The Helicopter Association Brains Trust

(The Editors are indebted to "Flight" for their permission to reprint the following report)

From time to time the Helicopter Association of Great Britain organizes a Brains Trust, during which both written and oral questions are discussed and answered by a team of experts On January 22nd, when another of these gatherings took place at Londonderry House, the panel consisted of Mr L G FRISE, technical director and chief engineer of Percival Aircraft, Ltd , Dr G S HISLOP, chief designer, helicopters, of the Fairey Aviation Co , Ltd , Mr K REED, chief helicopter test pilot of Saunders-Roe, Ltd , Mr J SHAPIRO, aviation consultant and previously chief technical officer of the Cierva Autogiro Co , and Mr R H WHITBY, performance and analysis manager of B E A Mr RAOUL HAFNER was prevented at the last moment from attending, and his place was taken at short notice by Dr HISLOP The Editor of *Flight* was Question Master on this occasion —

The team were introduced by Mr NORMAN HILL, chairman of the Helicopter Association, and the Question Master then explained the method by which a committee had used a marks basis to select the questions from the many submitted in advance The selection committee did not know the identities of those who sent in questions

The questions are set out below, together with—in abridged form—the answers A printed report removes the need for summing-up , the Question Master's remarks have therefore been omitted

What is the maximum speed likely to be achieved by helicopters in the foreseeable future and what are the limiting design or other factors ?

Mr WHITBY thought that the limiting design and other factors were, in his view —though this was not shared in all quarters—the stalling of the retreating blade and compressibility effects on the advancing blade There were various ways of overcoming this—by limiting the speed of the rotor to minimize compressibility effects, or by reducing the working lift coefficient on the retreating blade, which could be done by putting up blade chord or, on the other hand, making the rotor turn faster If one employed these methods, more power was absorbed by the rotor to do a given amount of work, so that was a practical limitation Practicable speeds for pure helicopters, thought Mr Whitby, would be in the region of 150 m p h An alternative way of reducing the lift on the rotor and reducing the tendency to stall was to unload the rotor by putting some lift into fixed wings—almost turning the helicopter into a fixed-wing machine in forward flight In the foreseeable future one might then have speeds of the order of 200 m p h

Dr HISLOP agreed with Mr Whitby' suggestions Speculating upon what in turn would be the limiting conditions when there was a fixed wing to unload the rotor, he thought there were definite stability problems when the rotor became very lightly loaded—an Autogiro, in fact, taking perhaps a tenth of the aircraft weight, or even less With this lighter disc, one was then likely to be in severe stability troubles He would have thought that by careful choice of the parameters Mr Whitby's estimate of 200 m p h might be exceeded by just a little So far as pure helicopters were concerned he was substantially correct

Mr REED said that if we were approaching the maximum speeds being obtained with present helicopters, there were vibrational problems True, we were given to understand that they were more or less directly concerned with the rotor system and the tip of the blades , but were we going to assume that those blades—from the point of view, perhaps, of stalling at the tips—were going to be operated by the pilot to decrease the angle of attack of the tip in order to achieve these greater speeds ?

Mr SHAPIRO said that when he was working on jet propulsion his boss used to say, when he did not want to commit himself, ' A lot of people will be surprised ' He felt the same answer applied to the speed of the helicopter There was no doubt that the conventional answer had been given There was an unconventional school of thought, however, which was not so certain that either compressibility or tip stall were going to be the problems He had seen other opinions expressed by very serious designers Just to show how interlinked all the factors were in helicopter design, it had been put out as the official opinion of the Bell Company that the problem was one of rotor weight That seemed a very rational answer when one went into it

As he saw it, the real problem was that we did not know how to streamline certain essential components of the rotor He thought that was going to be by far the most difficult problem in designing for higher speeds He would like to correct one figure mentioned he thought that the unloaded rotor on such evidence as we had today —on the strength of model tests—could go to 250 m p h without exceeding our knowledge , but with present methods of performance prediction we ran into an uncharted field at about 150 m p h on pure helicopters and between 200 and 250 m p h on unloaded rotors Beyond that we had a lot to learn

Dr Heinrich Focke recently said that in 20 years' time everyone will be able to have a helicopter costing no more than a light car Do the team agree, and does this mean that no one could afford a light car ?

Mr SHAPIRO said that this was to him something of an article of faith, and without the training of a minister it was difficult to communicate that article of faith He had recently visited a friend who made racing cars, although perhaps a racing car was not exactly the type of light car which they had in mind As he looked at this car he had visualized a light helicopter Helicopters ought to be considerably cheaper , it was all a question of production We had not really entered the realm of production, and predictions on this subject could be based only on integration of two fields of experience One was the design of very expensive helicopters and the other was the translation of the design of a very expensive car into a popular car There was no reason whatever why the helicopter should cost any more than a light car , in fact, there were many reasons why it should cost considerably less Even with a mechanically driven helicopter (and this was by no means the only one which could be envisaged) the transmission was considerably simpler

Mr FRISE thought that before we could consider relative prices we had to compare the relative quantities of production Whatever faith we had in any form of flying machine he could not really see as many being used as were road vehicles on land , therefore, with the same production facilities, the cost would be higher Against that we could offset the chance of making simpler drive systems He had had in his little group some experience of looking into simpler forms of drive , none of them was quite so efficient as the piston engine, but all contributed to much lower first cost and maintenance cost of the vehicle Some simplified form of drive could be used to produce a small helicopter in the same price class as a light car

Mr WHITBY said that a thing to note about all aircraft was that if the engine stopped one came down again, whereas with a car you were merely left on the road A higher standard of maintenance had to be applied to aircraft, which meant that if everybody who now had a private car had a helicopter, the rest of the people would be employed on maintaining helicopters There was another objection to " a mass of aircraft Anybody who tried to get into London nowadays would appreciate the amount of traffic congestion on the roads Although it was true that the aircraft could move in three dimensions, one also moved out of sight of the kerb, so to speak , he could not see control of such traffic being a possibility

Mr REED had no doubt that such a helicopter could be manufactured, and, as with cars, if the demand was there it would be cheap , but he did not think there would be such numbers flying

Does the panel consider that since the A R B require rotor blades to be replaced at a relatively short life, these blades should be designed primarily for cheapness of production, even at the cost of loss of some aerodynamic efficiency ? In this connection, B E A 's report and accounts for 1952-53 stated that a set of rotor blades costing £6,000 for one of their helicopter types had to be renewed every 150 hours, whereas Bell s chief designer stated that some of the blades on Bell 47s were still running after 4,000 hours To what cause must this difference be attributed ?

DR HISLOP said that here we were up against the lack of experience of British helicopter designers in the field of producing lost of helicopters and lots of blades, combined with what might be termed the ' native caution " of the A R B The A R B were a body who recommended whether the Minister of Civil Aviation should or should not issue a certificate for safe carriage of passengers or freight, and thus they were very circumspect in granting long lives, especially in early stages of development Experience would show that as the British helicopter designers gained experience by building more helicopters, and built up the necessary background of

hours, the lives of the blades would lengthen very appreciably and eventually approach something of the order of 2,000 to 4,000 hours, in that case one should not sacrifice aerodynamic efficiency One should bend one's efforts to get at the basic problems which tended at the moment to restrict the lives The Bell figures were probably correct, but might possibly have been in reference to military aircraft There was no reason why, given the opportunity, British blades should not eventually reach such a figure

Mr FRISE agreed, saying that, primarily, two things had to be done to increase life One was to find something which would stop them from warping or changing their shape, such as corrosion by rain This happened a lot to composite blades, it brought in vibration and then they had to be scrapped The other thing concerned was fatigue in materials, those most suspect at the moment were light alloys The most direct attack on the problem was to use stainless-steel blades

With very few exceptions, pilots' controls in helicopters seemed to be designed as a curious modification of those on fixed-wing machines There is virtually no transfer of skill, so is this necessary? Could not the controls be designed on principles derived from human engineering studies into the most natural and ergonomic system of human control over a multi-dimensionally-free machine? If previously learned skills and habits are of value to a helicopter pilot, why not use the control system of the motor aar as a model?

Mr REED said that this was a sore point with him One tended to get away from the fact that a helicopter was an aeroplane and came under the normal rules and regulations of orthodox aircraft He could see no reason why an attempt should not be made to make it like an orthodox aeroplane from the point of view of normal controls, it was unnecessary to have extra controls A desirable feature of design was a constant-speeding rotor, and once we had that we would do away with the throttle-cum-pitch control and return to a normal throttle lever, the collective lever in itself was the only difference from normal aircraft control If one had a throttle and a constant-speeding rotor then the only difference would be in take-off, landing and emergency techniques

Me SHAPIRO recalled one design for which a very different control system was used—the Hoppicopter, in which a single control-organ did virtually all the controlling It was arranged in a manner which seemed very logical, inasmuch as every motion of the aircraft was initiated by a replica motion of the hand of the pilot He had closely interviewed the pilot who had has a great deal of fixed-wing experience, but no helicopter experience, this man had taught himself to fly on the machine

From this experience, said Mr Shapiro, his interpretation was that any control system was possible He did not think we had enough comparative studies to arrive at a really well-founded distinction between control systems, in the past, departures from the orthodox method had been resented by pilots What would happen to a novice on helicopters? He would not be likely to resent a new kind of control The speaker believed there was very little to choose, and he could not see there were enough reasons to depart from what had already become conventional systems on helicopters

(Part 1) Has any headway been made recently regarding blind-flying instruments? When will suitable instruments be available for commercial use, and in what way will they deviate from those used in fixed-wing aircraft? (Part 2) Supposing that the stability, instrument and automatic flying problems will be solved, and remembering that helicopters may be expected to operate in relatively close proximity to obstacles and local terrain, is there any reason to assume that limits for bad-weather operations will be lower than those for fixed-wing aircraft?

Mr REED said that there ought to be improvement in attitude-indication for the fore-and-aft condition of the airframe At the moment the aircraft could apparently be climbing, yet in actual fact it was descending with nose up and tail down That would be indicated on the present orthodox horizon, but by utilizing the rest of the instruments one would know what was going on With orthodox instruments used collectively it was impossible to get into a position in which " you do not know where you are ", but it would take a lot of sorting out

Dr HISLOP said there was no doubt that, to be worth while, commercial helicopters

must be capable of flying at night and in bad weather conditions, probably to considerably lower limits than fixed-wing aircraft, and, from the experience of which he had knowledge, he thought there was no special reason why this could not be achieved with what were substantially orthodox instruments modified to suit the particular helicopter characteristics He was very doubtful if there was a pressing need for any completely new instrument

Where the A S I was concerned it was a question of finding the correct source of static pressure He believed an instrument could be obtained which would give satisfactory indication down to the speed range that was set When the speed on a blind approach fell to 10 or 15 m p h, or even lower, the pilot would also have other assistance, such as electronic aids, to keep him on the correct heading and correct rate of descent

Mr FRISE said that the designer's job was to make the helicopter very easily controlled and so stable that the problem of having an automatic control when on instruments was simplified

Mr WHITBY, answering Part 2 of the question, said that the helicopter could operate to lower limits, generally speaking, but not in what was really the important matter—that of cloud ceiling Being conservative and looking into the immediate future, he could not envisage anybody coming into London to land at a " submerged " site (or, for that matter, an elevated site with spires in the vicinity) when cloud was on the deck He thought there would always have to be a fairly substantial cloud ceiling—in the order of 300 ft—and blind flying would then primarily become a problem of moderately low-speed cruising, flying blind In these circumstances, so far as one could make out, and if the flying characteristics of the aircraft were improved, the existing basic fixed-wing blind-flying panel would be adequate It would not be so if one attempted to hover or fly at very low speed without external reference, but he was not convinced that this would be a necessity Obviously, the pilot approaching with any sort of wind, was going to get an entirely wrong impression of his flight path if he was flying at the speeds indicated by his A S I Air speed was not of great importance to flight path at low speeds

Mr REED said that the matter really revolved around stability If stability was comparable with that of the fixed-wing machine it would be easier to say " yes " to the ordinary blind-flying panel

City planning and the various means of surface travel are already inadequate to meet traffic requirements The helicopter provides the future answer to most problems of speedy transport from one part of a city to another, and from city centre to airports But if a city were to be designed from the outset to take advantage of projected means of surface transport, diesel trains and cheaper electricity from atomic power, would the helicopter be likely to prove as economical or even as fast as surface alternatives?

Dr HISLOP said that were a city being planned from the outset—he cited a new city being built in India—an airport on the outskirts could be served by a surface transport system which would be almost as fast and certainly more economical for transport of large numbers of passengers than a large helicopter That might sound heretical, but he thought it could be done One could visualize the equivalent of an express tube or surface train system which could cover the distance in a very short time and very economically

Mr WHITBY was broadly in agreement but said the initial outlay of a tube system was expensive Above-ground trains were much cheaper, but he thought it cost about £1 million a mile to build a railway It would probably be worth while, however, in the long run

Mr SHAPIRO dissented from this view A curve demonstrating the power required to propel a motor car showed that at about 80 m p h most of the power was absorbed in overcoming air resistance The same thing applied to a helicopter and, for that matter, to an aeroplane This resistance had to be overcome, whatever vehicle was considered, and the remainder, which was small, was all that mattered in the difference between the motor car, the helicopter, the aeroplane and the train He did not believe that this small difference could make up for the enormous installations which would be required to bring surface transport to the speed of a helicopter or an aeroplane

Does the Brains Trust agree that present-day helicopters, and those which are likely to appear in the foreseeable future, must inevitably depend for their safety on a rotor system subject to intense cyclically-fluctuating stresses? If so, does the panel agree that the helicopter must be considered for some time as inherently less safe than a fixed-wing aircraft?

Mr WHITBY said that this was really a design matter, but the helicopter must, he supposed, be inherently less safe This did not mean that, provided one was prepared to pay the penalty in extra robustness to have a reserve factor to cater for any fatigue, the helicopter could not be made practically as safe as fixed-wing aircraft That was one of the economic penalties which the helicopter had to pay for the ability to fly at low speeds

Dr HISLOP thought that this question had a bearing on that concerning the A R B and life of rotor blades If we could design blades to give satisfactory lives of the order he had mentioned earlier, the general safety-level in cruising flight would be comparable with that of fixed-wing aircraft He was sure that, when close to the ground, the helicopter was very much safer than a fixed-wing aircraft ever would be In the long run it would be shown that the helicopter was a safer vhicle

Mr REED asked how one came to a conclusion as to what a degree of safety was The only way in which one could say that the helicopter was less safe than the ordinary aeroplane was if we had had accidents caused by cyclical oscillations , and he could not think of one

Mr SHAPIRO heartily agreed with Mr Reed Nine-tenths of all accidents had non-structural causes, and in these the helicopter was so much in advance of fixed-wing types that whatever difference there was in structural matters was completely insignificant

In view of the high operating costs and length of time taken by even experienced pilots to become proficient on helicopters, do the team consider that a synthetic trainer would be a practicable aid? If so, should there be a simulator for each type of helicopter or a general-purpose trainer , and in either case, should the simulator be built for visual or instrument flying, or both?

Mr REED said that he thought it was wrong to say that considerable training on helicopters was required That point had been overdone There were now a number of helicopters being operated, and consequently more pilots were being required than in the past One of the best examples to take was the Royal Navy So far as their helicopter pilots were concerned they were fully operational after 30 hours He did not intend to give the impression that 30 hours was enough for a civil operator, but an indication of a certain standard reached in that number of hours He did not think that a simulator would be of any great advantage With more stable helicopters it would be much easier

Mr WHITBY said that the B E A liked to rely on more than 30 hours before puting anybody on the job on his own , they felt it should be the best part of 100 hours Simulators were very expensive things and one had to have more or less "a production of pilots" before one could justify them They obviously would not give a pilot primary training in helicopters They might help to convert him to a certain type and save time, but he would actually need to do the exercises in a real aircraft—not just an armchair

In view of the recent statements in the Press concerning Sabena's expanding sphere of activities with their passenger-carrying helicopter services, does not the team think that in order to avoid being left at the post it would be better for B E A to operate immediately with well-tried American helicopters, pending the arrival of suitable British ones?

Dr HISLOP said he was in a cleft stick Sabena were expanding their services, and he thought they would be followed by other European operators According to a Sabena operations executive it was a good proposition for the time being Very much to his personal regret, he thought it would be some time before there were British helicopters available to carry passengers economically over the networks which were envisaged, and it meant that B E A stood in a position to find their traffic being filched by the other operators Their problem, then, was whether to stand by their decision to keep the nucleus of their knowledge in being and then to expand, or to

hold fire until British designs came along It was a very difficult question to answer off the cuff, but he had a feeling that it might be best to extend their operations with larger helicopters and attempt a more economical service if they could find a suitable traffic pattern They ought to do that for the next couple of years, because otherwise the rate of experience would die away and they would find themselves at a disadvantage when the time came when British helicopters were available

Mr WHITBY said that at this very moment there we no well-tried American helicopters suitable for the job, but at the rate of development it was likely they would be available before British types If there was any possible means of speeding up development of suitable British transport helicopters he would be delighted

Mr REED said he did not understand Mr Whitby's remark on no well-tried American helicopters We must remember that they were using American aircraft He asked if their degrees of safety were lower than British requirements ? Mr Whitby replied that the question was of a large transport helicopter—larger than the ones we were using at present, which, incidentally, were British He thought that twin-engine safety was an absolute essential for any extended helicopter services which could get into city centres and had any hopes of being commercial If the helicopterdid not make use of its slow-speed properties it was obviously less efficient

Dr HISLOP said that any British helicopter competing in European networks with Sabena would have to go across the sea Sabena used S-55s and operated across the land all the time Should an engine fail a helicopter could put down on land If B E A endeavoured to keep abreast they must cross the water, and to schedule services regularly across the Channel on one engine was a very difficult operation to take on

Does the panel consider that slow-speed, high-lift, fixed-wing aircraft constitute a serious threat to helicopters employing the same engine or engines ?

Mr FRISE thought it possible to do practically the same job with the same engine in the two types of flying machine One could carry the same payload and fly the same distances with the same fuel, but in one the minimum speed was about 38 m p h and the other it was zero The extra structure-weight that had to go into the fixed-wing aircraft to make ir come as near as 38 away from zero had used up what would normally be the extra payload that could go into a fixed-wing aeroplane One accepted the fact that the helicopter, flying sideways on a propeller and being rather a crazy affair altogether, was no so efficient as a fixed-wing machine , but the moment one tried to make the fixed wing come nearer to the helicopter one sacrificed the difference

Mr SHAPIRO agreed entirely He thought it much more sensible to go to the helicopter for everything from zero speed

Do the panel regard noise as a problem, and if so, what do they intend to do about it, on behalf of people outside the helicopter and those carried in it ?

Mr FRISE said that the yardstick used in the South Bank tests showed, surprisingly, that the existing method of using a piston engine with normal exhaust system was unacceptably noisy He would have imagined that people who commuted daily in tube trains would have become toughened to noise Noise had become a kind of modern Aunt Sally for constituents to consult their M P s about, and therefore there would be regulations laid on

There was no question that there were methods of making the helicopter less noisy Already experiments had been made to demonstrate that a gas drive could be less noisy The total energy being put through a low-pressure gas system gave less noise internally and externally than would the small proportion of exhaust from a free-turbine drive That, is was hoped, would soon be demonstrated completely, and not just be calculations

The helicopter only started to earn its keep when it pottered about in built-up areas where a lot of ratepayers lived He had recently come across a case where a certain company in America started a route from the centre of a typically skyscraperish town Within a week all the tenants of these big blocks of offices went in a body to the mayor and said they were going to pack in at the end of the week if it were not stopped , and it was stopped That was one example of people who paid money

to occupy premises in a big city objecting to the sudden introduction of the noisy helicopter Noise was a talking-point, and designers must face up to it from the very conception of the job

Questions "From the Floor"

The first question was with regard to the application of the turboprop power unit to the single-rotor helicopter and the provision for anti-torque at the same time Mr Frise said that the turboprop power plant with a rotor being driven instead of an airscrew was a next step, and it would take its place in helicopter development A lot of thought was being given to the matter, but he believed there was no question that the free turbine, with the weight of clutches avoided, was the obvious next step There was a shortage of turboprops in the power range which could be expected to go into existing helicopters immediately He did not think that the jet exhaust would contribute greatly to planning, or that it could be used easily for overcoming the torque of the drive

To an additional point regarding the part which blade-tip propulsion would play in development, Mr Frise added that tip drive by some form of jet was already well known, and there were examples flying The logical course was to try to produce air or gas at an economical compression ratio and pass the whole lot out to the tip There were the usual difficulties, as with any new developments , in this case the most efficient pipe to lead the gas out to the tip was too big to be the best aerodynamically So, as always, a compromise had to be made

Part of the compromise with this sort of power was its simplicity One could get perhaps half of the available fuel energy into effective use in driving the rotor, whereas with the free turbine one probably got three-quarters of it To offset this were the costs of development, the need for gear reductions, and maintenance costs , he thought that an overall benefit in favour of the free turbine could be shown on the operating cost of the finished vehicle—in spite of the fact that less of the available energy would be obtained This, however, would have to be proved

Summarizing, it seemed that the extra fuel consumption associated with any form of jet drive could be counteracted by lower installed weight, better disposable load, fewer parts, and cheaper maintenance The jet would undoubtedly find a home in the helicopter

A second questioner felt that in the matter of the large passenger-helicopter we seemed to be "fiddling about with a large number of very interesting but unduly advanced ideas," and in the meantime Rome was burning He asked the Panel's opinion as to what sort of helicopter could be produced most quickly to fulfil broadly the specification recently put out by B E A

Mr Shapiro replied that he had been associated with multi-rotor helicopters —three rotors, to be precise—and this work had been a means of utilizing existing experience on small machines in order to build larger ones He believed this was the quickest way of producing a large helicopter

Dr Hislop thought we found ourselves in a situation where we must try to produce a large economical helicopter which would be attractive to operators We could not afford to go through teething pains, and fall behind the Americans, with the orthodox We must try to "do a Comet" on them—to attempt to jump the years which we had lost and to get an advanced design which would be attractive and economical and make up the leeway If as a country we followed the lines indicated by Mr Shapiro, we might produce a large helicopter a little more quickly, but he doubted if it would be attractive to operators

Another questioner asked for the team's views on the possibility of rotor blades being replaced by something in the form of a slotted disc Mr Whitby said that such a system would have very high solidity, and the engine would need to provide a very large profile-drag torque It would also have to be a rigid rotor, with attendant problems High solidity with normal blade-loading would lead to a very high disc-loading, and thus a high power-off rate of descent In other words, if the blade loading were kept normal the machine would have very poor autorotational characteristics He added that he did not think this was the best way of doing things, or even an efficient way

In answer to a question regarding the optimum number of blades for a main rotor, Dr Hislop remarked that he could not just give an answer off the cuff , it depended

upon design requirements In general, one tended to have the fewest number of blades which would do the job One was driven to increase the number of blades in order to reduce blade loading To meet Naval specifications one tended to have a lot of blades , for the most efficient lifting capacity, very few It would depend entirely upon the job that was being done and the design limitations

Mr WHITBY said that a lot of blades tended to improve the smoothness of the rotor For the same blade-loading and a number of blades the individual blade would be working at a lower Reynolds number It was a matter of obtaining a nice balance Different designers had different views, and it was structural rather than aerodynamic considerations which decided things

A final question was in regard to the merits and drawbacks of tip drive by ramjets Mr FRISE said that, generally speaking, they had the one great merit of being the simplest and latest form of engine that could be put into a helicopter In first cost and maintenance there was everything in its favour—for any kind of aircraft the ramjet was the simplest and latest thing , the only thing against it was its high fuel consumption At the other end of the scale the compounded piston engine was the heaviest and had the lowest fuel consumption If one wanted a " crane," which was not fast in forward speed, but which would lift a lot of weight as quickly as possible, tip ramjets were the answer , but if one wanted " to cruise around for half a day like the Navy," one had to consider the aeroplane to meet that requirement Mr Frise thought that all the known power units, down to the simplest ramjet, had their uses

Mr SHAPIRO added that we had all now become accustomed to the fact that the jet was winning in fixed-wing transports This was mainly for two reasons that one bought better structural efficiency and thus got a higher payload for the same all-up weight, though with a higher fuel consumption , and that with fixed wings one got higher speed, and useful work done at a greater rate With the helicopter the second feature did not apply, for one got no higher speed with jet propulsion Helicopters were never going to show the superiority as a result of jet power which had now become apparent in fixed wings

https://doi.org/10.1017/S2753447200002079 Published online by Cambridge University Press