All Weather Operation of Helicopters

PART II Piloting Aspects

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INTRODUCTION

In a short time from now the civil licenced helicopter will be required to include among its capabilities the ability to operate in Instrument Flight conditions to lower limits than those currently laid down for fixed-wing aircraft operations

At the moment I estimate that the problem is roughly half solved and, if there is a helicopter suitable for city centre operations by 1961, the aids and equipment under development should be able to give safe flight conditions in 150 feet ceilings and 150 yard visibilities

Serious instrument flying of helicopters in Great Britain has been going on continuously for the past five years and it could, perhaps, at this time, be said that the art is in process of graduating from short pants into long That is to say, we are coming to the end of the assessment of the helicopter's instrument flying qualities and the type of radio aids it will require, and we are beginning to develop specific equipment and techniques such as auto-pilots, radio aids for slow steep descents, special instruments for vertical flight and flight director systems which will be coupled to automatic pilots so that instrument approaches may be done automatically

BASIC HANDLING OF SINGLE-ENGINED HELICOPTERS IN INSTRUMENT FLIGHT

The take-off This is more straightforward than in fixed-wing practice provided that the controls are properly positioned and trimmed The procedure is to use a mild form of towering take-off in order to pick up height and forward speed together , this prevents the possibility of the helicopter sliding off the ground cushion on to the ground Yaw can be quickly picked up on the gyro compass and corrected by the rudder pedals

The climb As the helicopter accelerates away into the climb the normal stick reversal is experienced but, if a good climb gradient is aimed for rather than the best rate of climb, then the magnitude of the reversal is minimised and quite able to be controlled from the artificial horizon presentation In the S 55 the rather nose down attitude in the climb presents a problem on the artificial horizon—the indicated difference between cruise and climb attitude

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being almost negligible and climb attitude in this case is best obtained from the V S I and A S I alone

Cruising *En route* cruising at normal power settings is straightforward, but for procedures a reduction in power and speed has been found desirable The reason for this is that when the pilot is faced with an increase in mental mathematics and concentration on the pattern, variations in the aircraft attitude become rather more pronounced, and in the case of an increase in speed from a normal cruise setting the helicopter's maximum permissible speed can be very quickly reached with all the unpleasant damper vibration, increase in RPM and large corrective control action necessary to restore the original flight condition A similar trouble occurs in level turns, when due to the change in the value of the forces acting on the rotor blades, RPM tend to increase and to remain at the new setting when the turn is completed unless a correction is made—in the reduced power configuration, however, this RPM fluctuation is slight and necessary adjustments are quite acceptable

Descent Instrument descents are normal in a helicopter except for the fact that because the descent is ' clean ' it has to be initiated a good deal earlier than its fixed-wing counterpart It has been found best to initiate the descent progressively by a gradual reduction in power, maintaining height by reducing airspeed until the desired glide angle is intercepted, from this point a reasonable airspeed is selected to give a satisfactory groundspeed to cope with the meteorological conditions prevailing and power adjusted to maintain the glide path In descents between 20 and 60 knots, drift becomes very apparent if the wind is more than 15 degrees off the Q D M , For example, approaching to land at 60 knots on a Q D M of 260 degrees with a wind of 215/30 knots the pilot has 30 degrees of drift to contend with This is most manifest in a break out in ceilings below 500 feet when the pilot finds he is looking for the landing site through the wrong window— psychologically I find it disconcerting, even after a number of years of helicopter instrument flying, to have to steer a course 30 degrees and more different to a Q D M in order to maintain it Apart from this, not much difficulty has been experienced in the transference from instrument to visual flight down to 100 feet break-out, the amount of yaw control on the helicopter appearing to be the governing factor Very low speed approaches have been difficult to evaluate on existing helicopters due to heavy control forces when on the wrong side of the power and speed curve—the Bristol 173, however, has shown marked docility in steep approaches made at 15—20 knots and 800 f p m , there still being ample yaw and speed control in this configuration

Helicopter Problems

One of the greatest problems in the development of helicopter instrument Flight has been the lack of stability in the early and current helicopters This has resulted in a high degree of pilot fatigue in turbulent conditions caused by having to make constant corrections to attitude and heading Automatically stabilized helicopters will largely overcome this problem and allow the crew to carry out instrument flight with a minimum of discomfort to themselves and their passengers

Another problem has been the lack of development of special helicopter instruments such as a low speed airspeed indicator, artificial horizons with readily adjustable horizon bars and an efficient radio altimeter which can be used in conjunction with stabilized hovering devices A further problem has, of course, been the lack of power in the helicopters under development —this has made it difficult to explore backward take-off techniques on instruments while lack of stability and high vibration level in slow flight has been a deterrent to the development of approach techniques into restricted sites in cloud bases below 200 feet The ability to fly very slowly with a high degree of stability at operating payloads will mean that the helicopter will be able to make use of radio aids of short range and high definition to achieve very low operating limits

Meteorological Problems

Helicopters operate in the most difficult meteorological layer of the earth's atmosphere and, due to the fact that helicopter airways will probably be below 4,000 feet and perhaps even lower inside existing control zones, any inaccuracies in forecasts of 0° isotherms, areas of freezing rain, thunderstorms' cells, etc , will constitute considerable hazards in scheduled operations Helicopter pilots may well find themselves faced with far more let downs per day than any pilots have had to do in the past, due to a high frequency service operating over the same route and, perhaps, experiencing days of obscurity at a time Because of this it will be most desirable to have trained meteorological observers on duty at larger city centre alighting areas so that a sound knowledge of local weather conditions can be built up As an example of the value of local knowledge in city centre operations, it was found during the winter of the South Bank operation that, in fog conditions accompanied by a very light southerly air movement, smoke from Battersea Power Station caused premature night flying conditions, so much so that cockpit lighting was required at one o'clock in the afternoon , also, a great deal of variation of visibility occurred during the approach to land—the reported visibilities often changing 800—400—800—200 yards during the last two miles of the trip An interesting point which has come to light when flying in fairly shallow fog is that the problem of losing sight of the approach lights or landing area which occurs frequently when starting the descent in fixed-wing aircraft can usually be prevented by doing a steep approach

Icing is obviously going to be a major problem in winter operations in Europe and although electrically heated mat systems are being developed the need really appears to be for a system that can be operated from before the rotors are first started as I have seen considerable ice accretion on ground run rotors in both freezing fog and freezing rain

Lightning strikes on helicopters tend to be alarming because the discharge is always close to the occupants, and in my own experience usually in the nose of the aircraft via the pitôt head or instrument panel coaming—I think designers might give thought to providing discharge points

Terminal forecasts for helicopters could well cut out the middle and upper cloud information and go back to the old turbulence reports in their place

Fog dispersal may well become a reality at busy heliports due to the much lower cost of operating F I D O

Where services are delayed or diverted by bad weather, considerable problems will arise on restricted sites due to disturbance, a matter which requires a great deal of investigation before expensive sites are developed for heliports

Air Traffic Control Problems

Once an Air Traffic Controller knows what manoeuvres a helicopter can reasonably be requested to perform, little delay is experienced when integrating rotary wing and fixed-wing traffic At mixed airfields it has been found that the best way of integrating the two is for the rotary wing aircraft to make their approaches at 90 degrees to the runway in use, holding if necessary at a point about a mile short of the runway if fixed-wing aircraft are landing or have left the outer marker on final approach With faster helicopters I think it may be better at airfields to use the fixed-wing approach paths in order to avoid dangerous situations arising after missed approaches

Traffic control of helicopters not integrating in any way with fixed-wing traffic still presents some problems due to the limited altitude range in which helicopter airways will have to be constituted Experiments we have carried out on multiple track separation were not entirely satisfactory and I well remember breaking cloud in company with another helicopter which was maintaining a parallel track on Decca a mile away, and thinking how uncomfortably close he looked—especially as I had been flying in cloud with visions of deeply instilled fixed-wing separation

If the multiple track type of separation is adopted for helicopters then crossing airways will have to use a climb and descent procedure through a sterilized area on either side of the airway being crossed and probably at one thousand feet level separation over the airway itself

Holding procedures can be carried out over geographical points using area coverage systems of navigation, and this fact should prevent long delays at entry points prior to helicopters commencing approach procedures —this will avoid the necessity for stacking and permit a much faster traffic flow than could be achieved with, say, one or two beacons at the approach entry point

Instrumentation

There is little doubt that the development of special instruments for helicopters is lagging far behind the development of the actual helicopter itself There are still no satisfactory slow reading airspeed indicators capable of coping with slow steep descents There are artificial horizons, still in general use, which cannot correctly interpret divergence in the pitching plane, when climbing they show descent and when in steep rapid descent they show climb

As the success of the inter-city helicopter will largely depend upon how it will compete with various forms of surface transport as far as punctuality and regularity are concerned, I feel that the time has come for a new approach to the problem of instrument presentation to the helicopter pilot First, by reducing the area of the present layout to give much better visibility in breakouts at, say, 100 feet in a restricted area and, secondly, by making the instrument interpretation more straightforward so that deviation from a selected flight attitude is more readily apparent than at present

It can be seen from Fig 8 of the flight instrument panel, that, in the new presentation there are two dial type instruments and four ribbon type instruments, albeit with more than one specific type of information on a particular instrument, whereas on the existing panel there are ten or more dial type instruments

On the extreme left of the flight panel is the rotor R P M indicator using a ribbon type indication and just to the right is the airpseed indicator, again using ribbon type presentation

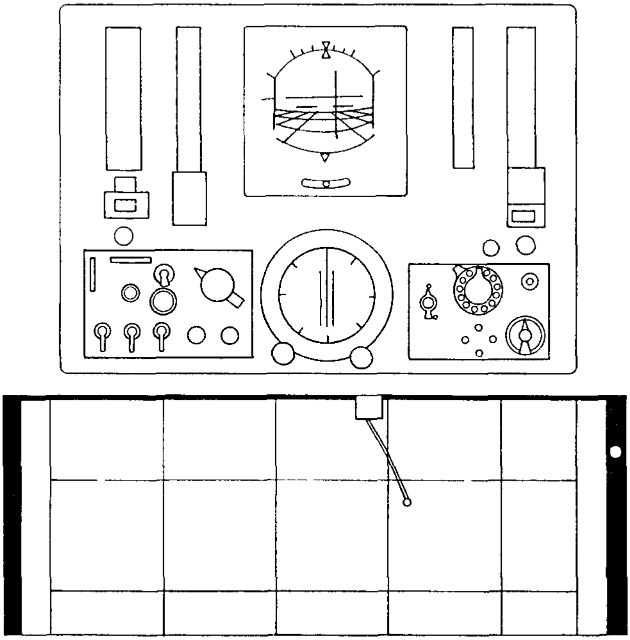

Fig 8

In the centre of the display are two dial type instruments, the top one gives the pilot the most important part of his forward looking information and is a combination pitch-roll attitude and flight director indicator—the latter capable of giving both pitch and turn steering information from take-off to approach In addition there is incorporated in this instrument the normal turn and bank needle and ball, unusual, in that the needle is tilted 90 degrees so that the pilot only sees its tip Elevation in relation to an ILS glide-path is shown on a small indicator to the left of the artificial horizon Heading is shown by a vertical bar which moves across the face of the flight director system This bar can be fed by ILS or Decca signals or simply by a selected course on a gyro compass

Immediately below the flight director is a gyro magnetic compass, which in conjunction with the Decca Flight Log or V O R gives relative position to radio aids or destination The Decca Flight Log is placed immediately beneath this instrument

To the right of the dial instruments are the vertical speed indicator, and the altimeter which is in three parts, an expanded scale for approach and landing, a reduced scale for cruising, over which, a radio altimeter causes a red perspex screen to move to show terrain clearance Both these instruments indicate by means of the ribbon presentation The great advantage of this type of display is that, by a system of moving indicators such information as assigned altitude, required cruise I A S , selected rate of climb, required rotor R P M can be indicated on the instruments without ambiguity Small windows are situated under the various instruments for indicating the selected settings

RADIO AIDS

The approach and landing

Extensive trials have been carried out using Ground Controlled Approach systems but the results to date have not been reassuring from the pilot's point of view In azimuth, the large corrections which have to be applied to heading to cope with deviation from the approach QDM are disconcerting to both the ground controller and the pilot and I have yet to work with a ground controller who can pass reasonable corrections to a helicopter in conditions of pronounced wind shear and shift This is of course due to the large variations in drift caused by an aircraft with a low airspeed encountering the friction area near the earth's surface In elevation the helicopter's slow acceleration and deceleration without large change of attitude makes it difficult to regain the glidepath quickly after displacement

Using pilot interpreted aids, the picture is rather different, indication of displacement is instantaneous and the QDM can be regained without making corrections of more than 10 degrees to the heading—in many cases using GCA, corrections of 30 degrees are necessary In elevation, too, corrections are more natural with say ILS—when the glide path needle drops below the centre line correction is made by lowering the collective pitch lever—if the needle is above the line the collective pitch lever is raised to fly back into the beam

Results obtained from microwave ILS at present under development show promise of filling the helicopter bill at expected glide paths of 15 to 25 degrees and down to 100 feet above the transmitter From 100 feet to touchdown it appears that we have three alternatives 1 Projecting a transmitted image of the ground lighting pattern on to the windscreen, 2 Making use of Infra Red if the difficulties found in fine precipitation can be overcome, 3 Make use of ground controlled hovering stabilizers, at least two versions of which are now under development in the United States In this method of course, there would need to be ample power reserve in the helicopter in order to establish the hover well outside ground effect and then a descent set up well within the undercarriage limitations (Since writing this I have received first hand information of a system which gives plan position indication for a hovering descent from about 30 ft using a sonic altimeter)

A Decca approach system using large scale charts on the Flight Log and showing displacement in azimuth and height against range is also under

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development and if a success it will serve as a valuable check and monitor on the U H F aid

Information, such as circles of interception of the glide path and circles for range of close-in aids and power and configuration change, will be shown on the let down chart Our great stumbling block with Decca has been the lack of reliability, especially when needed most in precipitation and storm areas Despite this it appears that the Decca Navigator will be entrusted with the *en route* navigation of helicopters and there is no doubt that when it is working well it has no peers It could well be, that, experiment in aerial locations might cure the troubles encountered in storm cells

As a standby *en route* navigation aid it may be possible to align the U H F transmitter to give Visual Aural Ranges of about 15 miles, or, failing this, to get heading information from low power U H F beacons forming part of the ILS system The cost of providing omnirange beacons for helicopters alone will probably prevent the use of V O R —the siting troubles in cities would also be considerable

Because of the very precise flying required in the restricted helicopter airspace and on city centre approaches a modified Flight Director system coupled to the automatic pilot is most desirable, and work is scheduled to begin on this project as soon as the equipment is available from the manufacturers

There may have to be some adjustment to the VHF Air-to-Ground communications system for helicopters as we frequently find ourselves out of coverage at present due to the low operating altitudes

Night Flying

Instrument flying at night presents few new problems Lighting of the instruments and radio navigation equipment has made good progress, most current helicopters now having a combination of infra red and ultra violet lighting—the Decometers used in the Mark VIII display could be easier to read—the decimal pointer often becoming lost

After much experiment we have finally accepted a ' Cross of Lorraine ' type of ground lighting pattern which gives plenty of attitude information on the approach and in the hover prior to touch down To make smooth landings, a good deal of ground illumination is a help and it is suggested that a city centre ground lighting pattern could have four rows of floodlights which retract to ground level and operate as position lights when not forming the crossbars to the QDM

The readily adjustable landing-light controlled from the top of the cyclic pitch control is a splendid piece of equipment and can be readily adjusted on to the landing area after a cloud break at night However, the company to whom this bouquet is thrown finish the underside of their rotor blades in shiny black and the effect when landing on a well lit site is like Battersea Fun Fair on a Gala night

Crewing Problems

With Helicopters above 12,500 lbs all up weight, there will definitely be a requirement for a two man crew for all weather operations, and anyone who has studied the Fairey Rotodyne's systems will appreciate that the cockpit will be a busy place for two people in an instrument let down

Collectıng weather data from dıversıon poınts, mannıng of radıo aıds, monıtorıng flıght dırector systems, checks on fuel figures and C of G and loadıng for quıck turn arounds wıth the rotors turnıng, quıte apart from emergency work ın the event of equıpment or powerplant faılure wıll leave very lıttle tıme for ın-flıght coffee or the Sunday papers

Dıscussıon

The **Chaırman** saıd that the two most ınterestıng lectures whıch the Authors had gıven were based on a background of factual experıence The many problems encountered had been tackled ın a realıstıc manner and the objectıve was quıte clear These papers ındıcated the manner ın whıch ıt was hoped to achıeve ıt

No one system would meet all requırements, and ıt was a sıgnıficant comment by one of the lecturers that none of the engıneerıng equıpment descrıbed ın the papers was radıcally new Thıs ındıcated a broad mınded approach, because there was always a great deal to be learned from other people, even from other countrıes

In exactly the same way that the Helıcopter Assocıatıon thrıved on the enthusıasm of ıts members and a sıngle track mındedness ın relatıon to the goal, so the encouragıng results beıng obtaıned on these problems of all weather operatıons were due to team work Tonıght's lecturers were the outward expressıon of behınd-the-scenes work that had gone on ın the Helıcopter Unıt

The CHAIRMAN saıd that the mentıon of blınd flyıng prompted hım to dıp ınto the past by recallıng that twenty years ago a small handful of pılots were flyıng the Cıerva Autogıro on ınstruments More recently, durıng the wınter of 1949/50, a regular scheduled nıght maıl helıcopter servıce was operated for sıx months by the B E A Helıcopter Experımental Unıt between Peterborough and Norwıch That was the first tıme ın rotary wıng avıatıon that such a thıng had been done, and ıt had not yet been repeated elsewhere It was worthy of mentıon to ensure a sense of perspectıve and proportıon

Mr K Reed (*Test Pılot, Saunders-Roe Ltd*) (*Member*), saıd ıt had been brought home to all of us here thıs evenıng that manufacturers and operators were faced wıth a tremendous task ın a relatıvely short tıme

If ıt was agreed, and obvıously ıt must be, that commercıal helıcopters needed to be capable of all-weather operatıons, partıcularly ınto and out of cıty centres, then ın the next three years—thıs was the perıod durıng whıch a large Brıtısh aırcraft was threatened to be avaılable, desıgners, manufacturers and operators, ın hıs vıew, could not possıbly produce the necessary answers ın the form of accepted equıpment unless ımmedıate steps were taken at the hıghest level to produce practıcal polıcıes and realıstıc requırements He saıd thıs because thıs evenıng we have been gıven a very faır coverage of the equıpment more than lıkely necessary towards makıng ıt possıble for helıcopters to operate ın all-weather condıtıons Nevertheless, ıt must not be forgotten that all thıs was goıng to present a consıderable weıght penalty and severe restrıctıons would obvıously be placed on the smaller helıcopter

The papers were, to say the least, most ınterestıng concernıng radıo and navıgatıonal aıds, etc , but, he felt that the fundamental problems stıll needed more elaboratıon ın the form of dıscussıon, thought and actıon

The first of these problems was stabılıty As Mr Hearne poınted out, the helıcopter was fundamentally unstable Thıs obvıously was a prımary problem and ıt was encouragıng to hear that the devıce fitted to provıde artıficıal stabılıty was producıng desıred results Nevertheless there was very lıttle doubt that the authorıtıes would requıre duplıcated systems In consequence, the weıght penalty mıght, together wıth other matters yet to be consıdered, be severe

He stıll thought that further serıous ınvestıgatıon should be carrıed out concernıng more aerodynamıc stabılıty ımprovements

For many years now ıt had been hıs personal opınıon (and he should lıke Mr Hearne's comments on the matter) that as ıt was the rotor that was fundamentally unstable, then thıs should be that whıch the pılot flıes, and not the fuselage The prıncıple, broadly speakıng, would be that sıgnals should be passed from the flappıng lınk of each rotor blade through the usual ' black box ' so that finally the rotor attıtude

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