



**Early Test Flights
in the
Bristol 173 Helicopter**

By Mr C T D HOSEGOOD

I must depart at once from my script to thank Wing Commander BRIE for his kind introduction, and add that with such a formidable array before me my immediate reaction is to take refuge in a corner and re-write much of my little paper packing it with graphs, square roots and at least a mention of omega. However, time does not permit this.

As you know, this is a short paper outlining some experiences that have come my way while testing helicopters. I hope I have been able to strike the right note, and that in my avoidance of "digging up" technical data and figures, the general facts are not too woolly.

I am very honoured that The Helicopter Association of Great Britain should invite me to prepare such a paper, and I must thank the Bristol Aeroplane Company for allowing me to read it to you.

The words "test flying" cover a multitude of sins, and helicopters being as new and novel as they are, almost all pilots who fly them indulge in "test," or if you like—experimental flying in the course of their normal duties. The aspect of test flying relative to prototype helicopters to date is perhaps not such common knowledge since very few really prototype helicopters have been flown in this country. It is about the preliminaries leading up to and the first flights of just such a helicopter that I intend to frame this paper.

In the beginning, at the drawing board stage, and even later at the production stage, the Test Pilot is a welcomed onlooker, and though his advice may at times be asked it can by no means always be accepted. Any Company building a helicopter today has indeed many masters, all of whom give advice most freely. Although much of this may be very sound, it is somewhat naturally coloured by the individual operator's personal requirements. It is for the unhappy designer to see that as many of these possible customers are satisfied, as time, money, weight and patience will permit. I mention the latter not altogether frivolously, because in the time that elapses between the start of the design and the first flight, many conditions alter which in turn necessitates modifications, which in their turn lengthen the gap. It has all the makings of a vicious circle, and it is not only broth that a surfeit of cooks can spoil.

Meanwhile the Test Pilot looks on, sometimes unhappily, but always hopefully. It is not until the day of the first flight is at hand that he enters seriously into the picture. He will get plenty of advice—indeed he needs it, but in the final analysis it will be his judgement, based upon the advice he has selected to act upon, that will make or mar the occasion. It cannot be any other way.

It would perhaps for the sake of clarity be fair to segregate the '173' trials under the following headings:

- (1) Engines and rotors run at low power with the collective pitch lever locked at zero, but the azimuth and rudder controls free
- (2) Engine and rotors run at high power with all the flying controls free (collective pitch lever unlocked) and the machine tied down firmly with a rope harness
- (2b) A repetition of the previous condition, but the geometry of the ropes so arranged that the nose wheels could rise some four feet off the ground, the machine being securely tied to prevent movement beyond this, or in any other direction
- (3) Taxying of the machine
- (4) Take-off vertically to a hovering position within the ground cushion, and check controls for effectiveness

After this there was to be a substantial pause while additional ground running, followed by a complete inspection was made.

- (5) Further hovering and slow movements in all directions, keeping within the ground cushion
- (6) Forward flight—eventually climbing out of the ground cushion and descending again

Such was the rough programme as I remember it. Here I would apologise for the continual appearance of the personal pronoun, but if I am to write my thoughts on my experiences I see no way out.

We were all alive to the hazards of tethered flight which we might encounter during the tethered running, but there was no alternative if the effectiveness and forces of the flying controls (particularly the collective pitch lever) were to be checked before the machine was actually committed to the air.

Following this procedure, as all the helicopter world knows, we ran into ground resonance troubles almost at once. This resulted in some slight structural damage to the machine and brought to light a weakness in the rear undercarriage, which we were able to rectify at a conveniently early time. Happily before the resonance occurred I had learned enough about the controls to make further tethered flying unnecessary.

It seemed reasonable to assume that the ground resonance had been caused by the tethering ropes, and after a limited amount of satisfactory ground taxying we were ready for stage 4, and here I should explain that when the '173' takes off normally the front wheels leave the ground first and are some four feet clear of the surface before the rear wheels become airborne. In some respects this is a very gentle way of getting into the air, particularly for the first time, as the pilot can literally "feel" his way off the ground. However, if resonance existed this was just the way to excite it.

On the first attempt we (KEITH TURNER and myself) felt a resonant condition building up, while the front wheels were clear of the ground, and

the rear undercarriage lightly loaded. By promptly reducing collective pitch, closing the throttle and applying the rotor brake no damage was done, but we now knew, in the words of Mr HAFNER, that "here we had a problem." We tried several minor modifications, and by, amongst other things, greatly increasing the rear wheel tyre pressure, we were able to get the machine into the air for the very first time on the 3rd January, 1952.

In many respects this was a successful flight, but following a flight on the next day the machine broke into resonance upon landing, and we knew then that there could be no short cut out of this fundamental problem.

To return to the flight on the 3rd January—which since it was the first time the machine had ever left the ground deserves some attention. Somewhat naturally we had chosen a calm day with a surface wind of only a few knots. We had good R/T between the aircraft and a "walkie-talkie" on the ground near us, and good intercommunication between Keith Turner and myself. We both wore a type of crash helmet, parachutes and a full Sutton harness. The machine itself was, at my request, made as light as was compatible with a central C of G loading. Both fore and aft and lateral trimming bias were set at neutral. The fore and aft trimmer (which in effect governs the C of G, and therefore attitude of the machine) was set slightly aft of what was estimated to be the correct position. We had an 'unstuck' indicator which told us when the rear wheels were clear of the ground.

We made our entry into the air, at what I'm told was an alarmingly steep angle (I had to a certain extent underestimated the effectiveness of the C of G trimmer). For my part I felt a certain embarrassment in finding the whole of the Brabazon runway before us, and a definite reluctance on the part of the helicopter to do anything but move slowly backwards. However, by a small alteration of the trimmer the attitude was corrected and all the other troubles with it.

On this flight, and indeed on many of the earlier ones, I found the attitude most difficult to judge, and in this respect called for constant assistance from the ground "walkie-talkie." Though probably part of a personal limitation, I found great difficulty in looking at anything but the most essential instruments, and next to impossible to alter either the trimmer or the two bias wheels, but these were read or worked for me upon request so expertly by Keith Turner that I really felt as if I had four hands and eyes. It was a great blessing that we had such good intercommunication. We found throat microphones to be most satisfactory.

After the resonance that followed the second flight on the 4th January, there was a long interval while the whole problem of resonance was gone into, in what can only be described as a "most thorough fashion." During this time the remaining ground running was satisfactorily completed. The machine was not ready to fly again until the end of July, but by this time a most careful resonance investigation had been completed, which resulted in a slight modification to the damping system of the rotor heads, and a fairly extensive modification to the undercarriage. Though this had taken a long time, had it taken twice as long the final results would, in my opinion, have made the delay worthwhile. Moreover much of this time did not, as is commonly thought, delay further flying, as it was during this period that the necessary additional ground running was completed.

This was the first time the machine had been cleared for unrestricted

flight By virtue of the hovering carried out in January we were much wiser about the controls and their operation than we would have been if those preliminary flight tests had not been carried out

The procedure for getting into the air was unchanged, but we now knew in advance where the trimmer should be set, and the addition of an inclinometer gave us a better idea of the attitude of the aircraft

The first task was to make sure the resonance trouble had in fact been cured, and to this end a number of landings were made under various conditions At no time were there any signs of the previous trouble, and we all felt very satisfied with the new undercarriage It was to get two very severe tests at a later day which settled any doubts that might have remained on this score

Up to this time the helicopter had been turned through 360°, moved slowly sideways, backwards and forwards, but no serious attempt at forward flight had been made Now we had reached this stage, and with the walkie-talkie mounted on a truck to follow us down the runway we made our first serious attempt to fly forwards The first attempt, was not successful

As soon as the speed began to build up the tail appeared to want to drop, and no amount of forward trim and/or forward stick would prevent it As the attitude had become unhappily steep, and in some respects the machine was out of control, I threw off all collective pitch and dropped the aircraft back on the runway

This resulted in a very heavy landing indeed, but no signs of resonance It was certainly the severest test to date Because of the very steep angle of the landing the tail of the fuselage had been damaged This was repaired and an alteration of the basic collective pitch between the two rotors was made No one pretended to be sure that we had the right amount of “mixing” between cyclic tilt and collective pitch, but we were content to discover this in practice, as indeed must everyone who builds a tandem rotor helicopter

The “mixing” is necessary because in a tandem helicopter, unlike a single rotor helicopter, the tilting of the rotor disc alone would not give sufficient control throughout the desired speed range However, by so arranging matters that in addition to tilting the rotor discs a differential collective pitch setting is introduced a powerful control indeed can be obtained So much is clear, but what is not quite so obvious is in what ratio, and over what portion of the total cyclic stick fore and aft range should these two controls be mixed, and as I have already said the final answer to this problem must be found in the air

The next attempt at forward flight was more successful, but only slightly so, because at a comparatively low speed the aircraft developed an uncontrollable yaw to the left which no amount of right rudder could counter This was discovered in the middle of August with the S B A C Show at Farnborough only thirteen days off¹

This effect was caused by an unbalanced couple created by the two rotors in forward flight, a temporary, but eminently satisfactory answer was found within hours, and it was at this stage that the curious tabs that are to be seen on the trailing edge of the tail plane made their appearance The aircraft could now be flown forwards with reasonable control, and many runs were made along the runway slowly getting faster and faster, but always stopping before the end of the runway was reached, and never going above

about seventy feet

We were almost ready for our first circuit when we suffered the last of our many, and sometimes disheartening, setbacks. This was a sudden but complete failure of one of our two engines. (Here I hasten to add that this particular engine failure is no reflection upon Messrs Alvis. It was caused, I regret to say, by the failure of an auxiliary piece of test equipment fitted to the engine by us.)

At the time we were not very high and almost stationary, actually we were flying sideways slowly. Had I realised in the time available that it was no more than an engine failure I could, I hope, have made a much better landing than I did. Once again our modified undercarriage was tested under very abnormal conditions and showed no signs of resonance, or of damage. The date was 20th August, 1952.

The engine was changed and the machine ready to fly again on the 22nd August, and on the 24th August KEITH TURNER and myself had the pleasure of at long last flying up the runway and not stopping at the end of it.

We flew straight on to the River Severn, and then made a large sweeping circuit to the right and landed again. It was a happy moment for us both, as indeed it was for all those who watched from the ground, and who had worked so hard on the machine, particularly during the recent weeks. The test programme proper had yet to begin, but a stage had been reached. A stage that enables the machine to be taken into the air with reasonable safety and flown if necessary from A to B.

It is the first chapter of a long book.

After his paper, Mr HOSEGOOD presented a film showing the early ground resonance vibration, some take offs and landings and the '173' being put through its paces at the S B A C Display at Farnborough last summer.

THE CHAIRMAN

Thank you, Mr HOSEGOOD, for a most stimulating account of what was undoubtedly a great first flight. I must also thank you for bringing along that most interesting film. At one stage I thought I was once again going to see the disintegration of a helicopter on a film, but fortunately that did not happen. After seeing that film, nobody need have any doubts as to the effectiveness of the steps taken by the Bristol Aeroplane Company to suppress any possibility of ground resonance.

Our second speaker is Squadron Leader GELLATLY, who is a serving member of the Royal Air Force. After qualifying in 1940 as a pilot with the Royal New Zealand Air Force, and seeing war service on light bombers, he transferred to the R A F in 1947. Graduating from the Empire Test Pilots School at the end of 1950, S/Ldr GELLATLY was posted to the Aeroplane and Armament Experimental Establishment, at Boscombe Down, in January, 1951, in fact, he is still there, and his familiarization with the helicopter began at that time. Of the 2,100 pilot hours behind him, 360 have been on helicopters of various types. S/Ldr GELLATLY's work at Boscombe Down is of a specialist nature and includes research investigation and the development of operating techniques.