The German Rohrback "paddle plane" was a helicopter design to a different formula. The rotor blades had their incidence varied as they travelled around the circumference.

relative magnitude of axial and rotational airflow in the slipstream changes with the flight path of the machine, and will be different according to whether the machine is hovering, climbing vertically or travelling horizontally. Probably research on contra-rotating airscrews will help to shed a certain amount of light on this problem, although the two cases are not strictly comparable. The nearest approach to helicopter rotor conditions is presumably that of an ordinary aircraft driven by contra-rotating airscrews doing a violent sideslip. Another factor which enters into the efficiency of coaxial rotors (and coaxial airscrews for the matter of that) is the distance between the two.

Having visualised some of the main difficulties encountered with coaxial rotors, one can begin to see why a large proportion of experimenters have obtained their first practical experience with two rotors placed side by side. There the aerodynamic problems were relatively simple.

Quite evidently the most attractive solution of the helicopter problem is to be found in the single lifting rotor, provided means can be found for counteracting the torque reaction. Two ways of doing this come to mind at once. By using suitably shaped aerodynamic surfaces it should be possible to utilise the slipstream from the rotor for resisting the torque. This sounds a little like sitting in a basket and lifting oneself by the handle, but is not actually so. The other solution, which is the one adopted by Igor Sikorsky in America, is to use a second rotor running in a vertical plane. Since the torque of the main rotor varies according to flight conditions, it is obviously necessary to have this second rotor so arranged that its thrust can be varied at the will of the pilot, either by varying its speed or its pitch angle. The widest range of control will evidently be obtained by the former method.

If fixed aerofoil shapes can be devised which will exactly counteract the torque under all conditions, then obviously that is the simplest and neatest solution. If that is not possible, the use of the second rotor becomes necessary, as in the Sikorsky VS-300. This entails mechanical complication in the form of a variable-pitch mechanism, and also a certain amount of extra weight.

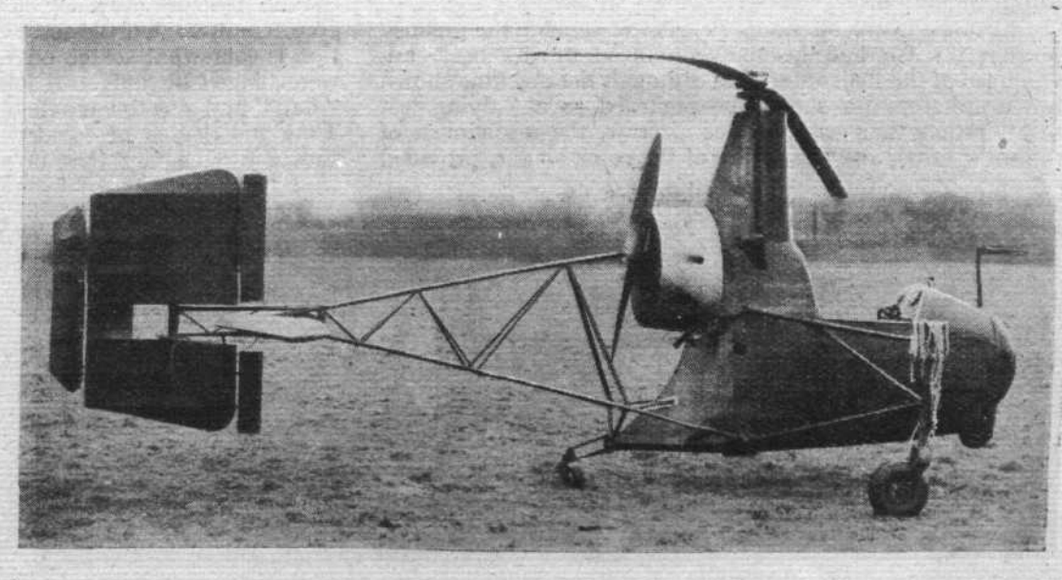
So much for the problem of torque reaction. There is still the question of lateral and fore-and-aft control. It is now generally held that these two controls can be achieved by means of the main rotor, either by tilting the head or by a variation in pitch angle of the blades. For stability certain other measures will probably have to be taken, such as fixed aerofoil surfaces in the vertical and horizontal planes.

In addition to the types of helicopter dealt with in the foregoing survey, there is the "paddle wheel" type with which experiments were carried out some years ago in Germany and the United States of America. In the latter (the Platt) the "paddles" were almost square, while in the Rohrbach they were of high aspect ratio.

The Rohrbach design is shown on this page. It will be seen that it comprised a normal type of fuselage with orthodox tail surfaces. The engine was housed centrally in the fuselage, and the wings were in the form of three high-aspect aerofoils on each side, carried on a cantilever shaft which ran right across from tip to tip and was carried in bearings on the fuselage. Drive was by worm or bevel gears. The torque reaction was counteracted by the pendulum weight of the fuselage, so that at greatest torque (that for vertical ascent) the tail was down some 6 deg. When gliding with power off, the nose was down about the same amount.

A Paddle Analogy

Older readers will probably remember the paddle steamers of their youth, in which the paddle blades had their angle changed on their way around the circle in such a way as to enter and leave the water "edge-on" while being at right angles to the water surface throughout their "power stroke." Something of the same sort was arranged in the Rohrbach paddle plane. At the top the blades had an angle of incidence of about 3 deg. At 90 deg., i.e., at the most forward point of their travel, they were set at an angle to give lift and thrust. At the bottom they were, of course, turned "on their backs," but still gave a little lift, and over the rear half the angle was reduced to give minimum drag. The cyclic change of angle was effected by cams or link mechanisms, and for control the angles could be changed differentially by the pilot to give lateral control as well as any desired slope of the resultant lift force.



In the Nagler Helicogyro were combined the gyroplane and the helicopter. The slipstream from the pusher airscrew impinged upon the "slotted" tail fin and so counteracted torque when the machine was flown as a helicopter.