Essays of an Information Scientist, Vol:3, p.167, 1977-78
Current Contents, #26, p.12-22, June 27, 1977

The Outlook for the Flying Machine*

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Also See Introduction on p.155, Essays, Vol:3

Mr. Secretary Langley's trial of his flying machine, which seems to have come to an abortive issue last week, strikes a sympathetic chord in the constitution of our race. Are we not the lords of creation? Have we not girdled the earth with wires through which we speak to our antipodes? Do we not journey from continent to continent over oceans that no animal can cross, and with a speed of which our ancestors would never have dreamed? Is not all the rest of the animal creation so far inferior to us in every point that the best thing it can do is to become completely subservient to our needs, dying, if need be, that its flesh may become a toothsome dish on our tables? And yet here is an insignificant little bird, from whose mind, if mind it has, all conceptions of natural law are excluded, applying the rules of aerodynamics in an application of mechanical force to an end we have never been able to reach, and this with entire ease and absence of consciousness that it is doing an extraordinary thing. **Surely our knowledge of natural laws, and that inventive genius which has enabled us to subordinate all nature to our needs, ought also to enable us to do anything that the bird can do. Therefore we must fly.** If we cannot yet do it, it is only because we have not got to the bottom of the subject. Our successors of the not distant future will surely succeed.

This is at first sight a very natural and plausible view of the case. And yet there are a number of circumstances of which we should take account before attempting a confident forecast. Our hope for the future is based on what we have done in the past. But when we draw conclusions from past successes we should not lose sight of the conditions on which success has depended. There is no advantage which has not its attendant drawbacks; no strength which has not its concomitant weakness. Wealth has its trials and health its dangers. We must expect our great superiority to the bird to be associated with conditions which would give it an advantage at some point. A little study will make these conditions clear.

We may look on the bird as a sort of flying machine complete in itself, of which a brain and nervous system are fundamentally necessary parts. No such machine can navigate the air unless guided by something having life. Apart from this, it could be of little use to us unless it carried human beings on its wings. We thus meet with a difficulty at the first step—we cannot give a brain and nervous system to our machine.

*Reprinted from *The Independent: A Weekly Magazine* 22 October 1903, pp. 2508-12.

These necessary adjuncts must be supplied by a man, who is no part of the machine, but something carried by it. The bird is a complete machine in itself. Our aerial machine must be ship plus man. Now, a man is, I believe, heavier than any bird that flies. The limit which the rarity of the air places upon its power of supporting wings, taken in connection with the combined weight of a man and a machine, make a drawback which we should not too hastily assume our ability to overcome. The example of the bird does not prove that man can fly. The hundred and fifty pounds of dead weight which the manager of the machine must add to it over and above that necessary in the bird may well prove an insurmountable obstacle to success.

I need hardly remark that the advantage possessed by the bird has its attendant drawbacks when we consider other movements than flying. Its wings are simply one pair of its legs, and the human race could not afford to abandon its arms for the most effective wings that nature or art could supply.

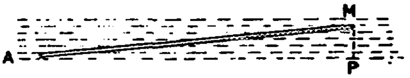
Another point to be considered is that the bird operates by the application of a kind of force which is peculiar to the animal creation, and no approach to which has ever been made in any mechanism. This force is that which gives rise to muscular action, of which the necessary condition is the direct action of a nervous system. We cannot have muscles or nerves for our flying machine. We have to replace them by such crude and clumsy adjuncts as steam engines and electric batteries. It may certainly seem singular if man is never to discover any combination of substances which, under the influence of some such agency as an electric current, shall expand and contract like a muscle. But, if he is ever to do so, the time is still in the future. We do not see the dawn of the age in which such a result will be brought forth.

Another consideration of a general character may be introduced. As a rule it is the unexpected that happens in invention as well as discovery. There are many problems which have fascinated mankind ever since civilization began which we have made little or no advance in solving. The only satisfaction we can feel in our treatment of the great geometrical problems of antiquity is that we have shown their solution to be impossible. **The mathematician of to-day admits that he can neither square the circle, duplicate the cube or trisect the angle. May not our mechanicians, in like manner, be ultimately forced to admit that aerial flight is one of that great class of problems with which man can never cope, and give up all attempts to grapple with it?**

I do not claim that this is a necessary conclusion from any past experience. But I do think that success must await progress of a different kind from that of invention. It is an unfortunate fact that we do not always appreciate the distinction between progress in scientific discovery and ingenious application of discovery to the wants of civilization. The name of Marconi is familiar to every ear: the names of Maxwell and Herz, who made the discoveries which rendered wireless telegraphy possible, are rarely recalled. Modern progress is the result of two factors: Discoveries of the laws of nature and of actions or possibilities in nature, and the application of such discoveries to practical purposes. The first is the work of the scientific investigator, the second that of the inventor.

In view of the scientific discoveries of the past ten years, which, after bringing about results that would have been chimerical if predicted, leading on to the extraction of a substance which seems to set the laws and limits of nature at defiance by radiating a flood of heat, even when cooled to the lowest point that science can reach—a substance, a few specks of which contain power enough to start a railway train, and seems to embody perpetual motion itself, he would be a bold prophet who would set any limit to possible discoveries in the realm of nature. We are binding the universe together by agencies which pass from sun to planet and from star to star. We are peering into the law of gravitation itself with the full hope of discovering something in its origin which may enable us to evade its action. We are determined to find out all we can about the mysterious ethereal medium which seems to fill all space, and which conveys light and heat from one heavenly body to another, but which yet evades all direct investigation. **Quite likely the twentieth century is destined to see the natural forces which will enable us to fly from continent to continent with a speed far exceeding that of the bird.**

But when we inquire whether aerial flight is possible in the present state of our knowledge; whether, with such materials as we possess, a combination of steel, cloth and wire can be made which, moved by the power of electricity or steam, shall form a successful flying machine, the outlook may be altogether different. To judge it sanely, let us bear in mind the difficulties which are encountered in any flying machine. The basic principle on which any such machine must be constructed is that of the aeroplane. This, by itself, would be the simplest of all flyers, and, therefore, the best if it could be put into operation. The principle involved may be readily comprehended by the accompanying figure. A M is the section of a flat plane surface, say, a thin sheet of metal or a cloth supported by wires. It moves through the air, the latter being represented by the horizontal rows of dots. The direction of the motion is that of the horizontal line, A P. The aeroplane has a slight inclination measured by the proportion between the perpendicular M P and the length, A P. We may raise



the edge M up or lower it at pleasure. Now the interesting point, and that on which the hopes of inventors are based, is that if we give the plane any given inclination, even one so small that the perpendicular M P is only two or three per cent of the length AM, we can also calculate a certain speed of motion through the air which, if given to the plane, will enable it to bear any required weight. A plane ten feet square, for example, would not need any great inclination, nor would it require a speed higher than a few hundred feet a second to bear a man. What is of yet more importance, the higher the speed the less the inclination required, and, if we leave out of consideration the friction of the air and the resistance arising from any object which the machine may carry, the less the horse-power expended in driving the plane.

Maxim exemplified this by experiment several years ago. He found that, with a small inclination, he could readily give his aeroplane, when it slid forward upon ways, such a speed that it would rise from the ways of itself. The whole problem of the successful flying machine is, therefore, that of arranging an aeroplane that shall move through the air with the requisite speed.

The practical difficulties in the way of realizing the movement of such an object are obvious. The aeroplane must have its propellers. These must be driven by an engine with a source of power. Weight is an essential quality of every engine. The propellers must be made of metal, which has its weakness, and which is liable to give way when its speed attains a certain limit. And, granting complete success, imagine the proud possessor of the aeroplane darting through the air at a speed of several hundred feet per second! It is the speed alone that sustains him. How is he ever going to stop? Once he slackens his speed, down he begins to fall. He may, indeed, increase the inclination of his aeroplane. Then he increases the resistance necessary to move it. Once he stops he falls a dead mass. How shall he reach the ground without destroying his delicate machinery? I do not think the most imaginative inventor has yet even put upon paper a demonstrative, successful way of meeting this difficulty. The only ray of hope is afforded by the bird. The latter does succeed in stopping and reaching the ground safely after its flight. But we have already mentioned the great advantages which the bird possesses in the power of applying force to its wings, which, in its case, form the aeroplanes. But we have already seen that there is no mechanical combination, and no way of applying force, which will give to the aeroplanes the flexibility and rapidity of movement belonging to the wings of a bird. That this difficulty is insurmountable would seem to be a very fair deduction, not only from the failure of all attempts to surmount, but from the fact that Maxim has never, so far as we are aware, followed up his seemingly successful experiment.

It may be surmounted in a way which may, at first sight, seem plausible. In order that the aeroplane may have its full sustaining power, there is no need that this motion be continuously forward. A nearly horizontal surface, swinging around in a circle, on a vertical axis, like the wings of a windmill moving horizontally, will fulfill all the conditions. In fact, we have a machine on this simple principle in the familiar toy which, set rapidly whirling, rises in the air. Why more attempts have not been made to apply this system I do not know. Were there any hopeful possibility of making any flying machine whatever, it would seem that we should look in this direction.

The difficulties which I have

pointed out are only preliminary ones, patent on the surface. A more fundamental one still, which the writer feels may prove insurmountable, is based on a law of nature which we are bound to accept. It is that when we increase the size of such a machine without changing its model we increase the weight in proportion to the cube of the linear dimensions, while the effectiveness of the supporting power of the air increases only as the square of those dimensions. For example, suppose that an inventor succeeds, as well he may, in making a machine which would go into a match case, yet complete in all its parts, able to fly around the room. It may carry a button, but nothing heavier. Elated by his success, he makes one on the same model twice as large in every dimension. The parts of the first, which are one inch in length, he increases to two inches. Every part is twice as long, twice as broad and twice as thick. The result is that his machine is eight times as heavy as before. But the sustaining surface is only four times as great. As compared with the smaller machine, its ratio of effectiveness is reduced to one-half. It may carry two or three buttons, but will not carry over four, because the total weight, machine plus buttons, can only be quadrupled, and if he more than quadruples the weight of the machine, he must less than quadruple that of the load. How many such enlargements must he make before his machine will cease to sustain itself, before it will fall as an inert mass when we seek to make it fly through the air? Is there any size at which it will be able to support a human being? We may well hesitate before we answer his question in the affirmative.

Dr. Graham Bell, with a cheery optimism very pleasant to contemplate, has pointed out that the law I have just cited may be evaded by not making a larger machine on the same model, but changing the latter in a way tantamount to increasing the number of small machines. This is quite true, and I wish it understood that, in laying down the law I have cited, I limit it to two machines of different sizes on the same model throughout. **Quite likely the most effective flying machine would be one carried by a vast number of little birds.** The veracious chronicler who escaped from a cloud of mosquitoes by crawling into an immense metal pot and then amused himself by clinching the antennae of the insects which bored through the pot until to his horror they became so numerous as to fly off with the covering, was more scientific than he supposed. Yes, a sufficient number of humming birds, if we could combine their forces, would carry an aerial excursion party of human beings through the air. If the watchmaker can make a machine which will fly through the room with a button, then, by combining ten thousand such machines he may be able to carry a man. But how shall the combined forces be supplied?

It is of interest to notice that the law is reversed in the case of a body which is not supported by the resistance of a fluid in which it is immersed, but floats in it, the ship or balloon, for example. When we double the linear dimensions of a steamship in all its parts, we increase not only her weight, but her floating power, her carrying capacity and her engine capacity eight-fold. But the resistance which she meets with when passing through the water at a given speed is only multiplied four times. Hence, the larger we build the steamship the more economical the application of the power necessary to drive it. The proportionately diminishing resistance which, in the flying machine, represents the floating power is, in the ship, something to be overcome. Thus there is a complete reversal of the law in its practical application to the two cases.

The balloon is in the same class with the ship. Practical difficulties aside, the larger it is built the more effective it will be, and the more advantageous will be the ratio of the power which is necessary to drive it and the resistance to be overcome.

If, therefore, we are ever to have aerial navigation with our present knowledge of natural capabilities, it is to the airship floating in the air, rather than the flying machine resting on the air, to which we are to look. In the light of the law which I have laid down, the subject, while not at all promising, seems worthy of more attention than it has received. It is not at all unlikely that if a skillful and experienced naval constructor, aided by an able corps of assistants, should design an airship of a diameter of not less than two hundred feet, and a length at least four or five times as great, constructed, possibly, of a textile substance impervious to gas and borne by a light framework, but, more likely, of exceedingly thin plates of steel carried by a frame fitted to secure the greatest combination of strength and lightness, he might find the result to be, ideally at least, a ship which would be driven through the air by a steam engine with a velocity far exceeding that of the fleetest Atlantic liner. Then would come the practical problem of realizing the ship by overcoming the mechanical difficulties involved in the construction of such a huge and light framework. I would not be at all surprised if the result of the exact calculation necessary to determine the question should lead to an affirmative conclusion, but I am quite unable to judge whether steel could be rolled into parts of the size and form which would be required in the mechanism.

I may, in conclusion, caution the reader on one point. I should be very sorry if this suggestion leads to the subject being taken up by any other than skillful engineers or constructors, able to grapple with all problems relating to the strength and resistance of materials. As a single example of what is to be avoided I may mention the project, which sometimes has been mooted, of making a balloon by pumping the air from a very thin, hollow receptacle. Such a project is as futile as can well be imagined; no known substance would begin to resist the necessary pressure. Our aerial ship must be filled with some substance lighter than air. Whether heated air could be made to answer the purpose, or whether we should have to use a gas, is the question for a designer.