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       Construction and Operation

Author: W.J. Jackman and Thos. H. Russell

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FLYING MACHINE: CONSTRUCTION AND OPERATION

By W.J. Jackman and Thos. H. Russell

A Practical Book Which Shows, in Illustrations, Working Plans and Text, How to Build and Navigate the Modern Airship.

W.J. JACKMAN, M.E., Author of “A B C of the Motorcycle,” “Facts for Motorists,” etc. etc.

and

THOS. H. RUSSELL, A.M., M.E., Charter Member of the Aero Club of Illinois, Author of “History of the Automobile,” “Motor Boats: Construction and Operation,” etc. etc.

With Introductory Chapter By Octave Chanute, C.E., President Aero Club of Illinois

1912

PREFACE.

This book is written for the guidance of the novice in aviation—the man who seeks practical information as to the theory, construction and operation of the modern flying machine. With this object in view the wording is intentionally plain and non-technical. It contains some propositions which, so far as satisfying the experts is concerned, might doubtless be better stated in technical terms, but this would defeat the main purpose of its preparation. Consequently, while fully aware of its shortcomings in this respect, the authors have no apologies to make.

In the stating of a technical proposition so it may be clearly understood by people not versed in technical matters it becomes absolutely necessary to use language much different from that which an expert would employ, and this has been done in this volume.

No man of ordinary intelligence can read this book without obtaining a clear, comprehensive knowledge of flying machine construction and operation. He will learn, not only how to build, equip, and manipulate an aeroplane in actual flight, but will also gain a thorough understanding of the principle upon which the suspension in the air of an object much heavier than the air is made possible.

This latter feature should make the book of interest even to those who have no intention of constructing or operating a flying machine. It will enable them to better understand and appreciate the performances of the daring men like the Wright brothers, Curtiss, Bleriot, Farman, Paulhan, Latham, and others, whose bold experiments have made aviation an actuality.

For those who wish to engage in the fascinating pastime of construction and operation it is intended as a reliable, practical guide.

It may be well to explain that the sub-headings in the articles by Mr. Chanute were inserted by the authors without his knowledge. The purpose of this was merely to preserve uniformity in the typography of the book. This explanation is made in justice to Mr. Chanute.

THE AUTHORS.

IN MEMORIAM.

Octave Chanute, “the father of the modern flying machine,” died at his home in Chicago on November 23, 1910, at the age of 72 years. His last work in the interest of aviation was to furnish the introductory chapter to the first edition of this volume, and to render valuable assistance in the handling of the various subjects. He even made the trip from his home to the office of the publishers one inclement day last spring, to look over the proofs of the book and, at his suggestion, several important changes were made. All this was “a labor of love” on Mr. Chanute’s part. He gave of his time and talents freely because he was enthusiastic in the cause of aviation, and because he knew the authors of this book and desired to give them material aid in the preparation of the work—a favor that was most sincerely appreciated.

The authors desire to make acknowledgment of many courtesies in the way of valuable advice, information, etc., extended by Mr. Octave Chanute, C. E., Mr. E. L. Jones, Editor of Aeronautics, and the publishers of, the New England Automobile Journal and Fly.

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FLYING MACHINES: CONSTRUCTION and OPERATION

CHAPTER I. EVOLUTION OF TWO-SURFACE FLYING MACHINE.

By Octave Chanute.

I am asked to set forth the development of the “two-surface” type of flying machine which is now used with modifications by Wright Brothers, Farman, [1] Delagrange, Herring and others.

This type originated with Mr. F. H. Wenham, who patented it in England in 1866 (No. 1571), taking out provisional papers only. In the abridgment of British patent Aeronautical Specifications (1893) it is described as follows:

“Two or more aeroplanes are arranged one above the other, and support a framework or car containing the motive power. The aeroplanes are made of silk or canvas stretched on a frame by wooden rods or steel ribs. When manual power is employed the body is placed horizontally, and oars or propellers are actuated by the arms or legs.

“A start may be obtained by lowering the legs and running down hill or the machine may be started from a moving carriage. One or more screw propellers may be applied for propelling when steam power is employed.”

On June 27, 1866, Mr. Wenham read before the “Aeronautical Society of Great Britain,” then recently organized, the ablest paper ever presented to that society, and thereby breathed into it a spirit which has continued to this day. In this paper he described his observations of birds, discussed the laws governing flight as to the surfaces and power required both with wings and screws, and he then gave an account of his own experiments with models and with aeroplanes of sufficient size to carry the weight of a man.

Second Wenham Aeroplane.

His second aeroplane was sixteen feet from tip to tip. A trussed spar at the bottom carried six superposed bands of thin holland fabric fifteen inches wide, connected with vertical webs of holland two feet apart, thus virtually giving a length of wing of ninety-six feet and one hundred and twenty square feet of supporting surface. The man was placed horizontally on a base board beneath the spar. This apparatus when tried in the wind was found to be unmanageable by reason of the fluttering motions of the fabric, which was insufficiently stiffened with crinoline steel, but Mr. Wenham pointed out that this in no way invalidated the principle of the apparatus, which was to obtain

large supporting surfaces without increasing unduly the leverage and consequent weight of spar required, by simply superposing the surfaces.

This principle is entirely sound and it is surprising that it is, to this day, not realized by those aviators who are hankering for monoplanes.

Experiments by Stringfellow.

The next man to test an apparatus with superposed surfaces was Mr. Stringfellow, who, becoming much impressed with Mr. Wenham's proposal, produced a largish model at the exhibition of the Aeronautical Society in 1868. It consisted of three superposed surfaces aggregating 28 square feet and a tail of 8 square feet more. The weight was under 12 pounds and it was driven by a central propeller actuated by a steam engine overestimated at one-third of a horsepower. It ran suspended to a wire on its trials but failed of free flight, in consequence of defective equilibrium. This apparatus has since been rebuilt and is now in the National Museum of the Smithsonian Institution at Washington. Linfield's Unsuccessful Efforts.

In 1878 Mr. Linfield tested an apparatus in England consisting of a cigar-shaped car, to which was attached on each side frames five feet square, containing each twenty-five superposed planes of stretched and varnished linen eighteen inches wide, and only two inches apart, thus reminding one of a Spanish donkey with panniers. The whole weighed two hundred and forty pounds. This was tested by being mounted on a flat car behind a locomotive going 40 miles an hour. When towed by a line fifteen feet long the apparatus rose only a little from the car and exhibited such unstable equilibrium that the experiment was not renewed. The lift was only about one-third of what it would have been had the planes been properly spaced, say their full width apart, instead of one-ninth as erroneously devised.

Renard's "Dirigible Parachute."

In 1889 Commandant Renard, the eminent superintendent of the French Aeronautical Department, exhibited at the Paris Exposition of that year, an apparatus experimented with some years before, which he termed a "dirigible parachute." It consisted of an oviform body to which were pivoted two upright slats carrying above the body nine long superposed flat blades spaced about one-third of their width apart. When this apparatus was properly set at an angle to the longitudinal axis of the body and dropped from a balloon, it travelled back against the wind for a considerable distance before alighting. The course could be varied by a rudder. No practical application seems to have been made of this device by the French War Department, but Mr. J. P. Holland, the inventor of the submarine boat which bears his name, proposed in 1893 an arrangement of pivoted framework attached to the body of a flying

machine which combines the principle of Commandant Renard with the curved blades experimented with by Mr. Phillips, now to be noticed, with the addition of lifting screws inserted among the blades.

Phillips Fails on Stability Problem.

In 1893 Mr. Horatio Phillips, of England, after some very interesting experiments with various wing sections, from which he deduced conclusions as to the shape of maximum lift, tested an apparatus resembling a Venetian blind which consisted of fifty wooden slats of peculiar shape, 22 feet long, one and a half inches wide, and two inches apart, set in ten vertical upright boards. All this was carried upon a body provided with three wheels. It weighed 420 pounds and was driven at 40 miles an hour on a wooden sidewalk by a steam engine of nine horsepower which actuated a two-bladed screw. The lift was satisfactory, being perhaps 70 pounds per horsepower, but the equilibrium was quite bad and the experiments were discontinued. They were taken up again in 1904 with a similar apparatus large enough to carry a passenger, but the longitudinal equilibrium was found to be defective. Then in 1907 a new machine was tested, in which four sets of frames, carrying similar sets of slat "sustainers" were inserted, and with this arrangement the longitudinal stability was found to be very satisfactory. The whole apparatus, with the operator, weighed 650 pounds. It flew about 200 yards when driven by a motor of 20 to 22 h.p. at 30 miles an hour, thus exhibiting a lift of about 32 pounds per h.p., while it will be remembered that the aeroplane of Wright Brothers exhibits a lifting capacity of 50 pounds to the h.p.

Hargrave's Kite Experiments.

After experimenting with very many models and building no less than eighteen monoplane flying model machines, actuated by rubber, by compressed air and by steam, Mr. Lawrence Hargrave, of Sydney, New South Wales, invented the cellular kite which bears his name and made it known in a paper contributed to the Chicago Conference on Aerial Navigation in 1893, describing several varieties. The modern construction is well known, and consists of two cells, each of superposed surfaces with vertical side fins, placed one behind the other and connected by a rod or frame. This flies with great steadiness without a tail. Mr. Hargrave's idea was to use a team of these kites, below which he proposed to suspend a motor and propeller from which a line would be carried to an anchor in the ground. Then by actuating the propeller the whole apparatus would move forward, pick up the anchor and fly away. He said: "The next step is clear enough, namely, that a flying machine with acres of surface can be safely got under way or anchored and hauled to the ground by means of the string of kites."

The first tentative experiments did not result well and emphasized the

necessity for a light motor, so that Mr. Hargrave has since been engaged in developing one, not having convenient access to those which have been produced by the automobile designers and builders.

Experiments With Glider Model.

And here a curious reminiscence may be indulged in. In 1888 the present writer experimented with a two-cell gliding model, precisely similar to a Hargrave kite, as will be confirmed by Mr. Herring. It was frequently tested by launching from the top of a three-story house and glided downward very steadily in all sorts of breezes, but the angle of descent was much steeper than that of birds, and the weight sustained per square foot was less than with single cells, in consequence of the lesser support afforded by the rear cell, which operated upon air already set in motion downward by the front cell, so nothing more was done with it, for it never occurred to the writer to try it as a kite and he thus missed the distinction which attaches to Hargrave's name.

Sir Hiram Maxim also introduced fore and aft superposed surfaces in his wondrous flying machine of 1893, but he relied chiefly for the lift upon his main large surface and this necessitated so many guys, to prevent distortion, as greatly to increase the head resistance and this, together with the unstable equilibrium, made it evident that the design of the machine would have to be changed.

How Lilienthal Was Killed.

In 1895, Otto Lilienthal, the father of modern aviation, the man to whose method of experimenting almost all present successes are due, after making something like two thousand glides with monoplanes, added a superposed surface to his apparatus and found the control of it much improved. The two surfaces were kept apart by two struts or vertical posts with a few guy wires, but the connecting joints were weak and there was nothing like trussing. This eventually cost his most useful life. Two weeks before that distressing loss to science, Herr Wilhelm Kress, the distinguished and veteran aviator of Vienna, witnessed a number of glides by Lilienthal with his double-decked apparatus. He noticed that it was much wracked and wobbly and wrote to me after the accident: "The connection of the wings and the steering arrangement were very bad and unreliable. I warned Herr Lilienthal very seriously. He promised me that he would soon put it in order, but I fear that he did not attend to it immediately."

In point of fact, Lilienthal had built a new machine, upon a different principle, from which he expected great results, and intended to make but very few more flights with the old apparatus. He unwisely made one too many and, like Pilcher, was the victim of a distorted apparatus. Probably one

of the joints of the struts gave way, the upper surface blew back and Lilienthal, who was well forward on the lower surface, was pitched headlong to destruction.

Experiments by the Writer.

In 1896, assisted by Mr. Herring and Mr. Avery, I experimented with several full sized gliding machines, carrying a man. The first was a Lilienthal monoplane which was deemed so cranky that it was discarded after making about one hundred glides, six weeks before Lilienthal's accident. The second was known as the multiple winged machine and finally developed into five pairs of pivoted wings, trussed together at the front and one pair in the rear. It glided at angles of descent of 10 or 11 degrees or of one in five, and this was deemed too steep. Then Mr. Herring and myself made computations to analyze the resistances. We attributed much of them to the five front spars of the wings and on a sheet of cross-barred paper I at once drew the design for a new three-decked machine to be built by Mr. Herring.

Being a builder of bridges, I trussed these surfaces together, in order to obtain strength and stiffness. When tested in gliding flight the lower surface was found too near the ground. It was taken off and the remaining apparatus now consisted of two surfaces connected together by a girder composed of vertical posts and diagonal ties, specifically known as a "Pratt truss." Then Mr. Herring and Mr. Avery together devised and put on an elastic attachment to the tail. This machine proved a success, it being safe and manageable. Over 700 glides were made with it at angles of descent of 8 to 10 degrees, or one in six to one in seven.

First Proposed by Wenham.

The elastic tail attachment and the trussing of the connecting frame of the superposed wings were the only novelties in this machine, for the superposing of the surfaces had first been proposed by Wenham, but in accordance with the popular perception, which bestows all the credit upon the man who adds the last touch making for success to the labors of his predecessors, the machine has since been known by many persons as the "Chanute type" of gliders, much to my personal gratification.

It has since been improved in many ways. Wright Brothers, disregarding the fashion which prevails among birds, have placed the tail in front of their apparatus and called it a front rudder, besides placing the operator in horizontal position instead of upright, as I did; and also providing a method of warping the wings to preserve equilibrium. Farman and Delagrange, under the very able guidance and constructive work of Voisin brothers, then substituted many details, including a box tail for the dart-like tail which I used. This may

have increased the resistance, but it adds to the steadiness. Now the tendency in France seems to be to go back to the monoplane.

Monoplane Idea Wrong.

The advocates of the single supporting surface are probably mistaken. It is true that a single surface shows a greater lift per square foot than superposed surfaces for a given speed, but the increased weight due to leverage more than counterbalances this advantage by requiring heavy spars and some guys. I believe that the future aeroplane dynamic flier will consist of superposed surfaces, and, now that it has been found that by imbedding suitably shaped spars in the cloth the head resistance may be much diminished, I see few objections to superposing three, four or even five surfaces properly trussed, and thus obtaining a compact, handy, manageable and comparatively light apparatus. [2]

CHAPTER II. THEORY, DEVELOPMENT, AND USE.

While every craft that navigates the air is an airship, all airships are not flying machines. The balloon, for instance, is an airship, but it is not what is known among aviators as a flying machine. This latter term is properly used only in referring to heavier-than-air machines which have no gas-bag lifting devices, and are made to really fly by the application of engine propulsion.

Mechanical Birds.

All successful flying machines—and there are a number of them—are based on bird action. The various designers have studied bird flight and soaring, mastered its technique as devised by Nature, and the modern flying machine is the result. On an exaggerated, enlarged scale the machines which are now navigating the air are nothing more nor less than mechanical birds.

Origin of the Aeroplane.

Octave Chanute, of Chicago, may well be called “the developer of the flying machine.” Leaving balloons and various forms of gas-bags out of consideration, other experimenters, notably Langley and Lilienthal, antedated him in attempting the navigation of the air on aeroplanes, or flying machines, but none of them were wholly successful, and it remained for Chanute to demonstrate the practicability of what was then called the gliding machine. This term was adopted because the apparatus was, as the name implies, simply a gliding machine, being without motor propulsion, and intended solely to solve the problem of the best form of construction. The biplane, used by Chanute in 1896, is still the basis of most successful flying machines, the only radical difference being that motors, rudders, etc., have been added.

Character of Chanute’s Experiments.

It was the privilege of the author of this book to be Mr. Chanute’s guest at Millers, Indiana, in 1896, when, in collaboration with Messrs. Herring and Avery, he was conducting the series of experiments which have since made possible the construction of the modern flying machine which such successful aviators as the Wright brothers and others are now using. It was a wild country, much frequented by eagles, hawks, and similar birds. The enthusiastic trio, Chanute, Herring and Avery, would watch for hours the evolutions of some big bird in the air, agreeing in the end on the verdict, “When we master the principle of that bird’s soaring without wing action, we

will have come close to solving the problem of the flying machine."

Aeroplanes of various forms were constructed by Mr. Chanute with the assistance of Messrs. Herring and Avery until, at the time of the writer's visit, they had settled upon the biplane, or two-surface machine. Mr. Herring later equipped this with a rudder, and made other additions, but the general idea is still the basis of the Wright, Curtiss, and other machines in which, by the aid of gasolene motors, long flights have been made.

Developments by the Wrights.

In 1900 the Wright brothers, William and Orville, who were then in the bicycle business in Dayton, Ohio, became interested in Chanute's experiments and communicated with him. The result was that the Wrights took up Chanute's ideas and developed them further, making many additions of their own, one of which was the placing of a rudder in front, and the location of the operator horizontally on the machine, thus diminishing by four-fifths the wind resistance of the man's body. For three years the Wrights experimented with the glider before venturing to add a motor, which was not done until they had thoroughly mastered the control of their movements in the air.

Limits of the Flying Machine.

In the opinion of competent experts it is idle to look for a commercial future for the flying machine. There is, and always will be, a limit to its carrying capacity which will prohibit its employment for passenger or freight purposes in a wholesale or general way. There are some, of course, who will argue that because a machine will carry two people another may be constructed that will carry a dozen, but those who make this contention do not understand the theory of weight sustentation in the air; or that the greater the load the greater must be the lifting power (motors and plane surface), and that there is a limit to these—as will be explained later on—beyond which the aviator cannot go.

Some Practical Uses.

At the same time there are fields in which the flying machine may be used to great advantage. These are:

Sports—Flying machine races or flights will always be popular by reason of the element of danger. It is a strange, but nevertheless a true proposition, that it is this element which adds zest to all sporting events.

Scientific—For exploration of otherwise inaccessible regions such as deserts, mountain tops, etc.

Reconnoitering—In time of war flying machines may be used to advantage