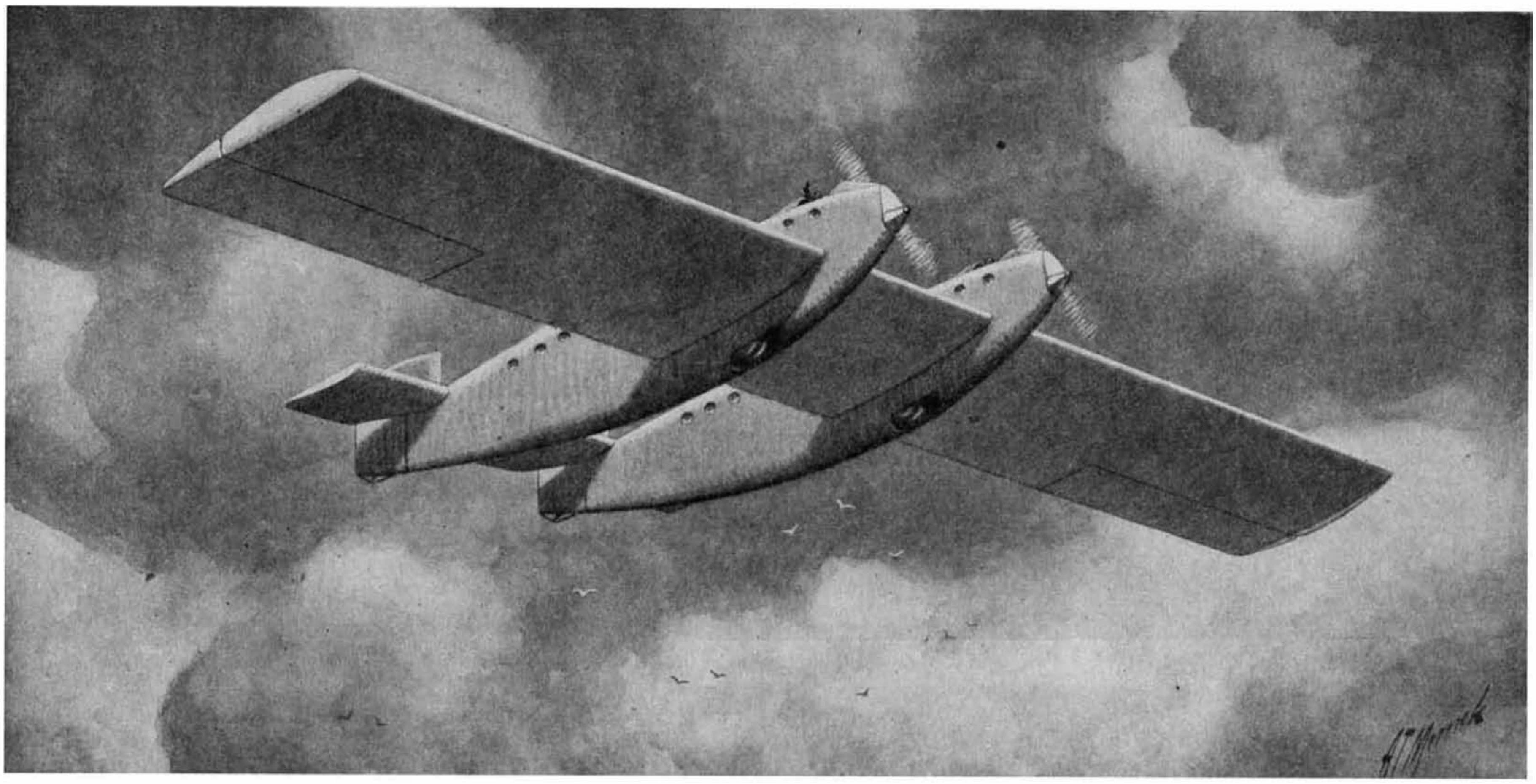


The Low-Resistance Airplane

The Technical Essentials of Commercially Profitable Aviation

By J. Bernard Walker

THE first public exhibitions of competitive airplane flight took place in 1910, at Boston and at the Belmont Park Meet, the latter being held at the racetrack of that name. The most successful flying machines of Europe and America were present, and for six days the public had an opportunity to study the very latest designs and witness the utmost possibilities of flight of the airplane of that day, now some fourteen years removed.

The writer, who was present at the Belmont Park Meet, visited every hangar, and, after a careful inspection of the various machines, came to the conclusion that, before any great addition could be made to the then highest speed, which was about sixty miles an hour, it would be necessary to pay attention to an element in aerodynamics which, in the machines as they then existed, seemed to have been almost totally neglected. He realized that the greatest defect consisted in the large amount of what is now known as "parasite resistance." In other words, the airplane of 1910 presented, with its mass of braces, trusses, wires and deep and cumbersome landing gear, an amount of end-on air resistance which was fatal to the realization of any degree of high speed.

Early Airplane a Veritable Birdcage

Those of us who can call to mind those early days will remember that the average airplane was a veritable birdcage in the multitude and complexity of its parts. So, in thinking the matter over, the writer sketched out an airplane, in which an endeavor was made to cut down all needless air-resisting members and reduce the machine to something of the sweetness of form of the fastest flying birds. This sketch and its accompanying article were published, merely as a general study of the subject, in the Scientific American of October 22, 1910, and the story was reprinted in our issue of August 14, 1920. In the reprint we spoke of the design of 1910 as a "loose study of a problem to which the engineering profession of that day was about to apply itself." The results of that study were to be revealed a few years later on the battlefields of France and in the memorable flights across the Atlantic. "The present-day interest (1910) of this article," we said, "will be found in its fruitful anticipation of subsequent developments as seen in the oval, stream-lined nacelle and the sheltered position of the pilot within it; in the substitution of interior metal wing beams for exterior ties and struts; in the retractable or folding chassis; the gyro control of the ailerons; and the use of alloy metal throughout, with corrugated covering for the wings." After a lapse of eight years there was produced, in the summer of 1918, the Junker all-metal war monoplane, with internally braced wings covered with corrugated metal. In 1920 the retractable chassis as suggested in 1910 was being made the subject of experimental effort.

In recent years, the work of refining the airplane with a view to cutting down parasite resistances has been steadily prosecuted, and in the present article we present a late design by James V. Martin, in which the problem of reducing end-on or head resistance, as suggested fourteen years ago, has been carried apparently to the full limit of its possibilities. It should be noted further that the machine has been equipped with the bi-convex wing which is so largely responsible for the sensational speeds of some recent racing machines.

The following description is based upon notes furnished to us by the designer. Our line drawing on the adjoining page shows an efficient, bi-convex, aerofoil in cross-section. If such an aerofoil be propelled in a direction from "B" to "A" at high speed the amount of propeller thrust required to propel it may be as little as one-twentieth of the amount of force along the vertical line which is marked "lift." In other words, for every pound of propeller thrust expended in driving the aerofoil forward twenty or more pounds of "lift" are obtained. The line marked "drag" at the top of the diagram represents the amount and direction of the air resistance which the propeller must overcome, while the adjoining vertical dotted line marked "lift" represents that component of the whole force which is available to overcome gravity. The reader will readily see from this diagram that the "lift" of a wing may bear a surprisingly large ratio to the drag. In most of the planes of today the "lift" and "drag" relationship does not work out so advantageously; for instead of obtaining twenty or more pounds of weight-carrying capacity for one pound expended in propeller thrust there is obtained from six to ten pounds of lift in conventional airplanes design and about six of these ten pounds are required to lift the weight of the structural parts of the airplane itself and the fuel required to drive it. Hence, a comparatively small amount of lifting capacity remains for the *pay-load.*

Commercial Airplane Must Have Large Pay-load

Needless to say the pay-load is vital to the success of a commercial airplane. Therefore, the direct road to the production of an airplane that will pay commercially will be found in correcting a condition which causes the majority of our present type airplanes to have only a moderate lift over drag ratio.

Most of the conventional airplanes of today have a poor "lift-drag" ratio varying from six to ten at normal maximum speed. By correcting this inefficiency until a high "lift-drag" ratio is produced of one to twenty, which laboratory tests show to be reasonable for airplanes of the type which is here shown and described, a paying airplane service becomes practicable.

The objectionable feature of the conventional airplane, from the standpoint of efficiency, is the amount and disposition of the parasite resistance, so called because it consumes the power of the motor without giving any lift whatever. Parasite resistance may be grouped under four classes: first, that of the body or fuselage; second, that of the wing trusses such as the struts and wires between the upper and lower biplane wings; and third, that of the airplane chassis, consisting of the wheels and chassis frame which support the fuselage while it is standing or running over the ground. A fourth classification includes various external wires, brackets and leads.

Enemies of Speed and Load Capacity

The above are the enemies of airplane speed, flying, endurance and useful load capacity. Our drawing below roughly represents the "drag" on one of the aerodynamically useless parts of an airplane, that is on one of the landing wheels; all the resistance of which represents a dead loss of fuel and engine power. This useless consumption of power, however, is not the only detrimental effect of parasite resistance, since each one of these structural parts of an airplane obstructs the air flow for a considerable distance around it. It is a fact that even some distance in front of a body when rapidly driven through the atmosphere the disturbance begins. This is crudely represented by the diverging lines preceding the wheel, as shown in the drawing. The effect of this resistance, and of others of a like character, in a typical airplane of today, is that a mass of interference is built up about the wings which prevents their functioning as they should. Interference is the technical term used to describe the effect of one body or shape on another juxtaposed body in motion through the atmosphere. If we could eliminate the useless resistance and constant interference of airplanes, we should be well on the road to perfection and toward a means of transportation safer and cheaper than any hitherto known to man.

Not only is the study of modern aerodynamics teaching us to get rid of the parasite resistance described above, but it is also leading us to a great refinement of the shape or form of the aerofoil or wing. Flat surfaces are practically inoperable, owing to their poor "lift-drag" ratio; although it is possible, given plenty of power, to "plane" a flat surface through the air.

After learning the first lesson of the value of the upward curve, early experimenters labored for many years under the supposition that not only the upper but also the lower surface of the wing should be upwardly curved. Even the famous Dr. Junkers, who in 1911 indulged in the conception of a downwardly-curved wing portion in the wing center, when he decided to thicken the wing for the reception of passengers, motor, etc., hastened to say that this was done at a sacrifice to efficiency and that the wing should quickly taper into thin sections of the normal type. The bi-convex wing shown herewith has been demonstrated as highly suitable for high-speed flight. Recently there has been an increase in the use of the bi-convex frame or wing, until in the recent Curtiss racer, which made two hundred and sixty-six miles an hour, excessive speed was conceded to be impossible except by the use of the convex lower as well as upper wing surface. The world's most efficient speed aerofoil, listed as such in the latest National Advisory Committee's Report No. 182, is of this class of aerofoil, with each ordinate of the lower curves a fraction of the corresponding upper ordinate.

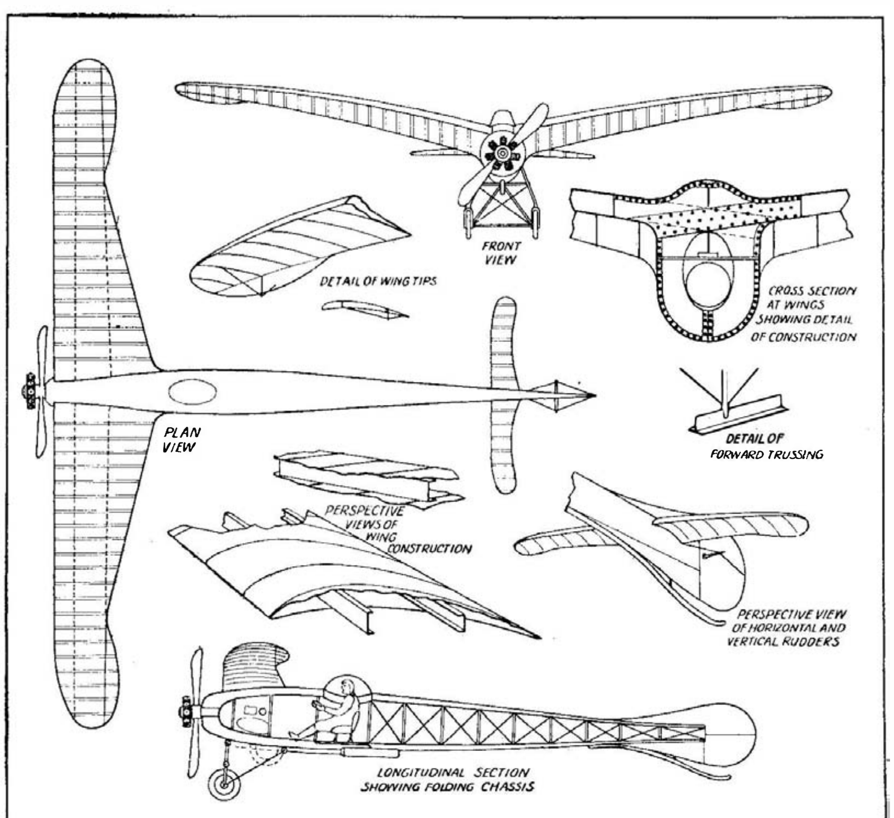
From what has been said, we are prepared to understand why the conventional airplane, with its low "lift-drag" ratio has been too inefficient to inaugurate on a widely extended and successful scale a system of successful airplane transportation. The large amount of parasite resistance presented by wires and struts of a biplane and by the fixed landing chassis protruding from the nacelle, to say nothing of the inefficiency of the existing form of wing has consumed so much of the available horsepower that the pay load has been cut down to a point at which profitable commercial aviation is scarcely possible except under very favorable conditions.

The bi-convex wing has the great advantage also that we can put the entire wing truss inside of the wing and thereby keep the drag of the wing at a minimum. The side and front elevations in the drawing show that the landing chassis may be retracted within the fin-shaped bodies during flight, and the relative size of these bodies to the wing has been so reduced that they offer practically no parasite resistance. The plane herewith shown, which is known as the MP I, is a medium-sized ship with three feet maximum wing thickness. In a later design, with an inner depth of six feet, accommodation for passengers will be provided within the wing itself. The flying performance estimates are computed from the Gottengen Laboratory test, without any scale allowance effect and, therefore, may well be below the usual full-scale performance. It is claimed by Mr. Martin for the machine presented, that it could carry forty passengers and five thousand pounds of freight in a non-stop flight from New York to Chicago in from five to six hours, depending upon the weather conditions.

Airplane Travel Safest of All

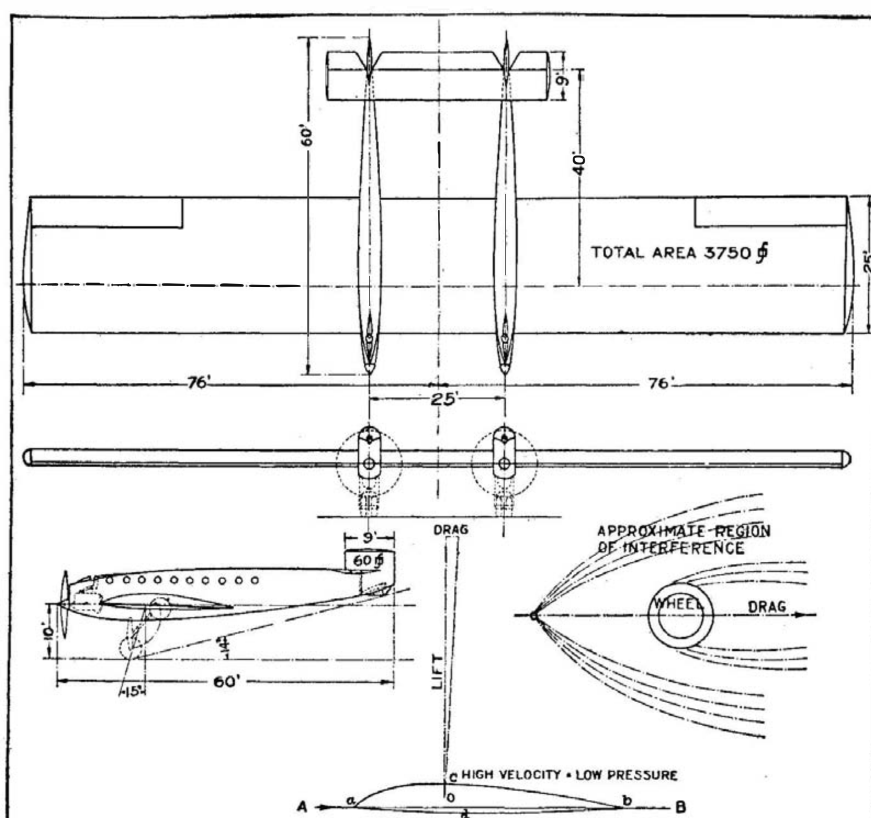
The designer of this plane believes that future air transport ultimately will be safer than any other means of travel, and much more comfortable. The machine here shown is provided with twin motors, in each of which there are three banks of six cylinders each, each bank driven through a clutch. Hence, should anything happen to a motor, the bank of cylinders having the trouble would be disengaged from the propeller drive, while the remaining banks continued to drive the airplane. This arrangement should practically eliminate the danger due to motor failure and guarantee continuous flight from flying field to flying field.

We have presented this design because of its extreme interest and its embodiment of the latest methods of meeting aerodynamical requirements. If the machine be built and tested it will no doubt attract the widest attention and interest of the aeronautical world. Claims for "lift" and for economy are high, but they seem to be based upon experimental demonstration and correct aerodynamic reasoning.



WALKER DESIGN FOR LOW-RESISTANCE AIRPLANE IN 1910

This sketch, a dream of future development, first published in 1910, embodies the internally-trussed wing, with corrugated metal covering, the oval-section body and the folding chassis. The machine was to be built entirely of metal



A 1924 DESIGN EMBODYING THE BI-CONVEX AEROFOIL

The monoplane of 1924 marks the complete fulfillment of the dream of 1910. Parasite resistance is entirely eliminated, the wonderful bi-convex wing is utilized, and metal is used throughout