Flapper Facts

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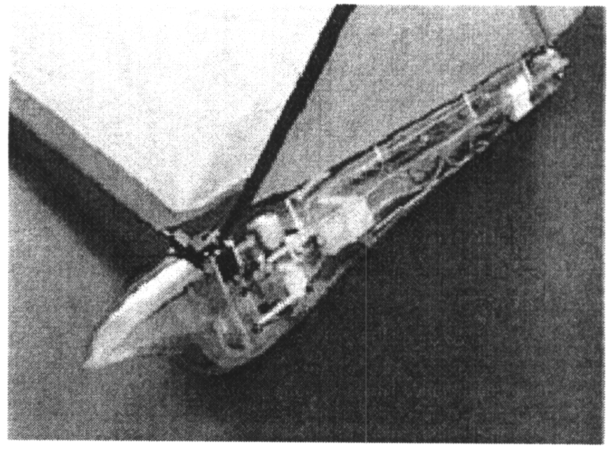
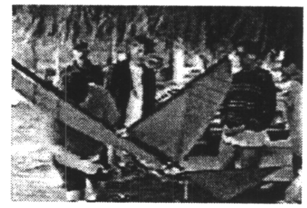




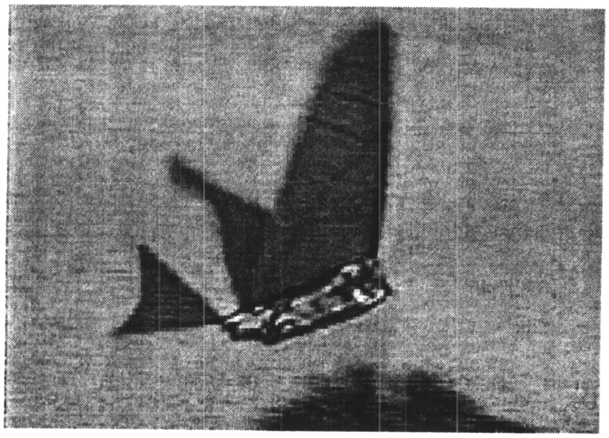
Above, clockwise: Purple Hawk, ancestor of VT2. VT2 flight preparations in the Tiki hut. Sean Kinkade about to launch VT2.

Sean Kinkade's VT2 Takes to the Air!

by Patrick Deshaye

During the month of January, Sean Kinkade of Chuluota, FL has made great progress in the development of a fully controlled RC sport ornithopter. His earlier Purple Hawk design suffered several setbacks, due mostly to structural failures and other problems associated with the molded plastic hull. Sean decided to focus instead on refining his more promising VT1 project; he altered the wingstroke and wing planform substantially, and made several modifications to the tail assembly.

Below: VT2 in flight.



The result is the VT2, which has been a spectacular performer. Videotaped records of the VT2's performance reveal its only limitation to be the amount of fuel in the tank! The ornithopter made fully controlled flights of over ten minutes duration, while turning, climbing, and swooping in for low passes, only inches above the ground.

Sean learned the secrets to establishing full control of his machine after a mishap caused his ornithopter to fly out of sight! After nearly losing the model, Sean made a few adjustments and is now rewarded with a model that brings cheers from everyone who sees it fly.

In This Issue:

Etienne-Jules Marey (1830-1904) by Reuben Hoggett

Marey was born in Beaune on March 5, 1830. As a child, he wanted to be an engineer, but his father's direction was unto medicine. His ordination was complete, but it is striking that he nonetheless returned, by way of biology, to his first inclinations: engineering, invention, and mechanism.

Scientists in the nineteenth century often had to set up their own school, equip their laboratory, and work independently of any institution, even if they became part of one at a later date. Marey did not escape this rule of "comparatively amateurish beginnings".

Marey first studied, and thus had to transcribe, the motions of the organs (heart rhythms, muscle tremors, lung ventilation). He then went to animal locomotion: the bird's flight, the horse's gallop, the insect's quiver. He would take it to its ultimate conclusion: kinetics of isolated flows, eddies in air, ripples in water, and wave patterns. At the same time he was constantly replacing crude "recorders" with more sensitive ones: mechanical would be superseded by electrical and then chemical recording (the chronophotographic gun, the partial photography of an animal or man reduced to a line, moving film stock, and so on). He simplified, halted, and merged; things were made uniform and blurred.

His apparatus for recording the movements of horses, for example, was relatively bulky. Marey used a triad, i.e. "a receiver, a transmitter, and a recorder" for his traces of movement. His system would need refinement: wires still had to link the bird to a terminal and, thus, to recording cylinders. The perimeter of the bird's flight had to be restricted, without taking away its relative freedom of movement. The bird had to be attached not only to enable it to be tracked by limiting its movement, but also to lighten the weight: the transmitting apparatus was stable and centrally fixed. The pigeon was "hitched up" to it and sent the three expected "signals" to the contraption. To put it simply, the bird moved within the mega-apparatus instead of having to carry it. Because it was not possible to "miniaturise" the measuring device, Marey inverted the terms and put the bird - without compromising its freedom of motion in the air - into the contraption (using straps that could travel the length of the rails).

In 1863, Marey conducted the first electrocardiograms (in the frog and the tortoise). The sphygmograph had been attached directly to the wrist. Marey had used water-filled lead pipes sealed at each end with a taut rubber membrane. A simpler method, transmission through air using hollow, semi-rigid rubber tubes, was suggested by a student. Marey improved the sending and receptor mechanisms by contriving tiny metal drums sealed with rubber membranes. These Marey tambours, as they were soon came to be known throughout the world, were critical in the evolution of physiological movement.

Early work was on animals. Locomotion in the air presented a different set of problems that soon challenged Marey's ingenuity. Neither birds nor flying insects propelled themselves by striking the ground, as terrestrial creatures did. So far, Marey had only applied the graphic method to movements that took place in a straight line. The movement of a bird's wing during flight was much more complicated; it did not simply go up and down, it also moved forward and back at each stroke. Undaunted, Marey soon found a way of adapting the instruments to suit his new subjects.

When he began in 1868 to decipher the movements of insects' wings, Marey made the insect itself do the writing by brushing its wing tips against the cylinder. The insect "was held by the lower part of the abdomen in a delicate pair of forceps; it was then placed in such a manner that one of its wings brushed against the blackened paper at every movement. Each of these contacts removed a portion of the black substance which covers the paper."

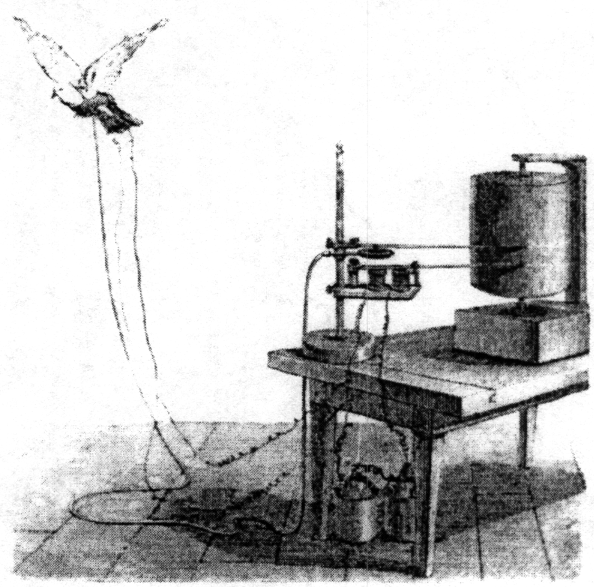
But the rubbing of the wing against the cylinder slowed down the frequency of the movement, indeed interfered with it, something Marey wanted to avoid at all costs. So he created a purely optical solution; he gilded the wing tips of a wasp to heighten their visibility and projected a ray of sunlight onto them. The gilded point "passing continually in the same space would leave a luminous trace." The trace, Marey saw, was an extended figure eight. By gilding the upper face of the wing, he was able even to detect the exact changes in the inclination of its plane as it moved. But the double loop he had seen seemed to contradict concrete evidence that insects moved their wings only up and down as they flew. Marey suspected that the figure eight was not controlled directly by the muscles of the wasp. It was, he proposed, created by the resistance of the air acting on the upper and lower surfaces of the wing, with its rigid framework in front and flexible web behind. To prove his theory he built a mechanical insect, a complicated artifice of wings, drums, levers, and an air pump. It confirmed that the up-and-down impulse from the insect was transformed by the wind acting on the unequal flexibility of the wing to create the double loop Marey had seen.

The effect of air resistance on a bird's wing was not resolved so simply. The optical solution Marey had adapted for insects was not possible for birds, because though the movement of a bird's wing is too fast to be followed by the eye, it is too slow to form a persistent impression of its trajectory on the retina of the observer. Nor was it practical to determine the frequency of the wing strokes by having the bird brush the cylinder with its wing tip as the insect had. Yet Marey aspired to nothing less than understanding the nature of the wing's movements in flight: What was the effect of the air in creating or sustaining these movements, and how much muscular force does the bird develop to propel itself through the air? Many theories had been offered to answer these questions. Now the graphic method offered the possibility of proof.

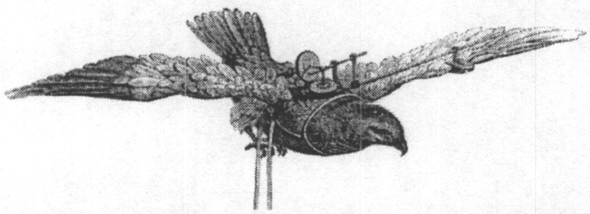
The direction of Marey's experiments with birds was guided by the method he had followed for the insect. Because the motion of the wing in flight was the key to deciphering the interplay of air and wing, he began by measuring the speed of the wing stroke. By substituting electricity for air pressure, he succeeded in transmitting the number of wing strokes to the inscribing cylinder. He attached a small circuit breaker to the tip of each wing, which was opened and closed as the wing was raised and lowered. Marey applied this method to different species of birds to compare the frequency of their strokes; and more important, because he could register the relative duration of the elevation and depression of the wings, he used it to prove that, contrary to general opinion, the descending period was the longer of the two.

When he could not trace the precise instant of the change of direction, however, Marey reverted to air transmission, placing a myograph over the pectoral muscle to signal their contraction and relaxation to the cylinder. The myographic tracing contained two curves, one longer and more intense than the other, and with further experiment Marey deduced that the different forms signaled the different nature of the resistance each muscle encountered. When he placed the myographic tracings over the electrical tracings, the results seemed to show that the downward stroke was the one that propelled the bird; the muscle acted not on the weight of the wing, but on the resistance of the air.

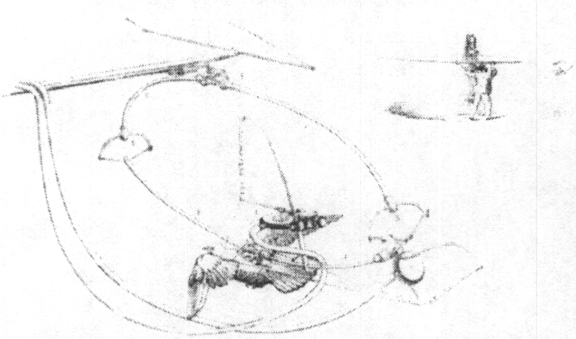
The next and most difficult step was to find a way of registering all the movements of the



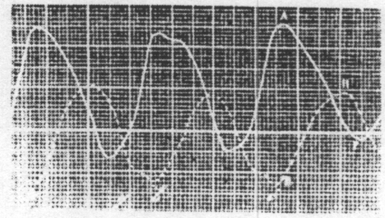
wing on an immovable plane as if, as Marey said, a pen attached to the tip of the wing rubbed a piece of paper by its side. To realize this ideal Marey made his most complex apparatus to date, one that translated both the up-and-down and the back-and-forth movements of the wing simultaneously. It "could transmit to a distance any movement whatever, and register it on a plane surface" - in this case a horizontally moving piece of finely polished glass - but it was heavy and needed a large bird to carry it. (Buzzards were the ideal subjects.)

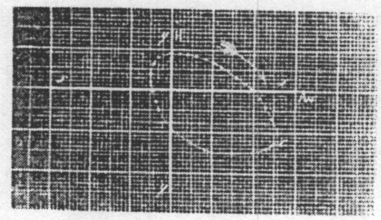


After many frustrating attempts and changes - the recording apparatus was extremely fragile and broke at almost every flight - Marey finally obtained a tracing of the wing's trajectory on his glass: the registering lever described it as an irregular ellipse. He then proceeded to modify the bird: rather than allowing it to fly freely, Marey put it into a harness and suspended it from a flexible metal frame by means of a long arm that turned on a central pivot. In this contraption the bird could flap its wings and do everything else it did while flying, without leaving the confines of the frame.

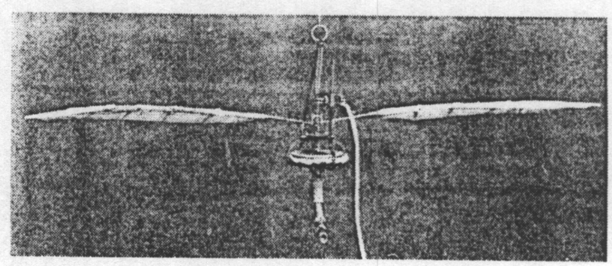


By adding a third transmitter, Marey was able to describe again the elliptical trajectory of the wing as it beat the air and even to provide an accurate characterization of the changes in the plane of the wing as it moved through the elliptical path. The tracings showed that the wings swept forward and downward, then on the upbeat traveled upward and backward until they began to make the next downbeat. This experiment refuted the theory, previously held, that birds in flight used their wings as one rows a boat, pushing backward and returning forward and upward.





Marey's investigations into the flight of birds were for him the foundation for human flight. "The insect and the bird realize one of the oldest and most unsuccessful aspirations of the ambition of man. All space belongs to them; they go and come in the aerial ocean, while he is chained by his weight to the earth." Marey's concern with flight (which again recalls that of Leonardo) stemmed from his more pervasive belief that by making visible the mysteries of nature, humans could imitate and thus reproduce them. By studying the flight of birds, they would learn the secrets of aerial locomotion. About 1870 Marey began to



construct mechanical birds, as he had done for the flight of insects, to test and synthesize the results given by his instruments. In 1874 Marey turned the project over to a new assistant, Victor Tatin (1843-1919). Like Marey, Tatin was fascinated by the possibility of mechanical flight. This is how Marey saw their task:

"The problem of aerial locomotion, formerly considered a Utopian scheme, can now be approached in a truly scientific manner. The plan of the experiments to be made is all traced out: they will consist in continually comparing the artificial instruments of flight with the real bird, by submitting them both to the modes of analysis which we have described at such length; the apparatus will, from time to time, be modified till it is made to imitate these movements faithfully. We hope that we have proved to the reader that nothing is impossible in the analysis of the movements connected with the flight of the bird: he will no doubt be willing to allow that mechanism can always reproduce a movement, the nature of which has been clearly defined."

These ornithopters brought Marey into the company of the dreamers and experimenters who for centuries had been searching for a way to give man wings. Marey counted among his friends most of the French pioneers in aviation. Gaston Tissandier (1843-99), author of La Locomotion Aerienne, and Nadar (Felix Tournachon, 1820-1910), an avid balloonist, followed Marey's experiments with intense curiosity. Tissandier, one of those universal amateurs that the nineteenth century specialized in, regularly reported on Marey's progress in the pages of La Nature, the popular science journal he founded in 1873. Tissandier edited the journal and wrote a column on photography covering the latest in processes and images. Like Nadar, one of the most famous photographers of the century, who first approached Marey to ask for his assistance in aviation matters, Tissandier found the combination of aviation and photography irresistible. Then there was Alphonse Penaud, whom Charles H. Gibbs-Smith, the doyen of aviation history, calls "one of the aeronautical giants." Although he worked with Marey on a successful ornithopter in 1872, 79 Penaud is known mainly as the inventor who made the first inherently stable model airplane to be seen in public, thus establishing the character of the modern airplane with its fixed wings and rigid body. Finally, Clement Ader (1841-1925), the French pioneer of the telephone, who built and attempted to fly one of the earliest full-scale airplanes, first presented his aviation experiments to the Academie des Sciences through Marey. The acceptance Marey found in the world of aviation was not at first paralleled in the world of French science. Because he was working in a field that today we would call applied biophysics, in a direction outside the mainstream of French physiology, Marey's entry into the established society of French scientists was accomplished slowly. Claude Bernard, for example, distrusted the complex instrumentation Marey depended on. In 1867, when Marey was appointed suppleant to the neuro-physiologist Pierre Flourens at the College de France and a laboratory was created there for him, Bernard's response indicated his feelings. "Thank you for warning me [of Marey's appointment]," he wrote to his friend Louis-Amedee Sedillot, who was secretary of the College, "for it would have been a disagreeable surprise for me." Marey was equally critical of Bernard's methods. He insisted that vivisection interfered with the regular function of life and could not understand why any scientist would mutilate or, worse, destroy what he was attempting to analyze. Vivisection, Marey wrote, "can do no more, so to say, than lay bare the phenomenon simultaneously with the organ which is the seat of it; it reveals to our senses only what they are capable of perceiving." More important, the necessity of directly studying human physiology "obliges us to renounce vivisection, and to substitute the use of apparatus." Bernard's use of poisons as investigative tools came under Marey's fire for the same reasons. In 1873, in his new book, La Machine Animate: Locomotion Terrestre et Aerienne was published in France (and in English as Animal Mechanism in 1874), he abandoned his earlier points of reference - cardiac cycles, ventilation, the twitch of a frog's leg at the application of an electric impulse. Marey entered an entirely new domain: the running of the horse, the flight of birds, walking, jumping and human gesture; and later the swimming of fish, the course of a jellyfish, and the movement of flies.

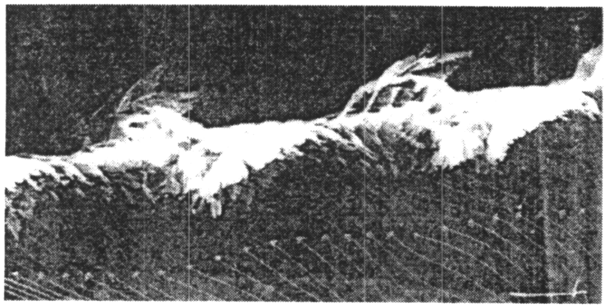
In his book's opening pages Marey reiterated his positivist and mechanist beliefs and professed his scientific credo : "The hope of reaching the truth suffices to sustain those who pursue [science] through all their efforts; the contemplation of the laws of nature has been a great and noble source of enjoyment to those who have discovered them." At the same time, Marey explained, to the general public science is only a means - it must "lead to some useful application." So he introduced the subject of the book, locomotion, by showing its practical importance. The study of flight, he wrote, will provide man with a means of extending his domain, so that he will one day "travel through the air, as he now sails across the ocean."

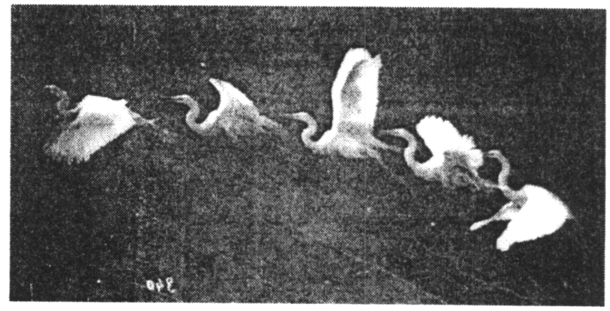
His lack of facility with the chemical side of photography - he never did become really expert at it - deterred him from carrying out investigations on his own. Before investing the considerable funds needed for such a system, he would wait and see what Muybridge could provide in the way of photographs of birds. As he waited for what he hoped would be a new way of analyzing flight, Marey continued to pursue the synthesis of flight with Tatin. A mechanical bird that Tatin built in 1876 had differed from the many others produced at the time by having a double eccentric working two levers connected to the front edge of the wing. The levers conveyed a twisting motion exactly imitating that of a bird's wing. The mechanical bird was used to demonstrate that, contrary to popular opinion, the force needed to move the wings was not as overwhelming as had been presumed and that the energy the soaring bird expended to maintain its flight was about equal to that provided by a small engine.

To garner more information, Marey returned to the core of his interest in aviation, the study of birds in flight. That was the state of things when Muybridge arrived in Paris in fall 1881; he brought with him the photographs that Marey had been expecting for three years.

The photographs of birds that Muybridge had made at Marey's behest were failures: they were not pictures of the successive phases of the wing, but instantaneous pictures of groups of birds like those Cailletet had already procured. "Apart from the fact that the sharpness of the images was insufficient," Marey recalled three years later, "the photographs were missing the one thing that made the pictures of the gait of the horse so interesting, a series which showed the successive positions of the animal." Muybridge could not achieve what Marey required. His battery of cameras, though adequate for representing large movements like those of the horse, could not successfully capture the movements of smaller animals like birds as Marey wanted. Muybridge had had the horse itself trip the successive shutters of the cameras by breaking wires along the path of its movement. This the birds obviously could not be made to do. More important, the method of having the horse break wires laid across its path meant that the non-uniform movement of its gait was transcribed to the cameras or, worse, that the wires might stretch or contract before they actually broke. The resulting transcription was unreliable for scientific purposes, since the rigorously exact time intervals necessary for this kind of work were beyond the reach of Muybridge's system. As Marey and other scientists now saw, the method was prone to inaccuracy. Since Muybridge used more than one camera, his subjects were not photographed from a constant perspective or from a single point of view. The intermediary phases of the movement were too hard to piece together from the ones pictured, because the distance separating them was too large. Muybridge had failed to represent the trajectory of the movement. He "could not avoid errors that inverted the phases of the movement and brought to the eyes and spirit of those who consulted these beautiful plates a deplorable confusion."

In 1882 Marey had succeeded in making the camera into a scientific instrument that rivaled his graphing instruments in its power to clearly express change over time. With a single camera that he both devised and constructed to make multiple images on a single plate and from a



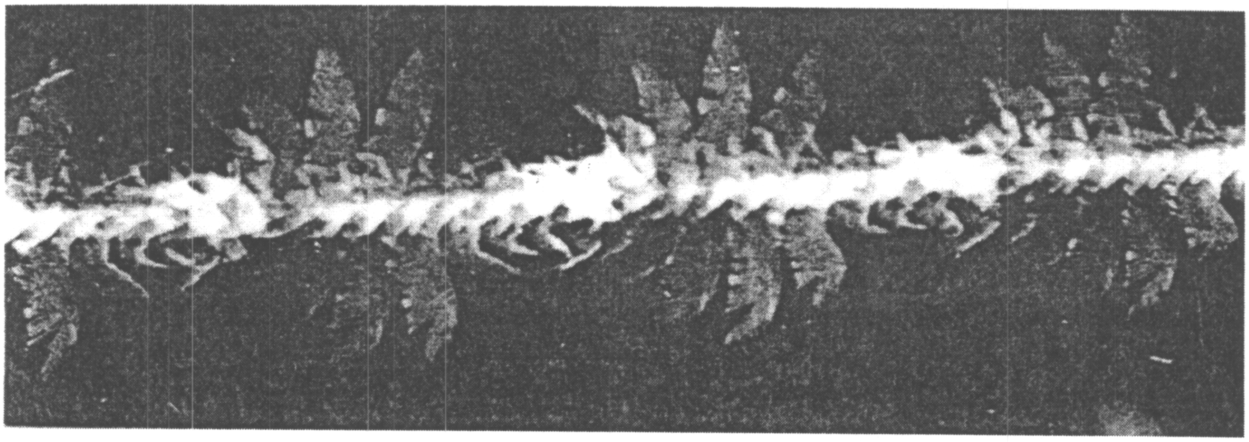


single point of view, he photographed movement in a way that did more than just stop time. He captured ongoing phases of movement and spread them over the photographic plate in an undulating pattern of overlapping segments. Almost without precedent in the history of representation (only Leonardo da Vinci had attempted to depict motion in the same form of overlapping contours), Marey's photographs gave visible extension to the present, virtually representing the passage of time.

Marey's belief in the identity of the laws that governed animate and inanimate nature and his desire to demonstrate the universality of chronophotography as a method of scientific analysis had prompted him in 1886 to begin to compile a sort of illustrated mechanics: pictures of the motion of balls and of batons as they were dropped from a ladder or thrown across the black hangar. Chronophotography convincingly illustrated how much the differently shaped trajectories these projectiles made depended on the direction of the propelling force and the resistance of the air. In a later study he showed how the method could be used to measure the vertical acceleration of falling bodies. There is a series of photographs of Marey shaking a long, thin rod to show the form its tip describes as the rod moves and another series, begun in 1887, that treats pure geometry: he photographed the solid figures engendered by a thin cord or an arched band of bristol board as it vibrated in space around a central or oblique axis. He used a stereo camera for some of these studies, envisaging this manner of making diagrams in relief as a replacement for the usual cones, cylinders, hyperboloids, and spheres created with string over metal armatures that students and teachers alike depended on. He was pleased to note that the figures he created with his camera recalled the experimental origins of the "now purely speculative science of geometry."

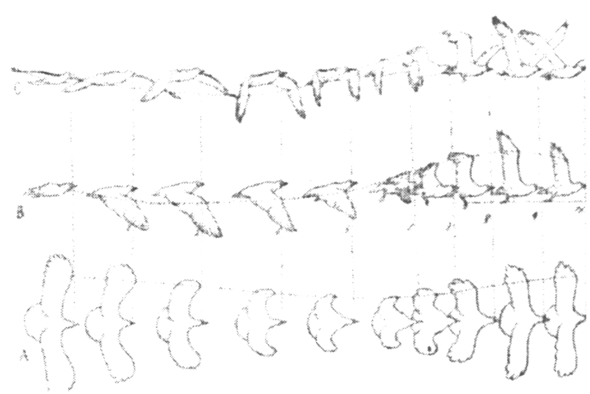
It was the absolute blackness of his hangar and the increased sensitivity of his plates that enabled Marey to begin photographing flight again, a subject he had not treated since 1883. Then the chronophotographs had given visible proof of the forward-and-backward, up-and-down motion of the wing, which he had so valiantly traced with his graphing inscriptors; now he hoped for even more spectacular results. Comparing the chronophotographs of 1883 with those he began to take in 1886, Marey wrote that, finally, "the pivoting of the large feathers on their longitudinal axis is perfectly visible and so are the movements which the up-and-down motion of the wing transmits to the bird's body."

Marey could also get pictures that clarified the different wing positions in takeoff and landing and showed how the individual feathers operated during flight. The primary feathers (the large upper feathers at the edge of the wing) cup the air during the lowering stage of their beat, and at the end of the lowering stage the primaries fan out so that the wind can pass through them more easily and thus make elevation of the wing swifter. That the feathers fan out had been deduced from anatomy, but now Marey proved it with his camera (his findings were reconfirmed by high-speed film). Most important to the concerns of would-be aviators, Marey's camera revealed critical aspects of the bird's navigation in the air. It showed how its center of gravity shifted and how the tips of the primaries (together with the tail) were used to regulate its movements.

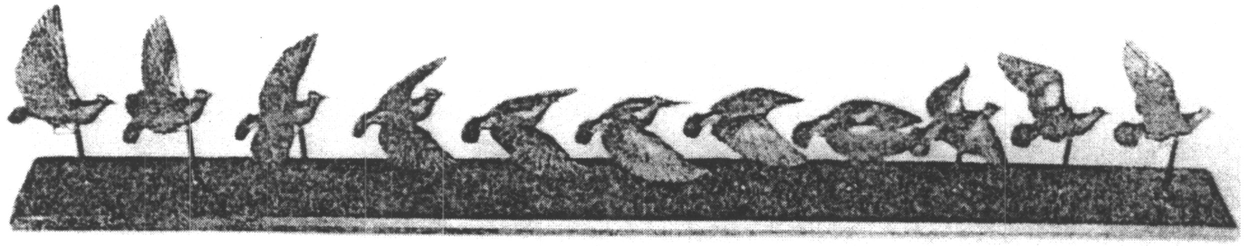


Marey's results were verified in pictures made by the photographer Ottomar Anschutz (1846-1907) of Lissa, a Prussian town now in Poland. Anschutz began making single instantaneous pictures in 1882 after the example of Muybridge, and he used the same system of up to twelve cameras side by side. Anschutz's version of the battery of cameras was more accurate than Muybridge's: in 1884 he was able to take instantaneous pictures of pigeons and storks in flight possessing a "sharpness and considerable size, which had not been attained before that time." Judging from the exchange of bills and receipts for each other's equipment and photographs found at the Institut Marey in 1979, Anschutz and Marey seemed to have been in regular contact. Marey would have been particularly interested in the experiments on equine and aerial locomotion that Anschutz had undertaken for the Prussian army beginning in 1885; his photographs of birds corroborated Marey's own findings about the movement and shape of the wing in flight, but the larger format of Anschutz's photographs provided details that were beyond even Marey's camera. So as soon as he got back to Paris, in 1887, Marey began to intensify his analysis of flight, a subject that seemed to provide the starting point for every technological innovation he made.

As was typical of his methods, Marey made the transition from describing the movement to measuring the forces that determine it. To assist in his understanding of the mechanism of the wing in relation to the movement of air and the effects of air pressure on the wing, Marey wanted to photograph the wing's movement in three dimensions. In July 1887 he put a new camera on the pylon, and in August he oversaw the completion of a second small hangar erected at right angles to the first. The camera took a thirteen-by-nine-centimeter negative and could be used for making both chronophotographs and instantaneous images. His idea was to make pictures from above the bird, which would then

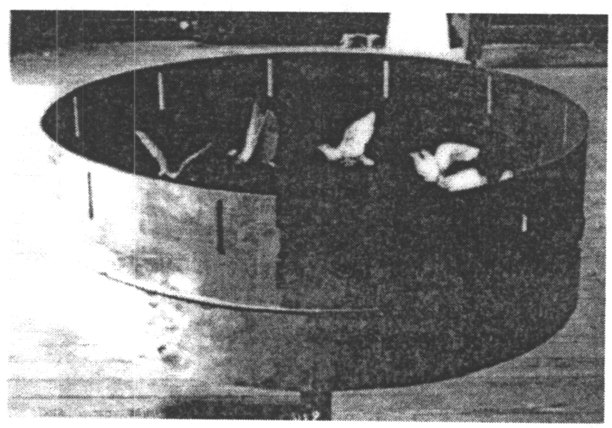


be coordinated with those he made parallel and perpendicular to the axis of its flight. Perhaps Muybridge was the inspiration for using more than one camera at the same time on the same subject. The photographs Muybridge had been taking in Philadelphia since 1885 were made with three banks of cameras working simultaneously at three different angles from the subject. Marey would no doubt have been aware of the work, but in his version he hardly ever operated three cameras simultaneously as Muybridge did: it was, Marey claimed, too expensive. And though it remains unclear precisely how he worked in this case, it seems



that he usually used only one camera at a time.

The applications of this study were extraordinary: from the data furnished by the different sets of photographs he sculpted plaster models of the gull and the pigeon in flight. Each model, slightly smaller than life size, depicted a single phase of the wing as it moved through one complete revolution. He then mounted the sculptures into a very large zoetrope, to make what he called his "synthesis in relief." As the zoetrope was spun, he could view the bird's flight from various aspects and reconstruct the revolution of its wings, invisible to the naked eye, in three dimensions in slow motion. He also took the models with him to Naples and had them cast in bronze. Three of these sculptures still survive. Two represent the phases of the wing's movement in separate figures; in the third Marey has melded the overlapping wings and bodies of the gull into one sinuous wave.



Marey's goal was to photograph free flight with the same accuracy he had attained in the field of human locomotion. With the fixed-plate camera, however, only those animals (and people) that could be made to perform in front of his black screen or connected to electrical apparatus could leave their imprint on the photographic plate. Thus, though the number of his possible subjects might have seemed at first infinite, eliminating parts of the surface of the subject by blacking them out could not be applied with equal success to all living creatures. Wild animals and insects and fish were still outside the range of his photographic instruments. Movement on the spot could not be photographed, nor could movements in the optical axis of the camera. That is, the technique of the fixed-plate camera functioned precisely because each new location of the subject in space was captured on a new location on the plate: the shutter was left open for the duration of the movement, and as the subject crossed the black stage it was frozen into precise segments by the rotating slotted-disk shutter. This meant that an immobilized bird flapping its wings would, under these conditions, be recorded as nothing but a blur on the photographic plate.

In 1884, George Eastman introduced "stripping films". The appearance of these films completed an era of photographic history and opened the floodgates of industrialized photography. And they were the key to Marey's invention of the technology that made motion pictures possible, but that's another story. The twentieth century owes a great deal to Marey and his discoveries.

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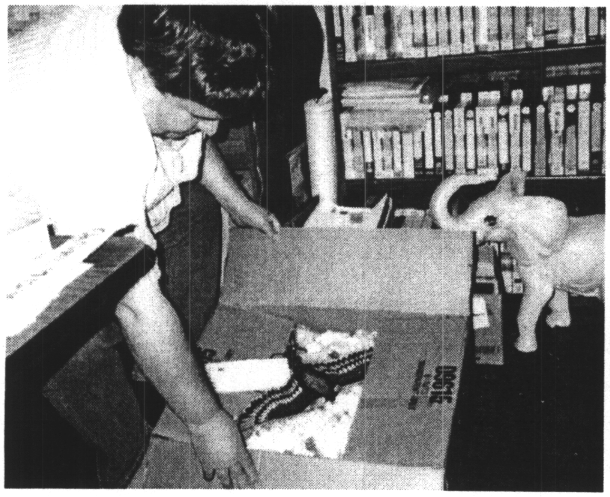


Wham-O Bird Discovery

Letters from Guy Foster

[Editor's note: A few issues back I published Guy Foster's request for help in finding a genuine Wham-O Bird ornithopter. The toy ornithopter, designed by RC ornithopter pioneer P. H. Spencer, went on sale in 1958. About 800,000 were sold, but they are now rare.]

The day of the WHAM-O BIRD has arrived. My wife and I just opened it and photo documented every move. You ought to see this thing... magnificent, magnificent is all I can say!!! It even still has the little yellow plastic handle on the crank. Right on the wing is printed Wham-O Bird on the left and PAT. NO 2,859,553 on the right. It is vivid red, orange, yellow, white, and black just as I remembered and on the tail it says... "MYLAR," Du Pont's registered trademark for its polyester film. The original rubber band (tan) is rotted and hanging from the crank.

The box is even more spectacular!!! I thought I remembered it having a clear cellophane window view panel but it doesn't. The color is magnificent with all sorts of stick figure like illustrations... including a picture of a boy and girl flying it through a hulahoop in a circle, another of a boy flying it twice around a tree, then two boys and one girl racing three 'Birds' in a straight line, and finally three kids playing for points trying to spot land the 'Bird' into a giant dart board type layout on the ground.

The box measures approximately 22" x 18". On the box front lower right it says... "We originated the Hula Hoop...this is even more fun!" At the top left corner it says... "giant 21" mechanical WHAM-O BIRD"... "FLIES BY FLAPPING WINGS!"... "Startling Invention!"... "just like a real bird"... "Flies up to 100 Ft."... "Loops, Climbs, Soars with adjustable control does what you want it to. First time in history a machine flies like a bird! Designed by a leading aircraft engineer 10 years and $50,000 in experimentation and design. Simple to operate wind up rubber power with unique leverage system gives long, exciting flights... fascinates boys, girls, and engineers."

"FLIGHT PATTERN ADJUSTING Attach coil weight to wing as in Fig. B for straight or circle flights. Test for desired flights. FLIGHT PATTERNS WITHOUT COIL WEIGHT Wind Wham-O Bird to right, will circle to right. Wind to left and bird will circle to left."

"REPLACEMENT RUBBER Use only one model airplane 1/4" rubber band 9 1/2" long doubled. CAUTION too much rubber attached to bird will damage bearings."

* * *

The bird needs work (4 problems; 3 easy and 1 tough) before I need to worry about rubber sizes (but thanks for the suggestions).

1) Here is the main (tough) problem: The left bearing plastic at the tee into the bronze eyelet [plastic post serves as wing hinge] is almost nonexistent owing to someone who over-torqued the rubber 40 years ago and broke it. (That is what likely retired the bird.)

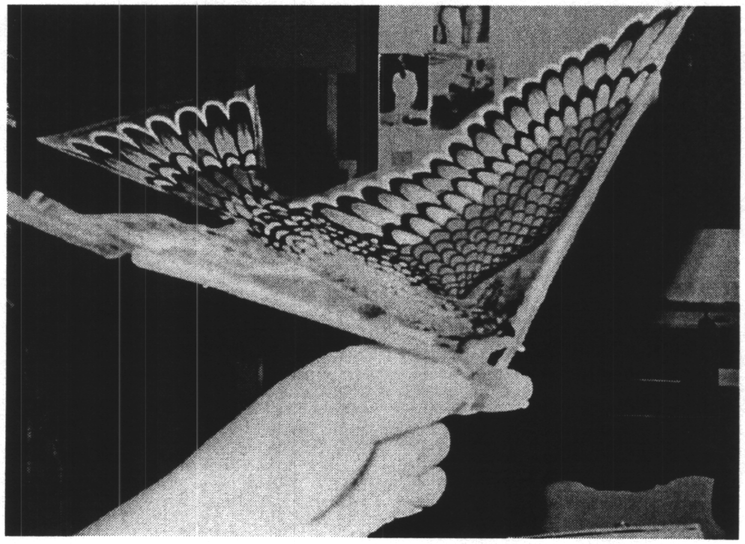
2) The rear hook for the rubber is missing (from same problem).

3) The leading edge wire on the right wing is bent to the point that straightening the wire may break it. (It is hardened wire that has brittled

with age as I quickly learned from item (4) below.)

4) The retainer clip for the tail cams is partly broken (my fault) and needs replacing.

I need to find some very stiff 1/32" music wire to remake the rear cam wire retainer at the tail, the rubber hook and the leading edge wire (should I decide to change it).



The front bearing is under study for a solution (I think I have decided to melt in a 1/32" wire into the remaining bearing block at the tee, melt over a plastic rod and super glue it to the tee, then carefully shape it to fit into the bearing eyelet). This part needs to be very strong to handle the flapping mechanism... the original tee was just barely strong enough so mating a piece onto same will be very, very difficult.

I am toying with leaving it unflyable (all original) and retiring it into a large shadow box with the box in the background. What do you guys think?

* * *

The leading edge wire (coming off the aluminum spars and comprising only last 30% of the wing span to the outer tip) is continuous along the wing's outer edge all the way back to the tip of the tail (including the 'U' bend that forms the cam for the tail's up and down movement during flight). The wire would be very difficult to re-manufacture and install considering the undoing and reattachment of the mylar wing membrane.

I have now successfully straightened this wire about 50% using the same idea you had, Pat. I bent it a little the first day and let it relax. That was on Wednesday and I could tell then that anymore bending pressure would have snapped the wire... so I will try again this weekend to bend another 10% or so... and so forth... a little every few days... until the wire is completely straightened, equal to the left wing's wire.

The 'tee' is still the BIG problem!! We are in complete agreement as to repair procedure and I believe I can pull it off where nobody would notice it. It will be very delicate surgery (one shot or bust) to say the least. It is not the procedure that concerns me... but only whether the final strength would be adequate.

* * *

I repaired every aspect of the 'Bird's' problems today (almost not detectable) and the bird now flies fine!! The leading edge wire straightened out just fine using Pat's suggestion. I was able to effectively repair the tee using my original idea. I salvaged the rear cam retainer and was able to fashion a rear rubber band hook per the package illustration using a piece of spiral notebook metal. Finally, I adjusted the aluminum spar ends at the cam winder to minimize friction. Once the crank could be turned without binding I knew the 'Bird' was ready!

When finished, I tested everything by gradually changing rubber band configurations


giant 21" mechanical
WHAM-O BIRD
FLIES BY FLAPPING WINGS!
STARTLING INVENTION!
--just like a real bird
FLIES UP TO 100 FT
LOOPS, CLIMBS, CIRCLES, SOARS
WITH ADJUSTABLE CONTROL • DOES WHAT YOU WANT IT TO
First time in history a machine that flies like a bird! Designed by a leading aircraft engineer—10 years and $50,000 in experimentation and design.
Simple to operate—wind-up rubber power with unique leverage system gives long, exciting flights.
--fascinates boys, girls and engineers
GAMES AND TRICKS
We originated the HULA-HOOP
--this is even more fun!

until sufficient power to enable flight was achieved (using a maximum of sixty winds per the manufacturer's recommendations). Once static testing was successful, I wound her up 50 turns and flew the 'Bird' in my den without giving her an upward shove. She flew right

from my hand in level flight for 5 feet and started turning to the right while slightly descending. I can tell that 10 more rubber turnings and a 45 degree upward launch will produce spectacular results. All repairs seem to be nice and strong and no original parts have been removed, so the 'Bird' is as good as it possibly can be for the age.

I am very excited over the outcome and thought I would share the results you guys. The 'Bird' flies too good to retire, so I will likely fly it outdoors soon on a calm, clear day.

Museum-Grade Kit Available

Robert Coyle writes:

I have a small model kit company devoted to the small scale manufacture of historical objects. I produce a model kit of my own design based on Leonardo's studies in flight. This kit has been very well received and I have also built a full size version that has been purchased for the collection of the Museum of Science in Boston. It, of course, does not fly, but after three years I have been seduced into the dream of HPF so much that given time I would like to continue studies. The great thing about my kit is that if built correctly the wings flap and flex and distend when you pull the cables.

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SRI and UTIAS to Study Polymer Muscle

From UTIAS press release

In order to address the technical challenges associated with developing lift and propulsion systems for MAVs (Micro Air Vehicles) suitable for operation in confined spaces, engineers at SRI International (formerly Stanford Research Institute) and University of Toronto Institute for Aerospace Studies (UTIAS) are looking to nature for guidance. A variety of small birds, bats, and insects can fly with both great maneuverability and high energy efficiency. Hummingbirds, for example, can hover in place, maneuver nimbly, and cruise efficiently. These creatures all use pairs of flapping wings to achieve this type of flight. The SRI and UTIAS team will perform research under DARPA sponsorship to develop technology for a an MAV with flapping wings to demonstrate the feasibility and benefits of this form of propulsion.

While a small number of hobbyists have built birdlike flapping wing aircraft (ornithopter) models that fly with some success, up until now the lack of a suitable actuation system for the flapping wings has blocked their development into practical systems. Most such aircraft to date are powered by small internal combustion (IC) engines with fairly complicated linkages to convert the rotary motion to flapping. Further, such engines are quite noisy and difficult to precisely control. In order to overcome these problems, SRI engineers again looked to nature for a solution. Flying creatures use muscle as an actuator for the flapping motion. SRI has been developing a new actuation technology based on the electrostriction (deformation due to an applied electric field) of elastomeric polymers. The actuator technology is termed artificial muscle due to the similarity in performance with natural muscle. Advantages of electrostrictive polymer artificial muscle (EPAM) actuators for flapping wing propulsion include the ability to efficiently and rapidly produce sufficiently large motions and forces using a lightweight and compact actuator. Such muscle-like performance is not available from other actuation technologies such as electromagnetic motors, piezoelectrics, shape-memory alloys, and electrostatics. The electrostrictive polymer artificial muscle actuators are also rugged and can tolerate a wide range of environmental conditions.

Electrostrictive polymer artificial muscle is inherently electrically powered. The energy density of electric batteries currently lags behind that of combustible fuels. However, the energy density of batteries is rapidly improving so that in the next few years the energy available from batteries may compete with that available from fuel-burning engines. Other advantages of electric powered propulsion include quietness and precise controllability.

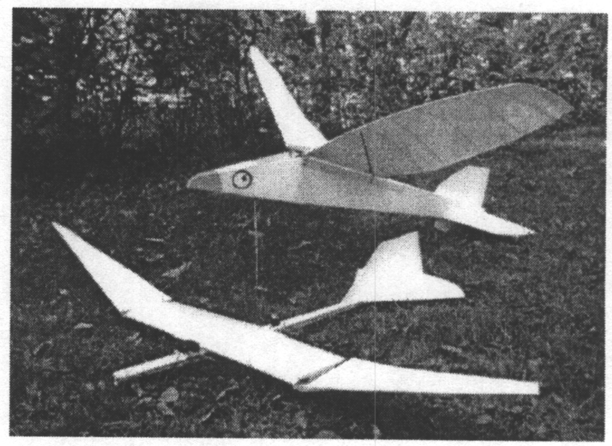
The proposed research will combine the different strengths of the two institutions, SRI International and the University of Toronto. SRI will be the prime contractor and will determine overall MAV design goals and will design, fabricate, and test the EPAM actuators. SRI's work will build on more than six years of experience in the development of EPAM technology for a variety of applications. Professor James DeLaurier of the University of Toronto's Institute for Aerospace Studies will lead his institution's effort to design the wings and air vehicle aerodynamics, specify the wing operating conditions, fabricate wing systems, and test the performance of the flapping-wing air vehicle configurations. The wing design will be facilitated by the development of analytical models that will accurately predict the performance of a design. Professor DeLaurier has more than twenty years of experience in the analysis of flapping-wing flight and the design and fabrication of small flapping-wing radio-controlled UAVs.

Servo-Powered Ornithopter

Georges Chaulet

Instead of using separate items (engine, gear reduction, crankshaft), one has just to fit one or two servos, in which all these elements are incorporated. By moving fore and aft a stick, the blades can flap, and it is very easy to adjust the speed of the movement, its amplitude, or stop it in flight. Also it is quite possible to immobilize the wings into a horizontal position, for gliding. (All that is theory!)

Tests have been made with a large model (7 ft span, 1.5 lb). But it appeared immediately that the power needed was excessive. Even by using the biggest servos available (as on quarter scale planes), the wings would flap very slowly.



Another, smaller model was built, conforming to the Lippisch layout (like on the Electric Dawn ornithopter), that is, with a central fixed wing.

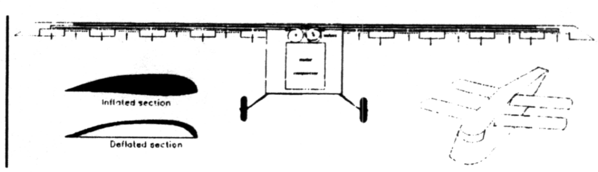
Both models have been trimmed for a glide, but as soon as the wings started to move, the lift disappeared and the models would pitch down.

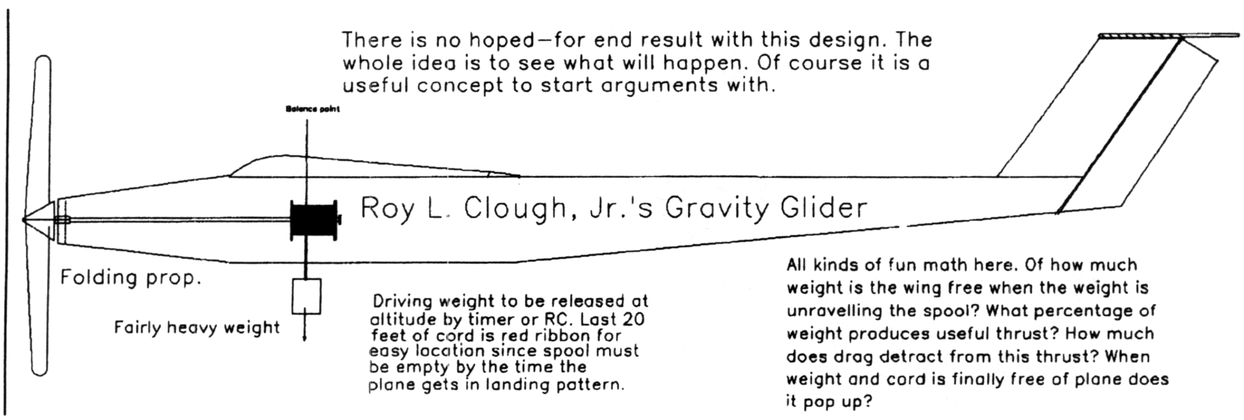
A possible solution would be to use larger central wings which would provide sufficient lift in all cases of flight. The servos would be located on the wing tip, to avoid any large connecting rods whose flexibility wastes power.

I lack time to lead more experiments but I hope that somebody may go on with this interesting research.

Interesting Ideas
from Roy Clough

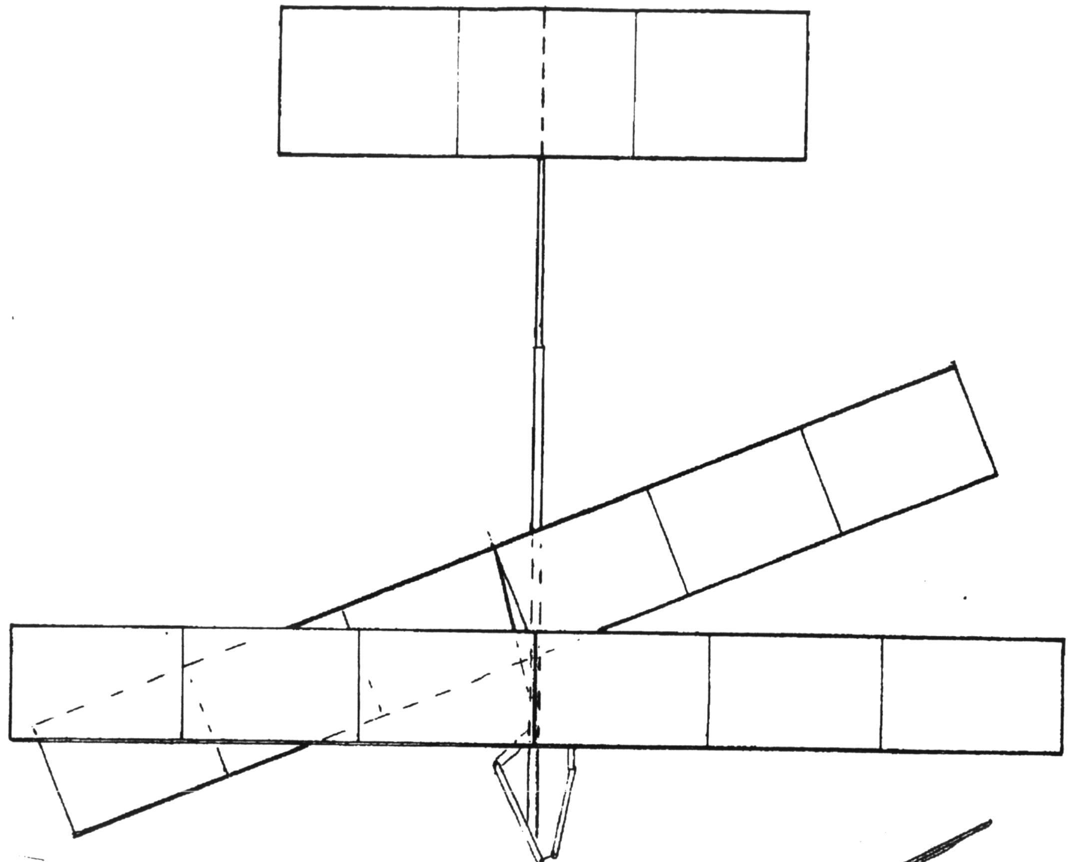
Although the gravity glider is not in any way an ornithopter, it might raise some familiar issues regarding the physics of flight. Just slightly closer to the realm of flapping flight, the model pictured at left is based on Clough's recollection of a late 1930s issue of Popular Mechanics. Rubber cells along the undersurface of the wing expand like an airbag to produce lift, the idea being that air behaves like a solid when pushed against very suddenly. Alternate bays collapsed and expanded by means of a valving system. Clough hopes that one of our members can look up some more info on this technique, since he no longer has the magazine.

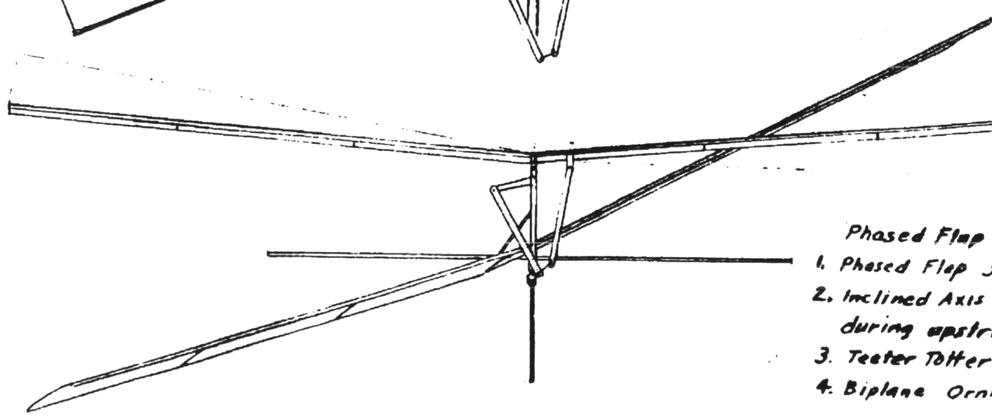


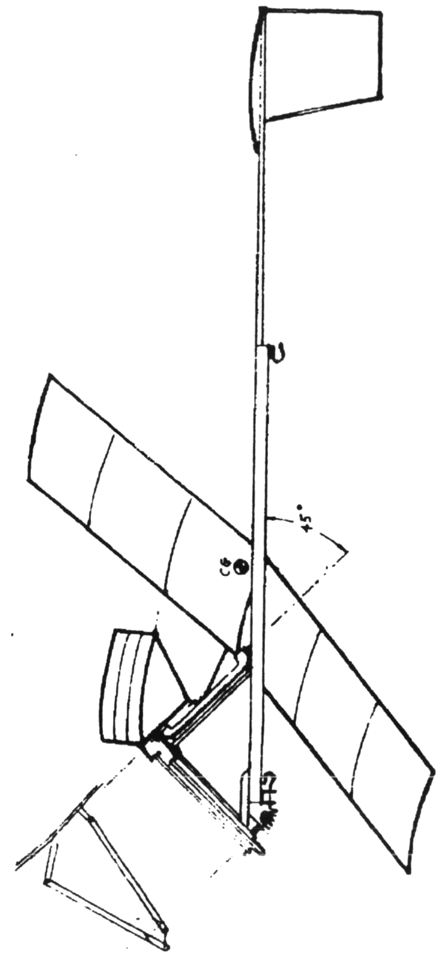


Angled wing flapping
TR Quermann

Believe it or not, I finally finished PFIATTBO [an ornithopter designed to flap its wings at a 45 degree angle to the motor stick, intended to improve lift]. The only way to end the procrastination was to ignore the troublesome second thoughts and fanciful redesigns and just build it. Actually the only significant change from the original 1995 design was a decrease in stabilizer area to meet the Bob Meuser proposed rule and some extra hinging and stops on the rear wing spars. These permitted the wings to twist more during the upstroke than the downstroke. It took me at least 5 tries at mounting the wings before they would clear when slowly moved through their cycle. Under power, lockup was more the rule than the exception. However I did manage to get it launched a few times with everything working and was rewarded with slow steady flights limited by the size of my living room and my reluctance to let it crash into furniture, etc. The motor I used was an old, short .052 x .040 loop with only 100-200 turns. I don't have a torque meter. The model without motor weighs about 1/8 ounce. I must fix the wing lockup problem before higher power testing is attempted.







PFIATTBO

DICK QUERMANN 4/25/95

Phased Flap Inclined Axis Teeter Totter Biplane Ornithopter

1. Phased Flap Smooths Power Delivery
2. Inclined Axis achieves higher Airspeed during Downstroke than during upstroke to produce Lift and Thrust
3. Teeter Totter eliminates root gap problem associated with 2.
4. Biplane Ornithopter required to implement 1. and 3.