autical Classics—No. 5

GLIDING

BY

PERCY S. PILCHER

TO WHICH IS ADDED

THE AERONAUTICAL WORK OF

JOHN STRINGFELLOW

One Shilling Net

Printed and Published for
THE AËRONAUTICAL SOCIETY OF GREAT BRITAIN,
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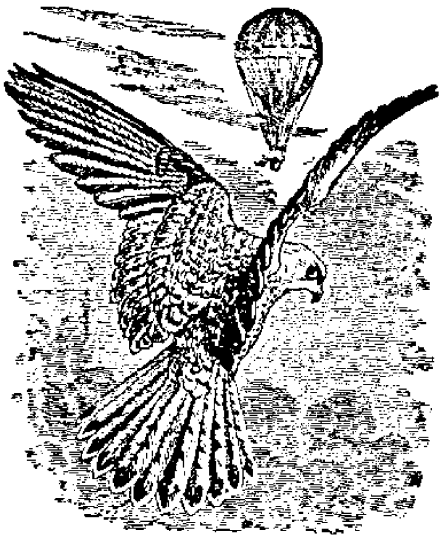

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Edited for the Council of the Aëronautical Society of Great Britain

by

T. O'B. HUBBARD & J. H. LEDEBOER

MEMOIR

Otto Lilienthal once remarked: "It is easy to invent a flying-machine; more difficult to build one; to make it fly is everything." These words picture not inaptly the three stages in the history of flight. Even in the dark ages the invention of a flying-machine presented few difficulties to any ingenious mind that ventured to brave the forces of theology, as the long succession of projects and designs for aerial conquest amply proves. Nor were the obstacles that beset the path of the builder ever of so serious a nature as to jeopardise his chances of ultimate success. Admiration in full measure falls only to the due of the rare adventurous spirits who, combining the qualities that make for greatness in invention and construction, added thereto the courage, conviction and high endeavour that characterize the great practical pioneers.

Of these was Percy Sinclair Pilcher, born in January, 1866. Joining the "Britannia" at the age of thirteen, he completed six years' service in the Royal Navy, from which he retired in 1885 in order to devote himself to the profession of engineering.

After working through the shops—at Elder's Shipbuilding Yard, at Govan, near Glasgow—he attended London University, and in 1893 was appointed Assistant Lecturer in Naval Architecture and Marine Engineering at Glasgow University. A few years later, in 1896, he joined Hiram S. Maxim, with whose experimental work, subsequent to the failure of the large steam-driven aeroplane, he was closely associated. Shortly before his death he became a partner in the engineering firm of Wilson and Pilcher, who were to have undertaken the construction of his future machines and engines at their works at Westminster. Becoming a member of the Aëronautical Society in 1897, Pilcher was elected to the Council in November of the same year; and, in the two short years of his membership, succeeded in instilling into the debates and the work of the Society a portion of the enthusiasm and energy that he himself so signally possessed.

The problems of flight fascinated him from an early age, but it was not until the first months of the year 1895 that an opportunity was vouchsafed him of putting his ideas to the momentous test of practice at Glasgow. Here, in the intervals allowed by his duties at the University, Pilcher built his first glider, the "Bat." At this time his only knowledge of the active work pursued by Lilienthal in Germany was derived from inadequate and inaccurate reports in the Press; the "Bat," therefore, was entirely the product of his own original conceptions. At the very outset of his experiments Pilcher was confronted with a serious difficulty: owing to his engagement at the University he was forced to carry out the work of construction of the glider in the town, whereas the practical tests could only be made in the country, at a considerable distance. The machine, therefore, had to be built so as to be capable of being folded up to meet the requirements of transportation. This problem was successfully solved. Thus it is indeed noteworthy that Pilcher, Lilienthal, and Ader, the first three pioneers of practical dynamic flight, each succeeded in overcoming so serious an obstacle to efficiency before which their successors have hitherto uniformly failed.

The "Bat" was a monoplane, completed before June, 1895, when Pilcher visited Berlin, where he made several glides in Lilienthal's large biplane glider. The wings of the "Bat" formed a pronounced dihedral angle: the tips being raised 4 feet above the body. The spars forming the entering edges of the wings crossed each other in the centre and were lashed to opposite sides of the triangle that served as a mast for the stay-wires that guyed the wings. The four ribs of each wing, enclosed in pockets in the fabric, radiated fan-wise from the centre, and were each stayed by three steel piano-wires to the top of the triangular mast, and similarly to its base. These ribs were bolted down to the triangle at their roots, and could be easily folded back on to the body when the glider was not in use. A small fixed vertical surface was carried in the rear. The framework and ribs were made entirely of Riga pine; the surface fabric was nainsook. The area of the machine was 150 sq. ft.; its weight 45 lbs.; so that in flight, with Pilcher's weight (145 lbs.) added, it carried $1\frac{1}{3}$ lbs. per square foot.

The first glides were attempted in July, 1895, down a grass-hill situated on the banks of the Clyde at Wallacetown Farm, near Cardross. Owing to the exaggerated dihedral angle of the wings and to the absence of any tail-surface save the small vertical one, these first experiments were attended with but little success. Pilcher would take up his position on the top of the hill, standing upright with his shoulders passed through the opening in the wings and, grasping the body members, run down the slope with the wings tilted at a negative angle until sufficient speed had been attained, when the wings would suddenly be tipped up so as to allow the glider to be carried off the ground. But defective balance always brought the machine to earth again within a few yards.

To remedy these defects the "Bat" was transformed: the wings were lowered until the tips were only 6 inches above the level of the body, and a horizontal tail-plane was added to the vertical one crosswise; this horizontal plane was movable, being capable of being tipped up, but the vertical plane remained fixed. The forward spars of the wings, now built of bamboo, were arched transversely. On September 12 the reconstructed "Bat" was tried for the first time, and with gratifying results. During the first glide, picked up by the rising head-wind, Pilcher rose to a height of 12 feet and remained in the air some 20 seconds; at a second attempt the glider was towed by a rope, rose to 20 feet, and landed safely after the space of nearly one minute. Many successful glides followed; growing experience gradually increased their length and improved the balance in the air. But, in landing, the wing-tips were apt, owing to their small clearance, to come in contact with the ground, and many breakages resulted.

Accordingly, a second glider was built during the summer months of 1895, in which the wing-tips were designed to have a clearance of some 6 feet from the ground. This second glider, the "Beetle," differed considerably from the "Bat." The square-cut wings formed almost a continuous plane, rigidly fixed to the central body, which consisted of a shaped girder. These wings were built up of five transverse bamboo spars, with two shaped ribs running from fore to aft of each wing, and were stayed overhead to a couple of masts. The tail, consisting of two discs placed cross-wise (the horizontal one alone being movable), was carried high up in the rear. With the exception of the wing-spars, the whole framework was built of white pine. The wings in this machine were actually on a higher level than the operator's head; the centre of gravity was, consequently, very low, a fact which, according to Pilcher's own account, made the glider very difficult to handle. Moreover, the weight of the "Beetle," 80 lbs., was considerable: the body had been very solidly built to enable it to carry the engine which Pilcher was then contemplating; so that the glider carried some 225 lbs. with its area of 170 sq. ft.—too great a mass for a single man to handle with comfort.

This summer, of 1895, had been one of very light winds; during several days, in fact, the calm air had prevented him from making any glides. Influenced, no doubt, by these conditions, Pilcher built his third glider of far greater proportions. This machine, the "Gull," was completed at Glasgow in the early months of 1896.

In general it was a reversion to the type of the "Bat" save that the wings were arched downwards. It had 300 sq. ft. of area, weighed 55 lbs., and only carried $\frac{2}{3}$ lb. per square foot. It was tried during the ensuing summer months, but, owing to its large area rendering it suitable for practice only in the calmest weather, was severely damaged on several occasions when flown in a stiff breeze.

The fourth glider, the "Hawk," was also built early in 1896, at Eynsford, in Kent.

The "Hawk" formed a great advance on its three predecessors; indeed, in many respects, it was a thoroughly up-to-date, exceedingly well-built glider. From an engineering point-of-view, taking into account the serious difficulties arising from such requirements as collapsibility, this glider was undoubtedly a sound machine. With the single exception of the two main transverse beams, it was built throughout of bamboo, admittedly the most difficult material for building up a satisfactory framework. The wings were attached to two vertical masts, 7 ft. high, and 8 ft. apart, joined at their summits and their centres by two wooden beams. Each wing had nine bamboo ribs, radiating from its mast, which was situated at a distance of 2 ft. 6 inches from the forward edge of the wing. Each rib was rigidly stayed to the top of the mast by three tie-wires, and by a similar number to the bottom of the mast. By this means the curve of each wing was maintained uniformly. At their inner extremities these ribs were strung to the mast on rings so that, by loosening the attachment of the forward edge of the wing to the body, the ribs folded backwards into a position which rendered transport extremely convenient. The tail was formed by a triangular horizontal surface, to which was affixed a triangular vertical surface; and was carried from the body on a high bamboo member. It was also stayed from the masts by means of steel wires, but only on its upper surface*; in consequence, when acted on by the pressure of the air, the tail could only be forced upwards, and not downwards; by this arrangement the glider, when in flight, was prevented from adopting a dangerous dipping angle. The body consisted of a narrow aperture formed between the two wings by two bamboo rods bent into a "fair" shape. The operator took up his position by passing his head and shoulders through the body aperture, and resting his fore-arms on the longitudinal body members. Supports were provided for the arm-pits. It will be seen that, owing to this arrangement, the head, shoulders, and greater part of the chest projected above the wings; the centre of gravity was consequently only slightly below their level. Underneath the body were attached two bamboo rods fitted with wheels suspended on steel springs. When on the ground the weight of the glider rested on this elementary chassis, which also took the first impact of landing.

The following were the chief dimensions: Span 23 ft. 4 in.; chord 8 ft. 4 in.; length over all 18 ft. 6 in.; area of main plane 180 sq. ft.; camber 5 in. (situated 2 ft. 6 in. behind the forward edge); area of horizontal tail plane 12 sq. ft.; weight of glider 50 lb.; weight in flight 195 lb.; loading, a fraction over 1 lb. per sq. ft.

* The snapping of one of these guy-wires, causing the collapse of the tail support, brought about Pilcher's fatal accident.

The balance and steering of the "Hawk," apart from the slight degree of automatic stability afforded by the tail, were effected, as before, by altering the position of the operator's body; and, although this method appears to modern eyes crude in the extreme, it must be admitted that Pilcher acquired such dexterity in handling his machine by these means that he never met with a serious accident until the day of his death.

On this last glider, the "Hawk," Pilcher made some dozen glides at Eynsford during the summer months of 1896, and showed the value of his growing experience by the increased length of his glides and the ease wherewith he handled the machine in the air and in landing. But, the claims of business growing ever more insistent, opportunities for practice during this summer were limited. While postponing further experiments to the following spring, Pilcher was already occupied with the preparation of his plans for fitting a small engine and propeller to his latest glider; these plans would, in fact, have been carried out even earlier had there not arisen the usual difficulty that no engine of sufficient lightness could be found. An engine said to give one horse-power and to weigh but 15 lbs. was, it is true, reported to be in existence in America; but every endeavour to trace it was effectually baffled.

On January 21, 1897, Pilcher gave a lecture in Dublin before the Military Society of Ireland, presided over by Major-General Viscount Frankfort de Montmorency, commanding the troops in Dublin. This lecture gave, for the first time, a complete account of his own gliding experiments, and of those carried out by Lilienthal, and ended with a description of the work recently accomplished by Hiram Maxim with whom Pilcher was now associated. This lecture is reprinted in the following pages in its entirety, save for the concluding portion relating to Maxim's work which is already familiar to every student of aeronautics.*

During the spring of the following year the gliding experiments were resumed at Eynsford with the "Hawk." Unsuccessful in his efforts to secure a suitable engine, and unwilling to depend entirely on the rare chance of finding the favourable wind essential for his former method of practice—by running down a slope—Pilcher compromised by having his glider towed by a line passing over a pulley. This pulley was situated on the top of a hill; Pilcher took up his position on the crest of a neighbouring hill, and thus succeeded in making several long glides. Perhaps the best of these was accomplished on June 19 of this year, when he crossed the intervening valley at a great height and alighted, after a perfectly balanced glide of over 250 yards in length, on the opposite hill. The "rope" used on these occasions was a thin fishing line "which one could break with one's hands," and the pull on it, during flight, did not exceed 30 lbs.

In the absence of the American engine, Pilcher was now resolved to proceed forthwith to build a suitable engine himself. Observation had shown that the "Hawk," carrying a total weight of 190 lbs., glided at a speed of 20 to 25 miles per hour, the pull on the line

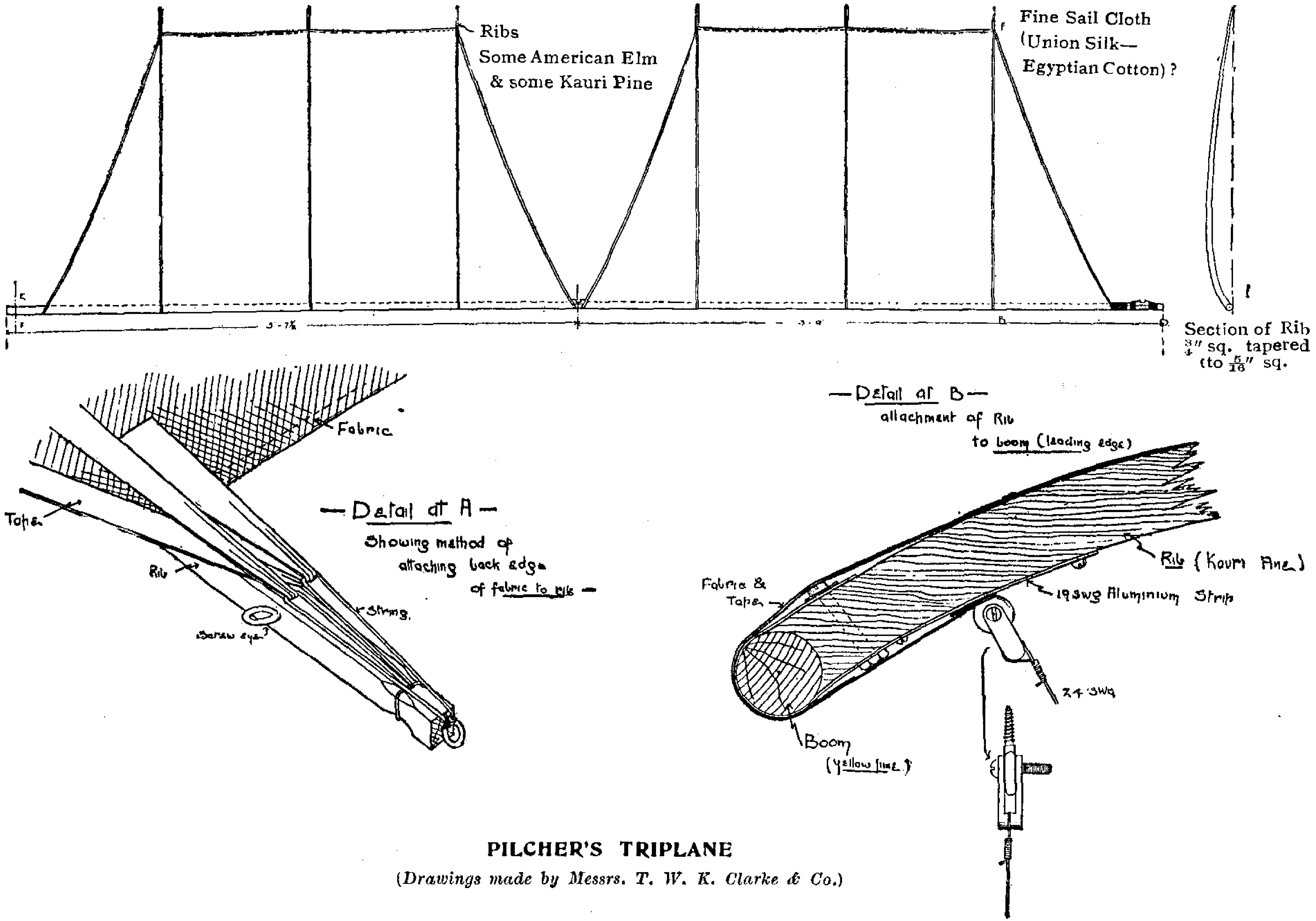
* "Artificial and Natural Flight," by Sir Hiram Maxim; London, 1909.

being from 20 to 30 lbs. Herefrom Pilcher concluded that from 2 to 3 horse-power would suffice for the maintenance of horizontal flight once the machine was in the air. Allowing for the additional weight of engine and propeller, and taking into account the latter's inefficiency, a 4-H.P. engine was deemed sufficient. The weight of this oil engine was estimated at 40 lbs.; the propeller, 5 ft. in diameter, with a 4-ft. pitch, built of yellow pine covered with light canvas, weighed but 3½ lbs. The driving mechanism was to be installed in the "Hawk" in the following manner: the engine, fitted in front of the operator, was to actuate, by means of an overhead shaft, the propeller situated to the rear of the wings. The whole of the year 1898 was occupied with the construction of the engine—a slow and tedious process.

At the beginning of this year Pilcher had formed, with Walter G. Wilson, the firm of Wilson and Pilcher, Ltd., for working out inventions and patented ideas. At first the firm only had some small shops in Clerkenwell, but as business increased rapidly, the works were moved to Great Peter Street, Westminster, where the construction of the oil engine was begun.

About this time, furthermore, Pilcher was actively endeavouring to found a company in order to carry out future experiments, and for this had obtained the support of Dr. Elgar, Mr. Yarrow, the famous shipbuilder, Professor Biles, of Glasgow, and the late Professor Fitzgerald, of Dublin. Writing to the latter at the end of 1898, Pilcher remarks:

> "During the last year I was not able to do anything with the flying work, as we were so very busy getting our new



PILCHER'S TRIPLANE

(Drawings made by Messrs. T. W. K. Clarke & Co.)

> business into going order; but the summer before, when I was able to devote some time to it, the results we obtained were most encouraging, and consequently we are most anxious not to let the experiments drop altogether. In America experiments are continually being made, and it would be heartrending not to try and keep one's place in the work that is being done."

Then, early in 1899, there happened an event that, but for his untimely death, would undoubtedly have influenced the entire future course of Pilcher's experiments. On May 26, Lawrence Hargrave read before the Aëronautical Society a paper on his newly-discovered "soaring kites." Pilcher, who was in the chair at this meeting and led the subsequent discussion most ably, was deeply interested in Hargrave's account and afterwards took with him the two soaring kites brought over by Mr. Hargrave and by him presented to the Society.

Many experiments were carried out with these soaring kites by Pilcher during the ensuing months, and there is some reason for believing that their principle was incorporated—to some extent, at least—in a new machine which was built by Wilson and Pilcher during the course of 1898 and 1899. Unfortunately only a few fragments of this machine have been preserved, from which it is impossible to re-constitute the glider. The only certainty is that it was a triplane. Some of its constructional features are indicated in the accompanying drawings, executed by Messrs. T. W. K. Clarke and Co.*

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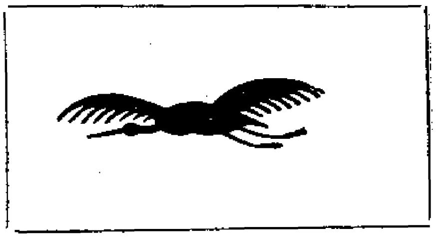
* This triplane, the "Hawk," and a Lilienthal glider purchased by Pilcher were presented after his death to the Aëronautical Society. The two latter machines are still in the possession of the Society and have several times been on exhibition.

But death overtook him before an opportunity had arisen to try this new machine. While on a visit to Lord Braye, at Stanford Hall, Market Harborough, Pilcher consented to give a demonstration of gliding flight on the afternoon of Saturday, September 30, 1899. Both the "Hawk" and the new superposed-plane machine were brought out, but, in view of the unfavourable weather—it had been raining heavily, the ground was drenched and the gliders sodden—it was resolved to postpone the trial of the new machine. The "Hawk" on this occasion was intended to rise from a level field, towed by a light line passing over a tackle drawn by two horses. On the first trial the machine rose easily after a short run, but when well clear of the ground the tow-line snapped and the glider, liberated, descended gently to the ground. Although the machine was weighted down by its sodden condition, another trial was resolved upon: the glider rose easily from the ground and was soaring at a height of about 30 ft. when one of the guy-wires of the tail broke, the tail collapsed, and the machine fell headlong to the ground, turning over in its fall. Pilcher, unconscious, was freed from the wreckage; at first sight his condition seemed to give hope of recovery, but, after lingering on through Sunday, he died, without recovering consciousness, early in the morning of Monday, October 2, 1899.

His services rendered to the cause of human flight stand out clearly from the foregoing brief record of his work, and in truth require no further words of appreciation. On the whole, he may fitly be assigned a place by the side of Otto Lilienthal. For these two, if we except the somewhat mysterious figure of Le Bris, were the first real flying men. The great German perhaps approached the matter in the more scientific spirit, and in so far, no doubt, his work is the more lasting. Pilcher, too, had the undoubted advantage of treading in Lilienthal's footsteps; though, be it observed, his work was original enough, witness the completion of the "Bat," before the visit to Berlin, with the express object of preserving any originality of idea that might have gone to its construction. In common with Lilienthal, Pilcher persevered to the end in balancing his machines by correcting the position of the centre of gravity—by body movements—in flight. But apart from this single defect, his gliders were thoroughly modern; nor can there be much doubt, to judge from his correct appreciation of the functions of the tail, that Pilcher would have adopted the movable horizontal plane for this purpose, had time permitted.

In one respect certainly he anticipated modern practice: the "Hawk" was the first machine to be fitted with wheels, provided with shock-absorbers, whereon to roll over the ground in its initial run. Two other points, on which Pilcher strongly insisted, are worthy of repetition: the great advantage possessed by the small machine over the larger one, in respect of the serious difficulties of construction and disproportionate weight of the latter; and the great skill required to balance too large a structure. Further, he laid great stress on the evil effects of a low centre of gravity; his tendency to place his weight as high as possible may, in fact, be clearly noted by comparing the "Bat" or the "Beetle" with the "Hawk."

When all is said, the final impression that remains from a consideration of his work is one of deep admiration for the originality, perseverance, and enthusiasm of this young engineer, whose life was sacrificed in his 34th year, but who, in the four short years that formed the full period of his activity, accomplished pioneer work that will render his name famous while the history of aerial navigation endures.



GLIDING

THE history of experiments with flying machines has been up to the present more or less a history of disasters. There has often been a certain amount of success, but in almost all cases where any success has been attained there has been a capsize, or a fall, or some accident, which has brought the experiments to a close.

The first man of whom we know as having attempted flight, after the days of mythology, was Roger Bacon, who, in about 1250, is said to have made a soaring machine; but he lost his longitudinal balance, having jumped from an eminence, and broke his machine and his legs*. He was shortly afterwards imprisoned for witchcraft.

J. B. Dante, a mathematician, of Perugia, Italy, is said to have sailed across a lake on wings at the end of the 14th century. Again, starting from a tower, he is said to have balanced himself for a long time in the air; but the machine broke in the air, and he fell on to the top of a church and broke his leg.

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* Pilcher appears to confuse Bacon with Oliver of Malmesbury.—EDS.

During the next four hundred years a good many experiments were made by various people with wings, but through want of elementary knowledge of the subject, and want of good materials to work with, none, apparently, had much success.

In 1854 Captain Le Bris, a French sailor, constructed what he called an artificial albatross. The apparatus was 50 feet wide, $13\frac{1}{2}$ feet long, and its sail area was 215 square feet; it weighed 92 lbs. This was really a simple soaring machine; but instead of moving his weight about in the machine to balance it, Le Bris had arrangements to alter the inclination of the wings by levers which he held in his hands, and he altered the inclination of the tail by a mechanism which he worked with his feet. His first experiment was made with the machine tied to the top of a cart by means of a slip rope, so that Le Bris, who was in the machine, could detach it from the cart just when he wished. The cart was driven along a road facing a ten-mile wind. When the pace was sufficient, Le Bris pulled at the slip rope which let the machine go, but somehow or other the rope had got round the carter, and Le Bris was taken up into the air, with the carter hanging on to the end of the rope underneath the machine.. The machine is said to have gone up 300 feet into the air, and cleared about 600 feet in distance, when Le Bris, the machine, and the carter came down unharmed. In the next trial, in which the carter did not go up, one wing got broken. Le Bris next tried the apparatus by dropping it from a crane at the edge of a quarry, 100 feet drop. He lost his balance, the machine was broken completely, and Le Bris broke his leg.

Thirteen years later a public subscription enabled Le Bris to build another machine. More experiments were made, but the apparatus got broken up on a gusty day, and Le Bris could not get enough money to go on with his experiments.

Since then there have been many experiments made with soaring machines, but much the most interesting are those of Herr Lilienthal, an engine builder, of Berlin, who, most unfortunately, got killed a few months ago* by losing his balance when in the air.

Lilienthal had been experimenting with models practically all his life, and spending all his spare time and money on them, until in the summer of 1891 he began experimenting with his first soaring machine, built to carry himself. It had about 100 square feet of surface.

Since then his machines have been much altered. In the spring of 1895, I saw him experiment with a machine of 150 square feet, weighing 56 lbs. These machines are roughly made, almost entirely of peeled willow sticks, covered with cotton shirting.

Illustration 1 shows one of these machines. A man is holding a machine in the position it would be when flying, and his forearms pass through padded tubes, and his hands hold a cross bar. This is the only way in which he is attached to the machine, so that he can, when standing on the ground, place the machine at any angle to the wind, and when supported by the air he can move his body a considerable distance forwards or backwards or sideways so as to preserve his balance and guide the machine. Professor Fitzgerald has one of these machines in Dublin.

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* August 10, 1896.

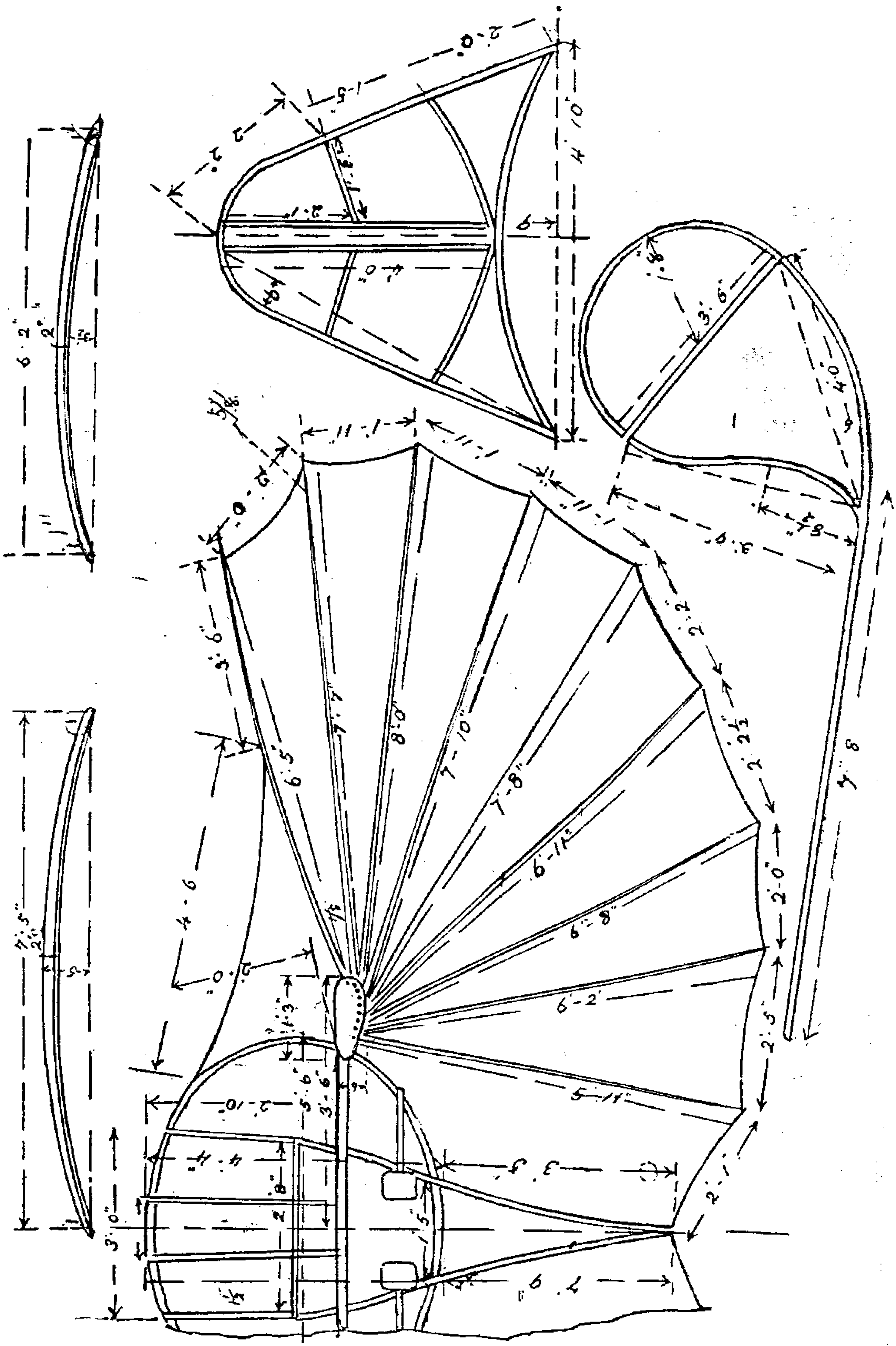


Fig. 1a.—Lilienthal's Monoplane Glider
Scale Drawings

To fold up, the front of the sail is unhooked from the front of the machine; all the spokes in the sail revolve round, and thus the machine shuts up quite small.

At first Lilienthal used to experiment by jumping off a spring-board, with a good run. Then he took to practising on some hills close to Berlin. In the summer of 1892 he built a flat-roofed hut on the summit of a hill, from the top of which he used to jump, trying, of course, to soar as far as possible before landing.

Illustration 2 shows the machine in a critical position. He has got the machine too much up in front; it has lost its forward motion, and consequently his legs are thrown very far forward to get the centre of gravity forward, so as to incline the machine down in front that it may shoot on again. One of the great dangers with a soaring machine is losing forward speed, inclining the machine too much down in front, and coming down head-first. Lilienthal was the first to introduce the system of handling a machine in the air merely by moving his weight about in the machine; he always rested only on his elbows or on his elbows and shoulders. There are two little pads with which his shoulders come in contact, when his arms are almost straight, to prevent him from tumbling through and breaking his arms; these are shown in illustration 1.

He added these pads because once, having thrown his weight very far back, he was unable to pull himself up again. He described his descent to me thus: "I was blown about exactly like a sheet of paper when it is caught by the wind. At first I saw only blue sky, and then I saw only green grass, and I thought now it is all over with me." He broke his wrist.

This method of support, although it appears uncomfortable, is not really so bad as it seems, and one can soon get accustomed to it. It allows great freedom in moving one's weight about, and gives one an excellent command of the machine when standing on the ground. It has often been suggested that it would be a good plan to have a pair of stirrups to fit one's feet into while in flight, to have a net to sit in, or some such device to relieve the weight on the arms; but so far the length of flight has never been so long as to make such a thing necessary, and anything of this kind would be an encumbrance, and would hinder free movement, fidget one, and keep one from slipping out of the machine quickly in case of accident.

In 1892 a canal was being cut, close to where Lilienthal lived, in the suburbs of Berlin, and with the surplus earth Lilienthal had a special hill thrown up to fly from. The country round is as flat as the sea, and there is not a house or tree near it to make the wind unsteady, so that this was an ideal practising ground; for practising on natural hills is generally rendered very difficult by shifty and gusty winds.

Illustration 3 shows this hill. It is 50 feet high, and conical. Inside the hill there is a cave for the machines to be kept in. Here he is shown sailing down the slope.

When Lilienthal made a good flight he used to land 300 feet from the centre of the hill, having come down at an angle of 1 in 6; but his best flights have been at an angle of about 1 in 10.

If it is calm, one must run a few steps down the hill, holding the machine as far back on oneself as possible, when the air will gradually support one, and one slides

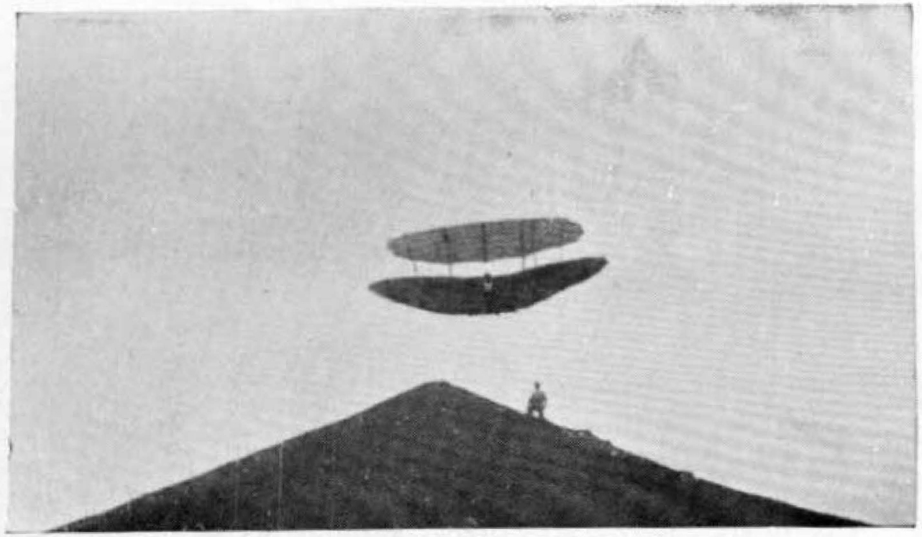


Fig. 4.—Lilienthal's biplane glider soaring

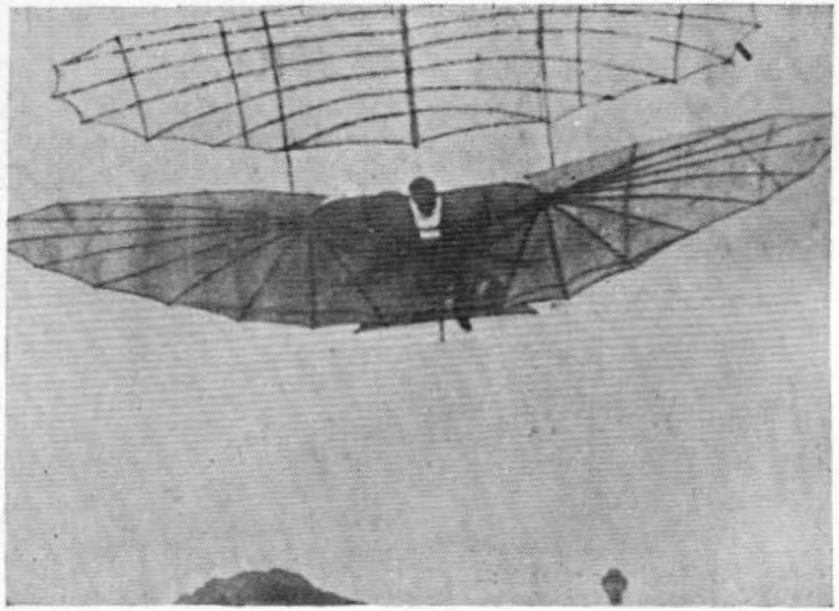


Fig. 5.—A near view of Fig. 4

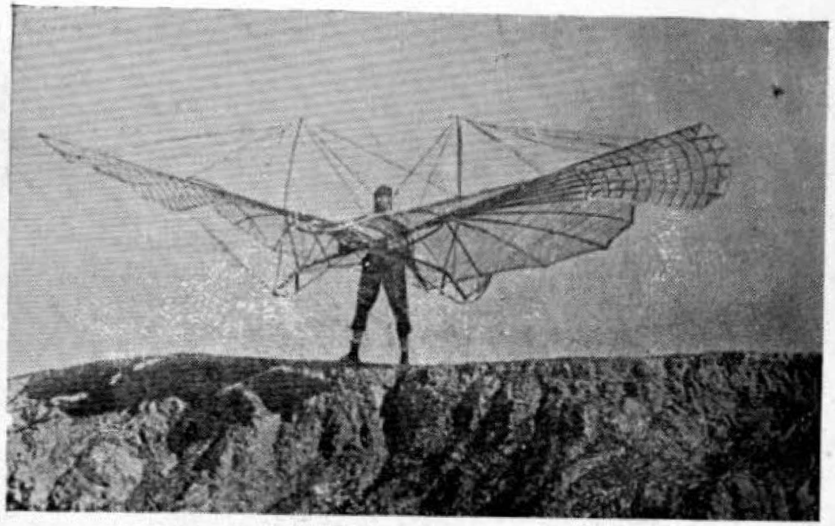


Fig. 6.—Lilienthal's power-driven machine

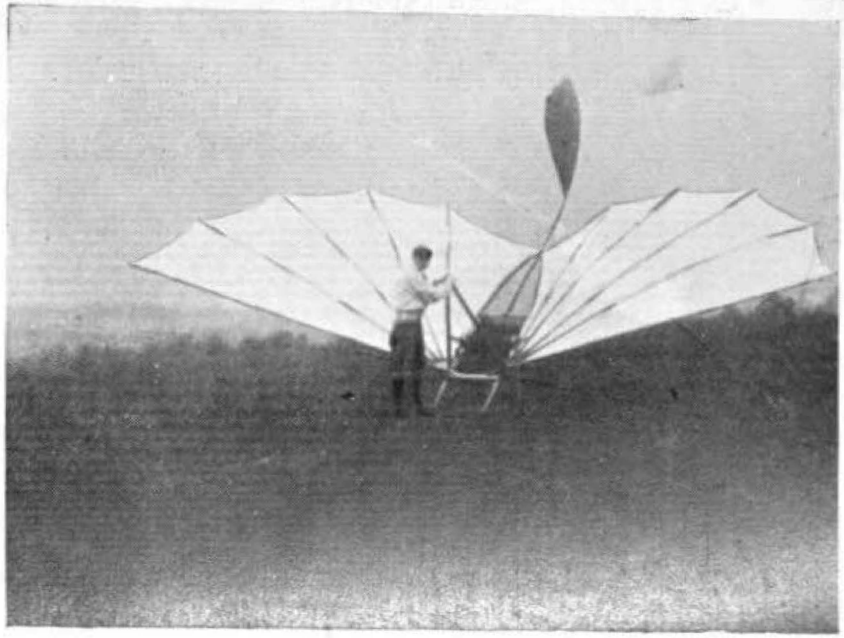


Fig. 7.—The "Bat"

off the hill into the air. If there is any wind one should face it at starting; to try and start with a side wind is most unpleasant. It is possible after a great deal of practice to turn in the air, and fairly quickly. This is accomplished by throwing one's weight to one side, and thus lowering the machine on that side towards which one wants to turn. Birds do this same thing—crows and gulls show it very clearly. Last year Lilienthal chiefly experimented with double-surface machines. These were very much like the old machines with awnings spread above them.

In illustrations 4 and 5, he has been picked up above the top of the hill by a sudden gust of wind striking him; he, being at rest and possessing considerable weight, was able to be lifted several seconds before the wind overcame his inertia. I myself have often been lifted in this same manner. It is necessary to get well forward in the machine at the right instant, so that one may shoot forward against the wind, and not be carried away with it. I have been picked up fully 12 feet from the ground, and put down again on exactly the same spot.

The object of making these double-surface machines was to get more surface without increasing the length and width of the machine. This, of course, it does; but I personally object to any machine in which the wing surface is high above the weight. I consider that it makes the machine very difficult to handle in bad weather, as a puff of wind striking the surface, high above one, has a great tendency to heel the machine over. The machine shown in illustration 4 had about 250 square feet of surface.

Herr Lilienthal kindly allowed me to sail down his hill in one of these double-surface machines last June. With the great facility afforded by his conical hill the machine was handy enough; but I am afraid I should not be able to manage one at all in the squally districts I have had to practise in over here.

Herr Lilienthal came to grief through deserting his old method of balancing. In order to control his tipping movements more rapidly he attached a line from his horizontal rudder to his head, so that when he moved his head forward it would lift the rudder, and tip the machine up in front, and *vice versâ*. He was practising this on some natural hills outside Berlin, and he apparently got muddled with the two motions, and, in trying to regain forward speed after he had, through a lull in the wind, come to rest in the air, let the machine get too far down in front, came down head first and was killed.

The object of experimenting with soaring machines is to enable one to have practice in starting and alighting and controlling a machine in the air. They cannot possibly float horizontally in the air for any length of time, but to keep going must necessarily lose in elevation. They are excellent schooling machines, and that is all they are meant to be, until power, in the shape of an engine working a screw propeller, or an engine working wings to drive the machine forward, is added; then a person who is used to sailing down a hill with a simple soaring machine will be able to fly with comparative safety. One can best compare them to bicycles having no cranks, but on which one could learn to balance by coming down an incline.

Illustration 6 shows a machine which Lilienthal made in the summer of 1895, in which more than simple soaring is attempted. The extremities of the wings are made to flap, and constructed so that flapping will drive the machine ahead. The power was derived from a cylinder of compressed carbonic acid gas, and when Lilienthal pressed a valve with the thumb of his right hand, a piston in a working cylinder made a stroke, and caused the wings to give one flap. With this type of engine he was only able to carry enough power to last for about half a minute. He had several minor accidents with the mechanism of the machine which delayed him, so that he made no real horizontal flights with it.

MY OWN EXPERIMENTS

I began to make my first soaring machine at the beginning of 1895. I had seen photographs of Lilienthal's apparatus, but I purposely made my own before going over to Berlin to see his, so as to get the greatest advantage from any original ideas I might have; but I was not able to make my first trials with this machine till June, 1895, after I had seen Lilienthal fly. Illustration 7 shows my first machine tipped up to show the details. The object of the triangle is to obtain points from which to bring the wires which stiffen the sails. There were three wires from the top of the triangle to each rib in the sails, and three wires from one of the lower corners of the triangle to each rib on the same side. Please note that there is a vertical, but no horizontal, rudder.

I am going through my own course of experiments somewhat in detail, because it has been instructive.

Illustrations 8 and 9 show the next development. There is a horizontal rudder as well as a large vertical rudder. Without the horizontal rudder I was able to do nothing—it was not until I had put on the horizontal rudder that I was able to leave the ground at all. Lilienthal told me that a horizontal rudder was absolutely necessary. I would not believe him, but found out that he was quite correct. These two "model gliders" show the point very clearly. They are quite similar, except that the one has two surfaces, the second surface acting as a rudder, and the other has only one surface. When I throw the single-surface one you will see that it will only go straight for a yard or two, then keep on turning head over heels, whereas the double-surface one will probably sail perfectly well.

In the illustration please note that the wings are very much turned up at the points. I did this because I believed that it would facilitate transverse balance, on the principle that a piece of paper bent into a **V** shape will always come down edge first, and a cone will, if dropped, always come down on its point. If stability is got by having the weight very low, as in a parachute, there will be a big oscillation.* It must also be remembered that a man soaring, if he meets with an accident, gets a comparatively very much worse fall than a smaller

* These facts were illustrated by Mr. Pilcher with a paper cone which, when dropped from the roof, came down quite steadily, whereas a small parachute, made of linen and weighted with lead, showed a great deal of oscillation.—EDS.

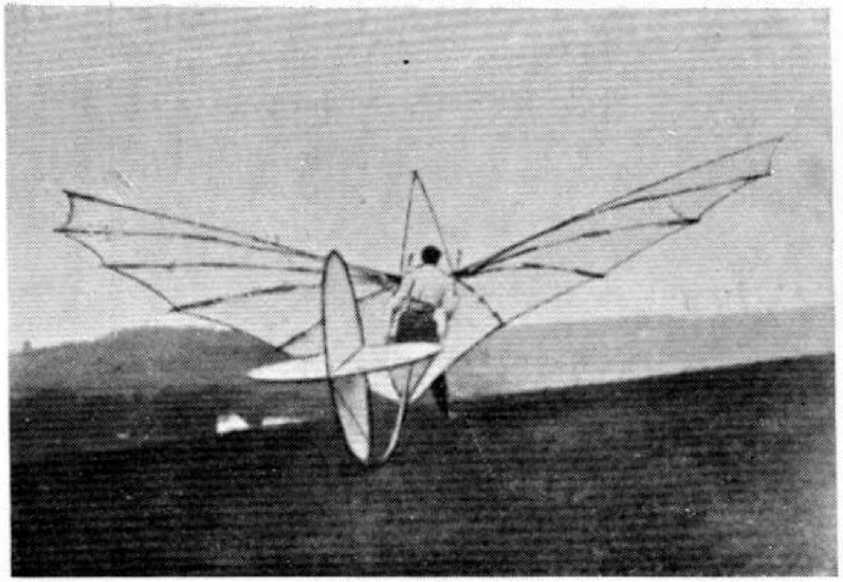


Fig. 8.—The "Bat" with a tail

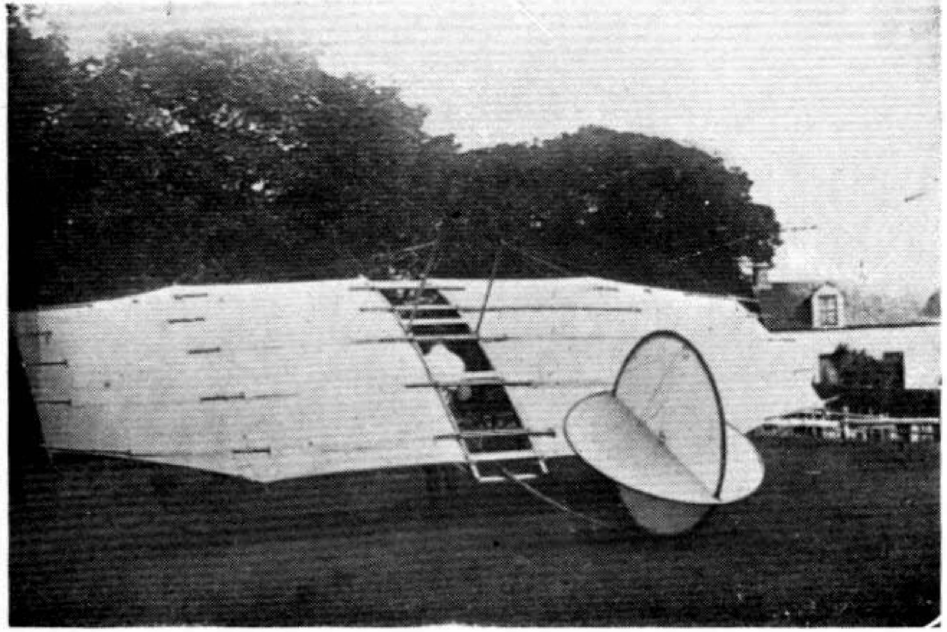


Fig. 10.—The "Beetle"; rear view

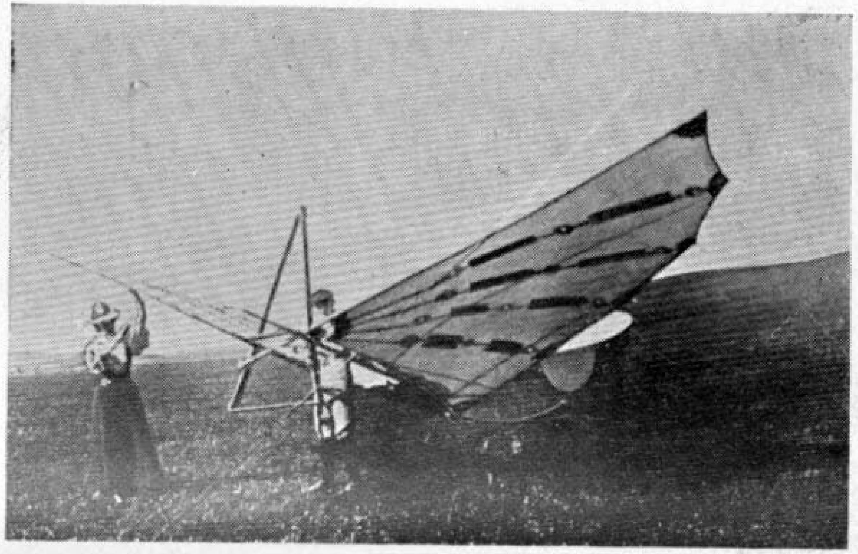


Fig. 9.—The "Bat"; side view

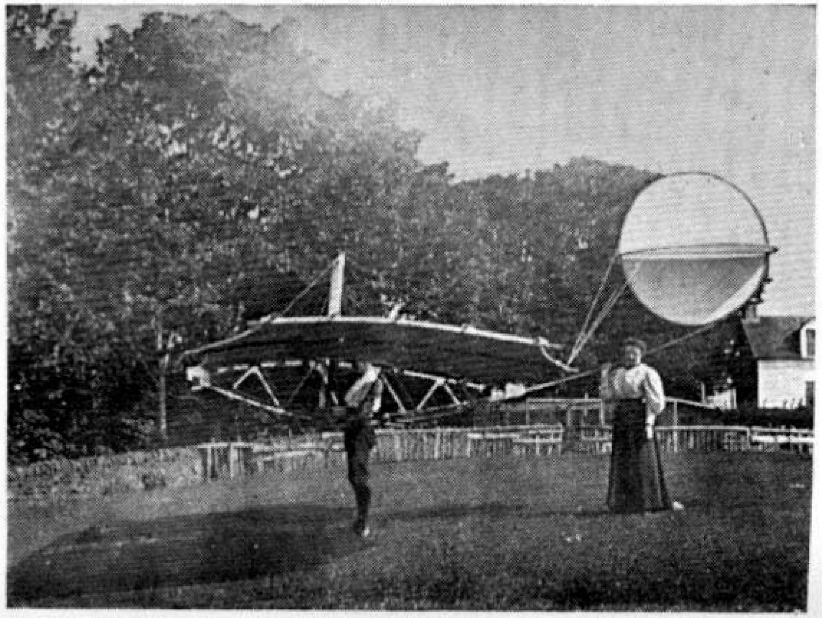


Fig. 11.—The "Beetle"; side view

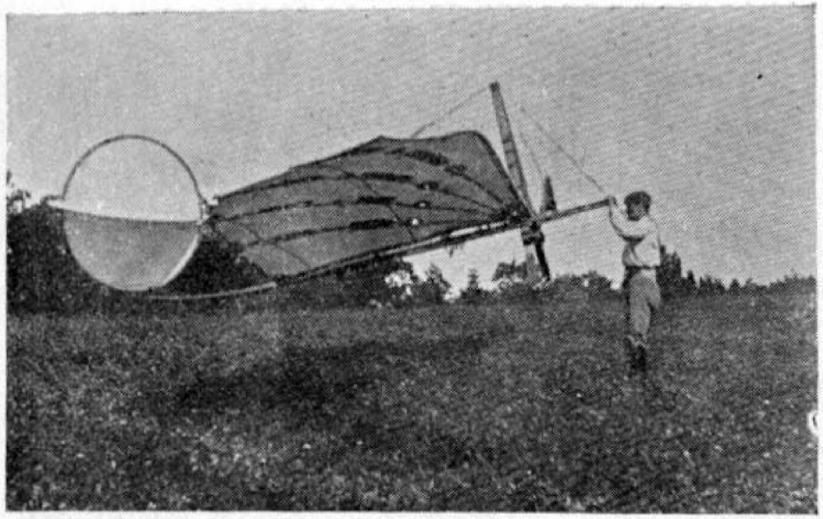


Fig. 12.-The " Bat " modified.

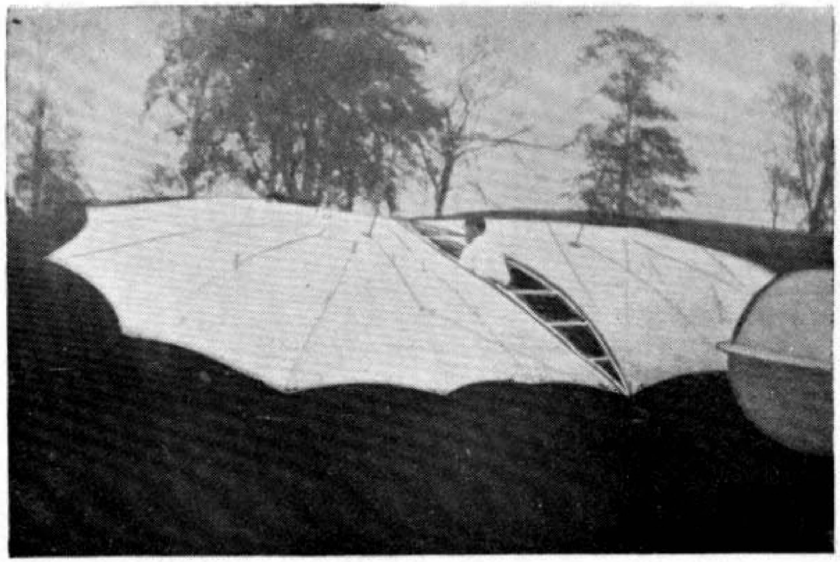


Fig. 14.-The "Gull"

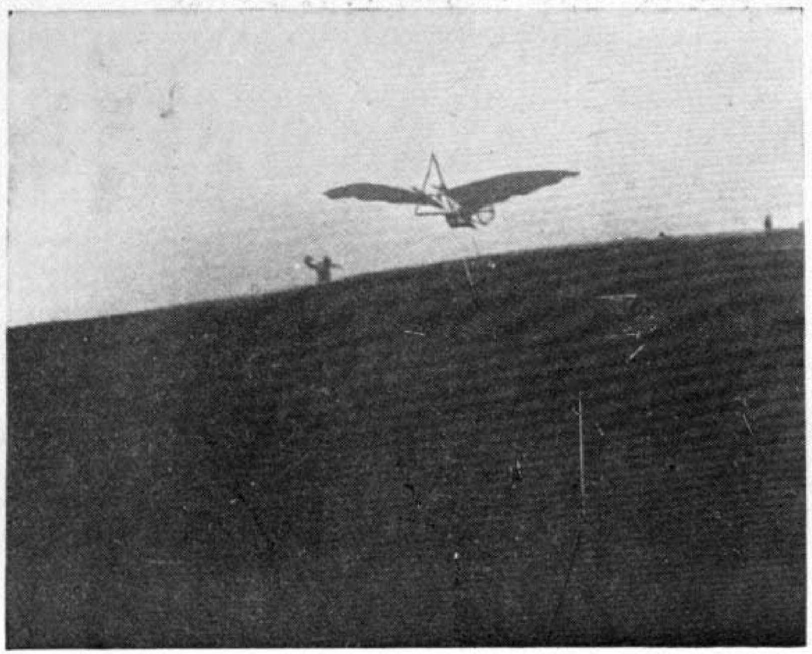


Fig. 13.—The "Bat" in flight

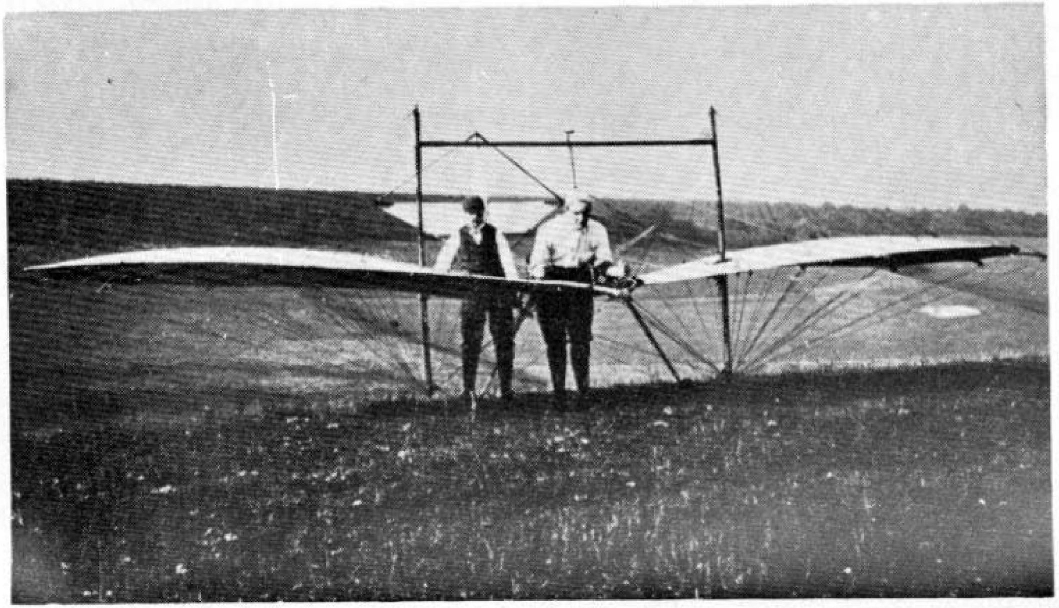


Fig. 15.—The "Hawk"

object. An insect can get knocked down by the wind, and remain uninjured.*

The upturned wings were all very well if there was no wind, or if the wind was steady; but if the wind shifted slightly sideways, and came on to one side of the machine, it would tend to raise the windward wing and depress the lee one, and capsize me sideways, which always meant a breakage in the machine.

To obviate this I built a second machine quite flat transversely, with the whole surface considerably raised so as to keep the wing tips a good distance off the ground (illustrations 10 and 11). This machine was, unfortunately, very heavy, and the wing surface being placed considerably above me, I had very little control over it. A sudden puff of wind would carry the machine backwards, leaving me, because of my weight, as it were behind, and it was only by slipping out of the machine when it was above my head that I several times avoided going head over heels backwards with it.

Illustration 12 shows the next alteration in the first machine. The wing tips have been considerably lowered, and with this machine in this condition I obtained by far my best results at Cardross, on the Clyde, where I experimented in the summer of 1895. The illustration shows the machine floating in the air. When being held at the front, any of the machines can be held in the wind quite easily with one finger, although they weigh from 50 to 80 lbs.

* To illustrate this point two cards of equal area but one weighing four times as much as the other, were dropped from the roof, the heavier one falling in exactly half the time that the lighter one took to drop.—EDS.

I had better mention the names these machines were always called by. The first one was the "Bat," the second flat one was called the "Beetle," because it looked like a beetle; my fourth machine is the "Hawk."

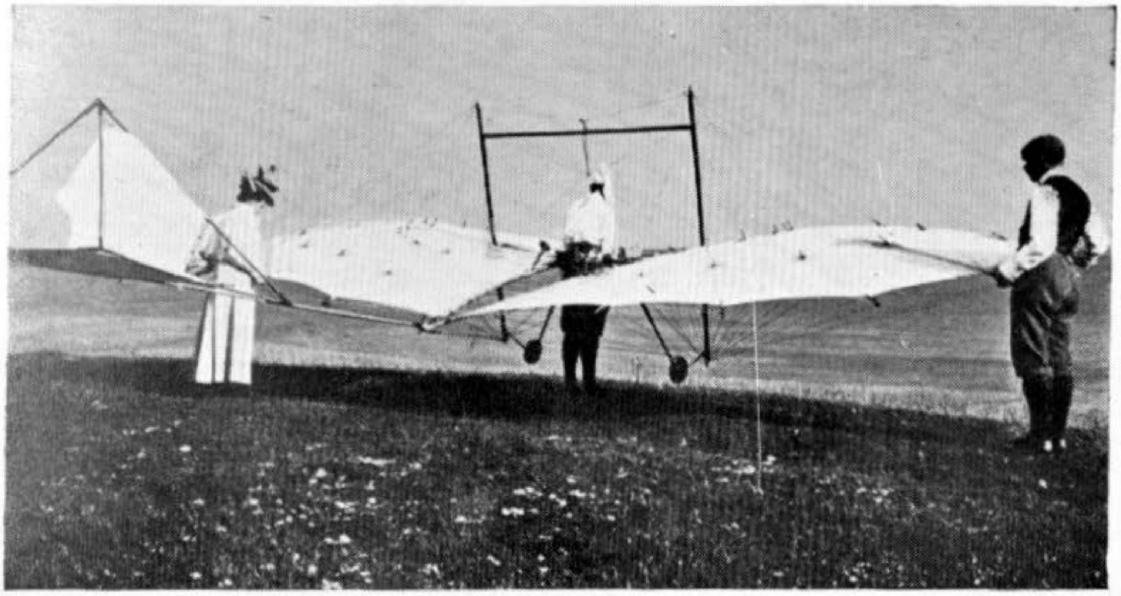
Illustration 13 shows the "Bat" flying. The wing surface of the "Bat" is about 150 square feet; that of the "Hawk" is 170.

Illustration 14 shows my third machine, the "Gull," with 300 square feet. I got it broken up twice last year, and have not yet had time to rebuild it. It was intended for practice only on calm days; but I had not patience to wait for them, and took it out when there was practically no holding the large wing surface. The "Hawk," the machine with which I am practising now, is very like the "Gull," the curvatures being exactly similar.

The "Hawk" I built last winter. It weighs 50 lbs. I think this is the best system for building a soaring machine; it seems to be stiffer and lighter than any of the other methods. During the latter part of last summer* I had the machine out about ten times at Eynsford, in Kent. I have, unfortunately, had to be very busy about other things, and have not been able to spend much time in experimenting. Please remember this machine has been drenched several times, and several times I have landed in bushes, and once caught in a wire fence while going fast, and so she does not look so fresh as when she was first built.†

* The year referred to is 1896.

† The "Hawk" was exhibited in the room during the lecture, and its handling demonstrated by Mr. Pilcher. When landing the glider was tipped up, the weight being well back; when sailing fast the weight had to be well forward.—EDS.



Fig, 16—The "Hawk"; rear view

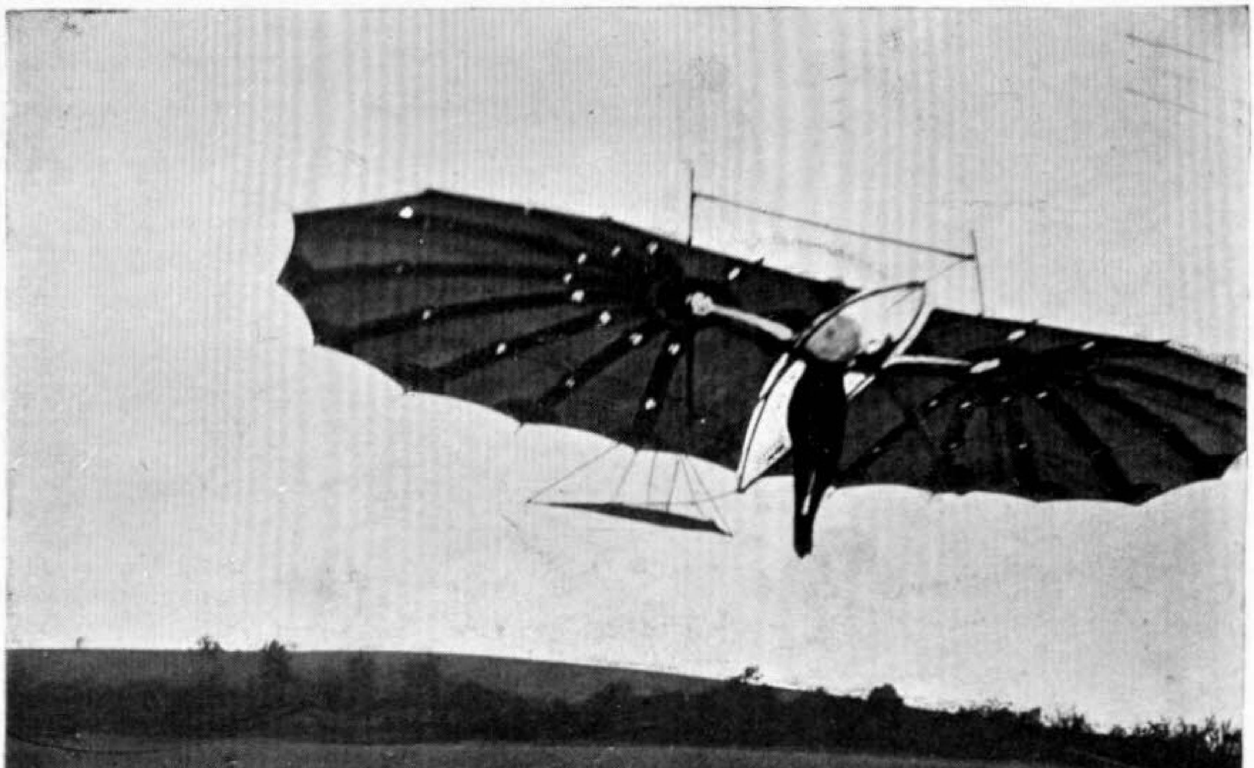


Fig. 17.—The "Hawk" in flight

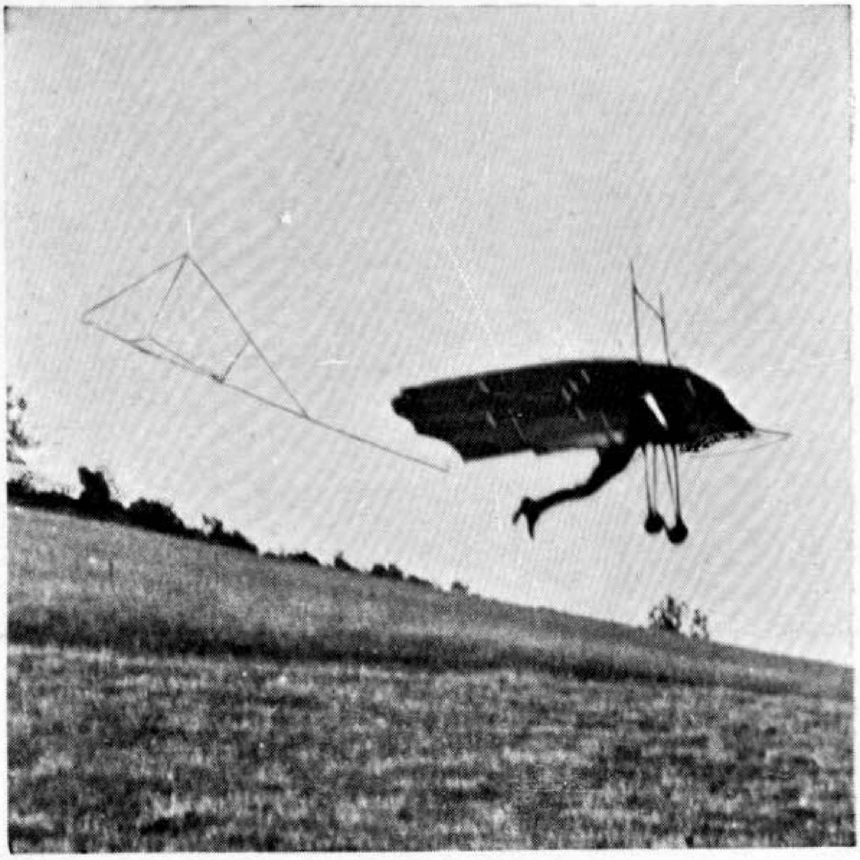


Fig. 18.—P. S. Pilcher on the "Hawk"

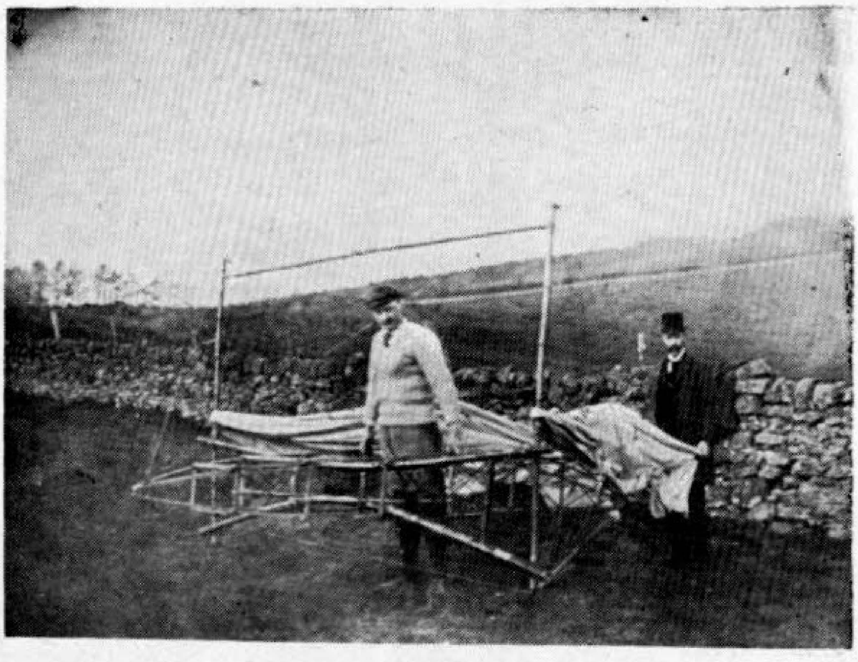


Fig. 19.- The "Gull" with wings folded for transport

In this machine I have done away with the first rudder altogether. Whether this is an advantage or not I am not certain. The greatest distance I have cleared with this machine is about 100 yards—once with a slight side wind, once in a dead calm. Most unfortunately I have never had the machine out when it has been blowing up the best hill for experimenting at Eynsford, or I should be able to record much longer distances.

This is the first machine on which I have ever had any wheels. If I make a bad landing these two small wheels are able to take a great part of the jar, as behind the bamboo which supports them on each side there is a very stiff spiral spring.

The great thing to be learnt with these machines is to land properly. One must, before landing, get right back in the machine, so as to tip it well up in front, and so bring the machine to rest in the air instead of on the ground.

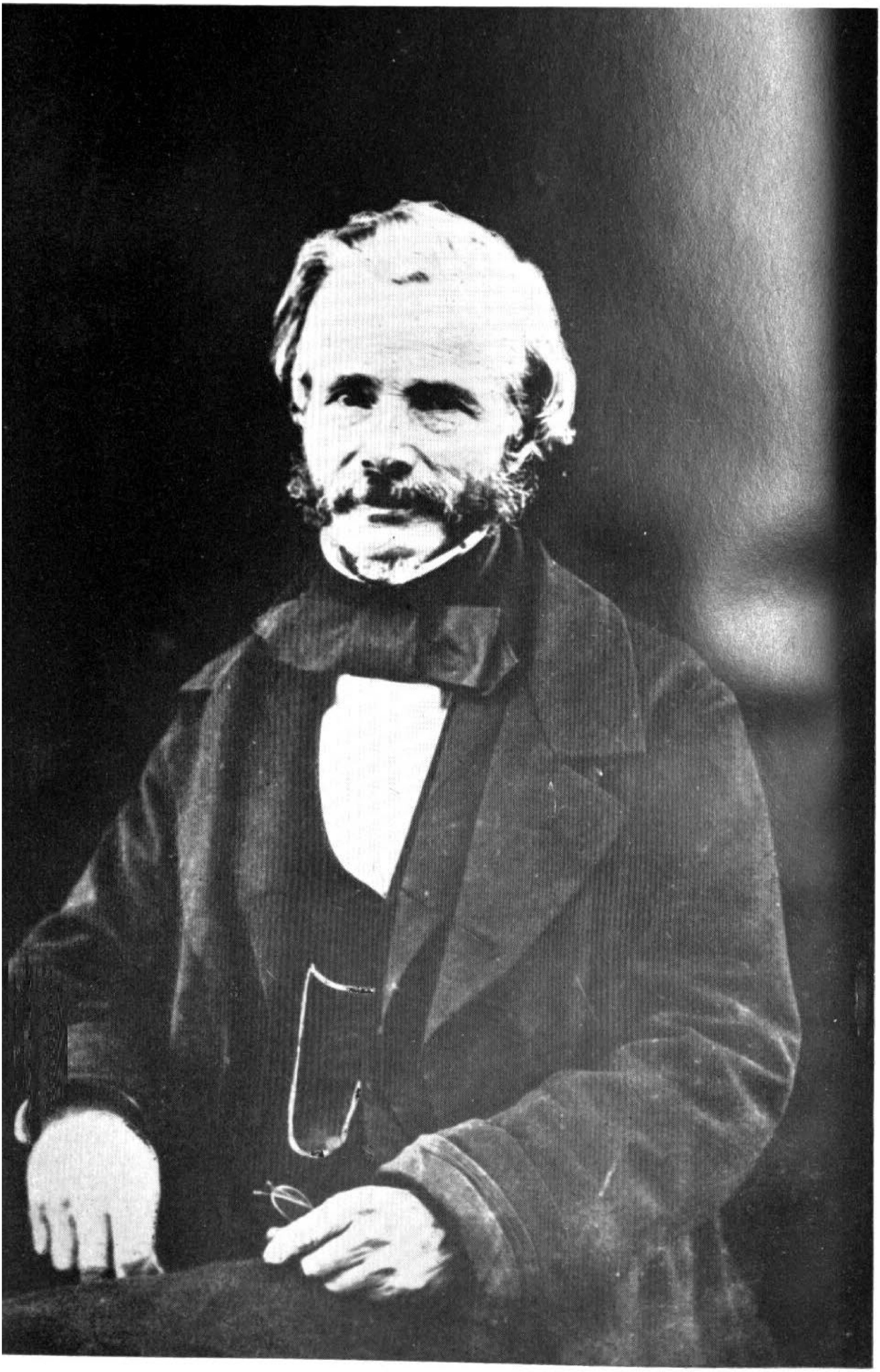
You will note that the horizontal rudder is made so that it can be lifted, but cannot be depressed. This seems to allow it to answer the purpose which is required of it, and saves it from getting broken if one tips the machine up a great deal, as is frequently necessary when coming to the ground.

It is my intention this winter to make another machine very similar to this, but having a small oil engine situated just in front of me on the machine, with a shaft passing over my head, working a screw propeller of about 4 feet diameter, situated behind me. The machine will be started in exactly the same way as the soaring machines, by running down an incline, and when in the air the screw will be started to revolve, and in this way I hope to be able to maintain horizontal flight. From soaring machine experiments, it appears that an expenditure of energy of about two H.P. per minute is necessary; I shall therefore use an engine of about four H.P., because of the inefficiency of the screw and other losses. The flying speed would be about 30 miles per hour.

THE AERONAUTICAL WORK

OF

JOHN STRINGFELLOW



JOHN STRINGFELLOW

THE AERONAUTICAL WORK

OF

JOHN STRINGFELLOW

WITH SOME ACCOUNT OF W. S. HENSON

JOHN STRINGFELLOW, the first man to make an engine-driven aeroplane which flew, was born on December 6th, 1799, at Attercliffe, near Sheffield, and at an early age was apprenticed to the lace trade in Nottingham. His father, William Stringfellow, had been noted for his mechanical ingenuity, which blossomed again with increased vigour in his son. About 1820, having gained considerable reputation as a bobbin and carriage manufacturer he removed to Chard, prospering to such an extent that a few years later he set up an establishment of his own for the manufacture of lace machinery. Thence onward to his death his prosperity and popularity never waned, and though he has been more than a quarter of a century in his grave there are many in the little Somersetshire town that remember the cheerful and vigorous personality of Stringfellow, the " flying man."

It happened that there was residing at Chard, with his father, a young engineer named William Samuel Henson,* who was deeply interested in the problem of flight. Drawn by mutual engineering interests into friendship with Stringfellow, Henson did not hesitate to confide to him his hopes and aspirations, and it is recorded that during one heroic evening at Stringfellow's house the world-famed aeroplane was planned.

Henson almost immediately afterwards left for London, but correspondence continually passed between the two friends, and Stringfellow, interested more at first in the question of motive power as his undoubted skill in lace-machinery would warrant, began building the first of the series of light steam-engines upon which his reputation principally depends. In 1840 Henson began his experiments with gliding models, tentative constructional devices, and a light steam-engine. The engine seems to have cost him endless trouble in spite of the advice and assistance of Stringfellow, who supplied him with parts for his boiler. At the end of 1841, Stringfellow visited Henson in London and received an order for an engine from his friend, who, in the letter which follows, specified the peculiar cone construction in the boiler, which Stringfellow had probably suggested to him.

7, Ralph Place,
London,
January 10/42.

My dear Sir,

I beg pardon for keeping you so long in suspense, but I unexpectedly went out on Sunday

* Born at Leicester about 1805.

week and I waited to give you some more particulars respecting my little engine. There are two cylinders of 1 inch dia. and 2-inch stroke. At first I cut the steam off at $\frac{1}{4}$ of the stroke, but finding I had plenty of steam, I now cut it off at $\frac{1}{2}$. The boiler consists of two cones, $4\frac{1}{2}$ inches dia. and 7 deep. From the widest part downwards the cylinders are let into the cones in the manner I mentioned to you when you were in town; the cones are like the tin one I showed you at that time, having the upper part large enough to hold one of the cylinders above the water line at wide part. I find your cylinders will hold 3 times the quantity that mine will hold, consequently there should be something more than double the quantity of heating surface, but it will be advisable not to have double the weight of water, a gallon of water weighs about 10 lbs. One quart of water is about the proper quantity for your boiler, it won't last long it's true, but that does not matter. My engine is heavier considerably than it ought to be, in addition to which it holds more water than is necessary. This is against me, but still it is very powerful for its weight, and I have no doubt about making it act. I have not yet got my model sufficiently advanced to have a fly, but I continue as sanguine as ever as to the results. I think you had better make the boiler to consist of several small cones, each holding a very small quantity of water, so as to get about $2\frac{1}{2}$ times the quantity of surface with the same quantity of water—such as 6 or 8 cones of about

3 or 2 inches dia. at the broad part, well studded with copper wire. My engine with water and fuel altogether with the fire-place weighs about 10 lbs., and I am quite sure an engine may be made of double the power with the same weight including everything; and I know also that you can do it and will. I wish much I could have had your engine for my present model, as it would assist so much in making up for those natural defects which all models possess more or less. Wishing you success,

I am, my dear Sir,

Very faithfully yours,

W. S. HENSON.

To John Stringfellow, Esq.

About this time Mr. Colombine, an attorney, and a Mr. Marriott appeared on the scene—Colombine would be necessary for the Company work, settling the patent, etc., while Mr. Marriott knew a Member of Parliament. Besides, they were both extraordinarily excited over the idea which Henson laid before them, and promised to take shares in the Company as soon as it was formed. The patent, No. 9478 of 1842, was taken out in September, an application was made to Parliament for an Act of Incorporation for the Aerial Steam Transit Company, and the M.P., Mr. Roebuck, moved to bring in the Bill on March 24th, 1843. The patent was for "Certain Improvements in Locomotive Apparatus and Machinery for Conveying Letters, Goods, and Passengers from Place to Place through the Air, part of which Improvements are applicable to Locomotive and other

Machinery to be used on Water and on Land," and specified *inter alia* a steam-engine incorporating Stringfellow's suggestions.

Sir George Cayley had shown in 1809 the way to success, and Henson, developing his idea of the resistance offered by the air to surfaces moving through it, evolved the project of a large monoplane singularly like those of the present day, but with flat instead of curved surfaces, a circumstance that robbed him of the success he undoubtedly deserved.

"In order that the description hereafter given may be rendered clear," he wrote in his patent specification (1842, No. 9478), "I will first shortly explain the principle on which the machine is constructed. If any light and flat or nearly flat article be projected or thrown edgewise in a slightly inclined position, the same will rise on the air till the force exerted is expended, when the article so thrown or projected will descend; and it will readily be conceived that, if the article so projected or thrown possessed in itself a continuous power or force equal to that used in throwing or projecting it, the article would continue to ascend so long as the forward part of the surface was upwards in respect to the hinder part, and that such article, when the power was stopped, or when the inclination was reversed, would descend by gravity only if the power was stopped, or by gravity aided by the force of the power contained in the article, if the power be continued, thus imitating the flight of a bird.

"Now, the first part of my invention consists of an apparatus so constructed as to offer a very extended surface or plane of a light yet strong construction, which will have the same relation to the general machine which the extended wings of a bird have to the body when a bird is skimming in the air; but in place of the movement or power for onward progress being obtained by movement of the extended surface or plane, as is the case with the wings of birds, I apply suitable paddle-wheels or other proper mechanical propellers worked by a steam or other sufficiently light engine, and thus obtain the requisite power for onward movement to the plane or extended surface; and in order to give control as to the upward and downward direction of such a machine I apply a tail to the extended surface which is capable of being inclined or raised, so that when the power is acting to propel the machine, by inclining the tail upwards the resistance offered by the air will cause the machine to rise on the air; and, on the contrary, when the inclination of the tail is reversed, the machine will immediately be propelled downwards, and pass through a plane more or less inclined to the horizon as the inclination of the tail is greater or less; and in order to guide the machine as to the lateral direction which it shall take, I apply a vertical rudder or second tail, and, according as the same is inclined in one direction or the other, so will be the direction of the machine.''

The proposed machine itself, as may be seen from the accompanying illustrations (Figs. 1 and 2), was an enormous monoplane, and was to be built of bamboo and hollow wood spars braced with wires. The surface of the planes was to measure 4,500 sq. ft. and the triangular tail 1,500 sq. ft. These dimensions were calculated to sustain ½ lb. to the square foot, including the machinery, fuel, and load. A steam-engine of 25-30-h.p. was to drive it, and propulsion was to be effected by two six-bladed propellers with the blades set at an angle of about 45°.

Naturally, the publication of this patent roused public curiosity to a considerable pitch, and the papers of the day produced fanciful pictures of the machine flying over Hyde Park, the Pyramids, the English Channel and the Thames at London Bridge, and published

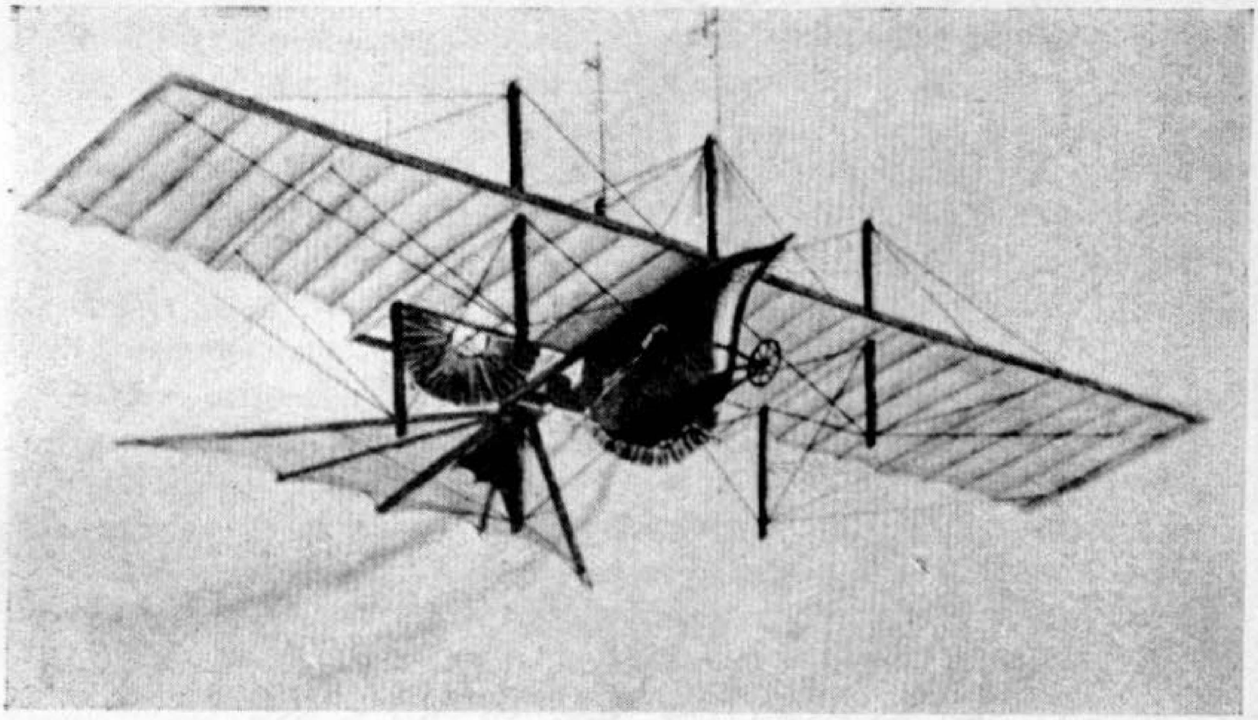


Fig. 1

articles in which scientists either totally condemned or fervently endorsed the new wonder.

Henson, Stringfellow, Colombine, and Marriott took shares in the Company, and Colombine drew up the following prospectus appealing for funds :—

PROPOSAL

For subscriptions of sums of £100, in furtherance of an Extraordinary Invention not at present safe to be developed by securing

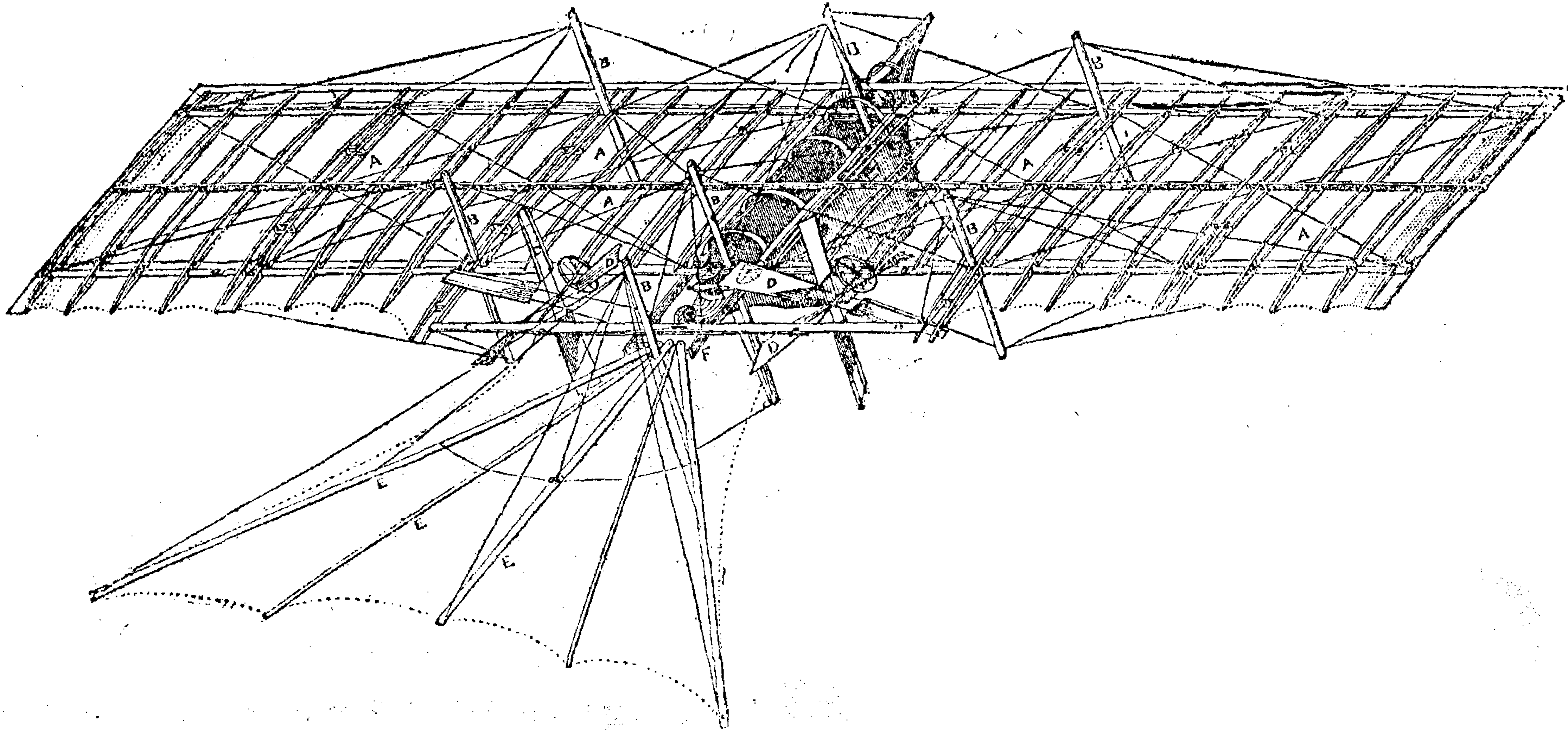


Fig. 2

the necessary Patents, for which three times the sum advanced, namely, £300, is conditionally guaranteed for each subscription on February 1, 1844, in case of the anticipations being realised, with the option of the subscribers being shareholders for the large amount, if so desired, but not otherwise. . . .

An Invention has recently been discovered, which if ultimately successful will be without parallel even in the age which introduced to the world the wonderful effects of gas and of steam.

The discovery is of that peculiar nature, so simple in principle yet so perfect in all the ingredients required for complete and permanent success, that to promulgate it at present would wholly defeat its development by the immense competition which would ensue, and the views of the Originator be entirely frustrated.

This work, the result of years of labor and study, presents a wonderful instance of the adaptation of laws long since proved to the scientific world combined with established principles so judiciously and carefully arranged, as to produce a discovery perfect in all its parts and alike in harmony with the laws of Nature and of science.

The Invention has been subjected to several tests and examinations and the results are most satisfactory, so much so that nothing but the completion of the undertaking is required to determine its practical operation, which being once established its utility is undoubted, as it would be a necessary possession of every empire, and it were hardly too much to say of every individual of competent means in the civilised world.

Its qualities and capabilities are so vast that it were impossible and, even if possible, unsafe to develop them further, but some idea may be formed from the fact that as a preliminary measure patents in Great Britain, Ireland, Scotland, the Colonies, France, Belgium, and the United States, and every other country where protection to the first discoveries of an Invention is granted, will of necessity be immediately obtained and by the time these are perfected, which it is estimated will be in the month of February, the invention will be fit for Public Trial, but until the Patents are sealed any further disclosure would be most dangerous to the principle on which it is based.

Under these circumstances, it is proposed to raise an immediate sum of £2,000 in furtherance of the Projector's views, and as some protection to the parties who may embark in the matter, that this is not a visionary plan for objects imperfectly considered, Mr. Colombine, to whom the secret has been confided, has allowed his name to be used on the occasion and who will if referred to corroborate this statement, and convince any inquirer of the reasonable prospects of large pecuniary results following the development of the Invention.

It is therefore intended to raise the sum of £2,000 in 20 sums of £100 each (of which any Subscriber may take one or more not exceeding five in number to be held by any individual) the amount of which is to be paid into the hands of Mr. Colombine as General Manager of the concern to be by him appropriated in procuring the several Patents and providing the expenses incidental to the works in progress. For each of which sums of £100 it is intended and agreed that 12 months after the 1st February next, the several parties subscribing shall receive as an equivalent for the risk to be run the sum of £300* for each of the sums of £100 now subscribed provided when the time arrives the Patents shall be found to answer the purposes intended.

As full and complete success is alone looked to, no moderate or imperfect benefit is to be anticipated, but the work, if it once passes the necessary ordeal, to which inventions of every kind must be first subject, will then be regarded by everyone as the most astonishing discovery of modern times; no half success can follow, and therefore the full nature of the risk is immediately ascertained.

The intention is to work and prove the Patent by collective instead of individual aid as less hazardous at first and more advantageous in the result for the Inventor, as well as others, by having the interest of several engaged in aiding one common object—the development of a Great Plan. The failure is not feared, yet as perfect success might, by possibility, not ensue, it is necessary to provide for that result, and the parties concerned make it a condition that no return of the subscribed money shall be required, if the Patents shall by any unforeseen circumstances not be capable of being worked at all; against which, the first application of the money subscribed, that of securing the Patents, affords a reasonable security, as no one without solid grounds would think of such an expenditure.

It is perfectly needless to state that no risk or responsibility of any kind can arise beyond the payment of the sum to be subscribed under any circumstances whatever.

* This sum was afterwards altered to £500, though, needless to add, it was never paid.

As soon as the Patents shall be perfected and proved it is contemplated, so far as may be found practicable, to further the great object in view a Company shall be formed but respecting which it is unnecessary to state further details, than that a preference will be given to all those persons who now subscribe, and to whom shares shall be appropriated accordingly the larger amount (being three times the sum to be paid by each person) contemplated to be returned as soon as the success of the Invention shall have been established, at their option, or the money paid, whereby the Subscriber will have the means of either withdrawing with a large pecuniary benefit, or by continuing his interest in the concern, lay the foundation for participating in the immense benefit which must follow the success of the plan.

It is not pretended to conceal that the project is a speculation—all parties believe that perfect success, and thence incalculable advantages of every kind, will follow to every individual joining in this great undertaking; but the Gentlemen engaged in it wish that no concealment of the consequences, perfect success, or possible failure, should in the slightest degree be inferred. They believe this will prove the germ of a mighty work, and in that belief call for the operation of others with no visionary object, but a legitimate one before them, to attain that point where perfect success will be secured from their combined exertions.

All applications to be made to D. E. Colombine, Esquire, 8, Carlton Chambers, Regent Street.

The public do not, however, seem to have got beyond verbal and pictorial speculation in the venture, and Mr. Roebuck declared that he had risked quite enough in bringing in the Bill. Colombine agitated, squibbed, and advertised; Henson conducted some experiments with models in the Adelaide Gallery, and, finding himself cramped for room, removed to a tent on the Hippodrome racecourse, Bayswater, "2 miles from the end of Oxford Street," for a fortnight; but all to no purpose.

Meanwhile, Stringfellow, who had been promised the construction of the machine as soon as funds were forthcoming, grew impatient, and in November, 1843, wrote urgently to Henson suggesting that they should construct a large model out of their private resources and trust to a happy issue for repayment. To this Henson replied as follows :—

7, Ralph Place,
Trinity Square, Borough,
London,
November 18/43.

My dear Sir,

I received your letter this morning and, as there is no post out of London to-morrow, I just drop you a line to say that I think you are quite right in your views. I knew how you would feel in the matter, and I said distinctly that whoever I might get to carry out the matter would expect to have the control of it during progress and very liberal treatment also, and that, in fact, neither of them (Colombine or Marriott) would know anything about it until it was done; if it succeeded they would have to fulfil the contract, if not, they would hear no more about it. I shall leave a note at Colombine's to-day to ask him for a rough copy or sketch of the terms for you, so that I think you will hear from me again on Tuesday or Wednesday. I quite agree with you about the Lawyer's. Don't you think the buying the patent—I mean Colombine and Marriott shares—would be a good move? I am quite sure that by good management the money could be got out of it again, even with only partial success. I shall have a try to get it into other hands yet, as I don't think it would prejudice an arrangement with you. Hoping you are better,

I am, my dear Sir,

Very faithfully yours,

W. S. HENSON.

P.S.—Remember me kindly to Mrs. Stringfellow and family.

Colombine and Marriott were accordingly bought out. With the agreement* in his pocket Henson travelled down to Chard that Christmas, and for the next few years no more was heard of the giant aeroplane.

The two inventors, however, were hard at work. "They commenced the construction of a small model operated by a spring, and laid down the larger model 20 ft. from tip to tip of planes, $3\frac{1}{2}$ ft. wide, giving 70 ft. of sustaining surface, about 10 more in the tail. The making of this model required great consideration; various supports for the wings were

* Memorandum of an agreement entered into by Mr. John Stringfellow, of Chard, in the County of Somerset, of one part, and Mr. Wm. Saml. Henson, of No. 7, Ralph Place, near Trinity Square, of the Borough of Southwark, of the other part.

Whereas it is intended to construct a model of an Aerial Machine to be employed in such a manner as the parties above named shall consider best and most profitable.

1st. It is agreed, if considered necessary, to take out patents for the same jointly, but be it understood that this agreement does not extend to England except for such parts as are improvements upon patent already taken out in England.

2nd. That all moneys advanced to be considered as lent and to be deducted from the profits that may arise hereafter.

3rd. That all profits after deducting expenses be equally divided.

tried, so as to combine lightness with firmness, strength, and rigidity.

"The planes were staid from three sets of fish-shaped masts, and rigged square and firm by flat steel rigging. The engine and boiler were put in the car to drive two screw propellers, right and left handed, 3 ft. in diameter, with four blades each, occupying three-quarters of the area of the circumference, set at an angle of 60 degrees. A considerable time was spent in perfecting the motive power. Compressed air was tried and abandoned. Tappets, cams, and eccentrics were all tried, to work the slide valve, to obtain the best results. The piston rod of engine passed through both ends of the cylinder, and with long connecting rods worked direct on the crank of the propellers. From memorandum of experiments still preserved the following is a copy of one :— June, 27th, 1845, water 50 ozs., spirit 10 ozs., lamp lit 8.45, gauge moves 8.46, engine started 8.48 (100 lb. pressure), engine stopped 8.57, worked 9 minutes, 2,288 revolutions, average 254 per minute. No priming,

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4th. That it is the intention of this agreement that the parties above named shall be on perfect equality as regards carrying out and working the same.

5th. That it is intended at a future time, if considered necessary and desirable, to enter into an agreement more definite and explicit, according as circumstances may arise to require it.

6th. That the parties hereby pledge themselves in honour to each other to do all that lies in their power towards carrying out the objects of this agreement.

7th. That nothing herein mentioned shall be construed into a partnership beyond carrying out jointly the objects of this agreement.

(Signed) W. S. HENSON.
(Signed) J. STRINGFELLOW.

December 29th, 1843.

40 ozs. water consumed, propulsion (thrust of propellers), 5 lbs. $4\frac{1}{2}$ ozs. at commencement, steady, 4 lbs. $\frac{1}{2}$ oz., 57 revolutions to 1 oz. water, steam cut off one-third from beginning.

"The diameter of cylinder of engine was one-and-a-half inch, length of stroke three inches.

"In the meantime an engine was also made for the smaller model, and a wing action tried, but with poor results. The time was mostly devoted to the larger model, and in 1847 a tent was erected on Bala Down, about two miles from Chard, and the model taken up one night by the workmen. The experiments were not so favourable as was expected. The machine could not support itself for any distance, but, when launched off, gradually descended. Although the power and surface should have been ample, indeed, according to latest calculations, the thrust should have carried more than three times the weight, for there was a thrust of five pounds from the propellers, and a surface of over 70 square feet to sustain under 30 lbs., but necessary speed was lacking."*

Stringfellow himself wrote of this splendid failure:—"There stood our aerial protégée in all her purity—too delicate, too fragile, too beautiful for this rough world; at least, those were my ideas at the time, but little did I think how soon it was to be realised. I soon found,

* "A few Remarks on what has been done with screw-propelled Aero-plane Machines from 1809 to 1892," by F. J. Stringfellow, Crewkerne, Somerset (Chard: Young & Son, N.D. pp. 14. Photographs). In this rare little pamphlet Mr. Stringfellow gives some account of his father's and his own experiments, from which much of the information included in this memoir is taken. Mr. F. J. Stringfellow died on August 25, 1905.

before I had time to introduce the spark, a drooping in the wings, a flagging in all the parts. In less than ten minutes the machine was saturated with wet from a deposit of dew, so that anything like a trial was impossible by night. I did not consider we could get the silk tight and rigid enough. Indeed, the framework altogether was too weak. The steam-engine was the best part. Our want of success was not for want of power or sustaining surface, but for want of proper adaptation of the means to the end of the various parts.''

For seven weeks successive experiments took place on the Downs, but the trials by running the machine down wide rails showed faulty construction and its lightness made it unmanageable in the slightest wind.

Discouraged and impoverished, Henson refused to go any further in the work. His London landlady's daughter, Miss Jones, threw the casting vote for matrimony against mechanics, and in 1849 he left with his wife for America, disappearing in the wilds of Texas from the ken of aeronautical science.

If Stringfellow was dismayed by the turn of events, he was not discouraged. Henson had gone, but he had learnt all that Henson knew, and was the richer for several years of practical experience. Accordingly, in 1846, he set to work on the small model upon which for all time his fame will rest as being the first engine-driven aeroplane to fly. This historic machine* was 10 ft. in span and 2 ft. (0,61 m) across in the widest part of the wings; length of tail 3 ft. 6 ins. (1,06 m), span of tail in widest

* See Fig. 3.

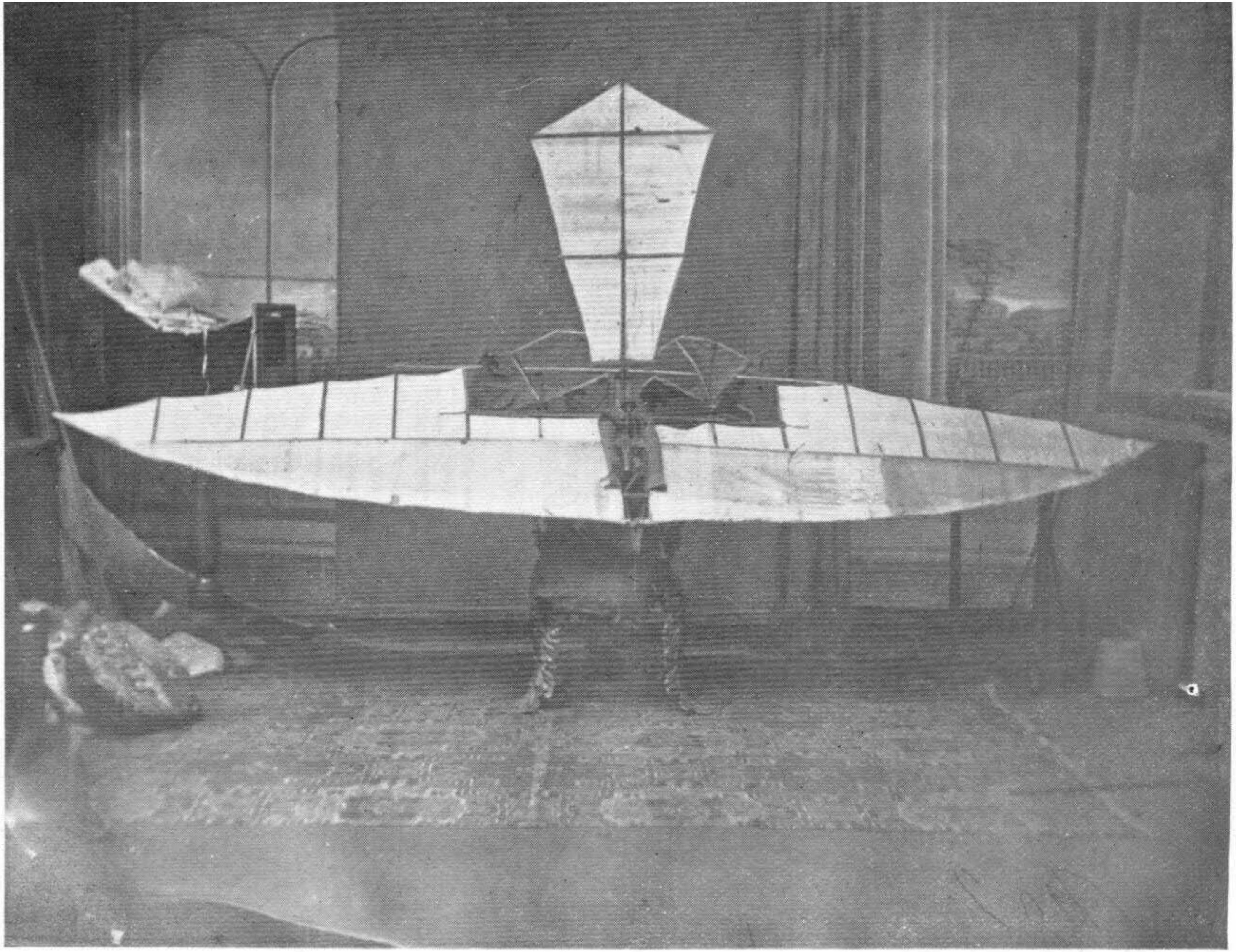

Fig. [illegible]

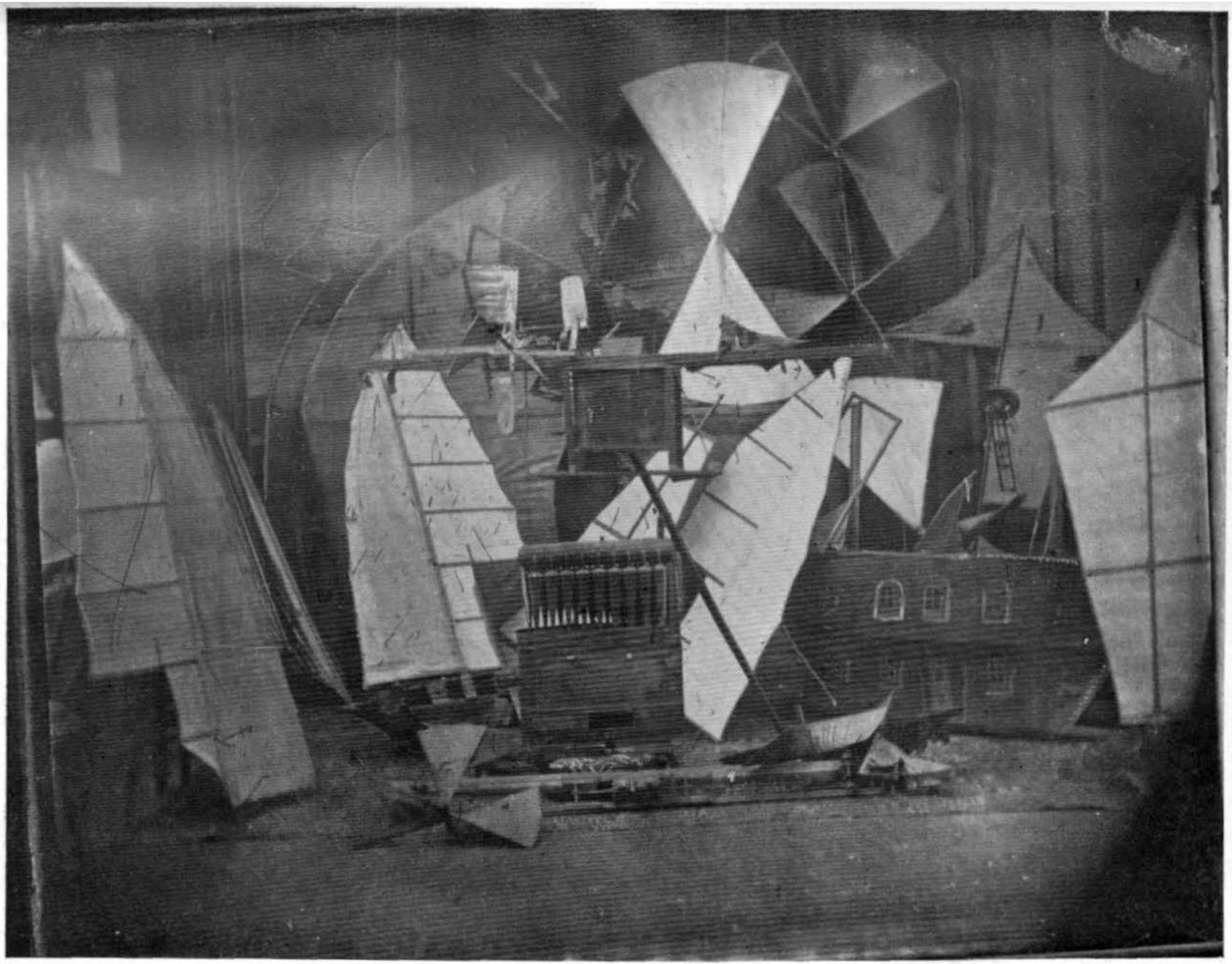

Fig. 5.—Relics of Stringfellow's Experiments
(A steam-engine is in the centre)

part 22 ins.; the total sustaining area was about 14 sq. ft. 1,37 The two propellers—a right and a left screw—had four blades set at an angle of 60 degrees, occupying three-quarters of the area of the circumference, and were 16 ins. in diameter. ϕ = 0,4 m

The cylinder of the engine was of $\frac{3}{4}$ in. diameter with a 2-in. stroke and a bevel gear to the crank shaft gave three revolutions of the propellers to one stroke of the engine. The weight of the entire model and engine was eight pounds—with water and fuel half-a-pound more. That his model actually flew was due in large measure to the wing form: slightly curved with a rigid front edge and a flexible trailing edge—a form of construction advocated by Da Vinci and Borelli, and re-discovered repeatedly by investigators for several hundred years, but until this moment never carried out. Stringfellow probably got the idea of the curve from Sir George Cayley, though certainly some credit should rest with Thomas Walker,* who advocated the flexible rear-edge in 1810, and with Dr. Thomas Young, who in 1800 proved that certain curved surfaces advanced into an impinging air-current.

The fullest account of the flight is given by his son, F. J. Stringfellow,† and is here quoted :—"My father had constructed another small model which was finished early in 1848, and having the loan of a long room in a disused lace factory, early in June the small model was moved there for experiments. The room was about 22 yards long and from 10 to 12 ft. high. . . . . . The inclined wire for starting the machine occupied less than

* *Vide* "Aeronautical Classics," No. 3.

† *Vide* "Screw-Propelled Aero-plane Machines."

half the length of the room and left space at the end for the machine to clear the floor. In the first experiment the tail was set at too high an angle, and the machine rose too rapidly on leaving the wire. After going a few yards it slid back as if coming down an inclined plane at such an angle that the point of the tail struck the ground and was broken. The tail was repaired and set at a smaller angle. The steam was again got up, and the machine started down the wire, and, upon reaching the point of self-detachment, it gradually rose until it reached the farther end of the room, striking a hole in the canvas placed to stop it. In experiments the machine flew well, when rising as much as one in seven. The late J. Riste, Esq., lace manufacturer, Northcote Spicer, Esq., J. Toms, Esq., and others witnessed experiments. Mr. Marriatt, late of the San Francisco 'News Letter,' brought down from London Mr. Ellis, the then lessee of Cremorne Gardens, Mr. Partridge, and Lieutenant Gale, the aeronaut, to witness experiments. Mr. Ellis offered to construct a covered way at Cremorne for experiments. Mr. Stringfellow repaired to Cremorne, but not much better accommodations than he had at home were provided, owing to unfulfilled engagement as to room. Mr. Stringfellow was preparing for departure when a party of gentlemen unconnected with the Gardens begged to see an experiment, and finding them able to appreciate his endeavours, he got up steam and started the model down the wire. When it arrived at the spot where it should leave the wire it appeared to meet with some obstruction, and threatened to come to the ground, but it soon recovered itself and darted off in as fair a flight as it was possible to make to a distance of about 40 yards, where it was stopped by the canvas.

"Having now demonstrated the practicability of making a steam-engine fly, and finding nothing but a pecuniary loss and little honour, this experimenter rested for a long time, satisfied with what he had effected. The subject, however, had to him special charms, and he still contemplated the renewal of his experiments."

The launching apparatus, which was used in these and other experiments, while simple, is of sufficient interest to warrant a description. It consisted essentially of three pieces of wood, two horizontal and one vertical (see Fig. 4). The larger horizontal member was slung from a stout wire by two grooved wheels; the small member—shown in section—was attached beneath it in such a way as to be free to slide an inch or two, the total movement of which was adjusted by means of a small screw fixed into the top member and passing

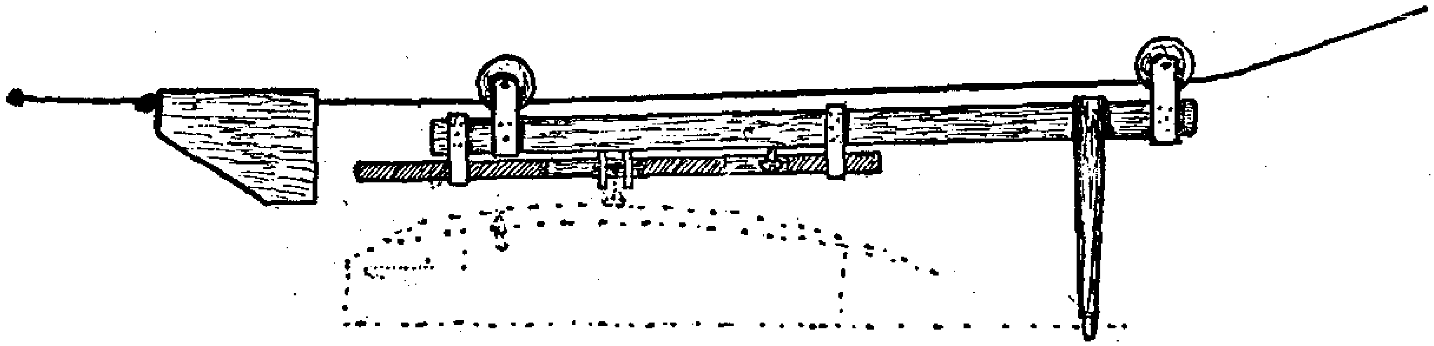

Fig. 4.—Stringfellow's Launching Apparatus

through the lower by means of a slot. In another similar slot two eye-bolts projected through which passed a steel pin attached to the lower member.

The model was suspended at its front end by a wire or string loop slipped over the steel pin in the position shown in the sketch. The tail or the rear projection of the hull or body was supported by the vertical member by means of two wire eye-bolts at its lower extremity. The model and apparatus ran down the slanting wire until a wooden block fixed on the wire was encountered. By the impact the projecting lower member was pushed back, and, simultaneously, the pin sliding back, released the loop. The inertia of the model drew it out of the rear support, and it was thus launched in free flight.

The following year Stringfellow travelled in America with his son, and on their return many years passed before the aerial problem was again attacked. The engine of the 1848 model was given to Messrs. Heathcote, of Tiverton, to drive a small lace-machine, and the relics of his experiments lay in idleness and neglect.

But his energies, dormant for more than 15 years, were destined to be aroused, for in 1866 the Aëronautical Society of Great Britain was founded under the presidency of the Duke of Argyll, and the following year he received a visit from Mr. F. W. Brearey, the Hon. Secretary. Stringfellow's old enthusiasm had been re-awakened by Wenham's now classic paper on "Aerial Locomotion,"* and, hearing that the Aëro-

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* *Vide* "Aeronautical Classics," No. 2.

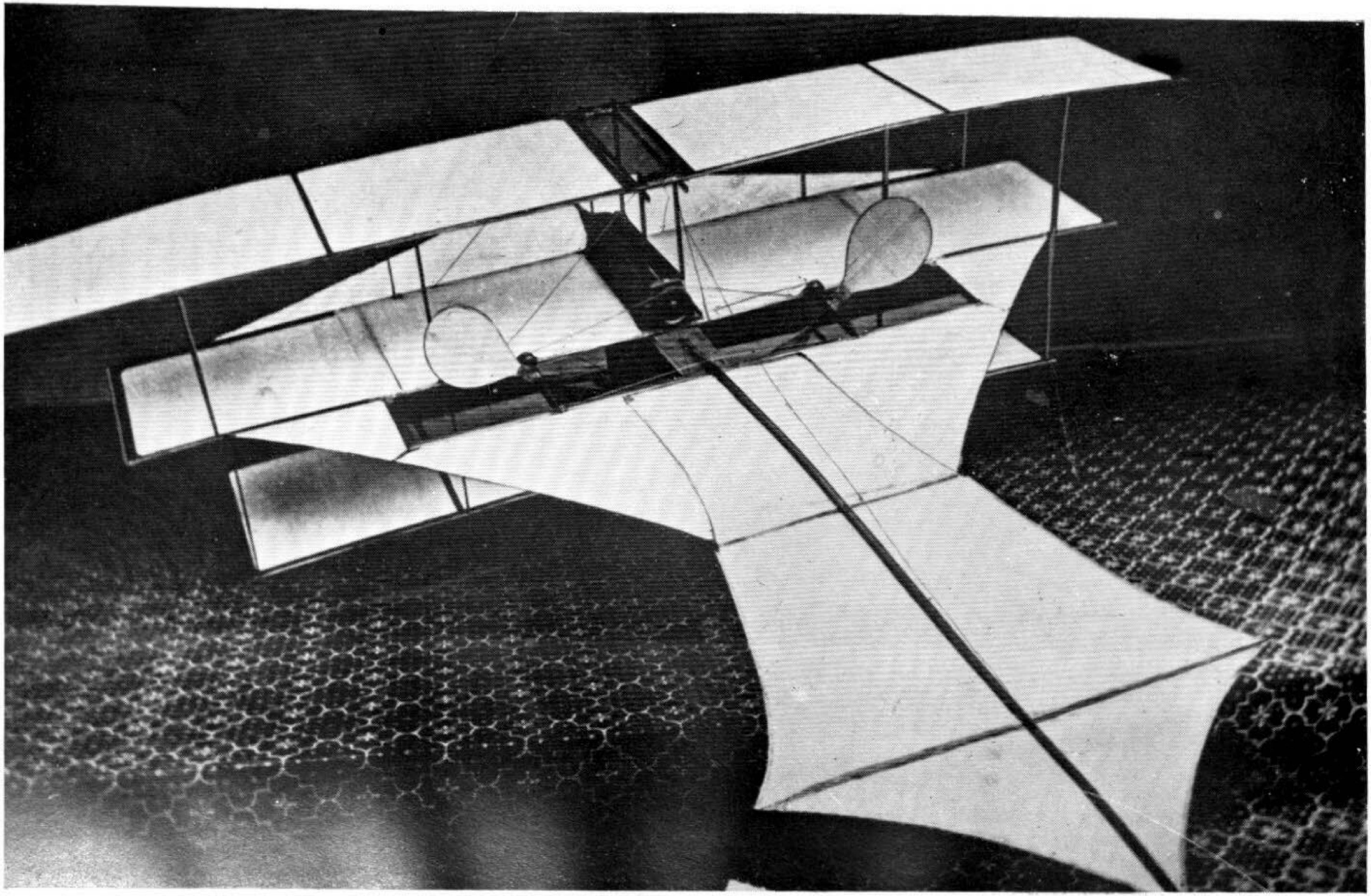


Fig. 6

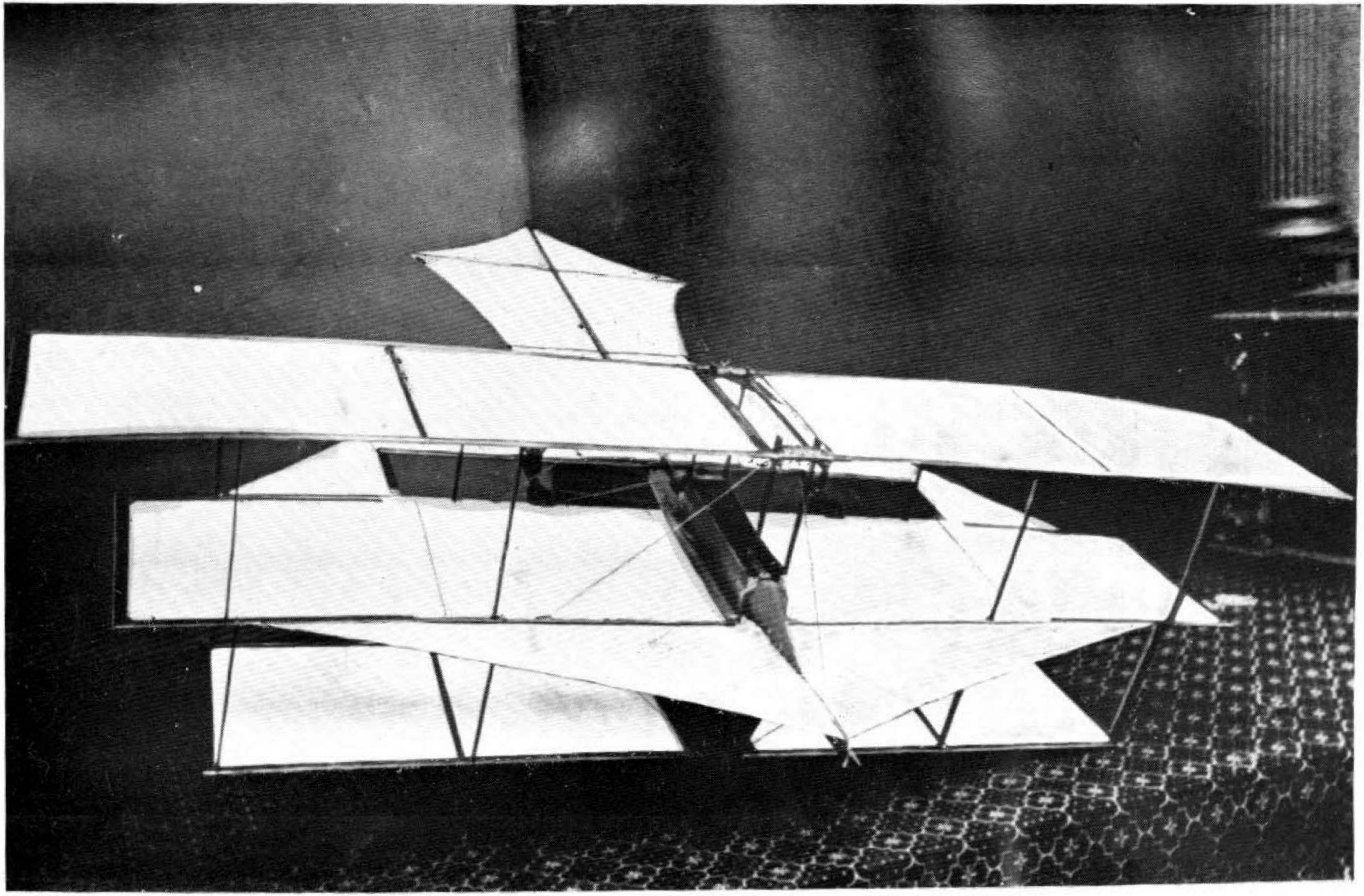


Fig. 7

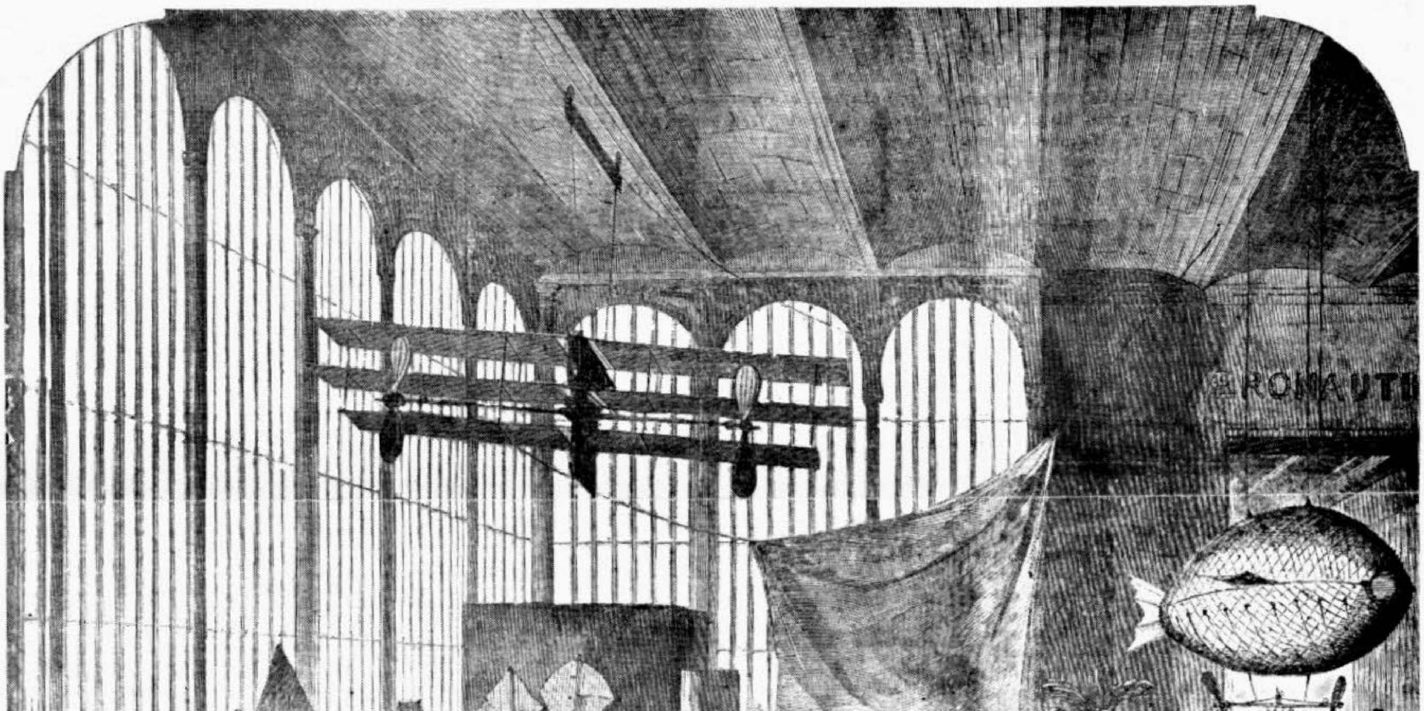


Fig. 8

The First Exhibition of the Aëronautical Society at the Crystal Palace, July, 1868.

The energetic figure on the left (marked with a cross) is John Stringfellow, and above him hangs his model triplane.

nautical Society proposed to hold an Aeronautical Exhibition in 1868 at the Crystal Palace, he resumed his long-interrupted work. Acting upon Wenham's suggestions for a machine with superposed planes he constructed a triplane model (see Figs. 6 and 7), and also a light aerial engine of rather more than one horse-power, and a one horse-power copper boiler and fire-place weighing about 40 lbs. and capable of sustaining a pressure of 500 lbs. to the square inch.

The triplane, which ran suspended from a wire in the nave of the Crystal Palace, contained, excluding the tail, a surface of 28 sq. ft., and weighed, including engine, boiler, fuel, and water, under 12 lbs. The engine, with a 1 3-16-in. cylinder and a 2-in. stroke, worked two propellers, 21 inches in diameter, at about 600 revolutions per minute and got up steam to 100 lbs. pressure in five minutes. It developed $\frac{1}{3}$ h.p. On account of danger from fire no free flight was allowed in the building, but the Aëronautical Society's Jurors' Committee and the reporters* observed that it lifted considerably when running along the wire. "It was a grand day for Uncle," wrote his niece, Rosa, to Mrs. Stringfellow, who, unfortunately, was prevented from coming to London to share her husband's triumph. "The Prince and Princess of Wales [afterwards King Edward VII. and Queen Alexandra], and Prince Alfred, and several of the Princesses with their train were there. The Prince was so charmed with the model that he sent the Duke of Sutherland for Uncle to go to the Royal Box."

* "Morning Star," July 6th, 1868, and "Standard," July 6th, 1868.

The steam-engine was awarded the prize of £100 for "the lightest steam-engine in proportion to its power" and was very fully described in the Society's Report on the Exhibition as follows:—"The cylinder is 2 ins. in diameter, stroke 3 ins., and works with a boiler pressure of 100 lbs. per square inch; the engine making 300 revolutions per minute. The time of getting up steam was noted; in three minutes after lighting the fire the pressure was 30 lbs., in five minutes 50 lbs., and in seven minutes there was the full working pressure of 100 lbs. When started the engine had a fair amount of duty to perform in driving two four-bladed screw propellers 3 ft. in diameter at 300 revolutions per minute.

"The data for estimating the power are taken as follows:—Area of piston 3 ins., pressure in cylinder 80 lbs. per square inch, length of stroke 3 ins., velocity of piston 150 ft. per minute, $3 \times 80 \times 150 = 36{,}000$ foot-pounds; this makes rather more than one horse-power (which is reckoned as 33,000 foot-pounds). The weight of the engine and boiler was only 13 lbs., and is probably the lightest steam-engine that has ever been constructed. The engine, boiler, car, and propellers together were afterwards weighed, but without water and fuel, and were found to be 16 lbs.

"The two-inch cylinder is of very thin brass tube; the covers, flanges, and glands are also as light as they can be made consistently with strength; the ports and passages are in one separate piece, screwed on; the piston-rod passes through each end of the cylinder, and, by means of long connecting-rods, works in opposite

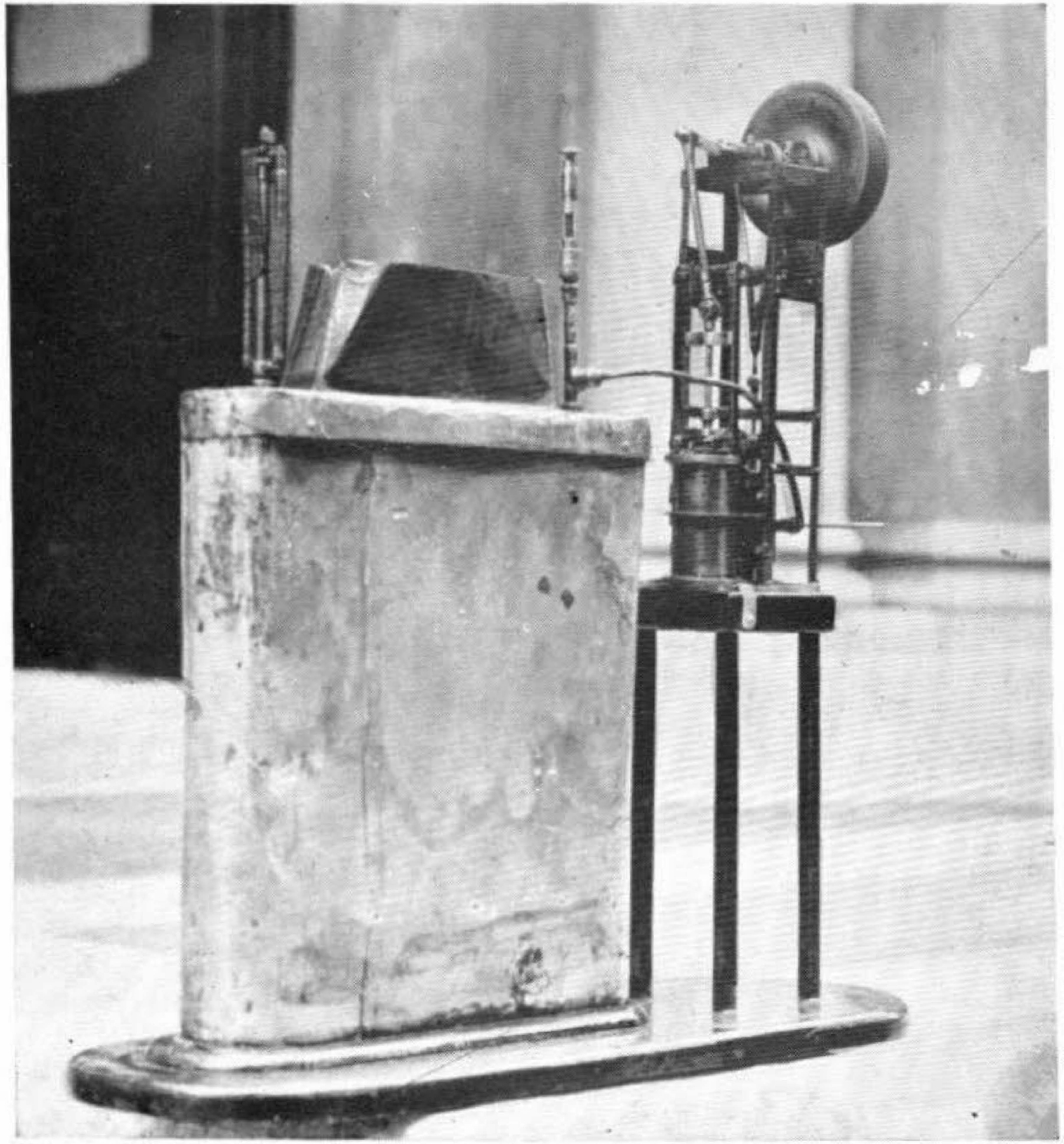
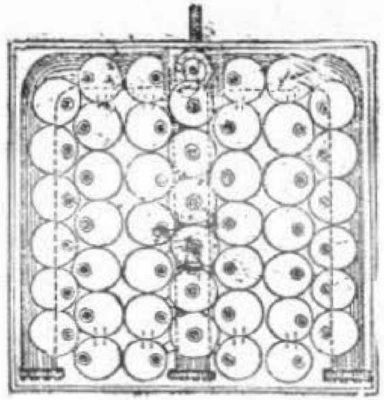
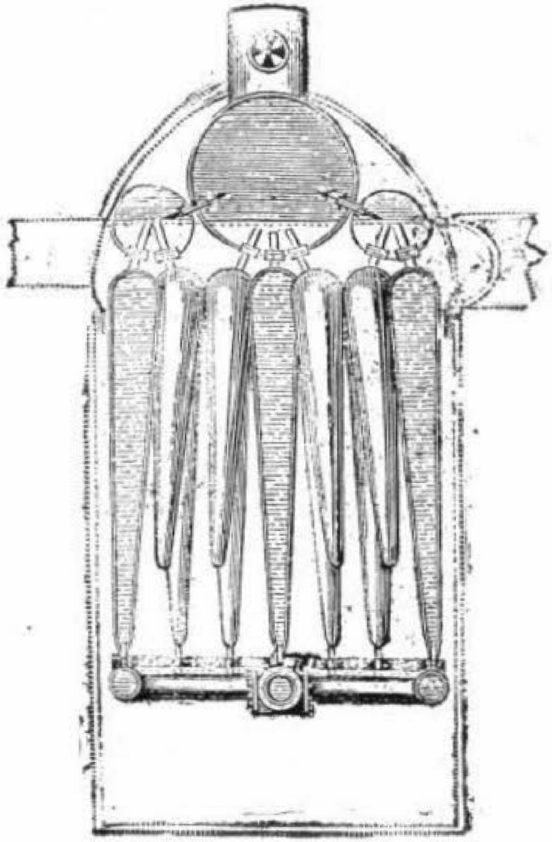


Fig. 9
One of Stringfellow's light Steam Engines for model Aeroplanes
(Now in the possession of the Aeronautical Society)



Horizontal Section of Boiler



Upright Section of tho Boiler

directions two cranks fitted to the axes of two four-bladed screws three feet in diameter; two light bars extend from the crank shaft down each side of the cylinder; these sustain the thrust of the piston, and a framing is thus almost dispensed with. The boiler consists of a number of inverted cones made of very thin sheet copper, with the joints soldered with silver solder; each cone is closed with a hemispherical cap. The cones are placed in parallel rows, the bottom ends or apexes of the series are all connected together by water tubes, and from the hemispherical tops a small steam-pipe conveys the steam away to a cylindrical chamber above the system; this is set in the smoke-box, and serves as a super-heater, and the steam is quite dried therein. The cones are not liable to prime, as the water surface for the escape of the steam is extensive, and the steam rises clear from the generating surfaces. The fire space betwen the bases being large and free, this form of boiler is particularly well adapted for burning liquid fuels. The question may be asked, is there not some hazard in employing metal almost as thin as paper for sustaining pressures exceeding 100 lbs. per square inch? But it is well known that in the so-termed 'tubulous' boilers, to which class this one belongs, if a rupture takes place in one of the elements a gradual and harmless escape of water and steam is the only consequence; this empties the boiler by degrees, and at the same time ends the danger by extinguishing the fire, thus differing in character to the explosion of a boiler, whose strength depends upon the external shell, the fracture of which causes instant destruction, both to itself and all within its vicinity."

For some time after this crowning effort Stringfellow pursued his work. He became a Member of the Aëronautical Society in 1868 and erected a building over 70 feet long for experimental purposes with the £100 awarded to him. But his eyesight began to fail; he was over seventy and he felt that his work was done. He lingered on, however, until 1883, when on December 13th he quietly passed away.

John Stringfellow possessed ideal qualities for his work. A clever mechanic with some private resources, energetic, level-headed and enthusiastic, he was able to use his knowledge to the fullest advantage. Moreover, in the words of Mr. Brearey, "his aspirations were fixed more upon the attainment of success in a special mechanical problem than upon the acquisition of wealth." Posterity has set the seal of success upon his labours by enrolling him among the immortals.

* * * * *

The editors desire to express their great indebtedness to Mr. V. B. T. Stringfellow (grandson), of Yeovil and to Mr. C. H. Alderson, of Farnborough, Kent, who have kindly placed photographs and much valuable material at their disposal for the compilation of this memoir. It was through the energy, researches, and personal labour of Mr. Alderson that the Henson-Stringfellow model and the Stringfellow model of 1848 were discovered and preserved for the nation. The generosity of Mr. P. Y. Alexander enabled him to restore these models, which were subsequently presented by these two gentlemen to the Victoria and Albert Museum.

The triplane and the light engine exhibited at the Crystal Palace in 1868 were bought in 1889 by Professor S. P. Langley, and are now in the Museum at Washington, D.C.

F. J. STRINGFELLOW

(*Vide* footnote page 29)

THE

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I.—OBJECTS OF THE SOCIETY

The Society (established 1866) was the first ever formed in any country, and is now in the 45th year of its existence. Its objects are:—

(*a*) To give a stronger impulse to the scientific study of aerial navigation in all its branches.

(*b*) To promote the intercourse of those interested in the subject at home and abroad.

(*c*) To aid, with advice and instruction, those studying the principles upon which Aeronautical Science is based.

From its foundation, the Society has made a special study of dynamic flight, giving it the priority over ballooning.

II.—THE WORK OF THE SOCIETY

In order to carry out the objects for which the Society exists, the following arrangements are made:—

(*a*) **Meetings** of the Members are held at which papers on aeronautical subjects are read and discussed.

These meetings are usually held quarterly, and have, except for a short period, been carried on ever since the Society was first established. The papers are read by Members and other persons interested in aeronautical science, and the discussions which follow them are often of great interest. All Members can attend these meetings and introduce two visitors.

Minor Meetings of an informal nature are also held at the Society's Offices.

(*b*) **A Quarterly Journal** is published and issued to members free of charge. The original "Reports of the Aëronautical Society of Great Britain" (23 in number) were issued annually, and are of considerable value, as they contain a great deal of useful information on aeronautical subjects, and may almost be said to form the basis of modern aeronautical science.

In 1897 the *Aëronautical Journal* was substituted for the Reports (the issue of which had lapsed), as it was considered that a quarterly issue would more effectually carry out the objects for which the Society exists. This Journal contains full reports of the Society's meetings, and is well illustrated. A great deal of miscellaneous aeronautical information is also given in it, a special feature being reviews of current aeronautical literature.

(*c*) **A Library** is maintained. This library contains nearly all the well-known aeronautical works, some of them being of great value, and all modern books and publications can be borrowed by members. It is well supplied with the journals, magazines, etc., of other societeis and clubs, both at home and abroad, and is a very beneficial institution to those who desire to gain a true knowledge of aeronautical science.

Books, lantern slides, and models for lecture purposes are issued on loan to Members only.

(*d*) **Advice and Information** on aeronautical subjects. Members requiring information on particular points are placed in communication with other Members specially qualified to give the required information. A great deal of general information is available to Members on enquiry at the Society's Offices.

Members travelling abroad are furnished with introductions to foreign aeronautical societies, and are thus brought in touch with foreign aeronautical lines of development.

It may be mentioned here that the Society is well represented on the *only two international scientific societies*, viz., "The International Commission for Scientific Aeronautics" and "The Permanent International Aeronautical Committee."

(*e*) **An Experimental Laboratory** is in process of formation, from which it is hoped to obtain exceedingly valuable data.

(*f*) **Medals** are awarded by the Society for distinguished services to aeronautics, particularly for scientific research and experiment.

A Bronze Medal is also awarded annually to the author of the best paper appearing in the *Aëronautical Journal* during the year.

GOLD MEDALLISTS.—Wilbur and Orville Wright (1909).
Octave Chanute (1910).
SILVER MEDALLIST.—Samüel F. Cody (1909).
BRONZE MEDALLISTS.—W. R. Turnbull (1908),
F. W. Lanchester (1909).
B. G. COOPER (1910).

(*g*) **Reports** by the Committees are published periodically. Reprints of valuable contributions to the science are occasionally issued. The following have already appeared:—

1897. "The Navigation of the Air," by Alex. McCallum. (Reprinted from the *Glasgow Herald*.)

1910-11. "Aeronautical Classics." 6 vols. (including the writings of Sir George Cayley, F. H. Wenham, T. Walker, F. J. Stringfellow, P. S. Pilcher, Borelli, which are being published at intervals).

III.—SUBSCRIPTIONS, ETC.

1. The Entrance Fee is £1 1s., which should be forwarded with the application for membership, and is returnable in the event of non-election.

2. The Annual Subscription to the Society is £1 1s., payable on January 1st each year. Members joining after October 1st in any year do not pay subscriptions for the following year.

IV.—MEMBERSHIP

Members' names come up for election at the first Council Meeting held after the receipt of their membership application forms.

Anyone desirous of becoming a member should apply to the Secretary, from whom all particulars may be obtained.

V.—PRESIDENTS OF THE AËRONAUTICAL SOCIETY OF GREAT BRITAIN

1866-1896. HIS GRACE THE DUKE OF ARGYLL.
1897-1900. [No President appointed.]
1901-1907. MAJOR B. BADEN-POWELL (*Scots Guards*).
1908-1911. E. P. FROST, D.L., J.P.