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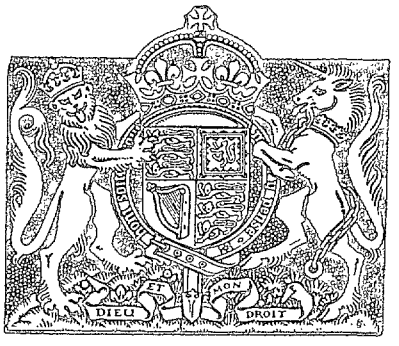

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Note on the Characteristic Curve for an Airscrew or Helicopter

By

C. N. H. Lock,

OF THE AERODYNAMICS DIVISION, N.P.L.

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Note on the Characteristic Curve for an Airscrew or Helicopter

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On reading Dr. Hislop's paper[1] on experiments on a Hoverfly I aircraft which reproduces the 'characteristic' curve of an airscrew as given in R. & M. 1026[2], and on re-reading the latter report and R. & M. 1014[3] after an interval of twenty years, it occurred to me that a modification of the method of plotting adopted in these reports would have certain advantages.

The proposed method is illustrated in Fig. 1. The variables adopted are

$$\left.\begin{aligned} x = 1/F^{1/2} &= \left(\frac{\pi}{2}\rho\right)^{1/2} uD/T^{1/2} \\ y = 1/f^{1/2} &= \left(\frac{\pi}{2}\rho\right)^{} VD/T^{1/2} \end{aligned}\right\} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1)$$

which are the square roots of the variables used in the previous reports.

In these equations:—

D	diameter of airscrew
T	thrust
ρ	density
V	wind velocity along axis
u	mean axial velocity at airscrew disk.

The velocities u and V are taken to be positive when they are in the opposite sense to the thrust and $T^{1/2}$ is taken to be positive.

The change of variables has three advantages,

1. The three principal working states now correspond to three different quadrants as follows:

Normal working states	x and y both positive
Vortex ring state	x positive and y negative
Windmill brake state	x and y both negative

2. The representation in the neighbourhood of the x-axis (static condition) and the y-axis (ideal gyroplane descending) is more definite since the curve has a finite slope at both these points.

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3. The formulae of the 'Vortex theory' take the simple form,

$$y = x - \frac{1}{x} \text{ (Normal working state } x > 1)$$

$$y = x + \frac{1}{x} \text{ (Windmill brake state } x < -1)$$

The following results are shown in Fig. 1.

(a) The data from R. & M. 1014[3] Table 7 and Fig. 2.

(b) The data from R. & M. 1026[2] Figs. 1 and 2.

(c) The formulae of the Vortex theory.

A comparison of (a) and (b) shows that there is a negligible difference between the results of R. & M. 1014 and R. & M. 1026 although these are calculated by slightly different methods and based in part on different experimental results.

A closely related method of presentation has been used by Hafner[4].

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No.	*Author*	*Title, etc.*
1	G. S. Hislop	Comparison between the Measured Performance of a Hoverfly I Aircraft in Vertical Flight and the Characteristic Curve of an Airscrew. A.R.C. 10210. (Unpublished).
2	H. Glauert	The Analysis of Experimental Results in the Windmill Brake and Vortex Ring States of an Airscrew. R. & M. 1026. 1926.
3	Lock, Bateman and Townend ..	An Extension of the Vortex Theory of Airscrews, with Applications to Airscrews of Small Pitch, and including Experimental Results. R. & M. 1014. 1925.
4	Hafner	Rotor Systems and Control Problems in the Helicopter. Anglo-American Aeronautical Conference, 1947.

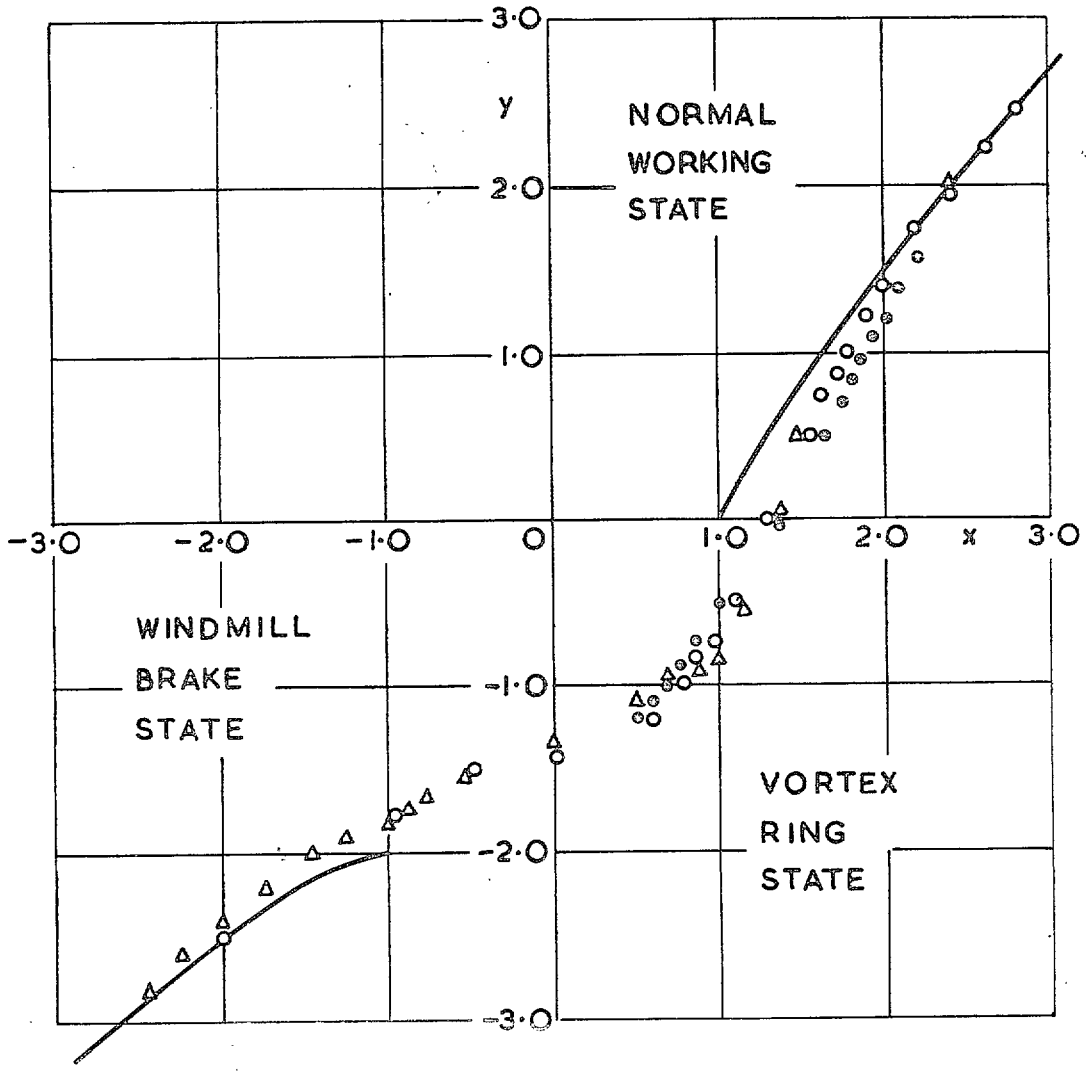

FIG. 1. Characteristic curve of an airscrew.

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