was a fruitful cause of unserviceability and need for replacements in the early operational helicopters Research on this phenomenon and the development of bearings which will give longer life under oscillating motion at small amplitude is urgently needed for the helicopter

Most helicopters are characterised by the complete inaccessibility of their power plants Engines are enclosed in cooling air ducts, completely boxed in by fire-walls and close to fuel and oil tanks in such a way that they can hardly be seen even by the most conscientious mechanic, and so receive little or no preventative maintenance Cases are known where the fuel tanks have to be removed to enable the plugs to be cleaned The designer all too often in the past has been responsible for an arrangement in which the aircraft virtually has to be dismantled in order to change the engine Maintenance under such conditions is naturally difficult and the designer must do better in the future

## Discussion

**W Tye** (Air Registration Board) On the general layout of rotor systems in present-day helicopters, Mr HAFNER would probably say why it was best to react the main rotor torque with a little fan stuck several feet behind where any decent fuselage ordinarily stopped , Dr BENNETT would then explain why the same function was so much better performed by a propeller asymmetrically mounted , and Mr SHAPIRO might even try to convince the meeting that both these solutions were wrong, and that the real answer was to suspend the helicopter from three remote corners Perhaps the problem was comparable with one debated many years ago on monoplanes, biplanes or triplanes, and whether the tail should be in front or behind He did not know who was right or who was wrong about the helicopter, but insofar as any residual engineering instincts were left to him, these instincts rebelled against all these configurations His instincts did not tell him what a helicopter should look like, but he hoped that someone might supply the answer He admitted that these criticisms might be quite unjustified

They were at the beginning of the development of the helicopter into a sound commercial vehicle, but if helicopters were to be made commercial vehicles, they must be more efficient (in the broadest sense), and safety, which had so far been good, must keep pace with the increasing uses of the helicopter

The authors had referred already to a number of directions in which improvements could be achieved, both in efficiency and safety These two developments must proceed hand in hand, although, inevitably they would pull in opposite directions The aim of airworthiness people was to see that a reasonable balance was maintained between the two

The problem was by no means new, for it had to be faced every day with fixed wing aircraft, but in that latter sphere they had many years of experience to guide them In the helicopter field the experience was much shorter, and he felt it would be easy to allow safety to suffer in the interests of efficiency, or vice versa The only satisfactory answer was to obtain as much information and as quickly as possible about the way in which helicopters behaved in operations or simulated operations

The following were examples of things they needed to know —

The loads applied by the pilots in manoeuvres , Information to assist in the determination of fatigue conditions for rotor blade design , The velocities of descent in normal and emergency landings , The use of engine power in typical flights , The effect, if any, of ice on the rotor blade , The degree of stability necessary for safety

That list was not intended to be exhaustive

He had served on the Air Registration Board's Rotorcraft Requirements Co-ordination Committee, on which designers, engine constructors, operators, and specialists from the R A E and the Ministry of Supply were striving to prepare a design code which would establish and maintain a reasonable level of safety The Committee's task was made extremely difficult by the absence of the kind of information to which he had referred



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**O Fitzwilliams** (Westland Aircraft Ltd ) *Founder Member* He wondered if Mr TYE objected to sailboats He could think of nothing more asymmetrical than those time-honoured vehicles From a performance standpoint it did not seem to matter in practice how many rotors there were or where they were placed, the result was always a lemon ! It was a matter of engineering convenience , they could not do what was required with just one rotor without some form of jet drive, and they had to choose the most economical means

The authors of the first two papers, and to a lesser extent the authors of the later papers (from the summaries he had read) had shown a tendency to continue at this meeting the habit of grumbling together about their mutual shortcomings That was a valuable and salutary purpose of the Helicopter Association, but he doubted whether it was proper at a meeting such as that with the Royal Aeronautical Society Surely one object of the meeting was to enable the helicopter fraternity not only to explain their problems but also the reasons for their obvious enthusiasm, in the hope that more of the highly qualified and experienced people in the aviation industry might be led to see in the helicopter a fascinating and thoroughly useful outlet for their talents He could not help feeling that those with a wider experience of aircraft engineering along orthodox lines would have noticed that most of the complaints which had been made that morning about the helicopter were of a curiously minor nature The main hold-up in helicopter development was not because of the existence of mysterious problems which could be handled only by a genius , the main holdup was, and always had been, lack of funds and lack of volunteers from the ranks of the more talented and experienced aircraft engineers

The position was by no means so pessimistic as might be assumed from the papers He thought that, far from being complicated, every successful rotor system now flying was of a simplicity approaching crudity and the contrary impression was an illusion arising from unfamiliarity with the simple swashplate mechanism involved The reliability of the mechanism was astonishing, considering the small extent of the facilities which had been available Improvement was a matter of skilled, but nevertheless straightforward, aircraft engineering Surprising attention had been paid to the servicing aspect in the existing helicopters It was not true to suggest that they were lacking in proper provision for maintenance Also, their power plants were reasonably accessible They were not perfect, and to suggest that maintenance was entirely satisfactory would be untrue, but in at least one type that was operating there had already been serious complaints that the time and energy called for on inspection schedules was out of all proportion to the trouble that was actually found in the machine when it was inspected Some of the major parts, the tail gearbox and so forth, were not even dismantled for inspection over a period of something like 600 hours That was the present generation of helicopter

Insofar as difficulties of this sort did exist, they did not involve anything peculiar to the helicopter nor anything which could not be cured by straightforward application of money and man-power in the design offices Without these progress must remain slow

The same remarks in the same degree could be made about stability and most of the other problems discussed In considering stability, they must think of the use to which helicopters were put and the kind of helicopter with which they were dealing For passenger operations twin-engined helicopters were needed because passenger operation meant efficient service into and out of the principal towns

At present helicopters are mostly single-engined and mainly for specialised duties, such as crop spraying, rescue and so forth

In a recent lecture to the Helicopter Association Dr SISSINGH had described a most elementary collection of bars and links which could perform all the functions of an otherwise highly expensive automatic pilot He did not think there was a designer in this country who would at the moment bother to incorporate it, for it was just not worth while in present conditions Later on, when they needed stability in passenger operations, and a great deal of work had already been done on the stability of the multi-rotor arrangements, when the law of supply and demand called for it, stability would be provided

Much the same could be said of cures for vibration He believed Mr SHAPIRO would point out that the vibration which bothered the occupant of the helicopter at the moment was due mainly to lack of foresight and effort in the design offices, which was unavoidable at the moment The vibration which was really inherent in the helicopter and which could not be eliminated, was small compared with the vibration of ordinary



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surface means of transport If they wanted to fly helicopters at speeds much above 140 m p h , where vibration problems really became severe, they might have to use forward propulsive airscrews and possibly fixed wings, but such aircraft should probably be called " convertaplanes, rather than helicopters

The further development of helicopters was dependent mainly on the money and manpower available, but the helicopter manufacturers were not waiting , they were going ahead with the production of helicopters, confident that customers would buy and use them and thus provide the funds necessary to bring the helicopter to the state of perfection desired by the operators

**L S Wigdortchik** (B E A Helicopter Unit) *Founder Member* He believed the future of the helicopter was dependent on its commercial potential to an extent that set it right apart from the fixed wing aircraft The latter, because of its over-riding military value, had never lacked funds for its development, but such an all-important incentive did not exist for the helicopter Therefore, they must understand from the outset that it was essential to make the helicopter a commercial proposition with a realism, and even ruthlessness, not hitherto seen in aviation

There was no longer any real problem in making a helicopter with acceptable flying characteristics , and, as the authors had shown, the practical problems were well on the way to solution The real problem was to produce a helicopter that could be made a commercial success by an efficient operator

Close economic analysis of contemporary helicopters showed that the operating costs were high and out of all proportion to the general service rendered, mainly because of the high ratio of initial cost to disposable ton-miles per hour Commercially they could only be considered in roles where either the payload against distance carried had a high intrinsic value, or a special service or novelty aspect was exploited

To some extent it might be possible to produce cheaper and more efficient machines by simplification of detail and overall design, without impairing ultimate performance and reliability Was it really necessary to follow fixed wing requirements for undercarriages, structures and other design criteria ? Similarly, could requirements for vertical flight performance be relaxed, in order to be able to operate at heavier all-up weights ? The engine-off landing was no longer such a hazard as they had thought , thus, his suggestion might be seriously considered Again, many existing helicopters carried excess structural weight, because of the unknowns that existed during their design stage To-morrow s helicopters would benefit by later experience

He believed that a great advance in commercial characteristics would be obtained with the large helicopter, in the 1,500-3,000 h p class, since all indications showed that such machines would have a much lower ratio of initial cost to disposable ton-miles per hour Such an aircraft would have to be able to maintain a ground speed of 100 m p h against a headwind of 40 m p h over blocks of 250 miles and must be able to carry 20-30 passengers

It was no use having helicopters if they did not know how they were going to use them and over what routes The work being done to-day was valuable in the operating lessons that were being learned, and from that they must take their guide His own view had always been that the helicopter was best suited for passenger transport because of its ability to reach city centres, but it must be able to offer a service that soon became indispensable and that could only be done by a service with a utility far in excess of anything that went before

The history of vehicles showed that they became really economic only when mankind evolved his society around their potential The helicopter had a chance to become part of the human fabric to an extent which might confound their thoughts to-day

**Air Commodore W H Primrose,** *Member* In his British Commonwealth and Empire Lecture* Mr MASEFIELD had laid down four basic requirements for air transport to achieve its role as an economic medium in the communications system —

1 Efficient aircraft
2 Efficient operators
3 An efficient ground organisation (meaning adequate airports and adequate air traffic control)
4 An air faring outlook—by the public

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* MASEFIELD, P G Fourth British Commonwealth and Empire Lecture Some Economic Factors in Civil Aviation JOURNAL R Ae S Oct 1948

The first and second of those requirements had been dealt with adequately in the first two papers and more would be heard, he hoped, from the other papers But there was a complete absence of any mention of the Masefield requirements 3 and 4

Let them assume that within the next five years intensive research and development would result in the production of the acceptable product at the acceptable price demanded by the operator, together with the evolution of a satisfactory operational technique and trained personnel How far advanced would they be towards the practical economic utilisation of the helicopter as a means of speeding up communications if there were no developments in the provision of city centre landing sites and other ground facilities ? Without those, few of the advantages which the special characteristics of the helicopter possessed over other forms of transport could be reaped It would be like having efficient trains or buses without railway tracks, roads, stations or termini Would they not be back at the situation that faced them in the late 1920 s, with the then Prince of Wales making his appeals to Lord Mayors and Corporations to provide airports for their cities to enable them to operate internal air services ?

The fourth requirement and the one which PETER MASEFIELD had considered most important, was an air faring outlook Even the provision of " City Copter Courts," as they had been called, would not ensure the full economic utilisation of the helicopter transport potential, unless the public were educated to be helicopter-minded Again, they should learn from the lessons of the past and remember ALAN COBHAM stumping the country in his efforts to make the public air minded and air travel conscious

Another matter that he would like to hear discussed was that of the type of undercart or alighting gear for the helicopter of the future Were they not in danger of following too slavishly the type of undercarriage that had been developed for the aeroplane, in the same way as they copied the lines of the horse-drawn carriage in the first motor cars ?

The aeroplane, because it had to run along the ground before it could become airborne, and on landing after it ceased to be airborne, *must* have some form of wheeled undercarriage The helicopter, because of its ability to take off and land vertically without forward run, did not require the wheeled undercarriage There seemed to be considerable room for the development of an alighting gear which would save a lot of weight and/or drag and at the same time would provide a good shock-absorbing medium Such a landing gear could also be made to spread the load over a larger area and so make less stringent the bearing strength requirements of landing sites If it were an air pressure type it might also provide the facility for the helicopter to alight on water and float in a stable condition The advantages of such an amphibious type required no stressing

A point in the economics of helicopter operation that was too often not fully appreciated, or was entirely overlooked, was that of its facility for rapid turn-round That might well give it the advantage of at least 10 minutes at each end of a stage journey over the normal transport aeroplane On a stage journey of 100 miles at 100 m p h enough time would be saved for an extra journey every three hours or so, which would go a long way towards nullifying the higher translational speed of the aeroplane, apart from time saved in surface travel between city centre and airport He thought that Mr MASEFIELD had not made full allowance for that factor in his comparison of the aeroplane and the helicopter on the short stages

**S Scott Hall** (P D T D (A) Ministry of Supply) He appreciated that Mr FITZWILLIAM had promised that when they had helicopters with multi-rotors the problem of stability would be solved But it was important to consider the helicopter as it was to-day, and he understood that it still lacked stability He had tried to fly an early helicopter and it had seemed to him very much like trying to balance a ball on the end of a pin , it was certainly unstable

There was also the difficulty of flying blind, and he hoped that these two points would be dealt with adequately in the discussion because he regarded them as being fundamental Good stability and blind flying qualities were absolutely essential to operation in bad weather

The authors of the papers had presented with clarity a subject which to many of those present was very obscure

**A McClements** (B E A Helicopter Unit) *Founder Member* The helicopter needed development before it assumed its full effectiveness as a vehicle of transport ,



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but if they came down to fundamentals, economics would probably play a much bigger part than anything else in determining when helicopters would become available as a means of transport to the " man in the street " One of the factors affecting economics was closely related to helicopter engineering and maintenance procedures, and much could be done by the designer and operator which would reflect favourably on the overall economic picture

Maintenance methods at present slavishly followed the tradition of past aeronautical practice They inspected machines at given periods, pulled them to pieces at other periods and put them together again, often doing more harm than good in the process More important they kept the machines on the ground during those performances Some idea of the drain which such methods imposed on the operator could be gathered from his own experience, which showed that for every hour flown by a helicopter they kept it standing on the ground tinkering with it for approximately 2½ hours That figure bore no relation whatsoever to the reliability of the type of machine in question In actual fact, current certificated helicopters were known to be remarkably trouble-free

Why, then, was the work done ? The main reason was because they did not know enough about the product they were handling and were forced to find out the hard way Such methods gave some assurance against breakdown and accident, but they were so unattractive economically as to make it obvious that attention must be paid in future designs to ensure higher utilisation and less maintenance effort They would go a long way towards their goal, and at the same time probably make one of the most forward steps in helicopter development for some time to come, if they worked on the following lines

(*a*) A realistic balance must be struck between performance and possible useability The designer must try to give the operator the maximum possible utilisation potential for the minimum amount of engineering maintenance effort The future commercial helicopter which would be popular would not necessarily be the one which had the highest performance, it was more likely to be the one which was reliable and required little attention

(*b*) The present system of maintenance in which all effort was aimed at discovering defects by searching for them at frequent intervals should be abandoned The manufacturer should find out what the lives of his helicopter components were, and let the operator leave those components alone until their lives were over and then change them This implied considerable effort by the manufacturer in the initial stages of a project, embracing bench and laboratory testing and full-scale evaluation under conditions of controlled intensive flying Such effort should be undertaken before the machine was offered for regular operation

(*c*) The closest attention should be paid to interchangeability and accessibility so that parts could be replaced quickly and without the need for ' fitting "

(*d*) The closest attention should be paid to easing the problems of servicing

(*e*) Adequate special tools should be provided so that servicing and maintenance could be done easily and quickly

There was nothing particularly original about those suggestions The lecturers had clearly touched on most of them and people interested in fixed-wing aeroplanes had been making similar suggestions for some time There was one important difference between the commercial aeroplane and the commercial helicopter , the helicopter had no background of convention to overcome and they had a golden opportunity to start it off properly

There was no point in just saying that the helicopter would have a great future, because its future would depend solely on what they made it Being new, they had an ideal opportunity of exploiting to the full the enormous possibilities which it undoubtedly had They could only do that by adopting the methods best suited to it and not necessarily those related to any existing form of transport The selection of such methods would call for the closest co-operation between designers and operators

**Group Captain E Fennessy** (Decca Navigator Co Ltd ) The navigation of the helicopter was a very different problem indeed from that arising with the fixed wing aircraft Bearing in mind the vast size of modern airfields used by fixed wing aircraft, it was not so much a problem of finding those airfields , indeed, they could hardly be missed The major problem of fixed wing aircraft was to get them down in safety On the other hand, the helicopter had to land in a small space, which probably had to be approached be a devious route The problem was more akin to that of marine navigation, where ships had to proceed by devious channels in close proximity



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to dangers in order to reach restricted and confined ports There was one most important difference between the problem of navigating a ship and that of helicopter navigation In a ship, it was possible to carry considerable amounts of navigational equipment, without regard to weight, and extensive facilities could be provided for plotting the ship's position and course on Charts In the helicopter, navigational aids must be of minimum weight, and furthermore, since the pilot was fully occupied with the problem of flying the helicopter, no technique involving any procedure of plotting the position would be acceptable

The pilot must have provided for him, in an automatic fashion, adequate information to enable him to follow the proper route in any weather and without his being involved in any manual operation, other than that required to switch the equipment on at the start of the flight

It was encouraging to note that many of those concerned with helicopter operation appeared to be well aware of these operational requirements As a radio engineer concerned with co-operating with the aeronautical engineers and the operating authorities, it was a pleasant experience to find such an awareness of the necessity for an early solution of these problems There was, indeed, a more live realisation of the need to solve the problem then was perhaps existing in the field of fixed-wing aircraft navigation and control

The Decca Navigator Company were working in close collaboration with the Helicopter Development Unit and the Research and Development Division of British European Airways, on the solution of these problems of automatic navigation The principles being followed were that firstly, a radio navigation system should be provided which gave the adequate basic information and the aircraft's position, and it had been found in trials conducted by British European Airways that the Decca System provided this basic facility To interpret this information to the pilot in an automatic manner, the Track Control Unit had been developed This was an electronic interpreter, in which the aircraft's position derived from the Decca System, was converted to a simple meter display, telling the pilot his position with respect to track, in terms of both his distance to left or right of track, and his distance to fly along track to destination The pilot had therefore only two meters to consider, one told him when he was on track, or how far he had deviated to left or right , the other told him how far he had to fly to reach his destination An equipment meeting this requirement had already been flight tested, and further models were under construction

It was not unwise to predict that within a year or two, it would be possible to present the pilot with an automatic map display of his position

The far-sightedness being shown by British European Airways in both the technique of helicopter flying and of automatic control would undoubtedly result in bringing much nearer the day when the helicopter would be widely applied to many forms of communication The mistake was not being made of producing a good flying machine and then finding that they were not able to operate because of lack of necessary blind flying and navigational facilities



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