The Low-power Aeroplane or Aviette.

By Prof. L. BAIRSTOW, F.R.S.

MUCH attention is being paid in the general and technical press of this and other countries to flight with low-powered engines. The addition of small engines follows quickly on the gliding successes of the past year, but no marked connexion is discernible between the new features of the two types of flying machine. The change from aeroplanes having two or three hundred horse-power, and carrying a single individual, to aeroplanes of five to ten horse-power is now so striking as to have stirred public imagination. Many of those now interested are probably unaware of the flights made by A. V. Roe more than ten years ago with a nine horse-power J.A.P. engine.

There is little in the new applications which would warrant the use of the word discovery, and the change is probably due in large measure to an emancipation from the fetters of war ideas. There is reason to suppose that aeroplanes designed for official use are subject to so many restrictions that development is difficult. The advent of the low-power aeroplane is therefore welcomed as a new outlet for ideas, one which gives scope to individual initiative, and one which it is hoped will make a popular appeal.

The unofficial character of the British development of the aviette is emphasised by the offering of a prize of 500*l.* by the Duke of Sutherland for a light aeroplane of British manufacture and design; for the Duke is Under Secretary of State for Air, though he is not acting in his official capacity. A separate prize of 1000*l.*, open to the world, is offered by the *Daily Mail*. The most striking conditions of the competition are: "The power unit must not exceed 750 cc. total cylinder capacity, and the prize will be awarded to the machine which flies the longest distance on one gallon of petrol, with a minimum distance of fifty miles to qualify."

Many other conditions apply which relate to ease of handling on the ground; there is also the usual vague reference to stability. It is in accordance with our present state of knowledge and application that, while the requirements for performance are always precise and well-defined, those for stability and control are valueless. In the competition rules for the low-power aeroplane there is neither definition nor means of checking aircraft as delivered in order to ensure a due measure of stability and control.

The French are, as is usual in matters relating to aviation, taking an active interest in the aviette, and in the *Times* of April 6 we find an article based on a flight by M. Barbot from Franczal to Toulouse in a seven horse-power aviette. The ideas of the flyer appear in the following quotation:

"M. Barbot, who is in Paris, expresses the belief that his aviette is the forerunner of the aero-taxi of the immediate future. He contemplates the production of a machine which will cost about five thousand francs (nominally 200*l.*), which can rise from almost anywhere and, furnished with a ten or fifteen horse-power motor, can land slowly within thirty yards of its objective and without any risk. . . . The cost will be only that of a gallon of petrol per hundred miles."

In the same issue of the *Times* is a reference to a British "power-driven glider":

"The test began yesterday at Ashton Park, Preston, of the first British auxiliary-engined glider, the Wren, designed and built by the English Electric Company at their Preston works. It is expected that the machine will provide valuable data on which to base the development of the economical aeroplane of the future. It has been constructed for the Air Ministry. It is remarkably light, being about 3 cwt., and the dimensions are: span 37 ft., length 23 ft., height 5 ft. The engine is a three horse-power A.B.C. motor-cycle engine, developed to seven horse-power, and gives a maximum speed to the aviette of forty-eight miles an hour. . . ."

These two extracts exhibit the features which define the low-power aeroplane, and in the remainder of this article it is proposed to analyse the projects and achievements in relation to the scientific knowledge involved. It will be found that the expectation of 100 miles per gallon of petrol in an aero-taxi carrying pilot and passenger is optimistic but not wildly in excess of what can be immediately foreseen, using arguments based on well-established data. On the other hand, risk is only incidentally reduced, and neither the extracts nor current technical literature show any attempt on the part of the designers of light aeroplanes to pay special attention to the fundamental problems of stability and control.

For the past eight or ten years it has been realised that all good aeroplane design tends to produce a result in which, for the most economical speed of flight, the weight carried is about nine times the resistance experienced. All high-power aeroplanes are able to exceed this most economical speed very greatly, with the result that at their maximum speed near the ground the resistance is more than one-quarter of the weight. If there be no great reserve of power, considerable height above the ground is unattainable, and the most economical speed is fixed by the design of the aeroplane, in particular by the magnitude of the load carried per unit area of wing surface. A common loading has been 7-8 lb. per sq. ft. corresponding with an economical speed of about 60 miles per hour; a reduction of loading to 2 lb. per sq. ft. would bring the best speed to about 30 m.p.h.

If the making of a specified journey be the basis of comparison, then speed in itself has no influence on petrol consumption per unit of weight carried, but the horse-power required is directly proportional to the speed. Indirectly, low speed is advantageous, since a smaller and light engine suffices for transport. Taking figures given in the Press as a basis, it appears that the aviette with a single occupant would weigh about 550 lb. all told, whereas the single-seater fighting craft weighs from three to four times this amount. The maximum speed claimed for the aviette is only about one-third of that achieved by the scout.

Further data lead to an estimation of a probable mileage per gallon of petrol. Many aero-engines exist in which the petrol consumption does not exceed 0.5 lb.

of petrol per brake horse-power per hour, and it is probable that an airscrew efficiency of 75 per cent. may be reached. With petrol weighing about 7 lb. to the gallon it will be found from those figures and a weight-resistance ratio of 9 that the number of miles possible per gallon of petrol consumed is roughly equal to thirty thousand divided by the weight of the aeroplane. To achieve 100 miles to the gallon, therefore, it would be necessary to improve on existing figures for performance, since a gross weight of 500 lb. yields only 60 miles per gallon. As an aero-taxi with pilot and passenger would weigh more than 500 lb. it would appear that M. Barbot's estimate is not to be easily achieved.

It will be noted, however, that the condition of a minimum of 50 miles per gallon in the competition rules for the Duke of Sutherland prize is reasonable. It will exclude seriously inefficient design without setting an impossible task.

In making the preceding calculations, no allowance was made for the use of energy obtained from the wind itself. As we all know, aeroplanes without engines, *i.e.* gliders, have maintained themselves in the air for several hours consecutively, utilising winds deflected upwards by a sloping hill-side. Up-currents of sufficient intensity for support are very local, and we are yet far from being able to use them for point-to-point journeys as distinct from tacking backwards and forwards in a chosen locality. The phenomenon of gliding, as we know it, does not modify the estimate of power already made, but does show how part of that power may be obtained from the wind. Langley contemplated the extraction of energy from the pulsations of the wind, quite apart from their direction, and this source of energy is probably very widely distributed. So far, however, little, if anything, has been attempted in practice in the extraction of this energy, and there

is no clear lead as to the direction in which one might hopefully proceed.

For some time to come, it may be expected that the aviette will carry the main source of power for its support; economy of fuel may be obtained by utilising up-currents in the neighbourhood of flight and so using the engine in passing from hill crest to hill crest. The condition attached to the Duke of Sutherland prize that the competition is to take place over a triangular course of not less than 15 miles reduces the chances of obtaining substantial amounts of energy from the atmosphere.

Since a claim for reduction of risk has been made, it may be as well to state the view that the only contribution made to safety is in the sense that it is less dangerous to strike the ground at 30 m.p.h. than at 60 m.p.h. The inherent defects of the modern aeroplane which make for danger on stalling are quite untouched by the new application.

The low-power aeroplane can scarcely fail to react beneficially on scientific knowledge and its applications. At the moment, however, it would appear that the aviette has derived its being from knowledge obtained for other purposes and has not reached the stage of reciprocation.

[Since this article was written, a very definite advance in the practical use of the low-power aeroplane has been made by M. Barbot, who, as was recorded in our issue of May 12, p. 645, succeeded in completing the round trip from the French coast to Lympne in Kent and back again, covering about 80 miles, in a machine with a 15 h.p. engine. His time for the journey was about two hours and a quarter, including nearly half an hour's stay at Lympne, and it is stated that his petrol consumption was about two gallons.]

The Earth's Electric and Magnetic Fields.¹

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II.

TWO of the most characteristic features of the earth's magnetism are the non-coincidence of the magnetic and geographic axis, and the secular variation. While a theory which is to claim any degree of completeness must account for these, one cannot resist the temptation of searching for any sort of phenomenon capable of giving a field of the order of magnitude of the earth's field in the hope that if such be found it may serve as a possible basis on which to build a more complete theory.

Attempts towards a theory of the earth's magnetism may be classed roughly in the following four groups:

(1) The earth is assumed to be made largely of iron, and to be a permanent magnet independently of its rotation, or to be magnetised inductively by an external field.

(2) The magnetic field is brought about by the rotation of an electrostatically charged system.

(3) The magnetic field arises from a state of magnetisation brought about by the rotation of the earth.

(4) The field is caused by electric currents circulating within the earth.

The high temperature of the earth's interior would be inconsistent with a state of permanent magnetisation unless the effect of high temperature is compensated in some way by that of high pressure. Induced magnetisation suffers from the same cause, and would, moreover, give a type of field totally unlike the earth's field.

As regards (2), a sphere of the earth's size, rotating with the earth's angular velocity, would have to possess such a surface charge as would give it a potential gradient a hundred million times the earth's potential gradient in order that the rotation of that surface charge would produce a magnetic field comparable with the earth's magnetic field. Even then, it turns out, as has been shown by Schuster and by the writer, that owing to the effect of the observer's motion with the earth's surface, a sign of charge which gave the right direction for the vertical component would give the wrong direction for the observed horizontal component.²

² Inclusion of the effect due to the atmospheric positive charge annuls completely the magnetic field which would be observed by one moving with the earth.

¹ Continued from p. 642.