CORRESPONDENCE.

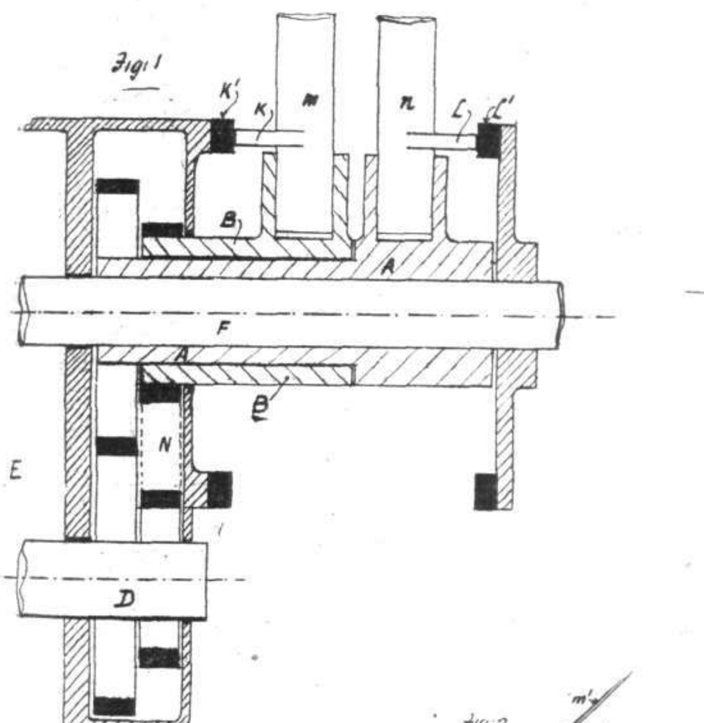
A Rotary Equivalent to Wing-Flapping.

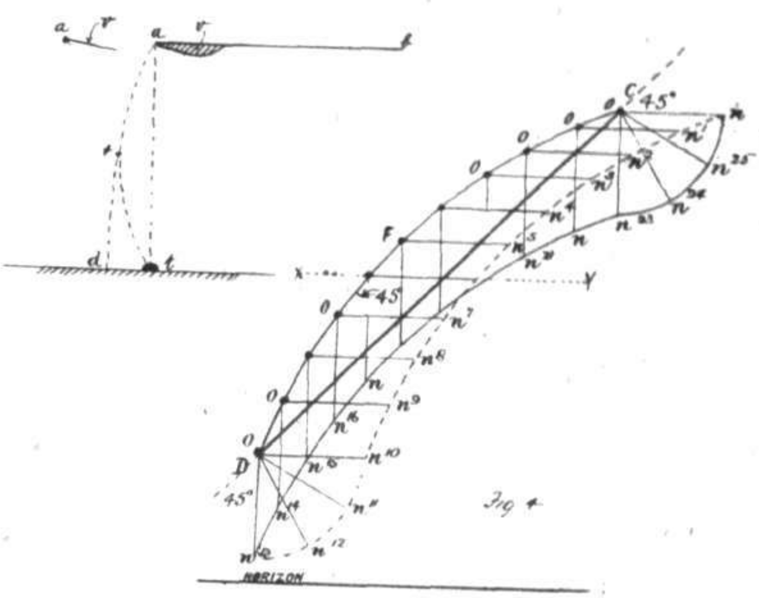
[1931] With reference to the note on M. Passat's wing-flapping machine, in your issue of September 14th. the bulk of experiment certainly appears to lie in detail improvement of existing design rather than in developing original types of machine, but I do not think the rapid reciprocation of artificial wing vanes is as yet practicable on full size machines; it is, of course, unnecessary since artificial wing mechanisms do not suffer from the limitation of arteries crossing the joint and can be made to flap by rotation as well as by reciprocation.

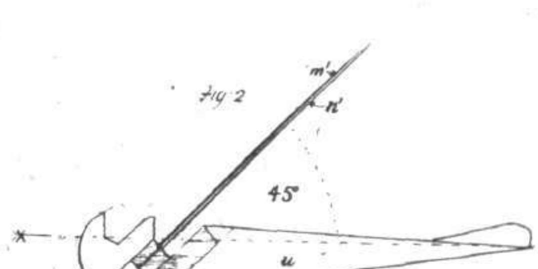
Two single-bladed or vaned propellers superimposed and rotating in opposite directions at equal speeds when correctly mounted and feathered will reproduce quite well the wing motion of the numerically largest class of wing-flappers—the insects.

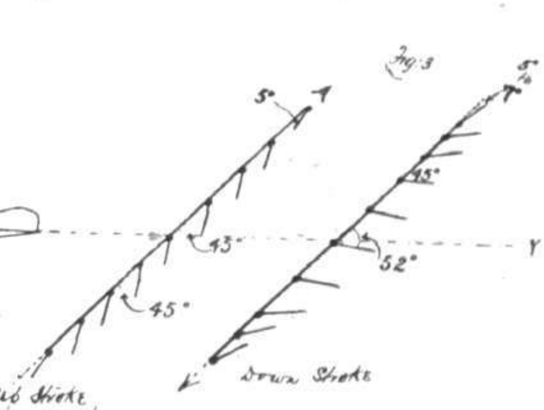
The arrangement is broadly as follows:—A radial type engine E drives two tubular shafts *A* and *B*, Fig. 1, concentrically mounted on a fixed central shaft *F* which is secured to the engine crank case. The crank-shaft *D* drives shaft *A* in one direction by a spur pinion, and shaft *B* in the opposite direction by a silent chain *N*. Two vanes or wings m^1 and n^1 are carried by wing spars *m* and *n* fixed so as to have axial movement in sockets on the shafts *A* and *B*. Each spar has a short lever arm, *K* and *L* respectively, the outer ends of which bear on corresponding cam plates K^1 and L^1. The steepness of the cams need not be more abrupt than 1 in 8. Attached to the cam plate L^1 is a body or fuselage (*u*, Fig. 2) of such leverage that when the said body is horizontal the engines, shafts, wings and cam plates are inclined at about 45 degrees from the horizontal, and the plane of rotation of the wings cuts the horizontal at about the same angle.

Starting with the two wings together (practically superimposed) at the highest position above the body, each wing makes a forward and downward stroke on one side of the body and then continues its movement as an upwards and backwards stroke on the opposite side of the body. The wings, therefore, cross at top and bottom of strokes. During their movement the wings are feathered by the passage of the lever arms over the fixed cams and in the following manner. Where the wings cross they are practically parallel to the plane of rotation and thus do not collide with one another, but as each wing moves on its downward stroke, Fig. 3, it is feathered with a gradual increase of inclination till at about half-way the vane is horizontal, *i.e.*, it has been feathered so that it is inclined at 45 degrees to the plane of rotation. At about ⅞ stroke the feathering is gradually decreased so that the vanes may again cross at the bottom of the stroke. On the up-stroke the vanes are feathered so that they are practically vertical on most of the stroke. The downward and forward stroke is therefore almost wholly a lifting stroke, and the upward and backward propels the machine. At the crossing points the wings are inclined at about 5 degrees to the plane of rotation, so that at both these parts of each revolution there is both lift and propulsion.









This general system of feathering may be inferred from the figure of 8 movement so characteristic of insect flight and from the following observations.

Let a flexible rod *ab*, having a vane *v*, be struck with uniform velocity vertically downwards at an object *t*, the vane being held at a small positive angle to the horizontal. The rod tip *a* will follow the path *ad* reaching the ground at a point *d* in advance of the object, the deflection being due to air reaction on the vane. If the rod be accelerated to maximum velocity at mid stroke *r* and have minimum velocity at *a* and *d*, the tip will follow a curved path, *a*, *r*, *t*, and a similar curve to this can be obtained at uniform velocity by feathering the vane as shown in Fig. 3 at different parts of the stroke.

The reciprocating wing of an insect corresponds roughly