The BRANTLY HELICOPTER

THE Brantly Helicopter embodies many novel conceptions, and its demonstration flights at Camden Airport have aroused much interest among helicopter men.

The Brantly machine* is a co-axial, with three blades on each of its two rotors and the flapping hinge placed far outboard from the center of the rotor. Designed for the personal market, it was first test flown in 1946 and, towards the middle of July, had more than 60 flying hours to its credit.

The main characteristics and dimensions are as follows:

Franklin No. 335, 150 hp, 6 cyl, air-cooled engine	
Gear Reduction	7 or 7.8 to 1
Weight empty	1375 lb
Useful load: fuel, passengers, etc.	625 lb
Gross weight	2000 lb
Power loading	13.3 lb/hp
Disk loading	3 lb/sq ft
Rotor diameter	29 ft
Over-all length (excluding tail wheel)	17 ft, 6 in
Over-all height	7 ft, 9 in
Radius of central non-flapping disk	6 ft
Spacing of rotor	24 in

The radius of the central non-flapping part of the blades is 6 *ft*, approximately 40% of the rotor radius. The non-flapping part tapers in plan form and in thickness, from 6 *in* at the inboard section to 1½ *in* at the outboard. The flapping parts of the blades are of uniform thickness, and weigh 1.3 *lb* per *ft* run with an average coning angle of 4½° in still air.

A double-cambered airfoil is employed in the blades. The outer blades are universally mounted at their root, and there is no damping of their motion about the vertical hinge. The length of the blades is short compared with the disk radius, and sufficient weight is required for appropriate coning. Thus efficient construction of all-metal blades becomes feasible. A new set of blades of the NACA *Series 8* has been installed. These blades have a low thickness ratio, high lift/drag ratio and a slightly reversed, thin trailing edge—only possible because of the metal construction. The reversed trailing-edge airfoils combine high aerodynamic efficiency with a constant center of pressure position.

As may be noted from the illustrations, no control columns or levers are exposed—so that the appearance is clean. One simple mechanism is completely enclosed inside the hub, runs in a bath of oil, has pressure lubrication of the aviation-engine type, and permits collective, cyclic and differential control. This feature has attracted considerable attention. The bearings in the rotor assembly are recommended for a life of 2000 *hr*.

A single-stage transmission comprises one pinion balanced between two bevels, with a 7 to 1 ratio—which is to be replaced by a 7.8 to 1. The engine is cooled by a fan which is an integral part of the flywheel. The over-running mechanism is inside the centrifugal-type clutch mounted on the front side of the flywheel and fair. An automobile-type muffler is being installed, with cut-out.

The fuselage seats two, side by side, with a maximum width of 3 *ft*, 4 *in*. It is built for test purposes only, of chrome molybdenum steel tubing with fabric covering. It has two full-sized doors with sliding windows, readily accessible from the ground. Vision should be good, although of the airplane cockpit type.

Equipment includes dual wheel controls, hydraulic wheel brakes and complete blind-flying instrumentation—comprising two-way radio, artificial horizon and directional gyro. It is stated that the machine may be flown entirely by instruments in hovering or cruising. Since the fuselage does not have to take care of a tail rotor and drive shaft, Brantly believes it may be built lighter than the fuslage of a more conventional type. An adjustable vertical tail surface is mounted at the tail-end of the ship.

The useful weight applies only to the present experimental model, since certain design changes are to be made in the fuselage and elsewhere to increase useful load.

The landing gear in the "mockup model" is of the conventional tail-wheel type, with main wheel tread of 4 *ft*, 2 *in*, and cantilever suspension with spring and oil shock absorbers.

Prototype of the Brantly ship during recent demonstration flight at Camden Airport

* Developed personally by N. O. Brantly, a weaving-machinery expert.

What is more important than these details of the design, is the general aerodynamic "philosophy" behind it—which departs boldly from convention. Here are a few "pros and cons" set down in preliminary fashion:

Saving of Tail Rotor Power. The co-axial type saves power loss in the rotor, which is highest in the hovering condition, and this aerodynamic advantage can be translated into greater permissible gross weight and appreciable increase in the percentage of pay load. It is doubtful whether elimination of the tail rotor gives any over-all saving in weight, because saving in the tail rotor elements is balanced by the necessity of building two drive shafts instead of one, etc.

View showing roomy side-by-side seating arrangement. Cabin has 2 doors, sliding windows

Stability by Use of Offset Hinge. It has long been known that the offset hinge produces both longitudinal and lateral stability in horizontal motion, and to a lesser degree in hovering—because disturbances from hovering give the equivalent of slow horizontal motion. There is every reason to seek the stabilizing effect of extreme hinge offset—if other untoward effects, such as vibration excitation, may be kept down. Though flapping does not equalize lifts completely, and the offset hinge introduces pitching and rolling moments into each hub—nevertheless the two rotors balance out the rolling moments for the machine as a whole. There is an interesting point here in both advantage and disadvantage.

No Damping of Lag Hinge. It has been frequently pointed out that, while freedom to flap is of inestimable value —because it equalizes lift—flapping brings the Coriolis effect, the vertical or lag hinge and the difficulties of damping the lag hinge under varying conditions. Apparently, in the Brantly helicopter, damping about the lag hinge is no longer necessary. This is because the restoring moment arm of the centrifugal force is so many times greater, and the inertia of the blade about the vertical hinge so much smaller, than in conventional designs. The elimination of the lag-hinge damping is one of the decided advantages.

Short Lengths of Flapping Blades. All other things being equal, it is a decided advantage to have short outboard blades, because: (*1*) the outboard portions of the blades contribute the most to control; (*2*) the shorter the blade, the less inertia and friction to overcome in control; (*3*) even in a flapping blade, there are less bending moments to take up in the spar; (*4*) there is less likelihood of twisting; (*5*) less likelihood of peculiar dynamic effects owing to twist; (*6*) less need for twisting the blade to secure greater efficiency in hovering; and (*7*) there is less likelihood of stick-force troubles.

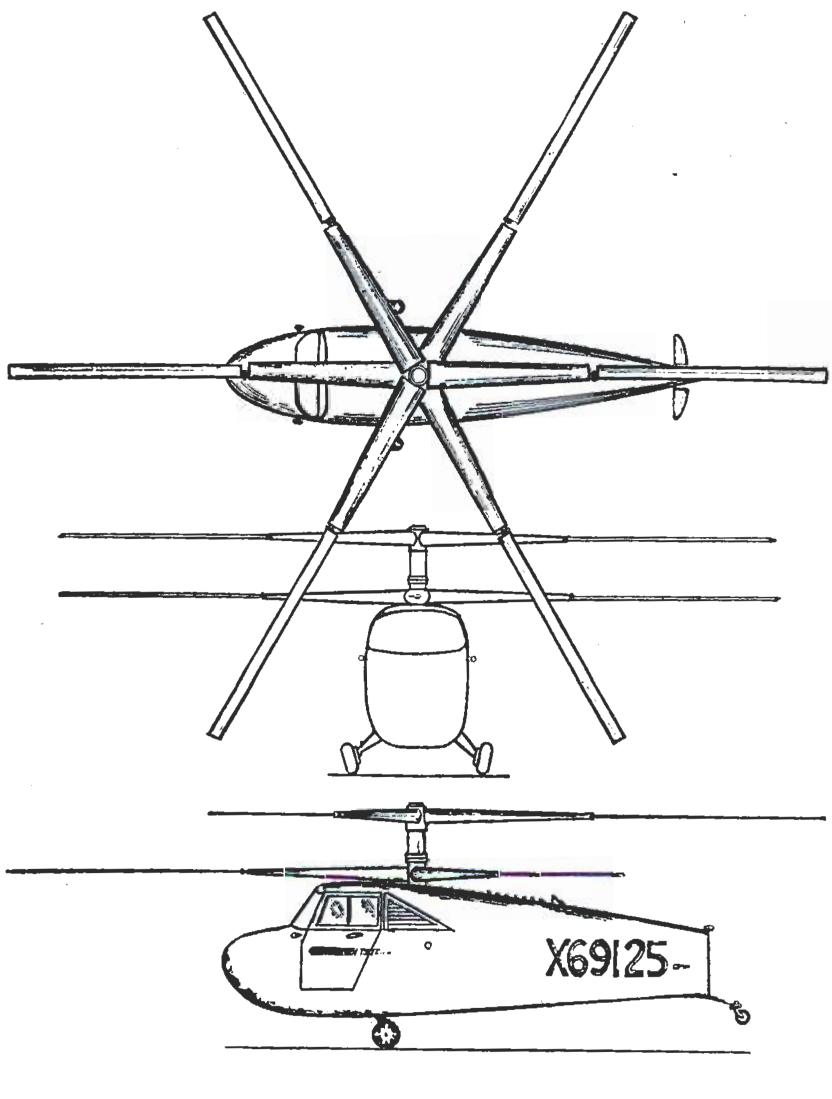
No Lift at Center of Rotor. Tests on the autogiro, as reported by Paul Stanley, indicate that there is loss in aerodynamic efficiency when the center of the rotor is replaced by a non-lifting disk. The loss is not very important, but may apply to the Brantly rotor—and has to be investigated.

Use of Three Blades per Rotor. Brequet, in his co-axial helicopters, has always used three-bladed rotors. Constructors in this country have been of the opinion that in the co-axial, only two blades per rotor should be used—because to have six blades would mean intolerable complexity of control and difficulty in keeping down the effective solidity ratio. Apparently, Brantly has managed to make his control system simple, while gaining the lesser vibration excitation of three blades.

Vibration is the curse of the helicopter and, from this point of view, three blades are definitely superior to two blades. Perhaps it is only with a large total number of blades that the offset hinge placed so far along the radius

(*Continued on page* 117)

Three-way Brantly helicopter. Franklin 150-hp engine powers co-axial, 3-bladed rotors



BRANTLEY HELICOPTER

(*Continued from page 63*)

becomes possible. It is also an advantage to have many blades and a narrow chord, from a stick-forces point of view. The designer writes: "We have noticed no inclination of the central disk to introduce any vibration as yet."

Reversal of Flow on Inboard Portion of Rotor. The inboard portion of the rotor must experience reversal of flow on the re-reating side. It is probably an advantage, n the Brantly rotor, that those portions of he blade which experience reversed flow lo not flap.

Controllability and Maneuverability. It an be claimed for the co-axial helicopter hat it has advantages over the conventional ingle-rotor type in controllability and naneuverability, because: (*1*) no asymmet-ic forces are produced by the tail rotor; 2) it is not necessary to coordinate pitch f tail rotor with the torque and/or pitch f the main rotor; (*3*) moments of inertia bout the transverse and vertical axes are educed. Moving pictures of the Brantly o-axial helicopter give an excellent impres-ion of its controllability and maneuver-bility.

Simplicity of Construction and Mainte-ance. Even though the conventional heli-opter does have a tail rotor and its drive burden it, it seems to be the simplest to uild and maintain. There are rumors that West Coast constructor, hitherto interested co-axials with two bladed rotors, is adopt-g a single-rotor type, because of cost and aintenance considerations. Six blades and e controls for them offer a problem. The sence of a tail rotor also adds to safety.

Directional Stability. Co-axials built therto have had short nacelle-like fuse-ges. It is entirely logical to combine a ng fuselage and a vertical tail, giving di-ctional stability, with the use of offset nges giving longitudinal and lateral ability.

Control Characteristics. Pilots often criti-e the helicopter control because, while ositive and powerful, it involves a lag. hen the control stick is moved, the tip-th plane and thrust line of the hinged or have to change in inclination before control moment is applied to the ship. nce the lag. With a rigid rotor, a con-l moment comes into action immediately en the stick is moved—the rigid rotor nsmitting moments to the mast. But the id rotor has been abandoned for other isons.

In the Brantly, there is a duplicate effect. plication of cyclical pitch to the blades uld produce, first, an immediate rolling ment, let us say, because of the partially id character of the rotors, and then a ching moment—after a certain phase an-—as the tip-path plane is inclined. intly tells us, "It is true that there is nediate response to the control, and oretically I believe there is a second re-nse a little later."

ome interesting research work is in or-. Perhaps by skilled combination of se effects, a control could be worked out ch would be equally certain and power-and have less lag than the usual cyclic h control of the flapping rotor. Then it

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would be possible to think more hopefully of using an automatic pilot.

Magnitude of Flapping Travel at the Tip. An important question to be answered is, whether flapping motion at the tip is reduced by the offset hinge. If flapping motion at the tip were reduced, then, for the same gap, there would be less danger of the blades coming together under heavy maneuvering or gust loads. At first blush it would appear as if the flapping motion would be reduced, because: (*1*) the length of the blades is so much less; (*2*) the centrifugal-force moment about the flapping hinge is more powerful in relation to the inertia moment.

Conclusion. From the above rather sketchy considerations, it appears that there are arguments both for and against the new configuration. But there is no doubt that the Brantly helicopter is well designed and represents well thought-out and desirable objectives. It deserves thorough investigation, analytical and experimental.

CONTROL-TOWER GCA

(*Continued from page 65*)

out — as hitherto — having to ask each pilot to perform time-consuming and possibly dangerous maneuvers.

Nothing is required in the airplane except the usual navigation instruments, plus a VHF communication set for this spot identification and to provide voice guidance from the tower for a landing under low visibility conditions. When an aircraft within the 30-mile search area tunes in a VHF signal on the FSDF receiver-indicator, a pattern immediately appears on the screen of the oscilloscope. This is in the form of a two-blade propeller, pivoted at the center of the scope, with blades extending out to the azimuth scale, indicating the line-of-direction of the transmission.

Height-finding antenna supplies data to search operator in control tower

When the "sense" switch is depressed, the propeller blade which indicates the true bearing disappears, the opposite blade now being understood as the reciprocal bearing. When the switch is released, the original propeller pattern reappears, and the rotatable *Plexiglas* filter cover is turned so that its selection arrow bisects the tips of the propeller blades. The true bearing is then read directly off the azimuth scale at the point to which the arrow is set.

In the case of airports which do not have very heavy traffic, the regular airport controller may act as the GCA search operator, handling the radar search scope and the Fixed-Station Direction Finder for identification — shifting this mobile instrument around to the right of where he sits. He guides each pilot in turn to a point from which he can make a straight approach to the runway. At very busy ports, the search operator is a separate individual, with his search scope and FSDF unit in his own corner.

The approach controller handles the GCA precision landing system with the aid of the azimuth and elevation operators. He has two scopes before him, the upper one being a replica of the search operator's PPI (Plan Position Indicator). The lower indicator shows the deviation in feet—both elevation and azimuth—as the plane approaches the runway. He gives directions to the pilot by voice radio, if he deviates from the correct flight line. This single indicator supplants the two Error Meters of wartime GCA.

Taken altogether, it appears that this first