always been the most important factor making for progress in aviation.

Calculating Lift.—In the mathematical section, an hypothesis that aeroplanes are supported in flight by the inertia of the air leads to the necessity of finding plausible expressions for mass and acceleration.

Two dimensions of the mass of air deflected are plausibly functions of the span and chord of the plane; the third, which defines the depth of the stratum, and is known as the "sweep," is taken as an empirical function of the chord; but this connection needs discussion. Acceleration is obviously a function of the angle of the plane, but difference of opinion exists as to how that angle should be measured. A suggestion is put forward in favor of the "angle of deflection" measured at the point of intersection of tangents drawn to the leading and trailing edges of the plane, which needs discussion. From the assumed premises a rough-and-ready formula for lift has been evolved (see summary of formulæ).

Skin Friction.—In order to extend the premises to cover a plausible expression for the resistance to flight and the power expended thereon, it is necessary to adopt a value for skin friction. Zahm's experiments have been accepted as data (see summary of formulæ), but the whole subject needs discussion. Skin friction is of such fundamental importance in aerodynamics that it is imperative to put it upon an accepted basis analogous to the position occupied by normal pressure.

Coefficient of Flight.—The coefficient of flight, representing the resistance per unit load, may be shown to be independent of speed, but to depend on the angle of the plane, and to have a minimum value depending on the coefficient of skin friction. On the present hypothesis, the minimum coefficient of flight obtains with planes of a very small effective angle (about 5 deg.), such as would necessitate flying at much higher speeds than have hitherto been realized. The existence of an angle of least resistance is very important in connection with the problem of variable speed machines.

Body Resistance.—Body resistance in a practical aeroplane is a supplementary resistance to that of the planes, and should always be considered as such. It stands in the way of realizing the higher speeds that would lead to the use of more efficient planes, but by enclosing all the principal masses in casings of stream-line form a plausible means is afforded of considerably reducing this quantity. A comparison of the coefficients of normal pressure and skin friction indicates a very large possible saving in this direction. In bodies of stream-line form the advantages of a hemispherical head are worthy of consideration.

Stability.—Stability in a flying-machine is either natural as a result of form, automatic as the result of self-acting mechanism, or controlled by human intelligence. No particular progress has been made along the lines of automatic stability, although the use of gyroscopes and wind-vanes to operate relay mechanisms has frequently been suggested. Natural stability has, however, been realized to some extent, and, coupled with modern expert control, the combined result has reached an extraordinarily high degree of perfection, considering the short period of evolution.

Natural stability in its elementary form may be readily demonstrated by means of paper models. In practical aeroplanes natural stability in the longitudinal vertical plane is mainly based on the principle of the dihedral angle. Natural stability in the vertical plane is also commonly based on the same principle, but alternative systems, one of which is the arched wing, have been tried. The arched wing and the dihedral being apparently diametrically opposite in principle, attention is drawn to two orders of stability—"stiff" and "rolling." The relative possibilities of successful development along each line is well worthy of discussion.

The acentric centre of gravity, in which the principal masses are placed well below the centre of pressure, is frequently suggested as a stabilizing principle; but the permanent existence of a couple between the centre of gravity and the centre of pressure indicates liability to pronounced oscillation, and the system does not find general favor. In connection with the under-carriages of aeroplanes, the advantage of landing direct on skids is urged; and in connection with the power plant, the possible disturbing influence of the gyroscopic force of heavy revolving masses is worthy of notice.

Conclusions.—Apart from the question of stability, progress in flying-machine design is mainly a problem of increasing the efficiency of the machine, just as it is in every other branch of mechanical engineering. It follows, therefore, that the need for further information on such subjects as the effective angle of a plane, sweep, skin friction, and other similar problems that come within the province of research work in physical science, is all important. If the aeroplane of the future is to carry heavy loads and to fly far and fast without interrupting its journey, it must be more efficient than the aeroplane of to-day. The air, like the ocean, permits of full speed ahead all the time, and a speed of 60 miles per hour through the air would halve the present latest crossing of the Atlantic. Before an uninterrupted journey across the 1,700 miles that separate the nearest adjacent points of land could be accomplished by a machine carrying only two men, it would have to be shown that an aeroplane could be built capable of carrying at least 1,500 lb. of useful load at 60 miles per hour, with a gliding angle more nearly in the order of 1 in 7 than the angle of 1 in 4 or five, which at present represents the efficiency of a good modern flyer.

Except so far as a pilot might be able to economize power, as soaring birds do, by taking advantage of favorable air-currents, skilful control has nothing to do with the theoretical possibilities of the aeroplane in undertakings of this order, which may be investigated by the aid of simple arithmetic. In matters affecting the use of machines in bad weather, for dangerous purposes, and under difficulties generally, nothing in the world gives any clue to the future except the present state of the art, for which the intrepid practice of pilots and the care of those who build machines is wholly responsible, and deserving of the utmost credit.

Summary of Formulæ.

The Two-Thirds Power Law.—If thrust $\propto V^2$ and power $\propto V^3$, then thrust $\propto H.P.^{2/3}$.

Mathematics of the Cambered Plane.—

$$\text{Lift} = \frac{V^2 \tan \beta}{200}$$

where V = flight speed miles per hour.
β = angle of deflection.

Skin Friction.—Zahm's formula—

$$R = 0.0000316 l^{.93} V^{1.85}.$$

Where R = resistance of double surface lb./ft. of span.
l = chord.
V = velocity miles per hour.

Approximation (1 to 90 miles per hour and high aspect ratio).

$$R = 0.000018 V^2.$$

Coefficient of Flight.—

$$\text{Pounds thrust per lb. loading} = \left(\frac{\tan^2 \beta + 0.0072}{3 \tan \beta} \right)$$

Minimum value obtains when $\beta = 5$ deg. approximate, and gives least coefficient of flight = 0.085.