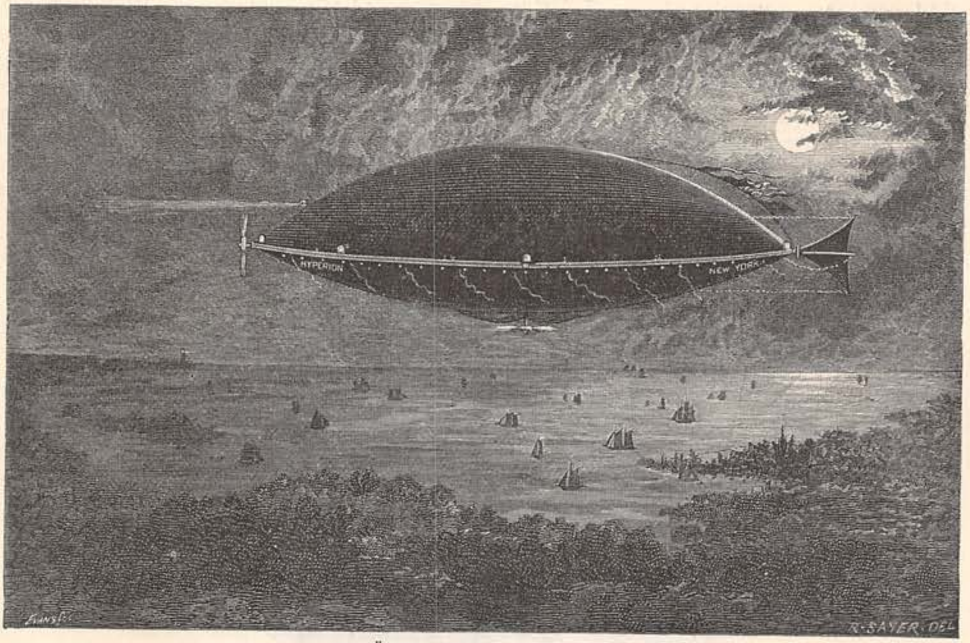
AËRIAL NAVIGATION.

(A PRIORI.)



AN AËROBAT OF THE NEAR FUTURE.

IN the folly, no less than "in the adversity of our best friends, we often find something which does not displease us." Hence I piously believe, as Gil Blas would say, that some who begin to read this article will even read it through. Thus much, if only to gratify themselves with a fresh illustration of the vanity of human wishes and the weakness of occasionally sensible men.

Meanwhile, I can assure them that *if* their assent shall be gained to the chief and practical portion of what follows, the subsequent matter will not seem to them an overstatement of consequences. The "if" is a haunting specter now before me. "Why, then, evoke it? What imp of the perverse drives you upon your fate? Do you not instantly recognize the touch of an amateur or novice in your proper department?" Yes; but we all are amateurs of something. The taste of every expert is severe as to his own profession, "popular" with respect to others, and his half knowledge of the latter may be dearer to his simple heart than a tested mastery of the art which is his handicraft.

Frankly, then, the writer has a hobby; not hitherto a pestilent monomania, interfering with every process of life and work; an innocent hobby, a pet conceit, cherished these twenty years; sometimes brought out and fondled for his own enjoyment and that of his contumacious friends. But often a hobby, after too much license, will assert itself and turn from jest to earnest as suddenly as the slave who was allowed to play at being king. It will fasten upon a man, and keep up a din at his ear, until he is forced to blazon it abroad,—as Mark Twain blazoned Bromley's horse-car poetry,—with the conviction that by no other means can he become rid of it.

So, if it must needs be that hobbies come, woe to that man by whom the hobby cometh! And whose hobby has seemed more pitiful than that of the man with the flying-machine,—the unread mechanic, or the unskilled doctrinaire, who believes himself to have solved the problem of aërial navigation? The writer, indeed, has one plea to offer in his own defense. He was reared in a down-east town, where every boy made his own boats, artillery, water-wheels and wind-mills. Mechanical work has for him an almost rhythmical charm, so that he would like to be an inventor, or even a journeyman mechanic, had not a stronger tendency made him a professional word-wright. The Duc de l'Omelette, in Poe's story, assured his sable antagonist, after beating him at piquet—the stake being the usual one—*que s'il n'eût pas été De l'Omelette il n'aurait point d'objection d'être le Diable.* Moreover, through all these years, I have succeeded in bearing my hobby alone, except as concerns those few companions who, like Job's, have had to share the affliction, and who, again like Job's, have revenged themselves by irreverently chaffing me therefor. Not without reason. A real inventor may be pitied, consoled, or even aided. There is no certainty, after all, that his hobby may not turn up trumps. But a pseudo-inventor,—who undertakes to produce a mechanical work as Leverrier found Neptune, by the *a priori* method,—his is a case which may deserve sympathy but surely never will receive it.

The present outbreak of my complaint is partly due to a second visit, after twenty years absence, to Greenwood Lake,—a sylvan, strangely beautiful locality dear to those lovers of nature who also love to cast their flies for the abundant bass. There, in an unwary moment, a New York journalist, the victim of numberless theories, was admitted to my secret. Forthwith, in "The Graphic," which from the outset he had managed very originally and successfully, always skillfully concealing his pet delusions, he gave some account of my own. But in certain details his statement of the case is not confirmed by my own familiarity with it, and it may be worth while, in the interests of truth, that the precise symptoms should be given to the readers of this magazine.

My confession begins with an episode of twenty years ago. It was late in the summer of 1858 that a hard-worked young fellow passed at Greenwood Lake a vacation,—short indeed, but well remembered, because, like the coat, it was long enough before he got another. After all this lapse of time he still is working hard, and certainly has done few of the brave things whose purpose then kept him in heart under all privations; but I have no other reason for doubting that this hopeful, semi-serious young fellow was my former self.

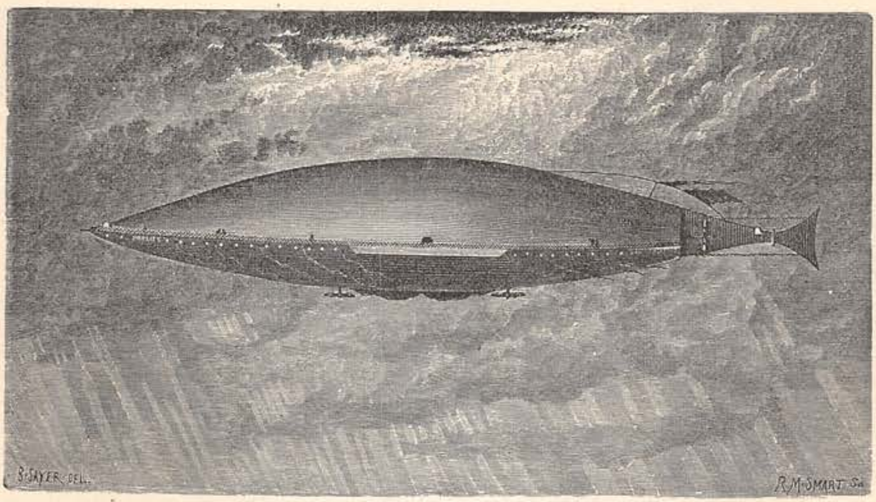
One afternoon, when the air was still and the lake calm in the shadow of the western mountain, I sat in my boat, looking through the clear water above a sandy shoal. Perch and sunfish were moving below, up and down, back and forth, as is their wont. I saw their easy and graceful wanderings, their complete adaptation to the element in which they lived, and called to mind the uselessness and lack of control, of a "balloon ascension" which had taken place near our town lodgings a few weeks before, and which thousands had assembled to witness. The thought occurred to me: "Why don't aëronauts take a hint from the fish, and contrive some means of rising and falling without loss of ballast or ascensive power?" Again: "Why can't they govern the horizontal motion of their floats somewhat after the fashion of these fishes?" This brought me to reflect upon the errors which thus far had made each effort to control the motion of a balloon a failure, and thus I returned to an idea which now took decisive shape—the fish is the true model.

From this belief I never since have varied. Jacob Little once said that "sure information and good bank facilities" would "ruin any speculator." If I had had any time to spare or money to lose, any means of experimenting, it is possible that my new fancy would have added one more to the pallid army of "inventors" who have sunk hope and fortune in the pursuit of some mechanical victory for which the genius was not theirs and the hour had not yet come. As things were, it only led me to make certain memoranda; first, of the reasons why aëronautics had been a failure; secondly, of the methods which, it seemed to me, should be followed to insure even a measurable success. These notes were accompanied by rude diagrams, —some of which I still possess—illustrating my ideas with respect to the form and mechanical requirements of the air-ship of the future.

These notes and diagrams form the basis of the present article. As here given they are modified in detail by later ideas, partly my own, partly the conceptions of practical aëronauts. But all the modifications are in accordance with the original thought—"the fish is the true model."

For a long time subsequent to the preparation of my early notes, little was invented that stimulated me to active interest in their topic. Nine years ago I found an amused listener in Doctor Sanford B. Hunt, and one sufficiently concerned to make a statement of my views, idealized by his own persistent fancy, in the Newark "Advertiser," of which he is the accomplished leader-writer. I forget how long ago it was that the term "cigar-shaped" first was used in popular descriptions of Winans's and other structures for submarine navigation. But when this phrase, ten years since, began to be applied to experiments in the making of aërostats, I felt that here was the first step toward the demonstration of my theory. Others have been taken, to which reference shall be made, and these so important that I believe a correct method will be adopted in our future attempts to navigate the atmosphere. Some little impetus or encouragement may be given to such attempts by the publication of even a purely theoretical article. At all events, I venture to print the notes and diagrams of which the origin now has been told, pointing out the ideas gained from the experiments of recent inventors whose designs have for me a significance in exact ratio with their approach to the theory herein set forth.

First, then, the preliminary memorandum of various



AËRONON OF THE TWENTIETH CENTURY. (SEE PAGE 580.)

CAUSES OF OUR FAILURE TO NAVIGATE THE AIR.

A. D. 1858. For seventy-five years after De Rozier, at Paris in 1783, had made the first balloon ascension, no point was gained in the practice of aëronautics beyond the substitution of hydrogen for heated air as a means of buoyancy. This was done in that same year by two Americans, Rittenhouse and Hopkins. Hundreds of balloons, large and small, have since been constructed upon a single model. No success has followed any attempt to guide the horizontal motion of these colossal playthings, except that afforded by the capricious air-currents which the balloon is made to seek by unphilosophical and temporary modes. The failure is due to certain causes :

1. The balloon only proved the fact that man, by its use, can float in the atmosphere. It is just what the French term it, an *aërostat*—a thing which can for a while sustain itself and its freight above the ground. The voyager prolongs his elevation only by losing ballast. He returns to earth at will, only by a loss of the gas which is the balloon's sustainer. Moreover, the covering of balloons is defective. In a brief time the gas escapes through its interstices, and it becomes unserviceable.

2. The globular shape of the balloon, and the method of attaching the voyager's "car," would balk his attempt to guide the whole, if a motive power were available and proper machinery had been devised.

A fish in the shape of an inflated bladder, with tiny fins suspended by a cord below, would be less helpless in the water than our balloon in the air. The motors thus far applied have been absurdly inadequate, and have worked at the extreme of disadvantage, attached to aërostats by long and flexible connections.

3. Aëronauts and theorists have been misled by the term "air-ship" and by other misnomers. A ship is partly in water, an inelastic fluid, and partly in the elastic air, and is propelled in the one by the other. The very elasticity of the air requires the perfect co-ordination of all portions of the vessel to be guided through it, and de-

mands a radical change in the traditional structure and material of the balloon.

4. Birds and winged insects have organisms which enable them to move through the air with a celerity proportionate to the tenuity of that element, and with a grace and freedom of which the secret is still open to investigation.* This has led the shrewdest theorists, and many inventors shrewd or silly,—having in mind the bird's greater weight than that of the volume of air which it displaces,—to claim that a proportional specific gravity is essential to the success of a "flying-machine," and to adopt the bird as a model. But Dædalus, thus far, has found no successful imitators, albeit many have tried to fly with artificial wings and have lost their limbs or lives in the attempt. All machines, similarly equipped, have been utter failures, in consequence: (1) of our inability to construct a machine combining sufficient strength and motive power for sustained or controllable flight (even the inventors' models of such structures quickly fly to pieces); (2) of the vibratory, irregular, eccentric quality inherent in a bird's flight.

Various hints, however, may be gained from the bird, one of which relates to the structure of the frame and machinery of a vessel that shall navigate the atmosphere. *The hollow bones of the bird furnish the natural model for the union of lightness and strength in aërial mechanics.*

5. What is the best motive power for the machinery to govern and propel an air-ship? and what is the best metal for the construction of such machinery? are still undetermined problems. Few experiments have been made for their solution. If sufficient power, compared with weight, could be obtained from a steam-engine, the peril of using fire as a motor for a vessel buoyed by inflammable gas is sufficiently obvious. What is the best material for the frame of an air-ship? How can the greatest lightness and strength be attained both in the machinery and in the vessel itself? Of what should the envelope of the aërostat be composed? These, and a score of important questions, await an answer.

6. In other words, there has been no deliberate and scientific endeavor to navigate the air. The want of a philosophical method on the part of inventors has been a radical cause of failure. Modern engineering has applied its wonderful resources, its trained skill, in all other directions, contemptuously leaving the most important to unlearned "aëronauts,"—each of whom has profited little by the experiments of his predecessors. Their projects have been so irrational and pretentious, and their failures so ludicrous, that the public—of late ever ready to do justice to the possibilities of man's inventive faculty—looks with indifference or hopelessness upon any fresh announcement of a plan to navigate the air.

7. The few, therefore, who have given financial aid toward the solution of our problem, have done so in a faltering and strangely inadequate manner. They have spent hundreds of dollars, at most a few thousands, where tens or hundreds of thousands would seem to be required. The aëronauts themselves have had small means, just enough to construct their fragile aërostats, fill them with cheap gas, and experiment upon the currents of the atmosphere. Scientific excursions for meteorological study have been made in these ordinary balloons. How differently capitalists have worked in other matters, devoting fortunes to corporate mining explorations, or investing millions in new railways—of which so many must come to naught!

My notes under this head ended with a reference to Captain Ericsson's invention, then a recent one, of the caloric engine for marine propulsion. While its economical success was still an open question (since decided adversely) he was able to test it in a steamer built for him at great cost. That half a million dollars could be raised for a possible extension of man's domain upon the sea showed that when the conditions are understood, or even imagined, capital is never wanting. To achieve a true aëronautic victory, to solve the noblest of mechanical problems,—the conquest of the upper element,—paltry sums have been devoted, scarcely sufficient to pay for a year's preliminary investigation by a corps of professional engineers.

To offset the discouragement resulting from previous failures, due to these causes, remained the undeniable statement that there is nothing in nature against the solution of the aëronautic problem. It involves no *reductio ad absurdum*, requires no new and undiscovered principle. It is purely a

* 1878. Doctor Pettigrew's modern analysis of the action of the bird's wing and of the motions of flying creatures has been close and scientific, and his elastic artificial wings have demonstrated its accuracy. See his treatise, "Animal Locomotion," etc. (International Scientific Series, N. Y., 1874), pages 235—258.

mechanical problem—demanding new mechanical combinations, an advance in control of mechanical power, possibly an increase in the production of certain materials, certainly a novel constructive ingenuity. The problem can be solved, and at this stage of civilization should be treated no longer with cowardice or contempt.*

My analysis of the causes of failure resulted, as has been said, in an effort to make an *a priori* statement of the elements requisite for aëronautic success, and to prepare a few diagrams illustrating it.

The following points are based upon my early memorandum of

WHAT IS ESSENTIAL TO A SOLUTION OF THE PROBLEM:

1. *Nature of the Structure.* Put out of mind the shape and uses of the old balloon, with its basket attachment, and its one quality of buoyant power. What is wanted is not a simple aërostat,—the name of which describes its fixed and helpless character,—but an *air-traveler*, a structure that can be guided upon a level, and can range the atmosphere† at the voyager's will. Forego attempts to construct a flying-machine, even though this may seem based upon a more obvious analogy with the processes by which art has imitated the motions of animals upon the land and in the sea.

2. *Best Model in Nature.* Take it from the fish. Exact imitation is not the method of mechanics. But as some form of the screw propeller, for instance, is an improvement upon the fish's tail, for uniform and unbroken power, so the principle of any natural motor can be sought out, and applied with precision in engineering.‡

The aërobat must pursue its way, not as a bird flies, but as a fish moves through the water. Each is wholly immersed in its own element. The fish effects a less "displacement," but has a greater "resistance" to encounter. To offset this, its motive organs have an inelastic and denser medium upon which to work. The average of compensation to the natural motor probably is not far from the same in both elements. But we repeat that the bird, a body vastly heavier than the air it displaces, sustains itself by varied forces of which even its weight is one; and these cannot be solely depended upon by an artificial body, whose ratio of weight to displacement is the same.

The aërobat, like the fish, of a specific gravity slightly less than the displacement it effects, profits by its "buoyant equipoise," and is adapted to the limits of human invention, which can apply the principle by which a fish resists currents and moves with ease and speed.§

3. *Specific Gravity.* It must, then, resemble its model in being so delicately upheld that the slightest motive power will elevate or depress it. There must be no actual loss

* "That the tramway of the air may and will be traversed by man's ingenuity at some period or other, is, reasoning from analogy and the nature of things, equally certain. * * * The materials and forces employed in flight are literally the same as those employed in walking and swimming. * * The same elements and forces employed in constructing locomotives and steamboats may, and probably will, at no distant period, be successfully employed in constructing flying-machines. Flight is purely a mechanical problem."—*Pettigrew.*

† 1878. The term *aërostat* (ἀήρ—ἱσταναι) cannot be applied to such a structure, as it describes a vessel which *stands,* or is upheld in the air: precisely this and nothing more. Feeling the need of a new word, properly formed, that shall describe a vessel capable of propulsion and guidance, I recently have sought the aid of various Greek scholars, and have received from them many noteworthy and curious suggestions. But nothing has been proposed which seems to me so terse, so apt for common use, and so logically correct in application, as the exact converse of "aërostat," namely, *aërobat* (ἀήρ—βαίνειν), meaning that which can *go,* as opposed to that which only can stand, in the air. For purposes of convenience and consistency, I shall venture to employ the new word in this article, and shall make use of "aërostat" to designate only the gas-reservoir of my structure. —P.S. See note on page 580.

‡ 1878. To quote again from Pettigrew: "It is the blending of natural and artificial progression in theory and practice which gives to the one and the other its chief charm. * * The wheel of the locomotive and the screw of the steam-ship apparently greatly differ from the limb of the quadruped, the fin of the fish, and the wing of the bird; but the curves which go to form the wheel and the screw are found in the traveling surfaces of all animals, whether they be limbs (furnished with feet), or fins, or wings." Despite these words, Dr. Pettigrew, when he comes to the question of aërial navigation, would restrict our efforts to an imitation and adoption *of the bird's wings;* indorsing the rigid theory that "as no bird is lighter than the air, no machine constructed to navigate it should aim at being specifically lighter." He demands a flying machine, and nothing else. So far as entire dependence upon "weight" and "artificial wings" is concerned, the theory of my article is in opposition to this recent and eminent authority. I do not deny that "flying-machines" can be devised, but doubt their utility. Whether rendered possible, or not, by the discoveries of Pettigrew and others, I was not and am not seeking for the principles of their construction.

§ 1878. The latest torpedo-boats illustrate the ability of mechanics to utilize the shape and motive principle of the fish in his own element, and furnish the submarine analogue of what the aërobat should be in the atmosphere.

of buoyant quality, nor of weight. It must *swim*, so to speak, up or down, to change its level, or seek a new current of air.

4. *Unity of Design.* Above all, it must, like the fish, contain its machinery, power, freight, *within itself;* must be an integral structure, not two bodies joined by links, rigid or flexible; not an aërostat with an appendage.

5. *Form.* The resistance of air to a moving body is proportional to the square of the velocity. This is increased by the circumstance of its elasticity; it becomes condensed in front of a moving body, and the latter, therefore, should be so shaped as to effect the minimum of condensation. Hence the conical front of a minie-ball. Water is inelastic; but the elliptic shape of the fish, which enables it to cleave the water, chances to be that which also is adapted to a body constructed for rapid motion through the air. To be more exact, modifications of the parabolic conoid should furnish the outlines of the aërobat's prow.

No organism so well opposes a current as that of the fish. Swift and strong birds are beaten back before a storm; the wind gets under them and above them, doubles up their wings, whirls them sidewise and over and over. Few water-currents resist the fish, with its wedge-like shape and its freedom from outlying impediments. Sportsmen know the motive qualities of the trout, which lies with his head to the current, darts up the swiftest rapids, and even *lifts himself upon the sheet of a water-fall*, when the descent is not so great as to break the torrent into spray. The salmon has even greater strength compared with his size. Observe a pickerel, the clipper of our ponds and streams, lying motionless above a stagnant bottom. Suddenly he disappears, like a phantom; a tiny cloud of dust in the wave assures you that he was there, has moved, and is gone. Ten feet away you rediscover him, lying just as motionless. His change of base was so swift that the eye could not follow the movement. The great ocean fishes have proportional speed. The shark and porpoise play around the bows of the swiftest steamers. The whale can move like a railroad train; and even the clumsy sea-lions can swim at the rate of fourteen miles an hour.

6. *Motive Power.* The fish, it is true, uses not only fin and tail, but a flexible body, to proceed by sinuous wavings, and is a motor in itself. But the pointed shape of the aërobat certainly renders it worth while to calculate the following problems: Given side vans or a screw of a certain size, to find the number of strokes or revolutions required to overcome the resistance of the vessel's beak to an opposing current of a given velocity; and again: To find a motor of sufficient power, compared with its weight, to produce these revolutions. I believe that the most improved modern steam-engine, compact and economical of power, would suffice for this, under the conditions of the proposed vessel. But then there are the dangers of heat and fire. Progress is making in the construction of the electric engine, and as soon as its ratio of weight to power shall be as favorable as that of the steam-engine, the question of a motor will be solved.

7. *Buoyant Equipoise.* The aërial vessel to have a buoyancy scarcely lighter than the air which it displaces. Ballasted so as to *float* at a short distance above the earth. For change of elevation to depend upon its motor.

To produce this buoyancy, with the greatest economy of size, it must use no carbureted hydrogen (coal-gas), but the purest hydrogen obtainable by chemical process. Pure hydrogen is fourteen and one-half times lighter than air. Aëronauts succeed, by clumsy appliances, in filling their balloons from retorts with an article six times lighter than air, having a lifting power of about one ounce to the cubic foot. With care, hydrogen gas can be made so free from admixture as to be nine times lighter than air, or even purer. Replenishment being seldom needed,* the increased expense of the purer article will be of small account. Possibly a non-explosive gas of equal lightness will be discovered. This, also, would of itself solve the atmospheric problem.†

8. *Structure and Material.* The aërobat to present the appearance of a prolonged curvilinear body, its length several times its height amidships, the latter exceeding its width of beam. The frame-work of this structure to converge above and below from a light, but unyielding, skeleton-deck, reaching from stem to stern, which also is the support of the machinery and cargo. The

* 1878. This year a covering has been invented so impervious to leakage of gas that it has been adopted by the British military authorities. It is stated, also, that after three months' use of the great captive balloon at the Paris Exposition, there has been no measurable loss of gas, and the varnish and white zinc upon the coats of linen, muslin, and gutta-percha are intact.

† The topics of motive power and buoyancy will be resumed elsewhere in this article.

aërostat thus will be divided into upper and lower chambers, the former being considerably the larger; these, however, to be connected by open passages, so that both will constitute a single reservoir of gas.

The materials used for the structure, its covering and appurtenances, to be as light and strong as possible. Frame-work of steel, brass, or bronze tubing, large and small. Covering of the aërostat to be very light, very rigid, impervious to gaseous filtration. Ultimately such structures will be made so large as to permit the use of a copper, or other metallic covering. Its greater surface, I repeat, to be rigid and inflexible; but at the lower vertex a portion must be of some flexible material, and even in folds, to allow for a certain amount of expansion and contraction, at different altitudes and temperatures. This amount will be reduced to a minimum by the use of a gas-condenser.

9. *Safety.* Thus made and buoyed, accidents should be rare. But a plan must be devised which, in case of a sudden loss of buoyant power, will convert the structure itself into a parachute, and enable it to reach the ground with safety.

10. *Center of Gravity.* Of course, under all circumstances, even in case of accident, the vessel must remain right side up. The location of the machinery, passenger-chambers, etc., at and below the deck-line, and the free passage of gas between the upper and lower portions of the aërostat, readily can be made to preserve the true center of gravity.

11. *Steering.* This may be effected in various ways: by a stern-rudder, with vans crossing at right angles; by vans at the sides, etc. Given the means of propulsion, and of ascent and descent, and the matter of guidance presents few difficulties.

12. *Field of Motion.* The aërobat naturally will avail itself of favoring currents, when practicable, and the science of meteorology will be utilized. When possible, the course of the structure to be comparatively near the ground,—just high enough to clear natural and artificial obstructions. It can be steered up and over the slopes of mountain ranges. A strong head-breeze would force it to seek a different elevation. As it rises, the condenser will come in play, and, on descent, the gas thus withdrawn may be restored to the aërostat. Officers and crew will know how to allow for lee-way with a wind on bow, beam, or quarter, how to make the most of a fair current, or to avoid a foul one. Each man will have his allotted task and station, and everything will be managed in a skilled, professional way.

13. *Dimensions and Outlay.* A common-sense view must be taken of the outlay required. Capital builds immense ships at vast expense, equips them munificently, mans them with educated officers and adequate crews. Similar ventures must be made to initiate fairly the conquest of the air. From the nature of that element, a beginner cannot start with a toy aërobat as the first sailor pushed off on his raft. The thing must be done on a large scale. It will be, as soon as the first practical demonstration shall have been made on the smallest scale permitted by the nature of things. The vessel making such a demonstration will be considered nothing but a "working model," when aërobats shall be constructed with a liberality proportioned to the dimensions, materials, power, safety, and general qualities, indicated under the previous heads. The question, after all, is one of purpose and means. Just as I believe the North Pole could be reached, or the Isthmus of Darien cut through, if the first order of professional talent were commanded to undertake either job, and equipped with every resource, so I doubt not that many engineers are living now, who, if given *carte blanche*, and stimulated by governments or corporations to exert their highest energies, could solve the aërial problem upon the principles suggested in this memorandum, and would require no very long time either.

The diagrams, which I entertained myself with drawing, to illustrate the foregoing notes, represent an aërial vessel similar in general structure to the design in the frontispiece of this article. But, in 1858, the properties of the screw-propeller not being so well understood as now, one mode of propulsion then occurring to me was by side vans, revolving horizontally, and so arranged as not to oppose the air during the forward half of their revolution. Another device was the use of two valvular vans on each side, oscillating back and forth, the valves of each closing on the backward stroke and opening on the forward. This involved one principle common to both fin and wing. In order that there should be no cessation of the stroke, the two vans, on each side, were made to work with opposing movements, so that the valves of one or the other should always strike the air.

These and other means of applying the motive power seemed cumbrous and intricate. Some years afterward, Nadir, in Paris, taking up an old theory, proposed to guide the car of his aërostat by vans revolving on

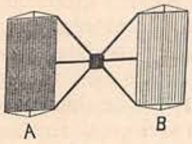


FIG. 1.

A, Retreating Van. B, Van moving forward, with open valves.

the principle of the screw. Nothing came of it, I believe, but, my attention thus being directed to the subject, I learned that no human invention so truly acts upon the principle of animal motion as the screw.

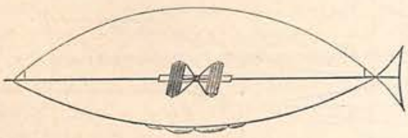


FIG. 2.

Fig. 2 represents the outline of a diagram with the foregoing arrangement.

(As Pettigrew has phrased it, "The tail of the fish, the wing of the bird, and the extremity of the biped and quadruped are screws structurally and functionally.") No other is so fitted to propel a vessel wholly immersed in water or in air. After much discussion by David and other theorists, Dupuy de Lôme, in 1872, made an experiment, attaching to the car of his balloon a screw, which eight men worked with a capstan. Under the conditions, this resembled an attempt of "the tail to wag the dog." Some progress, however, was made, and the course of the balloon altered by 12° in a windy day. These and other events convinced me that the screw, or a combination of screws, revolving with a rapidity proportioned to the resisting surface of the aërobat, must be the true propeller. The elastic quality and tenuity of the air, permit an immensely swifter revolution on the part of the aërial screw than can be made effective in the water; and Pettigrew since has very clearly shown that by following the "waved-track," or "figure-of-8" principle, there is scarcely any limit to the "effective speed."

At first, also, I relied on the rudder and condenser for change of altitude, which, so far as the former was concerned, could be effective only in prolonged inclined planes. But from the date of Cayley's experiments, near the close of the last century, attention has been called to the use of the screw as a means of ascent and descent. Last summer, Ritchell's experiment, to which I shall again refer, gave visible proof that an aërostat, in a state of equipoise, can be raised and lowered with precision by a vertical screw, and with trifling outlay of power. In

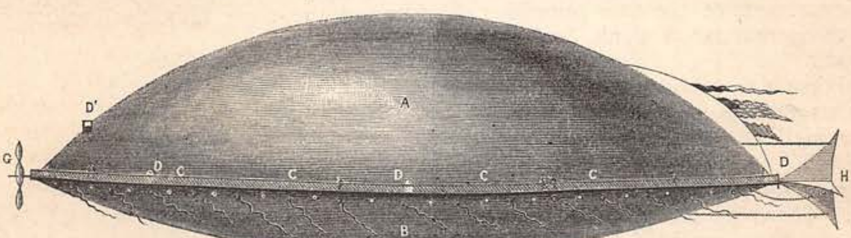


FIG. 3.

OUTLINE IN PERSPECTIVE.

A, Upper section of aërostat, the covering rigid and inelastic. B, Lower section of the same. C, C, C, C, Netted railing and passage-way around the vessel. This also indicates the line of the bow-shaped metallic tubes, united fore and aft, which form the "deck" of the structure, and are cross-braced for the support of the machinery, etc. From the deck, light and strong ties and braces converge above and below. Beneath the outer railing are the port-holes of a narrow chambered gallery for passengers, express freight, etc. D, Lookout station, reached by a cylindrical passage from shaft gallery. D, D, D, Lookout stations. These, as well as D, at night display the electric light. E, E, Flexible, elastic portion of the aërostat, in folds, adapted for expansion and contraction. F, Horizontal wave screw, attached to vertical shaft, for change of altitude and buoyant power. G, Main screw. H, Duplex rudder. Dimensions: length, exclusive of screw and rudder, 300 feet; height, amidships, 100 feet; width, 66.66 feet; total volume, 799.200 cubic feet; space allowance for machinery, galleries, etc., 39.200 feet; net capacity of aërostat or gas reservoir, 760,000 feet; lifting power of its contents, $\frac{18}{29}$ pure, 51,848 pounds.

the diagrams illustrating my amended designs, with various applications of motive power, this contrivance is adopted with due credit to those aëronauts who have given practical demonstration of its use.

In the selection from these diagrams, which is similar to the design in the frontispiece. the propelling-screw is at the prow, instead of the stern of the aërobat—an arrangement that some engineers prefer, and which, at least, gives freedom of action to the rudder. This is merely for example's sake, it being quite probable that screws fore and aft, or twin-screws, or a combination of such propellers at prow or stern, will be required for the control and movement of our structure. But with the aid of this drawing my general views, already expressed, of the true principles of aërial navigation can, I think, be fairly understood.

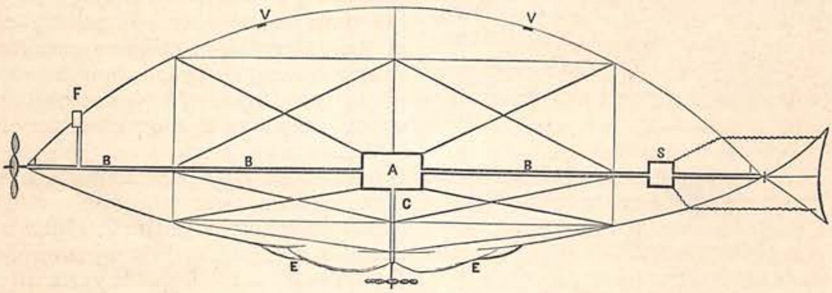


FIG. 4.

LONGITUDINAL SECTION.

A, Engine room. B, B, B, Longitudinal alley, for shafting, etc., etc. C, Well, inclosing vertical shaft. E, E, Flexible portion of covering. F, Lookout station. V, V, Valves. S, Steerage.

Doubtless a vessel of this shape, after the earlier stages of navigation, will be considered a kind of "Dutch bottom," a very clumsy affair, its width being two-thirds of its height, and its height one-third of its length. These are the proportions of the slower and more stupid fishes. From the measurements of various individuals of the following species, an approximate statement of their dimensions* has been obtained: Sun-fish—Height: Length : : 1 : 2. Sheepshead—H : L : : 1 : 2.33. Black bass—H : L : : 1 : 3. Striped bass—H : L : : 1 : 3.67. Yellow perch—H : L : : 1 : 3.75. Trout—H : L : : 1 : 4. Salmon—H : L : : 1 : 4.50. Spanish mackerel—H : L : : 1 : 5.50. Muscalonge—H : L : : 1 : 5.50. Great pickerel—H : L : : 1 : 6.

Ultimately, the shape of the aërobat clipper will more readily be indicated by the last than by the third of these measurements.

Metallic tubing will combine the lightness and strength requisite for the framework of the aërobat. On each side, within the lower section of the aërostat, depending from the main elliptic frames, a long narrow gallery will accommodate passengers and freight. This, like all dependent portions of the structure, to be made of the lightest wickerwork, wood-work, rope-work consistent with the strength required. *Papier-maché* and kindred material will be liberally used. Narrow alleys for shafting and passage-way will run from stem to stern and across the beam, leading, of course, to a central engine-room and a small steerage chamber.

Figure 5 is a vertical section, amidships, showing the cross alley, the position of the

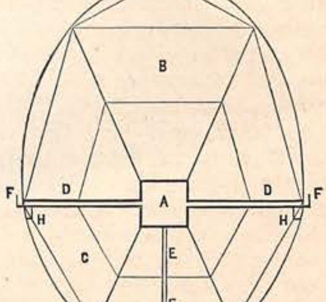


FIG. 5.

CROSS SECTION.

A, Engine room. B, Upper section of aërostat. C, Lower section. D, D, Transverse passage. E, E, Vertical well. F, F, External railing. H, H, Dependent interior galleries. I, I, Flexible portion of covering.

* Exclusive of the tail in each case.

external railing and of the slender galleries dependent from the elliptic frame.

For the covering, no less than in the machinery and frame-work, "lightness and strength" must be the constant watch-word. To successfully resist the wind, and preserve the integral nature of the whole structure, its envelope should be rigid and unyielding. For the smallest aërobats probably the new compound cloth-covering, zinc-varnished, would suffice, if made stiff and strong. For the larger, thin metallic sheathing would be required, the portion covering the structure forward of the beam to be made especially strong, like the armored head of a fish. All the internal stays, ties, braces to be made of strong but delicate metallic rods, wire and tubing.

Some years after I began to think of this subject, I fell into conversation with an intelligent machinist, the chance companion of a railway trip. He remarked that he thought the solution of our problem might depend upon the increased production of aluminium—then a comparatively new metal.

This, one of the most abundant of metals, is so difficult of extraction from the clay that the cost at that time was $1.80 per ounce. By 1867 it was obtained through an improved process from cryolite, at a cost of $0.90 per ounce. Recent authorities quote the cost of manufacture as low as $4. a pound. Its specific gravity, when hammered and rolled till strong as iron or stronger, compares with that of iron and copper as 2.67 to 7.78 and 8.78 respectively. It is, therefore but one-third as heavy as the lighter of these metals, and even weighs less than glass. There are signs that it yet will be produced so cheaply as to be useful for much of the jointed frame-work of our structure, and for portions of the machinery not subject to excessive heat. But though it cost its weight in silver, it might well be afforded, if by its use a structure could be made to navigate the air.

Aluminium bronze, ten parts aluminium and ninety parts copper, has a specific gravity of only 7.69. It is three times more rigid than gun-metal, and forty-four times more so than brass; and, in consequence of its transverse, tensile and elastic strength, exceedingly strong tubing and rods could be made of it, at a vast economy of structural weight.

The lower extremity of the envelope to be of flexible material, in loose folds. Here an automatic safety-valve may be adjusted. Ordinary valves to be placed in the roof of the envelope, for use in emergencies.

The motive power to be applied by the most compact and improved machinery. The electric engine will be required, and is now so well advanced that it should provide the necessary power. Electricity, in fact, will be as indispensable to the aërobat as to one of Jules Verne's imaginary structures. The electric light will flash from its lookout station, and illuminate the inner galleries; while the steering and propulsion will be governed by electric signals from the pilot and other officers at their various posts.

For the purpose of illustration, only one form of the aërobat has thus far been shown, to wit: that in which the screw is located at the prow. But experiment must determine, I repeat, the size, shape, and best position of the screw or screws. If placed at the stern, horizontal vans may be used at the sides for safety and steadiness, as applied to a recent submarine vessel. Or perpendicular vans could be used for steering, in this wise:

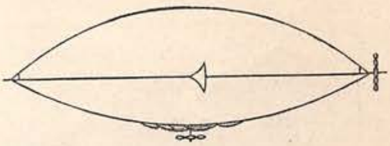


FIG. 6.

But my opinion is that the very best arrangement will be the use of *twin screws*, one under each quarter, the vessel being guided by a rudder at the stern, as in the following diagram:

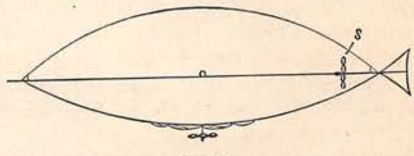


FIG. 7.

The greater proportion of resistant surface offered to a current by the aërobat would of itself prevent it from exhibiting the fish's ratio of speed to dimensions. Besides, motion is not at all proportionate to size in living or artificial organisms. If it were, the aërobat might go round the world in a day. Its propeller must be swift and strong.* As

* Pettigrew's compound arrangement of blades upon the principle of his "aërial twin screw," is claimed to make a powerful elastic propeller, both in water and in air. Whether it is not an attempt to imitate nature too directly, and whether its yielding quality can be utilized in violent currents and storms, must be determined by practice. On the whole, I think that a screw not very different from that proposed by this investigator will be found the best for aërial propulsion, and would refer the reader to the American edition of his treatise, pp. 256, 257.

I have said, the problems of its form and revolutions, and of the resistance to be overcome, will be scientifically calculated.

The blades of the propellers to be light and sturdy frames, rigged with prepared canvas, drum-head leather, or equally serviceable material.

Equipped with the vertical screw, an aërobat will not absolutely require any guide more complex than a simple fan-tailed rudder, to control its horizontal motion. But for sudden and slight deflections from either its horizontal or its vertical course, the rudder to which I give the name of "dart" or "duplex" is well adapted. It is an old and obvious contrivance which never has been effectively used, since no aërostat thus far has been supplied with adequate motive power.

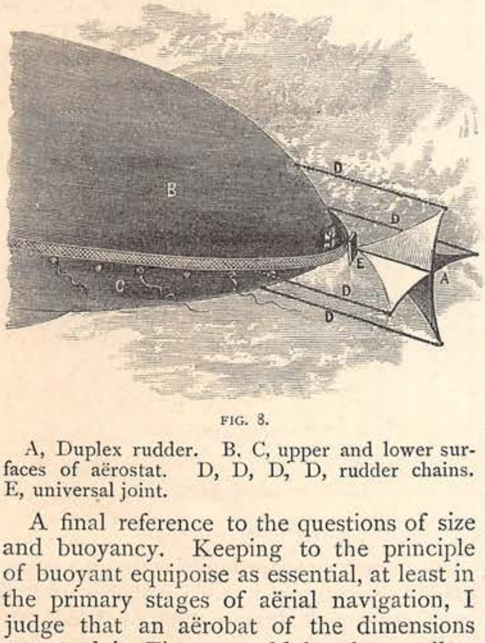


FIG. 8.

A, Duplex rudder. B. C, upper and lower surfaces of aërostat. D, D, D, D, rudder chains. E, universal joint.

A final reference to the questions of size and buoyancy. Keeping to the principle of buoyant equipoise as essential, at least in the primary stages of aërial navigation, I judge that an aërobat of the dimensions proposed in Fig. 3 would be the smallest that could be made of rigid material and propelled by a vigorous motor. And a vessel so proportioned would require the minimum of aid from its vertical screw, and demand the maximum from its propeller. The line of improvement would be in the direction of a sufficient gain in mechanical power to enable the vertical screw or screws to play a more important part in upholding the structure. This would decrease the *volume* of the gas-reservoir, and make the work of the horizontal propeller less arduous. In fine, aërobats at first will depend largely upon their structural buoyancy, improving through increase of lifting and propelling mechanical power, and through a corresponding decrease of resisting surface, as time goes by. This advance finally should be so great as to fully meet the views of theorists who claim that atmospheric navigation can be effected only by a machine far heavier than the air which it displaces.

So far as concerns the aërostat charged with hydrogen gas, the buoyancy increases as the product of the axes, and hence at a much greater rate than the resistance to progression. The former constantly gains on the latter. The dimensions given under Fig. 3 are not so large as they seem. The balloon constructed by the proprietors of the "Graphic" was able to contain 400,000 cubic feet of gas, with a lifting power of 14,000 pounds. Our aërobat (1), dimensions 66.66 x 100 x 300, with a net capacity of 760,000 cubic feet, the gas being one-sixth the weight of common air, will lift, including its own weight, 48,695 pounds=21.74 gross tons; or, as already given, the gas being $\frac{18}{29}$ pure, 51,848 pounds=23.10 gross tons. Increase the dimensions slightly, and the lifting power is greatly enlarged. For example: an aërobat (2), dimensions 80 x 120 x 360, will have a gross capacity of 1,382,400 cubic feet. Space allowance for chambers, alleys, etc., 62,400 feet. Net capacity, 1,320,000 feet. Lifting power—the gas being one-sixth the weight of air—84,578 pounds=37.76 gross tons; or, the gas being $\frac{18}{29}$ pure, 90,052 pounds=40.20 gross tons.*

These dimensions, I think, would make it possible to construct the primitive aërobats largely of metal, and to equip them with machinery sufficient for their propulsion, even at the present stage of applied mechanical power. Given, a speed of fifty miles an hour in calm weather, and against a head-wind of thirty miles an hour a progress of twenty miles would be made. With a favorable wind of the same force, the aërobat would travel eighty miles an hour, and reach Europe in a day and a half. But good luck and bad luck, fair weather and foul, fortune and wreck, must come by turns to the best of man's artificial conveyances, guided by his highest skill and heroism, whether on the land or sea, and as surely in the navigable air.

There are no absolute reasons why an

* So long ago as 1864, M. David made the rapid increase of buoyant volume, compared with enlargement of resisting surface, the basis of a strong argument in favor of increasing the size of aërostats designed for artificial propulsion.

aërobat should not have a width much greater than its height. Such a structure would be an automatic parachute, and could be made safe beyond peradventure. But on most accounts the shape already illustrated is preferable, and aërobats thus modeled will be equipped with a light external covering, arranged for expansion in case of accident and able to break the force of a descent to the earth's surface.

But I am not an engineer (" No need to tell us that! " the reader who *is* an engineer will say) and more safely may leave specific details to the arithmeticians. To use the patent agent's phrase, " what I claim " as my invention rests upon the following basis:

1. Model in nature, with respect to shape, motion, power and buoyancy—the fish.

2. The unity, integral quality, freedom from external impediments, of the whole structure. And therefore,

3. Rigidity and compactness of its architecture.

4. Buoyant equipoise; with preservation of the contents of the aërostat.

Having so long unfulfilled a purpose to put these notions at some time into print, it has required, I say, not only the pen of my friendly journalist, but a series of events to prick the sides of my intent. Each practical advance that has been made in the art of aërobatics, or toward the creation of such an art, has been upon the line of my early theories. The suggestion of the cigar-shaped aërostat, in France, and its adoption in America by Dr. Andrews and others, however little came of it, was a step forward. The " parabolic-spindle," or some modification of it, is the true form.

Ritchell's experiments, in Connecticut and elsewhere, as illustrated in " The Graphic " and " Harper's Weekly," were in every sense noteworthy. They involved the ideas of buoyant equipoise, the use of vans upon the principle of the screw for ascent and descent, and for horizontal propulsion. His experiments at least proved these ideas to be sound. Allowing for the cumbrous shape of his aërostat,—a cylinder with blunted ends,—for the division between it and its motor, and for the diminutive scale of the whole structure, he made an important demonstration.

Shortly afterward " The Sun " and " The Tribune " published accounts of the aërial vessel designed by Mr. Schroeder. This is to be spindle-shaped, driven by a screw, and sufficiently large to carry an electric engine in its gondola or car. The projector, it is said, relies upon side-vans acting like wings for the power required to utilize the buoyant equipoise of his aërostat and cause it to ascend. I do not believe that these can compete with the vertical screws. But in a different respect he proposes to make a notable advance. His car is to be shaped like the aërostat, and so closely and firmly attached thereto as to make the structure almost an integral body. I have not learned what progress, if any, Mr. Schroeder is making in the construction of such a vessel, but do not hesitate to say that its design, though imperfect, is more philosophical than any other of which I have heard; and that if he really has the skill and means to carry it out there is no reason why he should not prove himself the Disraeli of aëronauts and treat the community to a genuine " surprise." At all events his project and the experiment of Mr. Ritchell are signs of the times, full of significance to one who, like myself, ventures to believe in aërial navigation, and that its coming is nigh at hand.

RESULTS OF A SOLUTION OF THE PROBLEM.

In this belief, having ended the toilsome and venturous portion of our treatise, I will make a brief excursion outside the liberties of mechanical suggestion. What follows may seem but a day-dream—one of those visions

> " Which are the children of an idle brain,
> Begot of nothing but pure fantasy."

Yet an inventor's, or a poet's, dream may be true, if not to what has been, at least to what may be,—and hence not utterly wanting in a sage's wisdom. If not within the bounds of nature, we may be sure it will not long illude.

Moreover, dreaming and castle-building are the inventor's sustenance, the poet's diet, the poor man's riches, the delight of childhood, the solace and respite of a weary and often-baffled middle-life. It is the noble discontent of eager souls which sighs for what is not; but even at life's meridian one should look before rather than after. Let us set our thoughts toward the future, and forget our own helplessness in the youth and promise of the race. Who has not lived to find some of his dreams coming to pass—earlier, it may be, than he had thought? For one, I have a hundred dreams; one of them the always unfulfilled design of work so often studied in my brain that it seems already done; others in plenty of what may—of what will—distinguish the growth and destiny of the world to which we belong. And of all these last, none so broad in scope and alluring in promise as that of the results to follow the accomplishment of aërial navigation.

"Be fruitful and multiply, and replenish the earth, and *subdue* it." Man never has lost sight of the task committed to him. The depths of the ocean and the breadth of the land are under his dominion, and there scarcely is

—"a waste unknown,
From the fierce tropic to the frozen zone."

But there is one element unsubdued, wholly beyond his control, though it lends itself to waft his ships and turn his wind-mills, and anon to wreck them both. Possibly we are beginning to catch some notion of its courses and conditions. But still the air is the archbishop's "chartered libertine," the one unmastered rover. And what an element it is! Everywhere abounding, covering one all over like a cloak, earth's garment, man's aureola, in which he moves, breathes, and has his being; the most delicate, the strongest of all; invisible, yet making all things plain; light, yet pressing everywhere; elusive, yet waiting to be overcome, and to confer gifts upon its sovereign beyond his most extravagant conjecture!

Suppose the conquest of the air to be achieved, its secret found; suppose that men were free to have their will of it.

Result—freedom, illimitable freedom; freedom of movement, government, thought, of life in its widest possibilities and boundless range. A race must attain majority to have the skill for such a conquest, and with majority comes the right to such freedom. Earlier, it would be a fatal gift.

"What," I often ask, "will be the first and obvious effect of aërial navigation?"

To many answers, apposite or otherwise, I have added my own:

"Decatur, Illinois, will become a sea-port town."

"How a sea-port town? And why Decatur?"

Why Decatur, to be sure, more than any other city, or, indeed, any desert oasis or mountain peak? I say Decatur, because that place will do for an example of the dependent inland towns, impossible before the building of railways, inaccessible except for their construction. The smallest, the most remote, of them all will at once become sea-ports. The air will be the ocean; or, rather, let us say, that ethereal ocean, the atmosphere, at last having been utilized and made available for the commerce, the travel, the swift running to and fro of men, every spot of this globe will be a building-site, every acre a harbor, every open space, plain, hummock, the highest range, the humblest valley, an aërial port.

The Irishman then will not be called upon to admire the foresight of Providence in making great rivers flow by mighty towns. Air communications will be everywhere. The second effect, then, will be that our overgrown cities must relinquish their importance. Such "necessary evils" must even cease to exist, except for advantages gained by centralization here and there, for purposes of education, luxury, or governmental power. The instant these purposes shall be satisfied or abused, a growing city will cease to grow.

This, also, is in the direction of freedom. New York no longer will be the metropolis, St. Louis and Chicago no longer the West, Paris no longer France. The rural places—even the isles of the sea—will emancipate themselves from the centers by union with the whole. They will cast off the repressive influence of the former, and interchange their thought with the ideas and glory of the world at large.

Let us do justice to a man of honesty, genius, and enthusiasm. Charles Fourier, as a critic of the evils belonging to an immature social development, was truthful and discerning. The life-long servant of a commercial house, he was familiar with the systems of trade, and his generalizations were those of a philosopher. He was justified in his denouncement of the "Spoliation of the Social Body," by Bankruptcy, by Monopoly and Forestalling, by Agiotage, by Parasitism, by the corruption of Joint-stock Corporations. As a soothsayer he was more correct than many poets and prophets of olden times. Already some of his predictions of the good to result from legitimate Association have been fulfilled. In his effort to forecast the splendid civilization in store for mankind it is yet to be proved that he was a too visionary seer.

His mistake was twofold: 1. His imagination, allied with a severely logical temper, could not refrain from an *a priori* search for every detail of the future. 2. Having in view his own Utopia, and imperfectly comprehending the science of evolution, he conceived the idea of hastening the ultimate results of human progress by a kind of forcing process. He failed to see that in the present stage of growth there is not the demand for a perfectly economic social system, nor is it a possibility. He urged his disciples to create this in advance of time, and before the spread of population and the progress of science and art had on the one hand established the absolute necessity, and on the other given mankind the power. We cannot place the world in a hot-house, to ripen like a peach. Nevertheless, in the unfinished and often unscientific productions of Fourier there are many things of which the world may well take heed.

Among these is the prediction that great cities—wherein palaces and hovels crowd one another and the poor cling upon the rich like the camp-followers of an army—are to become, because great evils, things of the past. They, no more than desert tracts, can exist beyond a given time. In their stead he proffered the Phalanstery, a combination of people in groups assorted by natural law, according to the requirements of utility, luxury, taste and education. The attempts to realize this substitution have failed, as arbitrary attempts of the sort must always fail. Material causes prevent their success. Cities are agglomerations of the dwellings, warehouses, and industries, of men, at those central and accessible points where transportation can reach the commercial and distributing reservoirs.

Their decay, or, at least, our emancipation from their foremost evils, will arrive only with our sovereignty of the aërial sea above us.

Civic life will continue, but cities then will thrive in proportion to their advantages of learning, their attractions of art and pleasure, or as centers of political organization. The people will distribute themselves throughout the land.

The change will be gradual. The art of aërial navigation will be slow of perfection. Our primitive vessels and motors will be rude and defective, as Stephenson's locomotive now would seem to us. Heavy freights must long continue to move by water and rail. Aërobats at first will be used for the transmission of the mails and light express packages, and especially for their swift conveyance over sea. Soon the inland companies will have each its own "aërial express." By and by aërobats displaying the insignia and pennons of the great newspapers will leave town at 3 A.M., and whir over the country "as the crow flies," and at their utmost speed, dropping their packages in the towns and villages along the routes in every direction of the compass. Soon the more adventurous and resolute, and finally all classes of travelers will avail themselves of the great passenger aërobats and enjoy the unsurpassable luxury of flight, experiencing thrills of wonder and ecstasy, and a sense of power, freedom, and safety to which all former delights of travel may well seem tame by comparison.

A vital and most beneficent result of the new achievement will be the serious check given to the cruelest, most defiant and grasping, of all monopolies—the grand transportation companies, and especially to the railroad corporations with their atrocious system of management. The adjective is well considered. For many years duty has placed me within close observation of matters at the financial center. There I constantly have been impressed by two things: first, by the unpretentious, almost unvarying honor and devotion of the brokers whose profession it is to buy and sell the shares into which the estates of these corporations are divided; secondly, by the boundless rascality of the average railway director—a knavery specious and vast beyond even his own powers of comprehension. For to a blunted moral sense he adds an intelligence so preternatural, when defrauding investors and gaining control of the public wealth, as to put on the guise of genius and attain satanic power. Even the more ignorant among them survey a wider material horizon than men highly educated in other pursuits. We can imagine that personages like —— or —— or ——, if allowed the range of the stellar systems, would issue consolidation bonds on nebulæ in process of contraction, "corner" the planets, make coupons payable in moons, and create panics alike among fixed and wandering stars.

By a curious paradox, those of them who have the most selfishly straightforward aims, who by chance own and develop the properties under their control, are the most obtrusive and dangerous. Of course I yield an intelligent assent to the doctrine that great capitalists are needed, in default of something better, to institute great enterprizes. Great owners also are needed to run our vast industrial organizations.

There is not, however, a sufficient check upon them. By their monstrous faculty of accumulation they gradually manage our governments, oppress not only the poor but the public at large, build up a new feudalism, and in many ways increase the evils of the time. If the "reign of law" did not in the end break in upon this process, it could be demonstrated that a Vanderbilt would own not only all the properties conveyed on 'change, but all the wealth of the land. A long enjoyment of this kind of power breeds tyranny, and it is not surprising that our people begin to look right and left for a substantial foil to the arrogance of their railway kings.

Let them turn their faces upward and invoke the genii of the air—the trackless air! You may charter aërial companies, no doubt, but you cannot impede the right of way upon these higher than the "high seas." The teeth of the railway managers would soon be drawn, and the clipping of their claws would follow, should aërial navigation become an accomplished fact. At first the freight-carrying would remain with them, but even for that in time they would have to compete with a thousand, instead of half a dozen "trunk-lines," and, in short, come nearer to the level of their fellow-men.

Science will make instant and brilliant use of the new means at command, and economy, political and domestic, will adjust itself, with the aid of science, to the new conditions. Our standards will be revised, meteorology will receive intelligent and close attention; a class of astronomical observations will be made at will above the vapors of the lower atmosphere; the Pole, the desert, no longer can hide their secrets from the geographer; the geologist will explore formations hitherto inaccessible; the telegraph will be put to new uses; in numberless directions the sum of human learning will be advanced.

New processes of mechanical and manufacturing industry will arise, often utilizing material hitherto worthless. We shall have ceaseless invention of aërobatic appliances and improvements, and of the machinery to make the same. The impetus that will be given to the industry as to the commerce of the world cannot be overestimated. A *finesse* will characterize the new manufactures beyond anything previously known, and only suggested by the elegant adroitness of the races which people the Asiatic coast. Human skill will expend itself upon new combinations of grace, lightness and strength, in machinery and equipment.

Not only by these processes of construction, but also by the power and freedom gained through their success, a delightful reflex influence will be exerted upon the æsthetics of life. Poetry and romance will have fresh material and a new *locale*, and imagination will take flights unknown before. Landscapes painted between earth and heaven must involve novel principles of drawing, color, light and shade. Music, like the songs of Lohengrin, will be showered from aërial galleys. In every way the resources of social life will be so enlarged that at last it truly may be said, "Existence is itself a joy." Sports and recreations will be strangely multiplied. Rich and poor alike will make of travel an every-day delight, the former in their private aëronons,* the latter in large and multiform structures, corresponding in use to the excursion-boats of our rivers and harbors, the "floating palaces" of the people, and far more numerous and splendid. The ends of the earth, its rarest places, will be visited by all. The sportsman can change at pleasure from the woods and waters of the North, the runways of the deer, the haunts of the salmon, to the pursuit of the tiger in the jungle or the emu in the Australian bush. An entirely new profession—that of airmanship—will be thoroughly organized, employing a countless army of trained officers and "airmen." The adventurous and well-to-do will have their pleasure yachts of the air, and take hazardous and delightful cruises. Their vessels will differ from the cumbrous aërobats intended for freight and emigrant business, will be christened with beautiful and suggestive names,—Iris, Aurora, Hebe, Ganymede, Hermes, Ariel, and the like,—and will vie with one another in grace, readiness, and speed.

Observe also the swift advance which, from the nature of things, aërial navigation will effect in the science of government, and especially in the co-relations of the nations and peoples of the world. Boundaries will be practically obliterated when mountain-chains, rivers, even seas, can be crossed as readily as a level border-line, and oppose no obstacle to the passage of travelers, merchants, or men-at-arms. Laws and customs speedily must assimilate when races and

* For this excellent and ingenious formation I am indebted to Mr. W. P. Prentice, who derives it from *ἀέρο—νέω*, hence *ἀερονεῖν*, to swim in air—aëronon, "a thing swimming in air. A word euphonious and dignified, and describing a structure fashioned upon my theory. I should substitute it for "aërobat" throughout this article, were it not that it has seemed desirable to present the latter word as the correlative of "aërostat," a term already in scientific use.

languages shall be mingled as never before. The fittest, of course, will survive and become the dominant types. The great peoples of Christendom soon will arrive at a common understanding; the Congress of Nations no longer will be an ideal scheme, but a necessity, maintaining order among its constituents and exercising supervision over the ruder, less civilized portions of the globe. Free-trade will become absolute, and everywhere reciprocal: no power on earth could enforce an import tariff. War between enlightened nations soon will be unknown. Men will see "the heavens fill with commerce," but after a few destructive experiments there will rain no

"— ghastly dew
From the nations' airy navies grappling in the central blue."

Troops, aërial squadrons, death-dealing armaments will be maintained only for police surveillance over barbarous races, and for instantly enforcing the judicial decrees of the world's international court of appeal. Ultimately knowledge will be universally distributed, the purest and most advanced religion will shed an influence everywhere, and its gospel indeed be preached throughout the world and "to every creature."

The morning of a Saturnian age thus will dawn with the success of man's attempts to navigate the atmosphere. Sit down, separate yourself from the thought of things as they are,—speculate freely, but with sound imagination, upon what they may be,—and by irrefragable processes of logic you will see that what I predict must result from the solution of our problem, indeed that the half has not been suggested. The law is well understood: material progress determines the intellectual and spiritual progress of the human race. Its true perfection must follow this ultimate conquest of nature, and can be reached in no other way.

Have any commensurate efforts yet been made to achieve this result? Has it been considered otherwise than as a fantastic dream? Have any, save a few enthusiasts, mostly poor and unlearned, attempted to realize it? Is it not left, even now, to the accidents of time? Still, there is nothing yet undone but man desires to do it. His unrest, his eager insatiate daring, penetrates the heart of Africa, the depths of the seas. Visionary speculators waste fortunes upon impossible motors, upon luckless wells and mining-shafts, while here is the most tempting of all material achievements demonstrably within the bounds of invention, within the capacities of forces and matter already under our control. The determined effort, the liberal expenditure of a single government, even of one of our thousand moneyed corporations, can solve the problem. It is strange that a score of such efforts, of such expenditures, are not making; that the princeliest appropriations, the deftest intellects, are not devoted to the attainment of this end. But with or without them, I repeat, the end is near at hand.

THE OVERFLOWING CUP.

INTO the crystal chalice of the soul
  Is falling, drop by drop, Life's blending mead.
  The pleasant waters of our childhood speed
And enter first; and Love pours in its whole
Deep flood of tenderness and gall. There roll
  The drops of sweet and bitter that proceed
  From wedded trustfulness, and hearts that bleed
For children that outrun us to the goal.
And later come the calmer joys of age—
  The restful streams of quietude that flow
Around their fading lives, whose heritage
  Is whitened locks and voice serene and low.
These added blessings round the vessel up—
Death is the overflowing of the cup.