observer are very remote, when they are considered attentively and with the eyes of an artist.

Several eminent artists and amateurs, whom I have the honour to rank among my friends, having expressed their surprise that very little had been written upon sculpture, while the most petty scribbler thinks himself qualified to decide dogmatically on the merit of painters, and to dwell pedantically on all the parts of a picture; it occurred to me that the reasons for such a seeming neglect of the former art, and such an excess of criticism on the latter, were to be sought for in the essence of the two arts. In these few pages I shall therefore endeavour to give a general idea of both.

Painting strikes the senses most forcibly, and the aid of colours gives it the advantage of closely resembling nature. Not only do the abundance and *éclat* of its productions diffuse it more widely and facilitate its reception in the world; but the means of its execution are so familiar and so well known, that all men regard it as a common property. But it is not in this point of view, nor in this spirit, that it is made for all the world.

Sculpture, more confined to the workshop, less in view and of more difficult removal, slower in its operations and less extensive

* Translated from an unpublished manuscript of Count Caylus, in the possession of M. Fayolle, member of the French Institute.—*Magasin Encyclopédique.*

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