PRICE, 10 CENTS.

THE

# PROBLEM OF MANFLIGHT.

BY

JAMES MEANS



THE FLIGHT OF OTTO LILIENTHAL, OF STEGLITZ, PRUSSIA, AS ACTUALLY ACCOMPLISHED IN 1893. ACCURATELY DRAWN FROM AN INSTANTANEOUS PHOTOGRAPH.

BOSTON, MASS.:
W. B. CLARKE & CO.,
340 WASHINGTON STREET.
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PRESS OF
Rockwell and Churchill,
BOSTON.

# THE PROBLEM OF MANFLIGHT.

As the century draws to its close the interest in the subject of aeronautics steadily increases. There already exists a keen curiosity to know what the aerial machine of the future is likely to resemble, and also to know whether the nineteenth or the twentieth century will claim it for its own.

In the present article the writer wishes to show what inferences may be drawn from the laws of nature as so far ascertained by observation and experiment, and he wishes also to point out a way which may lead to further progress.

The investigators of this subject are now divided into two camps: on the one side there are men who, like Mr. Maxim, are endeavoring to construct machines which will carry motors and therefore be self-propelling; on the other side there are men like Mr. A. M. Wellington, who maintains that a motor is unnecessary and that wind-power is sufficient.

In the New York Engineering News, of Oct. 12, 1893, Mr. Wellington, in a very interesting article entitled "The Mechanics of Flight," makes the following statement: "If the conclusions so far reached in this paper be accepted, it is obvious that they greatly simplify the problem of artificial flight by reducing to a minimum the demand for power, making it chiefly necessary for acquiring the first initial velocity. All attempts at aviation which include any motor for propulsion are, in my judgment, on wrong lines, and predestined to certain failure, since they not only neglect, but destroy, the action of the forces by which true flight may be and is attained. I will not go so far as to say that some (soaring) birds, in the exuberance of power, may not use the wings to accelerate, as they do to retard motion. I think they do, but only in an abnormal way; it is wholly unnecessary, and even destructive of all normal flight. The fish needs a propeller, because it has no gravity in water; the bird does not need it, because it has gravity, and in that gravity has the best and smoothest of all conceivable means of propulsion, if he can make the wind lift him uphill whenever he has slid far enough downhill. If so, man commits an absurdity when he flies in the face of nature and assumes a propelling force where none is needed or exists."

Later on in this article, I wish to describe an instrument, experiments with which can be made to answer for us the question as to whether or not a motor is needed; but just here further quotations should be given to show the trend of the best thought.

Aeronautics (N.Y.) for January contains Professor Langley's remarkable paper entitled "The Internal Work of the Wind." The closing paragraph is as follows:

"The final application of these principles to the art of aerodromics seems, then, to be, that while it is not likely that the perfected aerodrome (air-runner) will ever be able to dispense altogether with the ability to rely at intervals on some internal source of power, it will not be indispensable that this aerodrome of the future shall, in order to go any distance — even to circumnavigate the globe without alighting, — need to carry a weight of fuel which would enable it to perform this journey under conditions analogous to those of a steamship, but that the fuel and weight need only be such as to enable it to take care of itself in exceptional moments of calm."

Mr. Octave Chanute, in his admirable chronicle entitled "Progress in Flying-Machines," which will soon be published, says in one of his closing chapters: "But it is possible to utilize a still lighter power [than that of engines], for we have seen that the wind may be availed of under favorable circumstances, and that it will furnish an extraneous motor which costs nothing and imposes no weight upon the apparatus.

"Just how much power can be thus utilized cannot well be told in advance of experiment; but we have calculated that under certain supposed conditions it may be as much as some six-horse power for an aeroplane with one thousand square feet of sustaining surface; and we have also seen that while but few experimenters have resorted to the wind as a motor, those few have accomplished remarkable results."

The indications seem to be that we must try to construct a machine analogous to the sailing-yacht rather than to the steamship, though perhaps the aerial machine of the future will be, so far as power is concerned, analogous to the yacht Sunbeam with its auxiliary screw.

Before continuing further with this subject, I wish to call attention to certain facts concerning the storage of power and the flight of soaring birds. First, in regard to the storage of power. It is well known that the construction of a useful electric storage-battery presents a most difficult problem. Such a storage device is needed for use upon the surface of the earth; yet, for purposes of aerial navigation, there is a much simpler accumulator which can be used. Take, for example, one hundred pounds of lead and let energy be stored in it by giving it altitude, just as energy is stored in the weight of a clock when it is wound.

What is known as one-horse power is the amount of energy which must be exerted in lifting thirty-three thousand pounds at the rate of one foot per minute, or five hundred and fifty pounds at the rate of one foot per second, or fifty-five pounds at the rate of ten feet per second. To give an illustration, it may be stated that if a man weighing one hundred and sixty-five pounds ascends a flight of steps ten feet high in three seconds, he exerts for the time being just one standard horse-power.

A small balloon which can lift one hundred pounds of lead three hundred and thirty feet high in one minute exerts one-horse power.

The lead when lifted to this height has stored within itself thirty-three thousand foot-pounds of energy.

Now, if weights can be made to slide downhill upon aeroplanes at very gentle grades, then the balloon becomes a valuable motor which stores energy in its load by giving it altitude, and the weight lifted becomes a reservoir of the very power needed for its own transportation, and the name of Montgolfier, the inventor of the under-estimated balloon, takes its place as that of the real founder of the useful art of aerial transportation.

Whether or not it is possible to transport freight by sliding it down long and gentle inclines by means of aeroplanes will be considered further on; just here we must consider the soaring power of birds.

In "The Reign of Law," by the Duke of Argyll (first published in 1867), there is a most notable chapter in which the flight of birds is analyzed. In a note the author makes the following statement: "I owe to my father [John, seventh Duke of Argyll] my knowledge of the theory of flight, which is expounded in this chapter. The retired life he led, and the dislike he had of the work of literary composition, confined the knowledge of his views within a comparatively narrow circle. But his love of mechanical science, and his study of the problem during many years of investigation and experiment, made him thoroughly master of the subject."

Every student of the subject of flight should read the interesting work just mentioned. We may not agree with all the conclusions which are reached, yet the author gives most stimulating food for thought.

The following paragraphs are among the most striking, showing, as they do, advanced ideas:

"In the first place, it is remarkable that the force which seems so adverse — the force of gravitation drawing down all bodies to the earth — is the very force which is the principal one concerned in flight, and without which flight would be impossible. It is curious how completely this has been forgotten in almost all human attempts to navigate the air. Birds are not lighter than the air, but immensely heavier. If they were lighter than the air they might float, but they could not fly. This is the difference between a bird and a balloon." (p. 130, Am. ed.)

. . . . . . . . . .

"No bird is ever for an instant of time lighter than the air in which it flies; but being, on the contrary, always greatly heavier, it keeps possession of a force capable of supplying momentum, and therefore capable of overcoming any lesser force, such as the ordinary resistance of the atmosphere, and even heavy gales of wind. The force of gravitation, therefore, is used in the flight of birds as one of the most essential of the forces which are available for the accomplishment of the end in view." (p. 131.)

. . . . . . . . . .

"The lightness of a bird is a limit to its velocity. The heavier a bird is, the greater is its possible velocity of flight — because the greater is the store of force; or, to use the language of modern physics, the greater is the quantity of 'potential energy' which, with proper implements to act upon aerial resistance, it can always convert into upward, or horizontal, or downward motion, according to its own management and desires." (p. 144.)

. . . . . . . . . .

"When a strong current of air strikes against the wings of a bird, the same sustaining effect is produced as when the wing strikes against the air. Consequently birds with very long wings have this great advantage, that, with pre-acquired momentum, they can often for a long time fly without flapping their wings at all. Under these circumstances a bird is sustained very much as a boy's kite is sustained in the air. The string which the boy holds, and by which he pulls the kite downwards with a certain force, performs for the kite the same offices which its own weight and balance and momentum perform for the bird. The great long-winged oceanic birds often appear to float rather than to fly. The stronger is the gale, their flight, though less rapid, is all the more easy, so easy indeed as to appear buoyant; because the blasts which strike against their wings are enough to sustain the bird with comparatively little exertion of its own, except that of holding the wing vanes stretched and exposed at proper angles to the wind. And whenever the onward force previously acquired by flapping becomes at length exhausted, and the ceaseless, inexorable force of gravity is beginning to overcome it, the bird again rises by a few easy and gentle half-strokes of the wing. Very often the same effect is produced by allowing the force of gravity to act, and when the downward momentum has brought the bird close to the ground or to the sea, that force is again converted into an ascending impetus by a change in the angle at which the wing is exposed to the wind." (p. 152.)

It is to be regretted that the limits of this article prevent more extended quotations from this remarkable book.

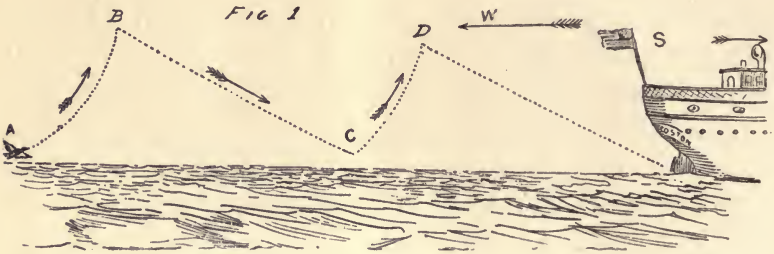
Now let us recall what we have seen at sea.

When one stands on the after-deck of a steamer in crossing the ocean, he may watch the soaring gulls to his heart's content. When the ship struggles painfully to force her way into the teeth of a gale, the birds make sport for themselves — they rise and dip, thus conquering the wind. How? Simply by *tacking;* in one sense, just as a yacht tacks to windward. Neither bird nor yacht can sail into the eye of the wind by the wind's power, but either can, by use of that power, reach an objective point lying to windward.

But here the reader may say that the parallelism between the bird and the sailing craft is not correctly drawn, because the yacht has a keel immersed in a dense medium which resists and prevents the making of leeway.

Yet the soaring bird has something which, at necessary times, holds it against the wind just as effectually as the keel holds the yacht: that something is *momentum*, which, while it lasts, holds the bird against the wind as firmly as the kite-string holds the boy's kite.

In Fig. 1, let S represent a steamship going eastward at the rate of twenty miles per hour; W the




wind blowing westward at the rate of twenty miles per hour; A a gull near the water's surface, with momentum which for the instant gives him an eastward velocity of twenty miles per hour. While the bird's momentum lasts it holds him firmly against the wind. At the point A the bird inclines his wings so that the wind strikes them on the under side, and he is lifted and lifted until, at the point B, his momentum is so reduced that he must tack; then he gives to the wind the thin edge of his wings and slides down to the point C, and then, with velocity regained, he repeats the manœuvre. Altitude sacrificed becomes velocity or momentum, and momentum sacrificed becomes altitude. In this description of the gull's soaring to windward, the movement is reduced to its simplest elements, and it leaves out of account the graceful sinuosity of the bird's airy travels, just as the teacher of dancing leaves grace out of account when she teaches the beginner the elements of the steps.

What has here been said about the storage of energy in weights, and concerning the elements of flight, is all intended to lead up to the important subject of sliding freight downhill upon aeroplanes. It may be asked, How about a calm?

There is no calm for the aeroplane. Give it altitude and it can gain velocity, and velocity gives the *wind of flight*.

The plan for the transportation of freight is simply this: at each shipping-point a power-house (D, Fig. 2)

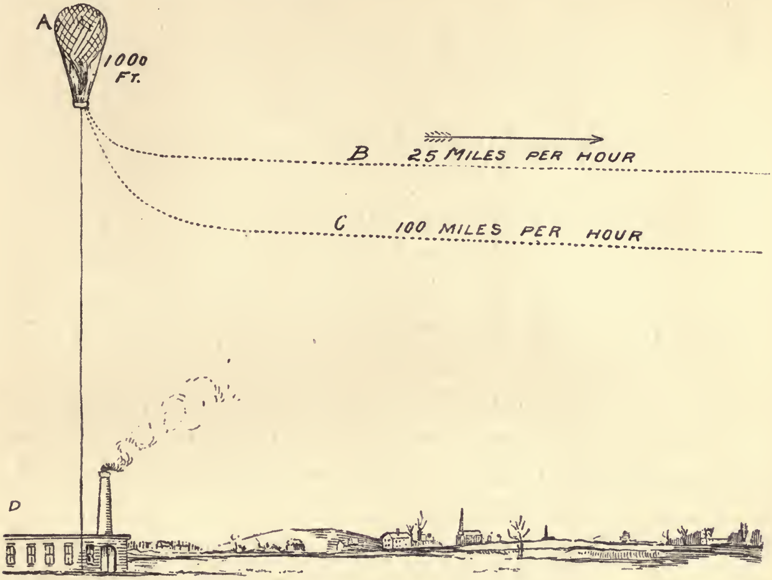



Fig. 2.

may be established to operate captive balloons. These should be cellular, and should be made to hold gas with little waste. In its action the apparatus would be what might be called an inverted elevator; that is, the steam or water-motor in the power-house would not hoist the freight, but, instead, would pull the balloon down after *it* had hoisted the freight and discharged it by means of a soaring machine, which will presently be described.

In Fig. 2 A represents a captive balloon at a height of one thousand feet. B and C represent the courses which would be taken by dirigible aeroplanes or soaring machines bearing loads of freight.

Perhaps this seems fanciful. Then let it be remembered that the feat of safely sliding down a long and gentle incline upon an aeroplane has already been performed by Otto Lilienthal, of Steglitz, Prussia. His experiments were illustrated and described in the Berlin Illustrirte Zeitung of Oct. 7, 1893, and one of the drawings — all of which were correctly made from instantaneous photographs — is here reproduced on the first page of cover. An improvement upon Lilienthal's device may be made by adding a pendulum.*

*Now, in order to travel long distances in the air it is only necessary to improve the dirigibility of the aeroplane so that the angle of descent can be brought to a minimum.*

How can this be done? By making repeated experiments with very simple and inexpensive mechanical contrivances called soaring machines, these to be dropped from a height.

In Fig. 2 it will be noticed that the course marked B indicates a speed of twenty-five miles per hour, that marked C a speed of one hundred miles per hour.

What speed may we expect of an improved soaring-machine? and upon how gentle a decline can we hope to see it maintain its initial velocity? First, note the fact that with a dirigible aeroplane or soaring machine the rate of speed is practically a matter of choice and depends at the start upon the length of the first swoop. The limit of speed will probably be decided by the

* See U. S. Letters Pat. No. 376937.

strength of the machine and the breathing requirements of the aerial pilot. Let us consider a railroad train. Man has safely travelled at a rate of one hundred and twelve miles per hour. On May 11, 1893, the Empire State express on the N.Y.C. R.R. reached that speed in a mile run in thirty-two seconds, one mile westward from Crittenden. So we know that man can safely breathe when travelling at over one hundred miles per hour; yet for this, of course, he needs the same protection which a cab gives to the locomotive engineer.

We will answer as well as we may the second question, Upon how gentle a decline may we hope to see an aerial machine maintain its initial velocity? When a railway car is at rest upon a smooth steel track having a down grade of one and twenty-three one-hundredths feet in every one hundred feet, it will remain at rest if undisturbed; but let it be once started downward by ever so slight an impulse and it will run down the track, gaining velocity to the end of the grade. It encounters the head resistance of the air and the friction of the track, but an aerial machine would encounter only air-resistance; is it not, therefore, reasonable to suppose that a dirigible aeroplane would in a calm, maintain its initial velocity while running upon a down grade of air of one foot in every one hundred feet? If so, an altitude of ten or twelve hundred feet would send a soaring machine eighteen or twenty miles, and greater altitudes would give longer flights, if, as may be supposed, the rarefaction of the air can be offset by an increase of velocity. These are surmises, but the way to learn is to experiment with soaring machines.

It is above all things important that a soaring machine should, when desired, automatically keep itself in a horizontal or slightly descending course. I have this winter begun a series of experiments with soaring machines, and when these are finished the full details will be reported.

In November, 1893, I launched several of these machines from the balcony of the tower of Boston Light, and more recently I have experimented from the top of the cliffs at Manomet. The former place is an ideal one for the purpose of experiment, being as it is, one hundred and eleven feet above the sea with a straight drop of seventy or eighty feet. Unfortunately, a gale of wind was blowing when I visited the light, and two out of the three machines were total failures, being badly bent by the wind before they were launched. The third machine righted itself before reaching the ground, but the pendulum, which will presently be described, was too light to do efficient work.

The experiments from the cliffs at Manomet were even less successful, owing to the fact that the descent is not sheer. All of the machines failed to gain sufficient velocity to clear the cliff.

Those who wish to experiment with machines weighing only a few pounds will probably find that a height of seventy or eighty feet will be sufficient if the position gives a straight drop. When it comes to experimenting with a soaring machine as large as Lilienthal's and carrying a weight representing that of a man, the summit of Mt. Willard, near the Crawford House, N.H., will be found an excellent place.

To any one who desires to take up this most fascinating study, Figs. 3 and 4 will give a general idea as to the construction of his first instrument for making experiments. A represents a backbone five-eighths of an inch square and four feet long, made of pine wood; B, the main aeroplane, eight inches wide and three feet

# A Soaring Machine.

An instrument for making scientific experiments

Designed by

James Means.

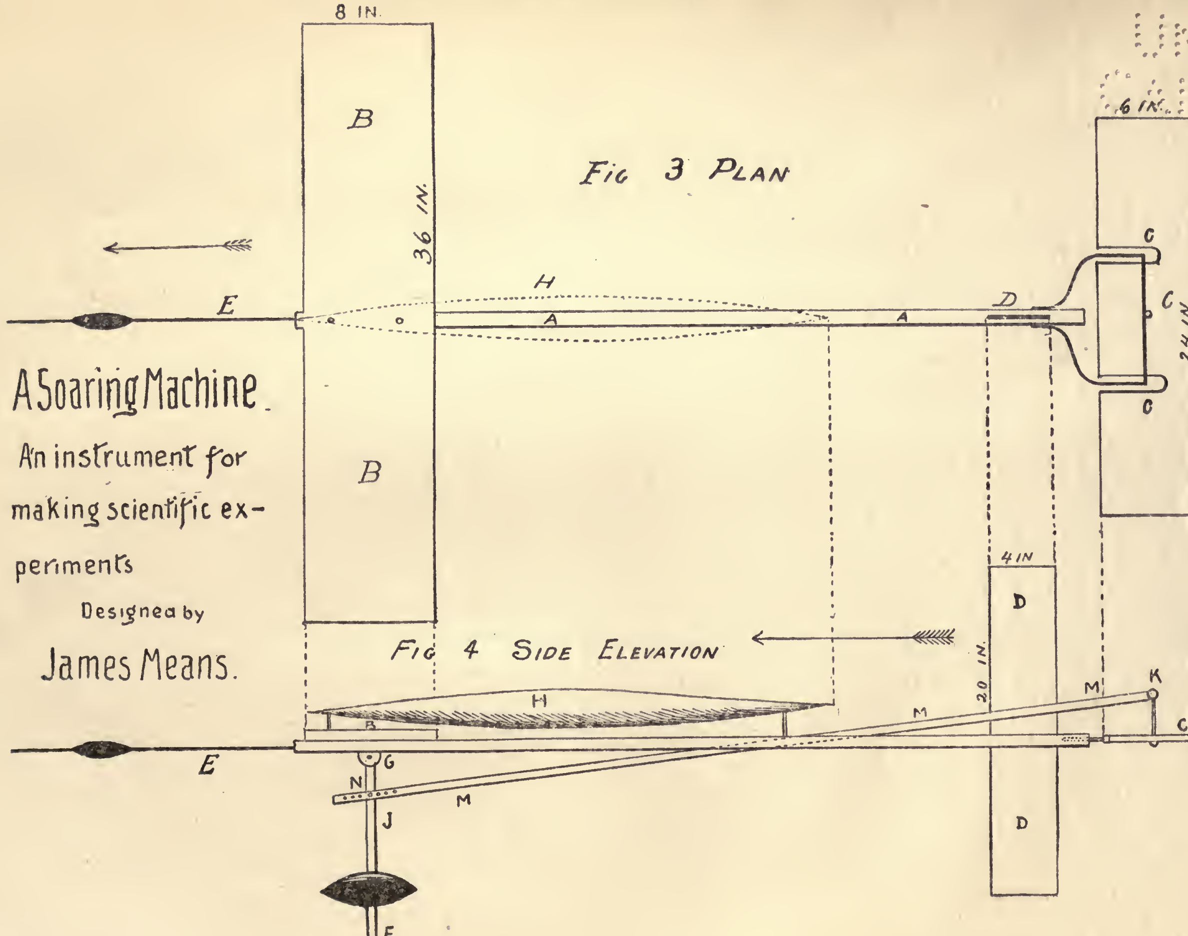



Fig 3 Plan

Fig 4 Side Elevation

long. This should be made of light tin plate, and bent in the middle so as to form a flattened V; the angle should be about one hundred and seventy degrees. C represents a steering aeroplane six inches by twenty-four inches, pivoted at cc, also made of light tin plate; D, a vertical aeroplane four inches by twenty inches, rigidly fixed in the wooden backbone; E, a rod of steel wire, eighteen or twenty inches long, and carrying an adjustable leaden weight of three ounces; K, a rod two and one-half inches long, soldered in the centre of and vertical to the plane C, with a pivot at the upper end with which the rod MM is connected. This rod should have five or six pivot-holes at its forward end N, so that its working length may be varied for different experiments; J, a rod pivoted at G, free to swing fore and aft; N, a pivot where the rod MM joins the rod J; F, a leaden weight adjustable higher or lower upon the rod J; its proper weight is x, an unknown quantity. Upon ascertaining by repeated experiment the right *weight* for F, the right *position* for the adjustable weight E, and the right *length* for the rod MM, the reaching of the maximum efficiency of a system of aeroplanes largely depends. I think that this sets forth with clearness the problem as it stands to-day. When it is fully solved — and it certainly seems solvable — right and left steering will be a less difficult matter, and alighting will be accomplished by killing the momentum when near the ground by an abrupt upward slant of the main aeroplanes; but this is an anticipation and a digression. Now to return to the instrument we are considering: this soaring machine is intended to gain velocity by a swoop, and then automatically steer itself into a horizontal or very slightly descending course, as indicated by B and C in Fig. 2. It depends upon the principle that the pendulum rod always seeks the perpendicular; for instance, when the machine is launched pointing steeply downward, the positions of the pendulum and aeroplanes are as shown in Fig. 5; therefore the steering aeroplane C will, as soon as velocity is gained, lay

Fig. 5

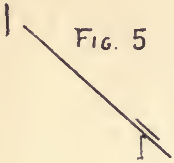


Fig. 6

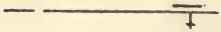


Fig. 7

a strong hold upon the wind of flight, and have a tendency to bring the machine into a horizontal course. Now, if the length of the rod MM is made correct by adjustment at the pivot-holes near N, when the desired course, a very gentle decline, is reached, both aeroplanes will be approximately horizontal, as shown in Fig. 6. If, however, the machine deviates either upward or downward from its intended course, the weight at the end of the pendulum causes the steering aeroplane to correct the error. Fig. 7 shows the effect of a slight upward deviation.

H represents a long and very slender air-receptacle made of thin rubber and inflated; this should be pointed at both ends. It may be used to keep the machine afloat when experiments are made near the water. I have not yet used this, but have allowed my machines to go to pieces. The design here given calls for aero*planes* as being more easily made than aero*curves* modelled after the wings of birds, but in all probability the latter will eventually displace the former.

We are brought now, after this consideration of the greatest mechanical problem of the age, to ask, What shall be done to bring to our own century the credit and honor of reaching the solution?

The answer is, encourage experiments with soaring machines. Have regattas and large prizes. Appeal to the people's love of sport, and show what possibilities of recreation have been suggested by the experiments of Otto Lilienthal. Tobogganing on ice we can have only a few weeks in the year: tobogganing on air is possible at all seasons. When we have made our aeroplanes or aerocurves automatic in their steering action, flights like Lilienthal's will be, to say the least, no more dangerous than football and quite as interesting.

In order to encourage the designing and construction of soaring machines, I suggest that a sum of money be raised to be offered as a prize to the constructor of the most successful soaring-machine, the award to be made after a public trial of the same, to take place early in September of the present year (1894).

I will subscribe one hundred dollars if others will subscribe, in any sums they choose, nine hundred dollars more, to make a purse of one thousand dollars, provided that the publisher of some journal of wide influence will be custodian of the fund.

One or two more thoughts in conclusion. We have seen how the soaring bird tacks, first up, then down, then up again, and then down again. That conveys the idea of the perfection of rapid transit for passengers and freight. With the captive balloon we can tack up, with the soaring machine we can tack down. Short tacks up, long tacks down; there is no calm for the aeroplane; give it altitude and it can seize from the calm the wind of flight.

Imagine a bowling alley four hundred feet long, perfectly level, with an athlete at one end and a boy at the other. Let the chute which returns the balls have a drop of fifteen inches in every one hundred feet; imagine the game to be one of rapid transit instead of tenpins. It is a competition between the two ends of the alley to see which end can make the most of what energy it has. Let the athlete exert all his strength to propel the spheres; see them arrive at the end of the alley after their journey of four hundred feet, with sluggish speed; the boy lifts them to a height of five feet to the chute, gives them a gentle push, and they are returned to the athlete's end, arriving, not as sluggards, but as filled with energy. A short tack up and a long tack down is what does it.

There you have the old and the new methods of transit represented. The athlete represents the steam locomotive which, with all its polish and glitter, wastes energy. The boy represents the balloon, the lifter, which stores energy in matter by giving it altitude. The chute represents the free highway which through all the centuries men have supposed to be lacking.

Aerial transit will be accomplished because the air is a solid if you hit it hard enough.

*James Means.*