CONTRA-PROPS

Recollections of Early Considerations by Advisory Committee for Aeronautics : A Pioneer's 1907 Patent : Suggestions for Further Research

By F. W. LANCHESTER, LL.D., F.R.S.

THIS subject came prominently before the Advisory Committee for Aeronautics as long ago as 1918, when it received close attention. In a communication by the writer, dated May, 1918 (R. & M. 1918-19, pp. 634 to 642), the problem was dealt with from a theoretical standpoint, following the lines of the writer's exposition in his specification of Patent 9413A, 1907, published some ten years previously. In this he divided the energy losses as due to three distinct causes: (1) skin-friction and eddy making, sometimes termed *form resistance*; (2) the sternward component of the slipstream essential to propulsion; (3) the rotational component of the slipstream, whose angular momentum is a measure of the driving torque.

ONCE more it is our privilege to publish an article by Dr. Lanchester, "Grand Old Man of Aerodynamics." And once again one is amazed at the insight into the details of the mechanism of flight which he possessed in those very early days. As long ago as 1907 he not only visualised the advantages of contra-rotating airscrews, or as he termed them "co-axial propellers with reverse rotation," but he patented a form of drive, details of which are given in this article.

It was shown that, under ideal conditions, the whole of the energy loss due to the rotational component of the slipstream might be avoided, leaving (1) and (2) above as the only sources of loss. Of these, (1) alone is to be regarded as a *propeller* loss; (2) is more correctly to be considered as a *propulsion* loss, for it is inevitable in the theory of propulsion and is not dependent on the *instrument*, whether it be a screw propeller or what not.

In order to avoid loss due to the rotational component, two conditions must be satisfied. The driving torques on the two members of the combination must be equal and opposite; that is, the algebraic sum of the two torques must be zero. The air acted upon must be the same for both propellers, and the action of the propellers must be homogeneous; without this provision it would be possible for energy to be lost in rotational currents and counter currents, in spite of the torques being balanced by being equal and opposite.

The first of these conditions is satisfied by a form of balance gear described and claimed in the 1907 specification, and illustrated in the figure. Following is a brief description:—

Two propellers, respectively of right-hand and left-hand pitch, are arranged to revolve about the same axis with equal and opposite torque. Their shafts are concentric, the outer one being hollow.

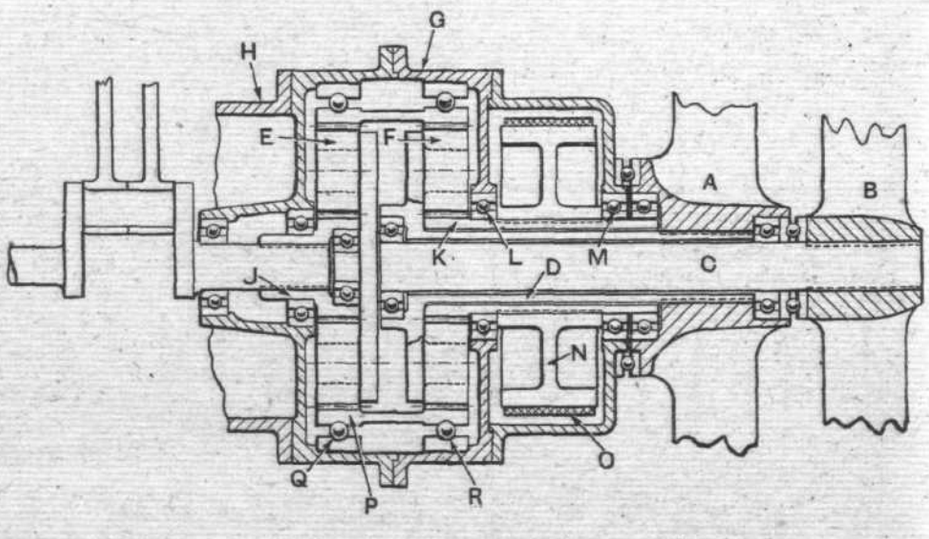
The drawing illustrates one form of the invention. Two propellers, A and B, of opposite hand, are mounted in driving connection with the shafts C and D, which are keyed to the planet elements E and F of the two trains of epicyclic gear contained within the casing G, bolted on to the extremity of the crank chamber H. One of the sun elements, J, is coupled direct to the motor shaft, and the other sun, K, is mounted to revolve in bearings L and M, and carries a brake drum, N, acted on by a brake shown as a band brake O. The ring element of the two trains of gear, P, is common to both, and is mounted in bearings in the casings Q,R, and is quite free to rotate, other than by its engagement with the planet pinions of the two trains.

When the sun element K is free to rotate, there is no driving effort exerted on either propeller; the planet elements can both stand still while both suns rotate in one direction, and the common ring element in the opposite direction.

When the sun K is brought to rest by means of the brake N,O, the planet elements are constrained to revolve (presuming the engine to be in action), but the extent to which they individually revolve is not determined except that, by the construction of the mechanism, the two propellers are acted on by equal and opposite torque. Thus the whole mechanism shown in the drawing is, in effect, a combined balance gear and clutch.

The second condition is by no means easy of fulfilment. It is just a question, as a practical problem, of how nearly the ideal can be approached; that can only be ascertained by experiment. As a "shot in the dark" the writer in his memorandum suggested that it might be hoped to save *half* of the rotational energy theoretically possible; his present view is that it should be possible to do better.

Whether the problem is to determine the data for the best possible design, or to find an expression for optimum efficiency, even on the supposition that the whole of the rotational wake energy is conserved, it is anything but



Dr. Lanchester's 1907 "balance gear."