Recent Helicopter Flight Testing Experience

By JOHN A CAMERON *

I wish to signify my appreciation of the honour of being asked to address the Members of The Helicopter Association of Great Britain and their guests I would also like to thank the Chairman for his introduction, and to pay tribute to the notable work being done by the first two speakers Both are test pilots of exceptional skill and experience, and congratulations are due to them on the papers they have delivered this evening

My paper deals with the development flying on a new British type of helicopter from a civil operator's point of view and, quite frankly, I find it a most difficult task, not because the subject matter is difficult, but because to date we have only flown 120 hours on this new type in 15 months The slow rate of progress was due mainly to the many teething troubles associated with prototype aircraft

In November, 1951, we in the British European Airways Helicopter Experimental Unit, received our first British helicopter—a Bristol 171, Mark III Any criticisms of this aircraft relate to the prototype as operated by the Unit over the past year, and as a result of these criticisms production 171's can be expected to be modified to eliminate all such small defects This machine was on loan from the Ministry of Supply, and we were given the task of carrying out the initial civil development flying Information required by the Ministry of Supply from B E A was set out in a loan agreement, part of which was as follows

" To obtain an overall assessment of the Bristol 171 helicopter from the viewpoint of operation as a civil aircraft, including

(1) Operating speed
(2) Comfort (Noise and vibration levels)
(3) Ease of handling
(4) Pilot utilisation as determined by fatigue
(5) Suitability for carriage of luggage and freight "

During my lecture I will make reference to the specification for a 30/45 seat helicopter prepared by B E A in 1951, and issued by the Ministry of Supply to British helicopter firms for the preparation of design studies

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*I wish to thank The British European Airways Corporation for giving permission for me to read this paper, and would add that the opinions expressed are my own and not necessarily those of the Corporation

OPERATING SPEED

The maximum forward speed for the type 171 as laid down by the Ministry of Supply is limited to 112 knots or 129 m p h at which speed the aircraft is just on the present World's speed record for helicopters, currently held by the Americans On several occasions I have had the 171 up to this speed, but, like other helicopters, large vertical vibrations manifest themselves, plus an increase of cabin noise level, which detract from the pleasantness of the machine A slight reversal of trim was also noticed at high speeds The 171 cruises nicely at 80-85 knots, which compares favourably with other helicopters in production today Fuel consumption rises steeply with the increase of power for speeds above 80 knots To enable operators to take full advantage of the aircraft's speed, it would be a good thing if the onset of rich mixture could be delayed so that a speed of 90 knots could be used economically

In common with other single engined helicopters at high forward speed, the 171 develops an unpleasant pitching tendency in the event of a sudden engine failure There is sufficient control to overcome this sudden change of attitude when flying on a natural horizon If one experienced a sudden power failure when blind flying on gyro instruments at high speed a difficult situation could arise For this reason, instrument flight on the type should, in my opinion, be restricted to a maximum of 90 knots, as long as the machine exhibits its present characteristics

The B E A specification calls for a design speed of not less than 130 knots with an increase in cruising speed from the 75/80 knots possible with current helicopters to not less than 120 knots This is in order to cope adequately with schedules when gale force headwinds are experienced In the light of present knowledge there is no reason why this figure should not be met

Comfort

The 171, which flies in a level attitude in cruising flight, may well prove popular with the travelling public During the Liverpool-Cardiff and Birmingham-London services, we invited passengers comments, and there was some criticism from users about the nose-down attitude of the Sikorsky S 51 in cruising flight

Another major cause of adverse passenger comment with the S 51 was the numerous draughts entering the cabin Unfortunately on early models, the 171 is no better Badly fitting doors and windows with inadequate cabin ventilation have already been reported by us, no doubt production aircraft will not experience this shortcoming

Based on the Corporation's present standard of comfort the cabin is much too small to accommodate four passengers and the pilot There is adequate room in the front two seats, but the rear seats are cramped, allowing little shoulder or knee room Passenger vision from all of the seats is good

NOISE LEVEL

The noise level inside the passenger cabin is comparable with other helicopters being in the region of 100 decibels in cruising flight This rather high level is capable of being reduced by a considerable amount when the cabin doors and windows are made to fit properly In fact, it is then comparatively easy to converse in a normal manner Unpleasant aerodynamic noise should not be allowed to persist The B E A specification calls for a maximum octave cabin noise level of 90 decibels, corresponding

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roughly to an overall noise level of about 93 decibels We expect production 171's to be much improved in this respect

VIBRATIONS

When the main rotor is properly tracked, the first order rotor vibration can be completely eliminated, and the aircraft is very smooth and pleasant to fly If the main rotor is even slightly out of track, very unpleasant first rotor vibrations can be felt, especially at speeds over 85 knots A sample of vibration records, taken on the 171 and the S 51, are shown on this slide (Fig 1) These records were taken at selected intervals with the " Kelvin Vibrograph "

As can be seen from the slide, the vibration characteristics of the 171 are of a lower order than those of the S 51 In fairness, however, I must point out that the S 51 referred to is an American built machine of 1947 vintage, the main rotor of which has fabric covered blades I believe the more up to date version with all metal blades and servo controls is a great improvement on the original

The composite main rotor blades fitted to the 171 have been found to be very sensitive, a thumb pressure on a trim tab of one main rotor blade is sufficient to put the rotor out of track and induce a first order vibration This is a possible source of annoyance to the operator which will no doubt disappear when Bristol all metal blades are fitted to the type

A frequent cause of vibration on the S 51 can be attributed to faulty action of the hydraulic dampers on the drag hinges These troubles have become more pronounced this last two years Although dampers are subject to rigorous bench tests before being fitted, they can give a lot of maintenance trouble and lead to unpleasant vibrations in flight, a primary cause being leakage of air into the system Friction type dampers as fitted to the 171, however, have remained completely trouble free throughout the 120 hours flown by us With our as yet limited experience on the 171, I would not like to commit myself as to whether friction dampers are going to prove superior, but results to date seem promising

ACCELERATIONS

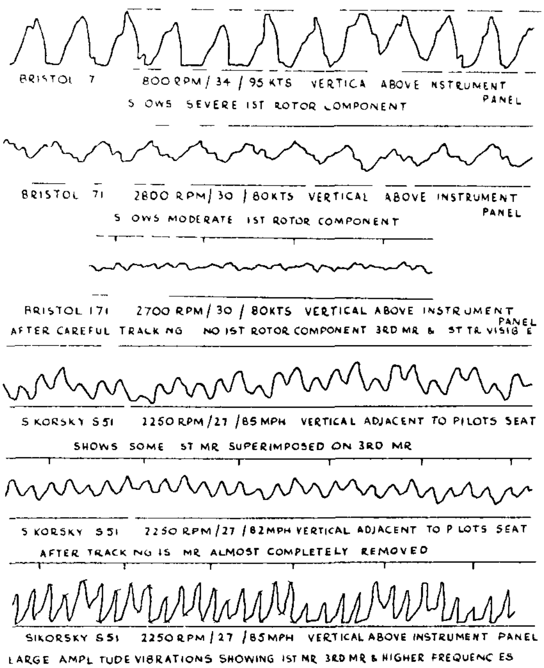
On the 171 at cruising speeds of 80 to 85 knots, measurements of vertical accelerations have been taken using the Peravia recording accelerometer, and the magnitudes have been found to be quite small In very rough air under cumulonimbus cloud they rarely exceed plus or minus 0 2 g

EASE OF HANDLING

The handling qualities of the 171 are good, and the aircraft is popular with pilots Control column forces can be trimmed out, and the helicopter flown for short periods completely " hands off " A certain amount of desirable longitudinal stability is present during cruising flight This is due partly to the fitting of a small aerofoil section located on the port side of the tail Providing the aircraft has been properly trimmed, finger tip control is possible After settling down in cruising flight, the 171 can be flown without yaw, with both feet off the rudder pedals Flying in turbulent conditions, the rolling and pitching motions experienced compares favourably with other designs This feature will undoubtedly prove popular with passengers who are inclined to airsickness There are, in my opinion, four reasons for this

(1) The clean aerodynamic shape of the 171, coupled with the fact that the resultant rotor forces acting on the fuselage allows the aircraft to fly straight and level
(2) The high tip speed of the main rotor
(3) As the result of (2) coning angles are small
(4) The reduced height of the main rotor above the centre of gravity

On the other hand, however, the low mounting of the main rotor on the type 171 constitutes a definite hazard to passenger handling on the ground unless special precautions are taken, but I am sure that some method could be devised to keep the rotor as low over the C of G as possible, and



HELICOPTER VIBRATION RECORDS

Taken with Kelvin Vibrograph

at the same time give ample clearance to passengers boarding the helicopter with the rotor turning

One important point in respect of handling which should be mentioned are the excellent qualities of the 171 in autorotation, and when carrying out engine off landings Under the worst possible conditions, *i e*, at maximum all-up weight, on a hot humid day in still air, the machine may be brought down in perfect safety from 500 feet with a short forward run of some 20—30 yards or so

There may be a few present this evening who are not familiar with those qualities constituting a good performance in autorotation Therefore, I will explain this by comparing the S 51 with the Bristol 171

In the event of an engine failure with an S 51 at maximum all up weight, the pilot immediately goes into autorotation by reducing the collective pitch to its full extent, and, with an air speed of 50 m p h, usually obtains 215 rotor revs (With a decrease in weight, the revs would be correspondingly less)

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When nearing the ground he reduces the air speed to approximately 30 m p h , and reduces the rate of descent by using the collective pitch The rotor r p m then fall off, and the main rotor blades naturally cone upwards, thus reducing the amount of lateral control left to the pilot If the forward airspeed is dropped below 30 m p h , and too much collective pitch is used to reduce the excessive rate of descent, then should the aircraft strike uneven ground with either of the main wheels first, this could result in the helicopter being overturned The makers stipulate that when doing engine off landings on the S 51, the rotor revs should not be dropped below 170 r p m , and this restriction may be for this very reason This means that on the type, pilots are limited to between 170—215 r p m rotor revs at best, with a forward speed of 30 m p h I would point out that the S 51 has been landed successfully with practically no forward air speed under no wind conditions, but it is not a safe practice as in order to reduce the too rapid rate of descent, the pilot is forced to reduce rotor r p m below permissible limits Such maneouvres should be frowned upon unless the pilot has intimate knowledge of the state of the terrain on which he intends to land

Engine-off landings on the Bristol 171 are a less hazardous proposition because of the greater range of rotor r p m , and hence the additional energy available in the rotor in the event of power failure The optimum figures are 210 r p m minimum and 287 r p m maximum As stated before, it is possible to land the 171 quite safely with the engine out, at a forward air speed of only 10 m p h in still air, so therefore a much smaller landing area could suffice in the event of engine failure

Engine starting on the 171 is poor In low outside temperatures it is difficult to start the engine at all and, once started, a very lengthy warm-up period, perhaps more than 20 minutes, is required to reach minimum oil temperatures This is most undesirable Conversely, when the engine is hot, it is difficult to start without inadvertently engaging the rotor with consequent rotor snatch, and strain on the transmission system In flight the cylinder head temperatures are lower than normal, which suggests overcooling and unnecessary power absorption in the cooling fan As a matter of interest, the makers lay down a figure of 210°C as maximum cylinder head temperature for continuous and weak mixture power Even on a hot summer day we have been unable to record cylinder head temperatures of much above 150°C Other complications follow as a result of over cooling the engine, such as short plug life, etc

Quick turn round times on the ground at rotor stations is undoubtedly a very important feature of helicopter operations After landing, it is essential that the main rotor can be stopped quickly This requires an efficient rotor brake On one occasion in 1952, Lord Douglas of Kirtleside, the Chairman of British European Airways, flew as a passenger from his office at Northolt to the Festival Site in the centre of London The flight from take-off to touch-down, took exactly 8½ minutes, but my distinguished passenger could not disembark from the 171 because of the low sweep of the blades until I had stopped the rotor turning some four minutes later

There were three reasons for the slow rate of development flying on the 171 whilst the aircraft was with us In the first place, cracks appeared on the undercarriage attachments to the fuselage, and these attachments have now been strengthened Secondly, and much more exasperating, were the numerous cracks which manifested themselves on the exhaust pipes

On one occasion, after a flight of 90 minutes, one of the exhaust stubs was almost severed right through, and was in danger of falling off The positioning of the twin exhaust stubs underneath the aircraft constituted a definite fire hazard in the event of landing in a field of dry grass A side exhaust system has now been evolved and this should prove much more satisfactory In the third place, we had no fewer than nine of the aircraft's instruments either going unserviceable or out of calibration within three months Greater care should be taken to ensure that all instruments are properly calibrated before installation

The question of ice accretion affecting helicopters is also of great importance It may seem as if I am digressing from my subject, but the matter is of such importance to the civil operator that a useful purpose would be served with a short resume of the position As members are well aware, no provision has as yet been made for the installation of any de-icing system to the rotors or control surfaces on any of the present day British production helicopters

During the Winter of 1951, I had rather an interesting experience of ice accretion on one of our Bell 47 helicopters, when I found difficulty in hovering, after a normal run-up The engine was developing full power, but the rotor and engine revs started to fall off immediately on take-off, and in less than a minute I found myself back on terra firma There was absolutely no vibration on the cyclic control column, and the only symptom of ice accretion, apart from the drop in revs , was that the stick seemed slightly heavy The rotors were stopped, and carefully examined, and found to be coated with clear ice The pattern of the ice formation on the main and tail rotor blades was very interesting At the tips of the main rotor blades the leading edges were found to have a thin coating of clear ice, building up considerably along the leading edges towards the centre portion of the blades, and falling off completely towards the roots The tail rotor blades had a thick coating on the leading edges at the roots, thinning out towards the tips

Relating this experience to several knowledgable people in the industry, I was perturbed by their lack of interest in the subject Some stated that this was a peculiarity of the semi-rigid rotor system, and would not occur on the fully articulated rotors of either the S 51 or the 171 Others seemed to think that friction heating at the tips of the blades should keep helicopters clear of icing troubles altogether It is my view that given the right conditions, helicopters are just as susceptible to ice accretion as any other type of aircraft, and therefore something should be done about it The B E A specification calls for full anti-icing of blades and control surfaces, etc

Since putting the finishing touches to this paper another occurrence of rotor icing has been experienced This happened during the recent flood relief work in Holland and proves conclusively my point that the helicopter is just as prone to ice accretion as ordinary aircraft

On Sunday, 8th February, two of our S 51'S were en route from Gilze-Rijen to Schiphel Airport, Amsterdam I was piloting one and First Officer Crewdson the other Twenty minutes after take off we flew into a heavy snowstorm Almost as soon as we touched the fringe of the storm, ice formed on the front perspex panels and the rotor revs started to drop off On this occasion we both experienced heavy cyclic stick vibrations and a general stiffening of controls due to the accumulation of ice on the rotor heads The build-up of ice on the tips of the main rotor could actually be seen whilst the aircraft was in flight With partial control we both landed safely in a field which luckily was not under water My ambient air temperature gauge was reading—3 degrees centigrade at the time We both found ourselves unable to bring the helicopters into the hover before landing despite the fact that the engines were producing full power I would like to point out that these landings should not be considered as precautionaries, they were forced landings in the true sense of the word

PILOT UTILISATION AS DETERMINED BY FATIGUE

The question of pilot utilisation must be assessed with the handling qualities of any given type of helicopter, the amount of effort necessary for night and blind flight, and the navigation aids provided

Flying by day under helicopter V F R conditions on routes familiar to the pilot, there is no reason why the 171 should not be flown 4 hours per day per pilot for fairly protracted periods This figure is capable of being increased to 5 hours per day if a reliable automatic means of navigation was installed

Our 171 has not yet flown intensively blind or at night, but drawing from experience gained on the Peterborough-Norwich Night Mail Run of 1949/1950, using Sikorsky S 51's, I would say that three hours would be a reasonable figure per pilot per night, with a maximum continuous stretch of $1\frac{1}{2}$ hours completely on instruments Again, I assume that a reliable automatic means of navigation has been installed Before these figures can be safely increased, designers will have to provide a greater degree of inherent stability in helicopters

SUITABILITY FOR CARRIAGE OF LUGGAGE AND FREIGHT

The 171 was not designed for the regular carriage of bulky freight The luggage space of less than nine cubic feet is only half of what is desirable on B E A services for four passengers On the 171's ordered by B E A for scheduled passenger services, a modification has doubled the luggage space

CONCLUSIONS

One of the reasons why the B E A Helicopter Experimental Unit was brought into being was to assess new British designs from a civil operator's point of view In my paper I have been purposely critical of the prototype 171 on many small points, which have since been modified to our complete satisfaction Other civil operators of this type will naturally benefit from this work as later production models will undoubtedly prove the excellence of this aircraft

From an operator's point of view, the biggest stumbling block with single engine helicopters is the weather minima below which we are not allowed to fly Limitations agreed for the H E U by the Ministry of Civil Aviation are 500 feet cloud base with a horizontal visibility of not less than 880 yards During winter in Great Britain, it is difficult to maintain 75% regularity on scheduled services, and this is just not good enough We must have twin-engined helicopters of good stability, and hence good blind flying characteristics in order to give the travelling public a service almost independent of weather limitations, and one which will equal, and eventually better, that given by conventional aircraft today The production of multi-engined helicopters in this country should be given super priority

Before closing, I would like to pay tribute to Mr RAOUL HAFNER for what is, in my opinion, the best designed helicopter of its class in the World I am sure it is the forerunner of many other first class helicopters It is regrettable that his aircraft, the Bristol 171, could not have been produced in quantity in 1949/50 Britain could, and should, play a leading role in satisfying the insatiable worldwide demand for these expensive aircraft

This is the Elizabethan era , let us not be a poor second best in this new field , let us be more aggressive, and lead the world in rotating wing development , let us emulate our brothers in the fixed-wing field with their Comets, Viscounts, and Britannias The challenge is there, let us meet it with the dash and courage of true Elizabethans

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THE CHAIRMAN

Thank you, Captain Cameron You have certainly taken us behind the scenes, and I hope now certain early teething troubles with the 171 type have been overcome that the Bristol Aeroplane Company will have a satisfactory flow of orders

Before throwing the meeting open for discussion, may I exercise my privilege as Chairman to raise one or two queries with our speakers S/Ldr GELLATLY, I am not quite clear in my mind as to the nature of the difficulty with autorotation at altitude to which you referred I understood you to say that there is a likelihood of a dangerous contingency Would you enlarge on that

Mr HOSEGOOD, would you please express your views on the advantages or otherwise of the castor type of undercarriage From past experience I know of certain ground handling difficulties experienced by pilots

Well, Ladies and Gentlemen, I think you will agree with me that we have listened to three very interesting accounts of helicopter pilot activities The meeting is now open for discussion, and I will call upon Mr J S FAY, of Westland Aircraft Ltd , to present his comments

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Discussion

Mr J S Fay (*Member—Westland Aircraft Ltd*) We have had three very informative papers read here to-day The lecturers differ in their approach to the subject, and they are to be congratulated on the way they have performed their task of giving us a good idea of their recent flight testing experiences

I have not carried out very much high altitude flying, and for this reason I found the first part of Squadron Leader GELLATLY s paper particularly interesting There are few people who like flying high in a helicopter and I should be interested in hearing pilots' views as to why this is so The main reason must be that there is no visible means of support The pilot is surrounded by perspex and he feels that he is just dangling in empty space An idea which occurred to me recently was that when the nose of the helicopter swings longitudinally, say 3 degrees, when flying at low altitudes, any point on the perspex in front of the pilot swings through the angle subtended by a small field , whereas, at high altitudes, the same swing will subtend half a county or so This might tend to exaggerate instability in the pilot's mind and make it seem worse than it really is However, the decrease in stability and control at altitude is a serious matter

When a fixed-wing aircraft climbs, the pilot maintains a constant mass flow of air over the wings by flying at a constant indicated air speed Stability and control therefore remain the same To obtain a constant mass flow of air over his rotating wings, the helicopter pilot would have to increase the rotor r p m as he climbs

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