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Discussion

After the showing of a film, the **Chairman** called on Mr SHAPIRO to open the Discussion

Mr J S Shapiro (*Consulting Engineer*) (*Founder Member*), expressed great pleasure at having the first opportunity of thanking the Author, saying that he had listened with interest and joy because the Author was a man who really lived his subject and was taking such a close part in something now being created, to which everyone looked forward with great interest and hope

The Author had been so self-critical and sober in his assertions, not exceeding the bounds of fairly well proved physics and aerodynamics, that it was extremely difficult to be critical, and he would, therefore, follow the implication of Dr Bennett's invitation to him, and offer a few philosophical remarks

As the Author had said, the convertible was not in itself a substitute for or successor to the helicopter, but another form of aircraft In fact, the helicopter was valuable because it was itself a convertible to fail to realise that would be to forget what the helicopter really was Whatever the mission, the value of the helicopter was that it had speed and range in addition to hovering power From that premise, the argument for the convertible could be developed , but his feeling had always been that the development of the helicopter had not anywhere near reached the point where it could fulfil all the manifold range of missions and uses which could be foreseen for it

In transport, the helicopter speed demanded was such that the general wind speed became of relatively minor importance , and we had seen—as the Author had confirmed—that the helicopter in its various versions was perfectly capable of reaching such speed The argument for the convertible began when that speed was found inadequate, namely when range had to be increased It was the general view of those concerned in transport that, particularly from the economic point of view, matching of machine to route and range was far more important in air transport than in any other form of transport The argument for the convertible in civil work was that there was such an enormous field of work in air transport, with so much to be done, that there was room for a number of convertible types

There was one major question mark, and the principal gap in what had been a forceful and lucid lecture What was the personal equation of the Weight Engineer of Vertol who had produced certain of the graphs ? On the reliability of one of the graphs stood or fell the VTOL, of whatever type, from the point of view of transport economics How accurate could one take the weight estimate to be ? He knew that when he came to estimate for pure helicopters, there was a certain stage when the human error was roughly predictable Knowing the designer—including himself —he had a good idea how big the error might be In the new field of convertibles, one was in the dark

How far had the Author examined the various relations between aspect ratio and number of propellers did the assertion he made, that the whole wing must be submerged, limit the choice rather more than necessary ? Choice might be considerably increased if a small percentage of the wing were left out of the slipstream

He was a little surprised at the cruising altitude of 25,000 ft This was possibly too high for missions of 200 or 300 miles Was it worth climbing to that altitude ?

As regards alternative configurations of VTOL aircraft, he had many years ago seen in one of the captured German documents—under the names Pabst and Focke —something which the Germans called, if one translated literally, the "Driving wing" What did the Author think about that ?

He recalled something said by Professor Max Munk, the famous aerodynamicist, at one of the very early conferences of the American Helicopter Society, when it was still only the autogyro which claimed attention He had made a short speech entitled, "Slow Flight with Safety" Many people tended to forget the importance of safety in disturbed air The wing loading of an aeroplane could be reduced, and by various artifices landing and take off runs could be shortened, but sensitivity to gust then became so great that, certainly in scheduled transport, the aircraft became useless Greater emphasis should be placed on safety in face of gusts, especially in confined spaces

The **Author**, in reply, said that as far as weight trends of rotor-propellers are concerned, he and his Corporation were to some extent in the dark, since, as regards statistical data, there were only helicopter rotors on the one hand and conventional propellers on the other Helicopter rotors represented the trend for fully articulated blades, while propellers for the rigid ones Would VTOL rotor-propellers go closer to the trend in helicopters ? They had assumed, in their original VTOL studies that they would go somewhere between the two As far as the Vertol 76 is concerned, it fortunately fell very close to the helicopter rotor weight trend Whether it would be true for larger sizes and blades designed for STOL operation, he did not know As regards wings and fuselages, they could use trends from fixed wing aircraft Also, as regards transmissions, gear boxes, and so on, they were on a rather firm ground

The weight picture as a whole was extremely important, as it could make or mar the whole concept In transports particularly, a slight difference in the assumed weight trends might lead in one case to an aircraft completely acceptable as far as the payload to gross weight ratio is concerned or something "out of this world" At the moment, however, it looked as if the only uncertain area in the weight predictions lay in the weight of propellers—or rotor-propellers, as he called them

Mr SHAPIRO had asked about a possible limitation imposed by requiring the whole wing to be covered by slipstream As the Author had explained in the published text, there were many possible combinations The propeller could be at the tip of the wing or almost anywhere Part of the wing could be exposed, as in the Vertol flying test bed, but the part of the wing not covered worried him to some extent, in spite of the fact that the flying model went very nicely through transition in the NACA tests A much wider relationship between disc loading and wing loading could be obtained, depending on how the propellers were arranged The arrangement selected in the Paper was used for simplicity

The altitude of 25,000 ft was considered only for transport, to see whether one could close the gap between installed power requirement resulting from hovering conditions and that resulting from forward flying, yet achieve good economy in flight They tried to go as high as possible, and believed that 25,000 ft was the limit In other cases, 10,000 ft had been taken For some missions such as observation or liaison work, the situation might be completely different, the aircraft being called upon to cruise at 5,000 ft or lower and hover at, say, 10,000 or 12,000 ft From the practical point of view, one would probably go even in transports to lower cruising altitudes, but then the gap between installed power requirement resulting from hovering and that resulting from forward flight would be even greater

The **Chairman** said that he had hoped representatives from firms engaged in VTOL projects would participate in the discussion and perhaps those concerned with such projects at the Ministry of Supply would like to contribute

There appeared to be much similarity between the various powered lift systems throughout the entire spectrum, but full discussion of this subject would have to be left until later in the 1957/58 Lecture Programme, when Dr Kuchemann would talk on integrated lift and propulsion systems Tonight the discussion centred on the submerged wing, in connection with which, in this country, development work had been initiated by Crouch and Bolas prior to the war Later an important contribution was made by Zimmerman at the Chance Vought Company in the United States with his circular wing project It seemed that the submerged wing was tending to do the same sort of thing as could be done by the jet flap both were amplifiers of lift in slow-speed flight instead of the wing being allowed to stall, the flow was made to reattach This was all right so long as there was an adequate slipstream

Was there, with tilt wing aircraft—especially those having a small number of propellers—a stability problem, should one engine fail or even during the decelerating transition stage prior to landing where power and, therefore, slipstream velocity, was eased off ? Had his project gone far enough for the Author to investigate such matters ?

The **Author,** in reply, said that the question raised not merely the stability problem but the entire design philosophy of safety Engine failure could be approached in different ways One approach, of course, was very simple—send flowers—another to provide as much chance as possible for a safe landing With a single engine aircraft as there was in the flying test bed the problem became even more acute In this case engine failure in hovering or near hovering would be most critical and safety would require that either flight altitude would be either low enough (say 50-60 ft) that landing in the helicopter configuration could be performed without acquiring too high contact speed, or that the altitude would be high enough to make a conversion to the airplane configuration and execute a dead stick landing But even at a low altitude, say at 50 ft one did not want the aircraft to fall in any position, and in their design they had accepted the philosophy that the pilot would have, should his one engine fail, a free selection of the attitude at which the aircraft hits the ground

Following that design philosophy, they had said that, so long as the rotor-propellers were turning, either because of auto-rotation—which was doubtful—or because of accumulated energy, the pilot had his controls , and for that reason the fans controlling pitch and yaw had been connected not to the engine but to the rotor propellers, so that there might retain some basic control over the aircraft

In multi-engine configurations, the question was different Should all power plants be interconnected in some way ? Should there be some arrangement (as had been suggested) so that if there was failure of one engine on one side an automatic device immediately switched off one engine on the other side ? Such an idea was

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attractive for its simplicity, but it meant an additional loss of power when one most needed it Connected power plants meant paying a penalty in weight

Very little was known about stability problems and general behaviour of the aircraft in the conditions following an engine failure In the case of the Vertol 76 they had made some assumptions and were putting calculations through a high speed computing machine All those studies were really no better than their assumptions , they knew very little about the behaviour of highly loaded propellers in such conditions Would there be any tendency to auto-rotate ? What moments and forces would be generated by the rotor-propellers ?—they did not know for sure However, they hoped to learn more soon when one of their propellers was tested in a full scale wind tunnel through 180 degs , or in other words from the helicopter attitude to that of airplane and finally in " auto-rotation " With that information, plus what they could learn also from models, they would be able to better predict the behaviour of the aircraft in the unorthodox regimes of flight

(The CHAIRMAN repeated his question—Was it true that decelerating transition would be more difficult than accelerating transition ?)

The **Author** agreed that decelerating transition would definitely be more difficult, and especially in level flight would transition be difficult One kept the wing from stalling by blasting air over it, and in order to do that one had to develop thrust, and, in so doing, one went faster or changed altitude instead of slowing down Unless the operation was carried out very slowly, there was definitely a tendency to stall in such conditions The picture was different in transition from hovering to forward flight one went as fast as possible, so long as the acceleration could be tolerated—and there might be quite strong accelerations

Mr G Austin (*Bristol Aircraft, Ltd*) (*Member*), thanked the Author for his very bold exposition of the problems involved in this new realm of flight, adding that he would not presume to criticise a Paper delving into the unknown, but wished to make one or two comments

The Author had suggested that the aircraft should be designed upon a compromise between two optimum design aims—optimum hovering efficiency and optimum forward flight cruising efficiency Should not a third point, transition, be taken into account ? The aim should be the compromise of the three—hovering, transition and cruise If hovering efficiency is optimized, with low disc loading, transition power might be rather larger than in hovering The Author had shown that power required fell off on increasing forward speed directly from hovering, but presumably that was with a somewhat higher disc loading, possibly 30 or 40 lb per sq ft It appeared that, with lower disc loadings, the wing must be stalled because there would not be the high slipstream velocity over the wing to stabilise the flow—as was seen in the very interesting film which had been shown There were the two extremes low disc loading with low hover power which increased power during transition, and high disc loading with high hover power which reduced the power during transition Perhaps the best approach would be to have a medium disc loading of, say, 20 to 30 lb per sq ft , which would give a reasonable power requirement in hovering yet increase the power still in transition This would mean that one could have, possibly, a four power unit aircraft operating at, or nearly at, full power during transition, which would give a power reserve for the event of losing one engine during hovering, and a similar amount of excess power would be carried in cruising, but that would, he thought, have to be accepted in order to give a safe aircraft in hovering and get over the region of transition This would result in a practical aircraft having less excess power available in cruise and also a lower installed powerplant weight, than the aircraft with the higher disc loading

The film showing flow stabilisation in the slipstream was very interesting What would be of even greater interest would be figures of wing lift against thrust coefficient of the propeller

The Author had suggested that one should use a section lift coefficient on the rotor, as was current practice, up to about 0 6 It should be possible to go rather higher in this type of machine because the values of μ remained quite low In tilting the rotor, one kept μ values not much higher than 0 1, so that there would not be retreating blade stall trouble

The Author had suggested in his paper that he would use a cruising optimum twist on the rotor blades Was that quite correct ? With a high disc loading, the induced power in hovering would be great and the use of an inefficient twist for that condition would result in a considerable increase in total power required over an already high value This would lead to an aircraft being grossly overpowered in forward flight If a high disc loading is adopted, hovering twist should be used, possibly dispensing with one inner lifting portion of the disc and having some form of elliptical fairing so that that part of the disc was not giving negative thrust in forward flight In the other layout, with large rotor area and low hovering disc loading, one could afford to use an optimum twist for cruise, as an already small induced power requirement would be increased by only a small amount

There were then, these two extreme types of machine, and the ultimate engineering compromise between them would probably result in a machine of intermediate characteristics having a disc loading in hovering of about 20 to 30 lb per sq ft

The **Author,** in reply, agreed that in transition, a rather highly loaded propeller was beneficial in order to get the best ratio of slipstream to transition speed However, the same problem could be approached from different angles The propellers could be used as the principal means of preventing separation but, if necessary, such other means as slots and slats, BLC control, etc , could be used Again, depending on the mission, and general philosophy of the aircraft design, either higher disc loadings might be selected, or some other means of flow stabilization might be chosen

As to the average lift coefficient in hovering, the 0 6 accepted in the preprint of the Paper was a figure taken from present-day helicopters, with this in mind, that probably in the tilt wing aircraft one might go to higher average lift coefficients than 0 6 This might become possible through the use of cambered airfoil sections, some kind of boundary layer control, etc Then, it would be possible in the future to use an average lift coefficient in hovering much higher than the 0 6 In that event, one could design the rotor-propellers of much lower solidity and probably make them lighter

The argument about twist could go both ways If hovering was the most important factor, then the twist optimum in hovering would be chosen , if however long distances were to be flown, then optimum efficiency of propellers in cruise would dictate the twist distribution Whenever there was a conflict, the outcome would to some extent depend on the mission The only thing absolutely certain was that one wanted to reduce the tip speed in forward flight to the lowest possible value

Mr W Stewart (*R A E , Bedford*) (*Member*), asked whether, when it grew up to become a proper machine, the tilt wing aircraft would have rigid or articulated propellers This was one of the questions fundamental to the future design of the type The Author had, in the general part of his Paper kept an open mind about the two types, but his description of the experimental machine showed that they had used the flapping type of rotor, and he had given some excuses for using this in that type of configuration Larger transport machines of this nature would require more and more engines, purely from the point of view of safety and reliability, and it would then be a design point that it would be much easier to drive from the engines direct on to the propellers as such Looking ahead to see the way in which the configuration might develop in terms of number of propellers and size of them, they appeared to be moving more towards the aeroplane type of propeller as one knew it rather than the helicopter rotor

People had learned to live with the articulated rotor system in the helicopter, but there was no doubt that the flapping blades had a serious penalty In terms of weight, there were the flap hinges and drag hinges, and one did not quite know how much weight was built into other places on account of vibration problems Many difficulties had been satisfactorily overcome, in that sense, in the helicopter, but a large penalty was paid Was not the tilt wing aeroplane a stage where one should forget about hinged blades ?

The **Author,** in reply, commented that that was a very good question, which could be debated for a long time should blades flap or not ? In the case of the

Vertol 76 it was Hamlet's problem in another form—" To flap, or not to flap " He had tried to present the reasons for finally deciding to use flapping blades Having no direct experience in the rigid blades, they had gone to the propeller manufacturers to ask the cost and weight of rigid propellers The cost answers were very encouraging, but weight was discouraging Actual figures were still classified, but he could say that rigid propellers were always about 50 per cent or more above their assumed weight of flapping propellers For simplicity and cost alone, they would be very glad to go to rigid propellers

Moreover, some very preliminary NACA test indicated that rigid blades would give rather high pitching moments in the initial part of the transition which would require some additional tail force for trim, thus leaving less for control

For those two reasons, it had been decided, in that particular aircraft, to use flapping propellers Immediately there arose the question whether to have drag hinges or not Having experience available of mechanical instability resulting from the drag hinge, they decided not to have any drag hinge on the flying test bed As to the Coriolis forces resulting from flapping, it was hoped that the elasticity of the whole drive system would be sufficient to take care of them

What kind of propellers would be used in the operational tilt wing aircraft, he could not say Much study was now going on propellers to the same specification were being designed, side by side, by rigid propeller manufacturers and by helicopter companies So far they were only paper studies, but when those studies were completed, they at least might contribute to answering the question about the structural weight of the two types The operators would probably like to see propellers without any hinges

The **Chairman** having asked that the Meeting should hear from a potential operator—

Mr R H Whitby (*British European Airways*) (*Member*), commented that many times he had had reason to bless the Author for the way he had made helicopter aerodynamics appear relatively simple in his published textbooks He had brought the same thoroughness of study and clarity of logical exposition to tonight's Paper on a very complex subject

The requirement in civil transport operations was for a vehicle which was cheap and safe, and the story unfolded by the Author had not been particularly encouraging Several people, including the Author, had drawn attention to the question of power balance between cruise and hovering conditions One could not go into much detail, because the vehicle, as such, was not in any sense developed yet, but this was a fairly good index of what sort of economy one was likely to achieve He felt that, in considering the balance between cruising and hovering, the Author had tended to stretch things , 25,000 feet was a very great height, and any more practical operating height such as might be necessary for shorter range operations would make the unbalance very much more marked Again, in comparing cruising power requirements with hovering power requirements, no question of power failure seemed to have been considered In a machine having the characteristics of the Vertol 76, circumstances might demand an ability to hover with at least one power unit gone, which, again, would exaggerate the unbalance between take-off and cruise power requirements

The complexity of the vehicle had a bearing on safety It was probably true that the aeroplane achieved its very high standard of airworthiness because it had been designed so that moving components were more or less independent of each other *e g* , if an engine failed, that did not lead to failure of other engines The type of vehicle now under discussion seemed to have some of the disadvantages of the shaft-driven helicopter—there was not such independence In order to maintain control, there would either have to be, as the Author suggested, four engines and an arrangement for cutting a second to balance in the event of failure of one (leading to an exceptionally severe power requirement), or, there would have to be transmission shafting of a complex nature as in the helicopter On top of that there would apparently be the need to tilt the wing By and large, it would be quite a box of tricks !

However, he did not say these things to discourage the Author How fine it was to see in the film the aircraft being wheeled out and going through its paces It was only by doing that sort of thing that problems could be uncovered and their solution reached. Nothing approaching it was being done in this country, he understood, and that was unfortunate.

The **Author,** in reply, commented that with all VTOL aircraft, the tilt wing being no exception, some weight penalty had to be accepted for the convenience of having vertical take-off and landing, combined with high cruising speeds. One of those weight penalties seemed to stem from the fact that, no matter how one tried to balance the power requirements resulting from forward flight and hovering, there was an excess of installed power resulting from hovering. When safety aspects were added to those of performance, the power plant weight started to grow still further. Since balance between the installed power resulting from hovering and an economic cruise cannot be easily achieved some engines had to be turned off in cruise. The idea of carrying something simply " for a ride " was abhorrent to the author personally, but he realized that after all, landing gear is used only twice, once for take-off and once for landing, yet the aircraft had to carry it all the time.

As to the complexity of the present tilt wing systems, the way seemed to lead through developing some concept and then trying to simplify it in every possible way. Their flying test bed, or anything else at the moment, was complicated, but there were means of simplifying the whole concept. Probably all VTOL concepts could be simplified, and become as simple and reliable as helicopters, and approach the standard of safety of the fixed wing aircraft.

Mr. R. A. Shaw (*Ministry of Supply*) (*Member*), added his congratulations to the Author, mentioning particularly the early part of what he had said when speaking about his own aircraft.

What was the Author's philosophy about the control of his own aircraft from the pilot's point of view—an aircraft having in it other variants not present in the conventional aeroplane or, in the same way, in the helicopter ? It appeared that the pilot was set a special problem in recognising the different ways in which he controlled his aircraft in the different stages of wing tilt.

The **Author,** in reply, said that they had tried to eliminate the problem for the pilot through a proper control system. How successful the attempt would be, he would not know until actual transition had been accomplished. However, in the wind tunnel a similar system worked successfully. Vertol 76 had in hovering the pitch control from the ducted fan while the elevator moved with the ducted fan, but obviously, was not effective until moving forward. With the increasing forward speed the elevator became more and more effective but, since it was controlled by the same control column, the pilot had not to think how much control he was getting from the fan and how much from the elevator. He simply looked at the reaction he was getting. Directional control was more or less the same. There was a fan which controlled in hovering but the pedals controlling the fan were also moving the rudder. In forward flight the rudder became more and more effective as in a conventional aircraft.

The difficulty existed with the roll control. In hovering the pilot used the differential collective pitch of the rotor-propellers to obtain roll. As the wing started to tilt, the whole control aspect became more complicated, because variations of the tilted thrust vectors would introduce not only roll, but some yaw as well. In addition, also some differences in the slipstream velocity were produced, which in turn varied the lift on the submerged portions of the wing again creating new rolling and yawing moments. Fortunately, the thrust vector and slipstream effects mutually compensated to some extent each other. Nevertheless, the problem remained of eliminating with the wing tilt of the rotor-propeller differential pitch control and introducing conventional aileron controls. The change was made in this way, that, as the wing tilted, rolling controls through differential collective pitch washed out, and the ailerons started to come in, and more or less from 45 degrees wing position down, controls through the propellers were practically eliminated and control was exercised through ailerons. Again, in this latter case, the pilot had not to think about the conversion of controls : all he had to do was to control the tilt of his wing, and when the wing reached a certain position the changeover proceeded gradually.

In hovering the pilot had for altitude control a collective pitch lever as in any

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other helicopter In forward flight that lever became a means for selecting propeller pitch with speed as in conventional variable pitch propellers

Flight Lieutenant J L Price (*R A F*, *Boscombe Down*) (*Member*), referring to the controls the pilot would have to use while converting from vertical to horizontal flight, asked whether this would be an easy process, or might the problem be solved by having a programmed auto-pilot ?

The **Author** replied that up to the moment they had not been in favour of using "black boxes" for the conversion programming However, the whole process of conversion had been analyzed using different wing tilt rates It looked that the wing tilt rate is one of the most important parameters in the whole manoeuvre of conversion However, as to the final selection of the wing tilt rate they had decided to let the pilot decide about it giving him the best possible representation of what was going on Some kind of indicator might be desirable to show how far the wing is from the stall What would be the final arrangement is difficult to foresee Perhaps there might be some kind of a black box which at the push of a button would automatically execute the whole transition following a prior established programme

Dr G S Hislop (*Fairey Aviation Co*, *Ltd*) (*Member*), referred to the multiplicity of power plants required to meet practical transport needs Because of necessary interconnection of these power plants, he said that there might be great difficulty in proving the integrity of such a transmission system because of the number of variables involved in a 4 engine/4 rotor mechanical transmission system Moreover, not only did the problem arise in hovering if one engine failed, but there was also the control aspect There had earlier been reference to the suggestion—which had been raised also at a R Ae S /I Ae S lecture at Folkestone a week or two back—that apparently these aircraft had to be controlled at low speed by means of black boxes That was a possibility If safety were to be dependent on the infallibility of the black box, in practice that would mean not just one black box but three In arriving at the comparative weight breakdowns in the development of the aircraft, had reasonable allowances been made for such an increase in complexity and multiplication of units ?

The **Author,** in reply, said that at the moment the aim was to fly the aircraft without any black box If black boxes became necessary, they would probably be very simple—nothing more than rate gyros Since there was a boost system, they could be connected to it, and the resulting weight penalty would be rather small

How difficult would be the flying of tilt wing aircraft in general it was very difficult to say until more flying experience had been gained The NACA mentioned that the Vertol 76 model was probably the easiest to fly The NACA were now (he understood) flying the Hiller model, and that also was quite easy But, only actual tests would determine how easy, or difficult the machine was to fly It would have been very difficult to theoretically predict the same thing for the first helicopters when they were in a similar stage of development as the tilt wing is now

Mr P A Hearne (*British European Airways*), said that the thing which impressed him most the first time he flew in a helicopter was not so much its ability to fly up and down and hover but its manoeuvrability near the ground and the ease with which the pilot could position it at high airspeeds with reference to various obstacles It would probably be necessary to fly the machine under discussion in the presence of obstacles, at appreciable air speeds How would such conditions affect the tilt wing aircraft ? With any sort of air speed, the effect of having the wing end on to the airstream might give rise to difficult control problems

Could the lecturer say why his choice lay rather in the tilt wing aircraft with rotors rigidly attached, as opposed to the tilting rotor shaft aircraft, which Bell's had produced ? Did he consider that Vertol's type had advantages over the tilting shaft and over the deflected slipstream type of VTOL aircraft which NACA had been working on ?

The **Author** explained that selection of the tilt wing type by Vertol resulted

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from several considerations First of all, the tilt wing was preferred because, from analytical studies performed at Vertol, it looked that this system would always have some edge over other types for transport application at moderate cruising speeds of say 300 knots Furthermore, this system was also suitable for observation liaison aircraft, etc Finally, they believed that they could best use their accumulated know-how in this type of aircraft

The final conclusion regarding the VTOL system best suited for various application could perhaps be reached when all the flying test beds now being constructed were flown, tested and compared by some independent body However, some indication that the tilt wing type may not be the most complicated one could be taken from the fact that Vertol had designed, constructed, and started to test their aircraft in a relatively short time of 11½ months

As to the other systems of VTOL aircraft, it is hoped that several flying test beds being developed under the same programme as Vertol 76 would shortly start to roll out Amongst them would be those of the deflected slipstream type and more would be known about this system Vertol studies, based on NACA published data, indicated that due to the thrust losses encountered in turning the slipstream through large angles, the tilt wing type always seemed to be somewhat lighter than the deflected slipstream aircraft designed for the same mission There were also some indications that control of the deflected slipstream type in the presence of gusts might be more difficult than for the tilt wing, but this latter point could not really be settled until the two aircraft were flown side-by-side in the same weather conditions

(Mr HEARNE repeated his question with reference to the ability of the aircraft to manoeuvre at high speeds in the helicopter phase)

The **Author** replied that they did not know for sure how far it would be possible to go, but, in spite of the wing (which, of course, presented a tremendous drag) they believed that it would be possible to develop " helicopter " speeds of about 30 knots or higher At the moment the aircraft had been hovering in 12 knot winds

The **Chairman** said that he understood there was discussion going on in Canada at this time about VTOL aircraft, and asked Mr NETTLETON if he could give the Meeting any information on Canadian interest in the subject

Mr. T R Nettleton (*College of Aeronautics, Cranfield*), answered that he had not yet heard the details of the discussions held at the Commonwealth Conference in Ottawa There was also to be a discussion on VTOL at the forthcoming joint meeting of the Canadian Aeronautical Institute and the Institute of the Aeronautical Sciences in Montreal

Current Canadian experimental research on STOL-VTOL seemed to be concentrated on the flap-deflected slipstream problem A recent picture in the Aeroplane illustrated a de Havilland Otter aircraft which had been mounted on a ground test rig to enable slipstream effects on flaps to be investigated by the de Havilland Aircraft Company of Canada The tests thus far had utilized the surface wind to simulate aircraft forward velocity Test rig towing would presumably be necessary to investigate moderate speeds He had heard that the results were quite promising Further full scale experiments with four propellers blowing over a flapped wing were to be conducted by the Canadian National Research Council

The **Chairman** replied that he understood the CAARC were discussing the subject at their Fifth Meeting now being held in Canada

The **Chairman** thanked the Author for a most interesting lecture, adding a word of special gratitude to him for having come such a long way to deliver it Congratulations were due to the Author also for having been one of the first in this field to reach the stage which the Americans called " hardware " in such a very short time since the project was initiated He was fortunate in obtaining considerable help from the Office of Naval Research It would be an excellent thing if similar sponsorship were provided in this country

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