Hughes OH-6A

Helicopter breakthrough?

Powered by a 250-s.h.p. Allison T63 shaft-turbine, the OH-6A has a top speed of 147 m.p.h. and maximum climb rate of 2,200 ft./min.

LAST MAY WHEN the U.S. Army selected the OH-6A as the best of the three light observation helicopters entered for its LOH competition, the Hughes Tool Company's Aircraft Division at Culver City, California, were assured not only of massive military contracts but were also put in a strong position to promote civil derivatives of the design. They are now forging ahead on both fronts.

The initial Army order, for 714 OH-6As, has recently been increased to 1,071 and knowing the extent of future Army requirements, Hughes are confident that OH-6A production will eventually run to something like 4,000.

Two civil versions have been developed from the OH-6A: the five-seat executive Hughes 500; and the utility 500U which can carry seven people, including pilot, or a maximum disposable load of 1,710 lb. A production line has already been laid down and although the prototype has still to fly, first deliveries to customers are scheduled for the summer of 1966. The Hughes 500 is the subject of an intensive sales drive outside the U.S.A., as well as in, and agents for Hughes machines in Europe, the Middle East and parts of Africa are recently appointed Trans World Helicopters Ltd. (see "World Air News").

Rival for the taxi

These civil versions, Hughes claim, represent an economic breakthrough and will be the first civil helicopters capable of competing with other passenger-carrying forms of transport, including in some circumstances London taxis. This seems a bold challenge but it is based on experience obtained during exhaustive tests with the OH-6A.

There are two features about this machine that stand out. First, it has been designed to be of minimum size and therefore weight for the job it has to do. This has led to a "minimum rotor" (only 26 ft. in diameter) and rigid weight control throughout the design. The machine can, in fact, carry a load 1.41 times its empty weight. Secondly, there has been a different outlook on performance: while most helicopters have usually been designed to go up and down, Hughes have concentrated more on the horizontal part of the flight path.

The thinking behind the development of the OH-6A, and how it has worked out in practice, was recently outlined in London by Mr. Malcolm Harned, Hughes' Vice-President Operations, while on a trip around Europe to discuss the civil versions with potential customers.

Principal requirements laid down by the U.S. Army for the LOH, said Mr. Harned, were that it should be a very simple, easily maintained, low-cost aircraft with a payload of 400 lb. in addition to its pilot. Cruising speed was to be at least 110 knots, endurance 3 hours, hover ceiling out of ground-effect 6,000 ft. at 95°F., and dynamic components were to have a minimum life of 1,200 hours.

The basic function of the LOH is to fulfil in the air the role which the Jeep has fulfilled so successfully on the ground: that of a minimum-size all-purpose utility vehicle. Minimum size is therefore all-important for the LOH as well. In fact, commented Mr. Harned, the U.S. Army not only wanted the smallest possible rotor size, but would actually have liked a rotor of no size at all.

Hughes' preliminary design studies were therefore aimed at determining the minimum possible rotor diameter which would accomplish the mission. Initial studies indicated that it should be possible by minimising the empty weight to design a helicopter with a rotor diameter of about 25-26 ft. which would meet the Army's requirements. Because of this it was decided to use the rotor blades of the Hughes 269A helicopter which had already been successfully developed with a 25 ft. diameter and were in production at a very low cost. The final rotor diameter selected for the OH-6A was 26 ft. 4 in.

The rotor system selected was full articulation, first because almost all helicopter experience has demonstrated that it provides the lightest possible rotor system weight. Another reason for the adoption of the articulated rotor was that it offers a significant reduction in vibration relative to that obtainable with the conventional two-blade teetering rotor used on most light helicopters. The two-blade rotor functions very satisfactorily in hover or when it is lined up in the direction of flight where the relative air velocity over the blades is the same as in hover. However, at the higher speeds the two-blade helicopter tends to go bouncing along through the air at a twice-per-rotor-revolution frequency. In contrast, the blade forces on a four-blade rotor are then balanced out in the rotor hub, maintaining a smooth flight to a much higher speed than that possible with a two-blade rotor.

Another important reason for the use of the articulated rotor is the ability to achieve a very high control power and rotor damping by means of offset flapping hinges. By this method the rotor is tilted by flapping of the blades up and down. Since the flapping hinges are offset from the drive shaft, the tilted blade centrifugal forces act on the offset hinges to produce a substantial control moment. Because the centrifugal force in the blades is of greater magnitude than the rotor thrust, it is possible to achieve a very high control power with this offset. For the OH-6A the control power provided by the offset is twice as much as that offered by the tilting of the thrust vector.

Fuselage layout

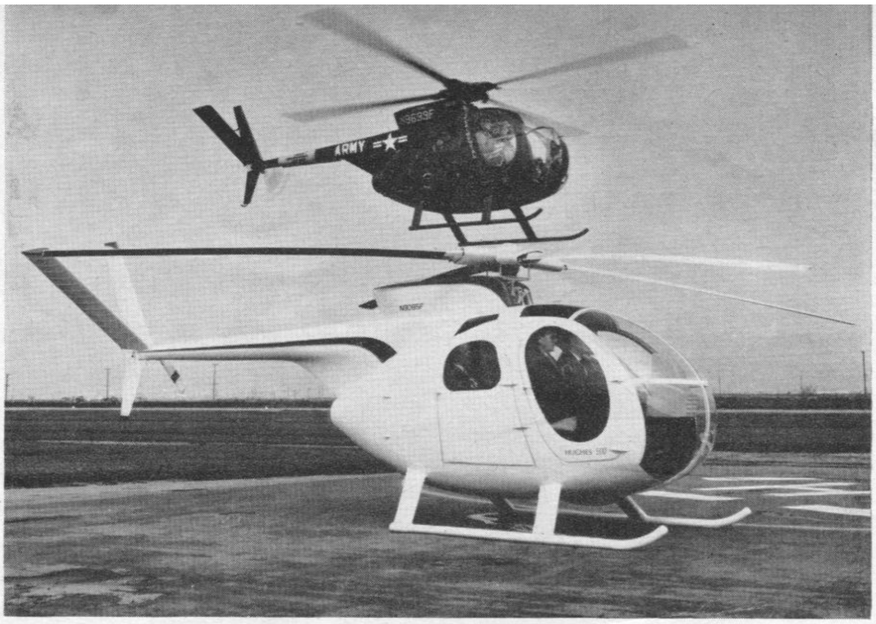
The selection of the fuselage configuration was based on the desire to obtain an absolute minimum of parasitic drag. To achieve this objective the drag characteristic as a function of fineness ratio was used to establish the basic teardrop shape. The size was determined by the frontal area required for the two crew members. The next step in the development of the fuselage configuration was to establish a cargo compartment which would accommodate four fully equipped men. This was mocked up to determine the size and this cargo compartment shape was then added to the fuselage configuration. The main gearbox and rotor shaft were located in the centre of the cargo compartment at the top of the helicopter. This location was selected in order to provide indiscriminate loading in the cargo compartment. The fuel cells were located directly beneath the cargo compartment to eliminate any effect of fuel consumption on centre of gravity.

Next the engine was located in the re-

Hughes OH-6A . . .

maining volume created by the teardrop configuration. This is a very desirable location for the engine because it places it low and to the rear of the occupants of the helicopter, eliminating any crash hazard associated with the engine. The tail rotor was located to provide adequate clearance from the main rotor and the ground. The same tubular tail rotor drive shaft configuration as that employed in the 269A helicopter was used: it has been very successful and is simple, light and inexpensive. This drive shaft is run directly from the main gearbox to the tail rotor, eliminating the need for an intermediate angle gearbox. The remaining space under the pilot and co-pilot was used for the installation of the radio equipment and battery—a location which is easily accessible, low in the helicopter, and tends to keep the overall centre of gravity as low as possible.

A flush ramp type of air intake was provided in the side of the helicopter above the engine. The air was taken in there and passed through a plenum chamber before entering the engine bellmouth. The tailboom configuration which was added had a flapped aerofoil cross section. The purpose of this tailboom design was to reduce tail rotor thrust requirements by producing a sideways lift force from the downwash acting on the tailboom.



An OH-6A flies past the mock-up of the Hughes 500 executive helicopter

The first wind tunnel testing for the OH-6A was carried out on a $\frac{1}{8}$th-scale model and was performed in preparation for the original proposal. This test resulted in a final parasitic drag area for the helicopter of 3.8 sq. ft.

Next, a very detailed and complete $\frac{1}{3}$rd-scale model was tested; it incorporated a blower system which took air into the engine inlet at the correct velocity ratios and exhausted it through the engine exit to enable engine inlet flow characteristics to be measured. This model test showed a parasitic drag area for the full-scale helicopter of less than 3.5 sq. ft. from -4 deg. angle of attack to $+8$ deg.—Hughes' objective was less than 4 sq. ft. for the actual helicopter.

After considerable development had been carried out on the details of the new inlet, very good pressure recovery characteristics were obtained both for hover and forward flight performance and excellent engine inlet profiles were obtained. The ram pressure recovery adds between one and two knots to the flight speed. This ram pressure recovery is not attempted in conventional helicopter designs and represents one of the many detail refinements which add together to produce the high performance of the OH-6A.

Minimum weight

In order to make the small-rotor low-drag configuration a success, it was also essential to attain a very low empty weight. A truss was developed with a deep beam and torque box forming the foundation. The two sides of the truss picked up the main gearbox at the top and supported the concentrated lift load applied there by the rotor. With this basic structural arrangement all the concentrated loads experienced by the fuselage are applied at the corners of the truss. There is relatively little bending in the structural system and there are minimum-length load paths in all cases. The forward bulkhead member of the truss is used as a seat back for the crew with an integral seat structure provided for the base; such integral seats provide a considerable weight-saving.

The mechanical parts of the drive system were also simplified as much as possible to save weight. The tail rotor drive shaft is a single light-weight aluminium tube which has eliminated the usual bearings, universal joints and angle gearboxes. The fan which provides air for the engine oil cooler was mounted directly on the engine drive shaft. In this way the separate shaftings, bearings, V-belts or gear drives used in conventional designs were all eliminated. The conventional main gearbox oil cooler and associated plumbing were eliminated by drawing the fan air in around the gearbox and cooling the housing directly so that the oil never leaves the gearbox.

Additional weight savings were achieved by the use of a simple, manual flight control system. The small-chord rotor blades and the articulated system require very low control forces and make it possible to eliminate any form of boost. Also, the large offset of the flapping hinges eliminates the need for any stability augmentation system. Consequently, the flight control system is approximately half of the percentage of gross weight found in most light helicopters.

One of the most significant mechanical advances made in the OH-6A helicopter is the strap retention system which is used to eliminate the conventional flapping and feathering bearings. A rotor blade is supported at each end of a strap pack which contains fifteen high-strength stainless steel straps, six of which can be broken with the remaining nine holding the rotor blades satisfactorily. Not only does this simplify the rotor retention system but it also saves weight principally because of the continuous load path from one rotor blade root across the hub to the other. The loads are not transferred from one part to another or into the hub. The lead-lag motion is provided by teflon bearings at the end of the straps which require no lubrication or servicing.

The strap retention provides a weight-saving doubly significant because each pound of added empty weight requires one to two pounds of additional helicopter to carry it. This weight multiplication factor means that the weight-saving in this strap retention system alone probably made the OH-6A close to 100 lb. lighter than a conventional helicopter.

Because of these weight-saving features, the empty weight of the OH-6A is only 1,082 lb., complete with the communications packages.

Flight development

The first problem encountered was that the aerofoil-section tailboom almost eliminated the capability of sideways flight. It performed the torque-reacting function as predicted. However, the combination of relative sideways air velocity with the downwash from the rotor gave a sideways lift on the tailboom which limited sideways flight velocity to about 5 knots. This tailboom configuration was quickly changed to a satisfactory one and the helicopter has since been flown sideways as fast as 70 m.p.h.

The favourable longitudinal dynamic stability characteristics for the OH-6A are the direct result of the large horizontal stabiliser, which is of comparable size to those used on equivalent fixed-wing aircraft. Such a size is quite reasonable because the OH-6A's speed is comparable to that of fixed-wing aircraft. The weight, cost, and complexity penalty of the OH-6A stabiliser is considerably less than that of a stability augmentation system. The location of the stabiliser at the tail rotor and the incorporation of dihedral prevent adverse effects in hover and transition.

In the final analysis the most important stability test is the pilot's reaction to the helicopter's handling characteristics. Hughes' Chief Engineering Test Pilot, Bob Ferry, who has tested over forty different helicopter designs, states:

"The OH-6A handles very much like an agile fighter plane. It climbs and rolls into banks much like a P-51. Bank angles of 60 deg. are normal flight practice. The controls are very responsive and precise. I have flown it under bridges, wires, trees, etc., with a high sense of security. The helicopter requires no stability augmentation and can be trimmed for hands-off flying which I have done even in turbulence."

At its full gross weight of 2,080 lb. the OH-6A has a maximum speed of 128 knots (147 m.p.h.)—it has been tested structurally up to 150 knots (172 m.p.h.)—and can climb at 2,200 ft./min.; range with full payload is 320 naut. miles. The machine has also been test-flown at a gross overload weight of 2,700 lb. with "complete satisfaction". Thanks to the low drag and light weight of the OH-6A, fuel consumption is only 6½ miles per gal. at 117 knots.

Autorotational landing characteristics are also good. The rate of descent at full gross weight is only 1,475 ft./min. at speeds of from 35 to 70 knots; this is 500-600 ft./min. slower than the current Army H-23. Glide ratio is 6:1 (more than twice that of current Army helicopters) which means that the OH-6A has twice the glide distance and four times the area in which to seek a landing site. In addition, its low drag enables the machine to zoom over 300 ft. upwards after loss of power if it has to search for a landing place.

Said and Done

A monthly commentary

THE LOSS OF B.E.A.'s Vanguard at L.A.P. on 27th October was a nasty shock. B.E.A. have a good record and the Vanguard too. Since the crew had made two successful overshoots, the enquiry will be expected to discover why the Vanguard flew into the runway on the third attempt.

Among the mass of speculative comment it was corrective to read the sober appraisal in *The Guardian* on the relative safeness of air travel and that by road. Robert Blackburn took this up in *Flight*. His readable column in that paper is also to be commended for flaying in print some of the arch aeronautical inaccuracies which occur periodically in *The Economist* which finds it hard to say anything good about British aeronautical endeavour.

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ONCE AGAIN IATA's annual shindig has come and gone, but inevitably at this year's conference, which was held in Vienna, there was a sense that things will not be quite the same again next year. Sir William Hildred, the secretary-general for twenty years, is to retire next April. This extrovert British one-time civil servant has succeeded throughout his tenure of office in making sure that the views of IATA, or at least the views of IATA as seen by him, have been published by the world's international daily press. No mean feat.

His last report will remain a work of reference for years. It opens with the satisfying observation that 1964 was an excellent year for traffic growth, in fact the best since 1955. World scheduled international and domestic air traffic increased by 16.4 per cent over that for 1963. Excited by these figures I have extracted some figures from *The Aeroplane* and *Flight* to see how the British companies have been getting on.

Here are the passenger-miles figures for 1964 compared with those for 1963 (in brackets). The percentage figures shows the increases, for comparison with the world figure of 16.4 per cent quoted by Sir William (all × 1,000): B.O.A.C. 3,756,482 (3,023,470), 24 per cent; B.E.A. 2,179,251 (1,993,596), 9.3 per cent; B.U.A. 114,413 (113,034), 1.2 per cent.

B.O.A.C. have every reason to purr about this year's success. How much, one wonders, has this to do with the introduction of the VC10, which made its inaugural flight on 29th April 1964? The latest inaugural is that to Boston, U.S.A., which set off at the start of November.

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SOME PEOPLE SEEM already to have the idea that Mr. Peter Masefield's latest job is obsolescent. For example, an article in *The Observer* of 7th November opines that LONDON AIRPORT MUST GO. The author of the piece, Andrew Wilson, is not unduly worried about the financial aspects of redundancy of installations and manpower on such a vast scale. All must give away to the threat of noise, but noise in no way defined and only dimly outlined by a rash of dots on miniscule maps. Mr. Wilson appears to assume that the building potential of the area is so high that there will be no difficulty in recouping the losses incurred by writing off the vast development costs of the site expanded to such a scale over the past twenty years from what was once the Fairey Aviation Company's Great West Aerodrome.

The idea is to build a new and very much vaster airport, replacing Heathrow and presumably Gatwick and a developed Stansted, on the site of the oldest British airfield, that of the Aero Club on the Isle of Sheppey in the Thames estuary. Shades of the young Moore-Brabazon and the brothers Short! The proposed new airport would be linked by underground railway (a new one) with the metropolis.

Whether this is a serious proposal or just a manoeuvre in the campaign to prevent the development of Stansted remains to be seen. Meantime our bet is that Mr. Masefield will continue to strain all efforts to sort things out at L.A.P.

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MUCH TALK CONTINUES about the future of the aircraft industry. The prophets of gloom continue their incantations with all the frenzied double-talk of a Pythian oracle. Whatever the babble there seems to be agreement that come what may, the size, measured in manpower, of the industry must get smaller. But in all the welter of speculative discussion there is no talk, no talk at all, of cutting down the enormous staffs of aviation civil servants employed by the Ministry of Aviation and the component departments of the Ministry of Defence (Air, Army and Navy). But reduced they will have to be if the industry is going to be cut down to size, whatever that size is to be.

This would be only fair seeing that the civil service must share the responsibility for the failures of the industry as well as its successes. There is a difference of course. The industry and its employees have to make a living out of their job and varying degrees of success must affect the standard of that living. The civil service employees (or should we say salariat) have their income and pensions guaranteed whatever happens.—**"Puffin".**