helicopter it is easiest at this stage to keep the heading the same and fly backwards The pilot now reduces height correcting continuously laterally as required

A feature of this system worth noticing in passing is that the display is in effect a display not of the actual displacement (say in feet) from the desired axis but an indication of the augular displacement referred to the transmitter Thus the sensitivity of the display will steadily increase as height is reduced This is, of course, quite an advantage but could become " too much of a good thing," if eventually the sensitivity becomes so great to cause " hunting " *i e*, violent over correcting This difficulty can be overcome by judiciously modifying the scale factor of the display automatically with height by inter connection with a radio altimeter (or distance measuring device) which I assume will be carried

With regard to this last mentioned distance measuring device, a conventional radio altimeter is possibly not very suitable because the ground level would appear to be changing violently due to buildings in the neighbourhood of the heliport A possible solution which appears to have economic advantages in addition is to use a short range F M radar on the ground to measure the height of the aircraft The height or distance information could be communicated to the aircraft via the set down beam This system ensures the very minimum of radio apparatus in the aircraft, and at the same time provides a means of control during orbiting

Thus to summarise I have described a proposed set down aid in which I claim the presentation is simple, the sense and magnitude of the error discernible at a glance (and what is more important) the sensitivity increases inherently as height is reduced

Finally, I have just touched on a possible distance measuring technique, using a rather sophisticated form of radar, in which all the complexity is on the ground and a minimum amount of equipment in the aircraft

## Discussion

The **Chairman** said he was sorry that Mr Hough was not present from Liverpool, because he would have found Mr WILSON's approach to the problem extremely interesting The three Papers were bristling with problems and potential questions It seemed to him that the questions would arise principally in the minds of those who were to fly the helicopters Mr SHAPIRO had given the economic justification of of the inter-city service and had given a figure of costs, which was at least arguable In the Chairman's opinion, it was not unreasonable that the direct cost would be 2½d —3d per seat mile

The most startling point was the advocacy of a strip type of landing ground, and he hoped that this feature would be strongly handled in the discussion When he considered the case of flying into the heliport, he immediately wondered what would happen in a very strong cross-wind or if an engine failed or if there was delay in the service How were aircraft then handled on this narrow landing ground ? What happened if an aircraft broke down on the roof top site and could not be flown off ?

Mr WARD had given a very interesting technical exposition, but the Chairman knew nothing about electronics and how to build up an electronics system His only comment was that the instrument might bamboozle him completely, since it seemed to give direction, distance, height and time all at once !

These were all operational features, and perhaps the most appropriate person to open the discussion was a representative of an operating organisation—Mr WHITBY, of British European Airways

**Mr R H Whitby** (*Member*) (*British European Airways Corporation*), said the Chairman had already mentioned a number of the questions which had formed in

his mind but perhaps he would be forgiven for repeating them Mr SHAPIRO had given a highly controversial introduction and it appeared that the views expressed by Mr WILSON and Mr WARD followed from Mr Shapiro s opinions

The essential element in Mr Shapiro's expositions was to assume that a helicopter could fly vertically upwards and downwards (which included the case which arose when an engine failed) and could land on a space about the same size as the aircraft itself in such circumstances that a missed approach would probably lead to a catastrophe

In his earlier Paper to the Rotterdam Conference, to which Mr Shapiro had referred, he had acknowledged that there were certain aerodynamic difficulties about vertical flight because of the vortex ring condition He (Mr Shapiro) had said that there were some dramatic smoke photos showing terrible things happening, but had contended that probably this state of affairs did not matter

Mr Whitby did not think that one could be as emphatic as that There was very limited experience in this field because in operation it was deliberately avoided, although he knew of at least one occasion in which a pilot entered the vortex ring conditions and was lucky to get away with it What measured data there was suggested that at least with some aircraft it could be serious for descents between 500 and 1,500 feet a minute As the disc loading increased the rate of descent at which the vortex ring condition was met increased He gathered from Mr Ward's paper that in the planned operation aircraft would take about one minute to get down 2,000 feet at one stage

Mr Shapiro intervened to say this had been an error , the maximum rate of descent would be 500 feet a minute

Mr Whitby said he would therefore assume that even with an engine out the rate of descent would not exceed 500 feet a minute Mr Shapiro had said that for this particular aircraft he had assumed a disc loading of about 5 lb /sq ft , if it just met an *en route* engine out performance requirement with a single rotor helicopter, the vertical rate of descent with an engine out would probably be about 500 feet a minute With the normal operational technique then, the aircraft would be operating right on the margin of the vortex ring conditions

One could reply, ' So what ? It had not been demonstrated that it was possible to fly in these conditions with complete safety and all the evidence went the other way If the velocity of descent built up beyond the pilot s control at a crucial stage he might find it impossible to avoid collision with the buildings

Because of the height of the building envisaged—and presumably this arose from town planning considerations—it was highly probable that a large number of landings would have to be made in cloud, if a reasonable regularity were to be achieved Mr WHITBY was not in a position to judge the ability of a pilot to fly the aircraft on the verge of the vortex ring conditions in cloud on the ingenious instruments suggested by Mr Ward Even if the aircraft could do it, he thought the pilot would require rather more information than was made available by this simple instrument display

When considering visual conditions it was rather pleasant to be able to see along the direction in which the aircraft was moving This would require a complete revolution—not that this was impossible—in the way in which the pilot sat and the direction in which he looked Perhaps it could be " done by mirrors," but a great deal of re-thinking would be needed

There were a number of minor points through which he would run quickly The aerodynamic scheme proposed for the roof was interesting Could Mr Shapiro amplify the data which suggested that this particular arrangement would minimise disturbance to the aircraft ? What tests had been carried out ?

Turning to Mr Wilson's Paper, his suggestion that a mechanical announcer should announce when a passenger was too fat was interesting ! In practice, that would not be popular with the fatter passenger, and presumably Mr Wilson was thinking more in terms of the number to be carried rather than singling our individuals There was no reason that this method should not be applied to any aircraft, but there was a potentially simpler means of avoiding weighing with a helicopter At the moment weighing of passengers was undertaken because small helicopters were in use The importance of weight in an aircraft, however (provided the structural limits were not exceeded) was not to operate in conditions where the performance was below a certain standard With a helicopter there was an admirable direct means of measuring this—simply to see whether the aircraft left the ground with a certain proportion of the available power This was more direct than giving people coloured

tickets, because that method did not take account of the weather , although presumably one could say, " On a hot day we will take five red tickets and on a cold day we will take 20 red tickets "

His personal feeling about landing on such a small platform high up in the air as had been put forward was perhaps influenced by the fact that he had recently flown off and on to the Port of New York Authority building , while admittedly this was with a single engine aircraft without good vertical climb, it was an exciting performance, and he wondered how the general public would react to it !

**Mr Shapiro,** in reply, said he had been prepared for the kind of questions which Mr WHITBY had asked and therefore had a picture dealing with the aerodynamics of this type of roof site This was from America and was presented by Mr Lichten of the Bell Aircraft Corporation To what extent it was based on wind tunnel tests he did not know, but it was certainly based on background knowledge of aerodynamics For the present they had assumed that it was a reasonable shape to avoid turbulence, so far as possible, in whatever wind was blowing

He did not think it would be very difficult to get some reliable information , at any rate, it would be much easier for a roof site which was high in relation to its surroundings than for a ground site surrounded by buildings

So much for the aerodynamics of roof sites As for the various dangers, he would like to hear a first-class orator describe what happened when a railway train over-ran its buffers It would in fact take a long time to discuss the question of reliability in a sensible manner and he could only suggest that it be made into a subject for a separate lecture Personally, he was satisfied that nothing he had proposed in the operations described was in any way less reliable than a journey by bus from Piccadilly Circus to the City That was the degree of safety, statistically, that they could expect It was a bold statement and he was prepared to spend hours discussing it with Mr Whitby—and hoped that Mr Whitby would enjoy it as much as Mr Shapiro !

Dealing with holding the helicopter in bad weather, he emphasised that they were assuming a fully stabilised helicopter He hoped that the representative of Sperry s would say a few words about the achievements which had been reported from the United States in this respect There was no doubt that this was one of the matters which could be classified under " engineering developments " , no questions of principle were involved When he said " a stabilised helicopter " he meant a helicopter stabilised with regard to gravity axes—in other words, vertically —and not with regard to the air

There was one open question which he would not like to answer for the moment, and that was whether stabilisation with regard to gravity axes was entirely sufficient and whether it would not be both necessary and very desirable to stabilise with regard to ground features It would be a very simple matter to stabilise with regard to ground features and he understood that it had already been done by Sperry's in America It could be used as an alternative let-down aid and it might be one of the methods of ensuring reliability of a specific level such as was required for air transport operations—that of having alternatives of different kinds as well as duplication

As far as he could judge, the whole equipment—comprising stabilisation, engine speed governing navigational aids, approach and communication aids with emergency equipment for complete electrical failure in the aircraft and several other luxuries—should weigh about 1,000 lb

He had no doubt that the vortex ring conditions would require a lot more knowledge before it could be suggested that one could fly in the vortex ring state, but the vortex ring state in vertical descent occurred about 1,000 feet per minute In this case they were talking about less than 500 feet per minute This was where the vortex ring started, and they could ask of a good helicopter that it would not easily fall into the vortex ring—at least, not inadvertently He thought they were sufficiently far advanced to *avoid* the vortex ring state

**Mr Wilson,** in reply, said obviously the right way to test whether they had the correct load was not to try to take the aircraft up and then bring it down again for another attempt Some pre-weighing system was necessary

When **Mr Whitby** intervened to comment that it was not only a question of weight but also a question of outside conditions, Mr WILSON replied that they would be established each day If conditions were unfavourable they might decide to take



https://doi.org/10.1017/S2753447200003954 Published online by Cambridge University Press

26 passengers instead of 30 But if they were operating on a five-minute turn round they could not make a trial run every now and then

Answering the question about the roof top site being in cloud, he said he had given a lower-most limit of 12-15 floors, and it was not often that cloud was experienced at that level, which might be 100 feet The building referred to in the drawing was 50 (a special case) floors high, perhaps 500 feet

**Mr Ward,** in reply, said he had been amused to note that while the Chairman throught the display system rather confusing, Mr Whitby thought it far too simple and giving insufficient information If Mr Whitby wanted more information presented, presumably there were other indicators already in the cockpit which would supply the need If he wanted this information provided in a more sophisticated manner, this was possible It was amazing what could be done with a cathode ray tube

**Mr G Hinchliffe** (*Decca Navigator Co Ltd*), said that any system of navigation designed to meet the requirements of a pattern of helicopter operations of this type must be a high accuracy area coverage type of navigational aid working at low frequencies He could justify this by saying that to allow safe operation at the density of traffic envisaged, far too many radio beacons would be required to be economically worth while, and high frequencies, with their optical range limitations, were unsatisfactory for these heights

The main object of Mr SHAPIRO s paper was to show the absolute necessity of reducing indirect operating costs One must therefore ask whether there was a system available which would give the required accuracy A diagram was then shown indicating that the Decca Navigator System provides a fixing service which, when the North Scottish Chain is opened in a few months time, will cover the United Kingdom, excluding a small part of Ireland, to an accuracy of 95% of occasions of plus or minus one and a half nautical miles at all times of the day and night throughout the year He submitted that plus or minus one and a half nautical miles was satisfactory for the *en-route* phase of the type of helicopter operations under discussion

In the final phase of the approach, where the helicopter pilot had to be able to position his aircraft within the cone of Mr Ward's landing beacon, plus or minus one and a half nautical miles was not good enough, but that was the worst figure which would be met only at the fringes of the areas marked in the diagram, and even on the fringes it was met only at certain times on winter nights

As an example of the higher accuracies in the centres of the areas marked he gave figures for the accuracy at various times of the day and night in the Central London area where on 75 per cent of the occasions, a spot fix would give accuracies on a Summer's day of plus or minus 15 yards , on a Winter's day, plus or minus 40 yards , on a Summer's night, plus or minus 80 yards , and on a Winter's night, plus or minus 100 yards

If one were using a flight log, the log would be giving a continuous series of fixes of the aircraft's position, and the track could be visually integrated so that the 75 per cent accuracy figures were those which it could be assumed would be realised

There were areas in the United Kingdom where this accuracy could not be achieved, and for those areas the Company suggested a very small low-power chain which should be provided to give satisfactory cover in the city centre It would not be necessary to have a chain for each rotor station , one would cover as many stations as were required in the city The slide showed that one chain, a master station and two slaves, on base lines five nautical miles long with 120 deg separation between them, would cover an area of approximately 20 square miles with a fixing accuracy on 95% of occasions of plus or minus 50 feet

Such a chain of stations would cost about £10,000 and would be fully automatically controlled and maintained from the nearest main chain station

The advantages to the pilot of map presentation had been set out many times and he would not repeat them

It was possible to provide Decca navigational equipment in many forms The simplest possible form was where an aircraft was always operating in satisfactory cover of one chain, in which case a single chain light-weight receiver with flight log presentation could be provided at a total installed weight of about 40 lb At the other end of the scale was more complex equipment, including lane identification and flight log with scale and pattern change facilities, with a total installed weight of

140 lb With the possible development of these equipments, he thought they could satisfy any requirement which might arise in the future

When considering the collision risk for close parallel track operation in high density areas, he took as an example an aircraft using a Flight Log chart with a scale of 2-in per Decca lane A Decca lane in the London area is approximately 650 yards The accuracy which one should expect to get would be better than plus or minus 2-in for both the original setting error and the reading error There was not time to justify this statement though he was prepared to do so This error was equivalent to one-tenth of a lane, so that the information presented to the pilot was accurate to plus or minus 65 yards

It must be appreciated that the pattern stability was accurate to plus or minus 100 yards in the London area, but this contributed nothing towards the collision risk because two aircraft using the same pattern in the same area would always be in error by the same amount and in the same direction It was only errors in setting and reading the aircraft equipment which contributed towards the collision risk

In the London area, therefore, parallel tracks 400 yards apart had, between them, a safety zone of 270 yards in which the aircraft should never appear , and he was prepared to say, " will never appear "

Much could be said about reliability, if there were time He would merely say that it was as good as any other airborne electronic equipment of comparable complexity They expected to improve it when they had had as much experience in the air as they had had on ships A large number of ships were fitted with it and the average period between maintenance was about six months

He had a comment to make on the air traffic control system—nothing to do with Decca, except that it was assumed that Decca would be used He felt that insufficient attention had been given to the possibility of incorporating not just a track plan but also a time plan in the air traffic control system Aircraft should be scheduled and expected to keep to a schedule, not just at the end of the route but all the way along it

He would like to amplify these remarks, and had prepared others, but this was not the appropriate time to say more

**Mr Shapiro,** in reply, said they had been unable to discuss the question of traffic control, but without doubt the ability to have a navigational system on which it was possible to rely would virtually provide a solution to the traffic control problem This would follow the lines along which the present train despatch system worked, because there was no problem in identifying trains The question of the reliability of a navigational system such as Decca was therefore of paramount importance, because that enabled the solution of the one big problem remaining—the traffic control problem

Another suggestion emanating from Decca—he had hoped that this would be explained—was that the display of height or distance measuring information should be made by the lighting of little lamps Thus, without adding another instrument to the dashboard, the pilot would know in which range of heights he was flying If he knew that his height was about 20 feet, that was all the height information required

The **Chairman** said the aspect of *en route* navigation was important but the Papers dealt with bus operation and perhaps the Decca side to this would be better dealt with in a discussion on navigation aids for helicopters or all-weather flying

**Mr C A Richardson** (*Companion Member*) (*Sperry Gyroscope Co Ltd*), said that the discussion had been mainly on the economics of the helicopter They had realised that it was necessary for the helicopter to establish its place in the transport system In order that the helicopter could do this its operation must be an economic proposition, it must be reliable—more reliable than present forms of transport, which meant that weather conditions had to be defeated

During this meeting a paper proposing a suitable approach aid had been presented His Company had for many years been working on the instrumentation of helicopters and had found that even to-day to fly a helicopter in all-weather conditions was a considerable task When they considered that it was now proposed to put the airports on roof tops, *i e*, into the clouds base on certain occasions, they realised that the position was made that much worse It must also be remembered that the helicopter would often operate over a short distance and the pilot would have to do a number of landings in a short period of time This placed a tremendous load on the pilot's

If they were to overcome the problem they must have some form of automatic stabilisation The series of slides would give an idea of the helicopter flight control system developed by the Sperry Gyroscope Company, New York, which was now being put into production This would show those who travelled in helicopters that they need not be too worried about the future and would show those who flew helicopters that there was yet hope !

The first slide showed a diagram of the various units of this control system Mr SHAPIRO referred to a total weight of 1,000 lbs for a flight control and navigational equipment, but if that were the actual weight it would obviously have no future for helicopters

Mr RICHARDSON said originally they had adapted a standard aircraft automatic pilot (the A-12) to helicopter operation and had achieved satisfactory results, but they had had to discard it because of the weight The total weight of the equipment shown, including a hovering control, rotor speed control and altitude control, had been reduced to about 60 lbs , which was not too great a penalty to pay for automatic stabilisation and automatic control The diagram was fairly self-explanatory

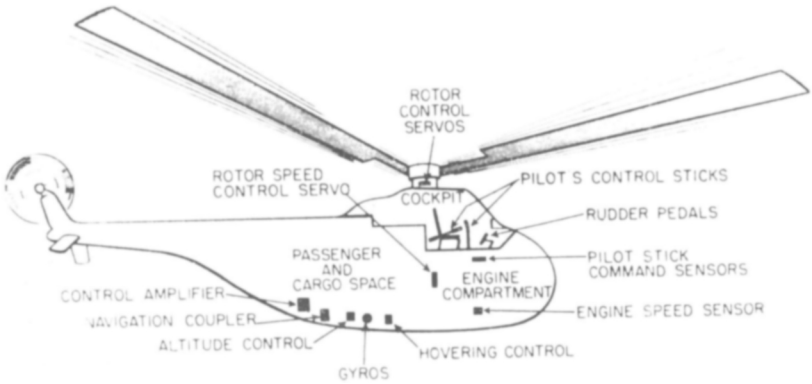
Slide 2 was a picture showing the flight simulator which had been used considerably in developing this pilot One of the force and motion sensor units could be seen In flying the helicopter through the automatic pilot, the normal controls were used The sensor element shown sensed the load which the human pilot was putting on the controls and transmitted a signal through the amplifier to the control jacks so that the helicopter would respond to effect the desired change providing stabilised flight all the time

Slide 3 showed a helicopter off the ground and hovering The passenger had his arms folded and the pilot was holding his hands off the controls This demonstrated automatic hovering just above the ground

Slide 4 showed the pilot doing a navigation problem while the automatic pilot flew the helicopter The little light on the cyclic stick showed the movement required over a period of 15 secs Its pattern of movement could be seen during this period of automatic control

Slide 5 showed the type of amplifier developed for this equipment It would be seen how far they had had to go in miniaturisation techniques to reduce the weight

This automatic pilot had been about four years flight testing before being put into production It was engaged simply by a switch and then the helicopter was stabilised, by gyros, on the existing flight path To change the flight path the pilot




*General arrangement diagram of the Sperry helicopter flight control system*

applied pressure to the controls as in manual flight For hovering, the couplers would accept signals from many different systems such as an inertial system or a Decca navigator in the aircraft or signals from the ground, either radio, radar or by wire or signals from submerged sonar units With those signals it would maintain itself constantly hovering over a spot

Heading and altitude were automatically maintained, except when the human pilot applied definite pressure to make a change If necessary, the pilot could temporarily fly away from his altitude, but the automatic pilot would return to it



https://doi.org/10.1017/S2753447200003954 Published online by Cambridge University Press

unless disengaged by the human pilot Various other forms of altitude control could be used, such as radar

There was an engine control which maintained constant rotor speed

Thus this equipment now going into production would make instrument flying in helicopters a far simpler and more reliable all weather operation

Mr RICHARDSON was not quite sure about the advantages of vertical let down, the flight control system described would accept such a system quite easily but the roof top landing areas described demanded approaches in a certain direction and, therefore, the normal I L S would seem to meet the requirement without the need for specially developed aids It was quite easy to fly a helicopter on a standard I L S if autostabilisation was fitted In restricted areas a steeper glide path might be required but no other changes would seem to be necessary and such a system would enable greater traffic movement per hour as inbound and outbound helicopters would not follow the same path to and from the airport

**Mr A E Bristow** (*Member*) (*Bristow Helicopters Limited*), said very little had been left for him to say as a helicopter operator because half the worthwhile criticisms had been made by the Chairman, and the balance had been made by Mr Whitby He thought that they both had made useful contributions to the discussion

Listening to Mr WILSON, he had visualised himself sitting by the radio listening to ' Journey Into Space ' because the Papers were so futuristic They were so far from reality that he wanted to address remarks to those present from Councils and Corporations and ask them not to be unduly influenced by the wild and imaginative stories they had heard during the evening It was all good clever stuff, but it did not bring inter-city helicopter services one step nearer What independent operators wanted was permission to fly into the cities—now, and with single engine helicopters

The authors had only discussed roof top sites, and their arguments implied that only roof top sites would be acceptable This was not true , ground and river sites were equally acceptable and each had to be considered on its merits The last thing operators wanted was for the local authorities to base their planning requirements on roof top sites of the size and shape mentioned by Mr Wilson, which were far too small anyway for the fifteen to thirty seater passenger helicopters at present under development

If any experienced helicopter pilot were asked to express an opinion whether he would agree to descend vertically, completely on instruments, onto a roof top site of the size given by Mr Wilson, even with the wonderful aids suggested (assuming he was flying a twin or multi-engined helicopter) he would almost certainly say " No, because it was just not practicable

In conclusion, he appealed to those from Municipal Authorities, " Please give us permission to fly into your cities, and keep the red tape to the minimum '

The **Chairman** said perhaps Mr SHAPIRO was paying the pilots a compliment in assuming their skill to land on a 70-ft platform !

**Mr Shapiro,** in reply, said they had heard from Mr BRISTOW what they had been accustomed to hearing from him , he was outspoken and no doubt he meant what he said The point was that Mr SHAPIRO was speaking of helicopters as they would be and Mr Bristow was speaking of them as they were at present, so they were not speaking of the same thing The fact that both belonged to the generic type of helicopter did not make them the least bit similar for the operator to fly

Speaking particularly of the architectural aspect, he said he realised that very many people employed on municipal duties tended to look after the safety of their cities with very careful eyes and would not be quickly persuaded of the roof top technique, but Mr Bristow was a very distinguished pilot, for whom they all had admiration, as they had for a steeplejack who climbed to the top of a spire But Mr SHAPIRO emphasised to those from municipal authorities that he was not speaking about the problems of a steeple jack but about those of installations What a steeple jack had to say about them was of little relevance

**Mr Wilson,** in reply, commented that having worked in a municipal authority for some time he found it a delicious experience to hear public authorities implored not to be imaginative

**Dr O P Mediratta** (*Louis Newmark Ltd*), referred to the automatic control system which Mr RICHARDSON had described as having been developed in the United States In this country they had an automatic pilot-stabiliser for the helicopter which had proved itself over the past year on numerous demonstration flights It was now in production Mr Richardson had given the weight of his equipment as 60 lb , and this coincided roughly with the figure on which they had settled in the first attempt to produce an autopilot in this country He would not be disclosing classified information, however, if he revealed that they had under very active development an autopilot for a light weight helicopter, and that the weight of this equipment would be roughly half the 60 lb mentioned

The system which had been adopted in this country had been influenced largely by the consideration that what the helicopter needed was something which would bring a little more stability Stability had therefore been imported into the helicopter and an autopilot provided which would give a certain sense of relief in flying

They had, in fact, gone a stage further to meet some of the official naval requirements which he was not in a position to disclose It was intended that a Paper should be presented to the Association on the subject in the next Session, when fuller details of the system would be given

The significant point was that while they were trying to reduce the weight of the equipment, reliability was the paramount requirement in their minds They had, therefore, so arranged the system that in a ' runaway ' the pilot had full control without first having to press any switches or buttons

He had been impressed by the schemes outlined in the Papers and had thought how remarkable it would be if the automatic system they had developed could be used to bring the helicopter under blind landing conditions

**Mr P A Hearne** (*British European Airways*), said he supported everything which Mr BRISTOW had said What they had been told in the Papers was a fantastic distortion of what could and could not be done with a helicopter

His views were based on actual operations in instrument conditions and simulated instrument conditions which are part of a large scale experimental flying programme aimed at developing a method of operating helicopters reliably in all-weather conditions Until completely automatic landing came into use in scheduled civil helicopter operations, which would not be for about 15 years when the necessary reliability had been achieved, the pilot had to see the ground before he made a landing No mention had been made of this in the Papers , a picture had been drawn of a helicopter descending at 500 feet per minute, completely in cloud, and the very next second landing bang on the deck ! Apparently, under this system, it was not necessary for the pilot to see the ground when making a landing !

Mr HEARNE emphasised that the pilot must see the ground Furthermore, he had to make the transition from instrument to visual conditions, which took about four seconds, and this was followed by manoeuvring time required to put the helicopter in the correct position for landing It followed from these considerations that until completely automatic landing was achieved, minimum visibility for regular operations was 400-500 feet, with a cloud base of 200 feet above the landing surface

Turning next to the type of approach he said that the steepest angle they had achieved with present helicopters in instrument conditions was an angle of approach of 9-deg , at a speed of 45 knots and rate of descent of 750 feet per minute With autostabilisation it was hoped to reduce this forward speed to 20 knots with a rate of descent of 750 feet per minute giving an angle of 20-25 deg

Dealing with the handling qualities of a helicopter, he said that vertical flight introduced appalling handling problems He had tried vertical flight with present helicopters—and it must be remembered that the unstabilised handling qualities of the larger helicopters of the future would be worse than those of present machines, and that autostabilisation, even though conferring very marked improvements in handling qualities, could not overcome the fact that the severe vibration problems and other basic rotor aerodynamic problems created, were incapable of solution by a little black box It must be borne very much in mind that in a vertical approach it was easy to get into the vortex ring state and difficult and dangerous to get out of it

Another reason that the vertical approach technique was impracticable was the wind effect which was referred to below To make a safe instrument approach an accurate approach aid and good approach lighting were needed, and so far five types of radio and radar approach aids had been tested by the B E A Helicopter Experimental Unit—a pilot interpreted Decca type and a ground interpreted radar type

among them They had thoroughly tested each type of aid by making some 50-60 instrument approaches and measuring the helicopters actual position in each, and knew pretty well what type of aid was needed for instrument approach Mr WARD was on the right lines, but unfortunately he had been misdirected by the concept of vertical approach

The major problem was the fact that it was necessary to combat the effect of wind, which was often as much as 50-75 per cent of the aircraft's forward speed of 45 knots Unfortunately, wind effects changed with height , there was wind shift which caused marked drift angle changes which the pilot must combat by changes of heading, and wind shear, which involved rapid adjustments in the rate of descent When an aircraft was descending at 750 feet per minute, the maximum rate of descent in a forward speed type of approach, it passed through all the wind change in 1¼ minutes, which required a very rapid rate of information to the pilot

There were two methods of handling this information either by ground radar, which left the ground controller to interpret the information, which relieved the pilot but introduced time lag , or by a pilot interpreted aid Mr HEARNE thought that the sector scan type of radar, which gave azimuth and glide path information, renewed once every half to one-third second, offered a lot of hope This was a radar type of aid, and it would be necessary to have what was called moving target indication which picked out the helicopter's target from the buildings and possibly an airborne transponder to produce a very strong ' target return ' from the helicopter on the radar screen

As a complementary aid, something on the lines suggested by Mr Ward, showed promise An advantage was that information could be fed into an easily interpreted form of presentation and the automatic pilot could be coupled in for the approach phase However, it remained obvious to Mr HEARNE, whose organisation had done about 500 instrument approaches and was now concerned with flying around the country in all-weather conditions, that the type of vertical operation suggested by Mr SHAPIRO was impractical Future stabilised helicopters would not be easier to fly than the present stabilised machines and these were difficult enough for the type of operation visualised

**Mr Ward,** in reply, said Mr HEARNE had agreed with his general findings on the type of system His reservations about display were matters of detail , this aspect could be turned inside out to suit any particular requirements That was a matter of psychology, if anything

**Mr Shapiro,** in reply, said he did want to re-emphasise the difference in outlook It was obvious that Mr HEARNE had been operating such helicopters as he could find , he had no other choice Mr SHAPIRO, on the other hand, was talking of a fully engineered system of helicopters and flying aids These were two completely different things and could not be compared

Moreover, he could see no justification for the statement that future helicopters would be more difficult to fly, nor for the statement that vertical flying at such low rates of descent was very difficult He had never experienced it personally, and therefore did not know what made Mr Hearne hold that view, but he believed that many vertical descents were made at 100-400 feet per minute and the handling problem was not particularly difficult Of course, stabilisation was necessary and stabilisation would certainly come , and with stabilisation the handling of the helicopter was completely transformed This point he made most strongly to those who had never flown a helicopter, or perhaps never seen one handling a helicopter might at present be a problem, but the problem was completely transformed once the helicopter was stabilised

A friend who had visited Kabul had once told him that 25 years ago a progressive ruler there bought two tram-cars, but these got no further than eight miles from the city, where they got stuck This progressive ruler was then chased out of his country, with the result that there were now two tram-cars near Kabul, though without rails This was the difference in outlook he had mentioned He was talking about tram-cars with rails and everything else properly organised, not about the tram-cars near Kabul

Incidentally, he had meant to say that all the equipment—navigational and everything else—weighed 1,000 lb , not the stabiliser alone

**Mr Hearne** commented that his remarks applied to an auto-stabilised helicopter He had flown in one and had tried for a very short time simulated instrument approaches of the type described

**Mr Shapiro** said it could not have been properly stabilised

**Mr Hearne** replied that it was, but the CHAIRMAN intervened to suggest that the discussion might now be directed to other features not so far mentioned Nobody had yet argued what would happen in the case of emergency with this narrow roof top strip

**Mr Wilson,** in reply, said that Mr BRISTOW had condemned the size of the operational dimensions suggested in the Paper and at the same time had appealed to local authorities to allow him into their cities This was a contradiction , for unless operators tried to keep down to the size of operation which the Papers had outlined they could not hope to operate either economically or, from the town-planning point of view, advantageously The Authors had been concerned with precisely such considerations of space and expense He did not know the speaker or what financial organisation he had behind him, but clearly his concept of helicopter operations would require a lot of space and he would either have to have multi-millionaires behind him or would have to go out of business ! The Authors had tried to work on what was the smallest amount of space reasonably likely to be available Mr Wilson suggested that the concept of inter-city operations either stood or fell on whether this system worked He did not speak as a technician but simply as a town planner—somebody who was trying to envisage this happening as a possibility in the context of finance and normal building sizes and densities

**Mr A P Bale,** speaking as a chartered mechanical engineer, said he had great sympathy with the pilots in their problems With this rather fantastic lay-out, why had not Mr Shapiro made a good job of it ? He could have had two buildings, one very narrow, and on the same scale of imagination there was no reason that he could not have bridged the two buildings with light alloy bridging members, covered in some form of transparent plastic and if necessary reinforced No great weight was involved when the helicopter landed, unless there was some trouble, and the transparent plastic extension to the very narrow runway, or heliport as it was often called, was on a par with the remainder of the Authors' remarks If the remainder of the concept was practicable, so was the provision of a plastic extension

The Authors pre-supposed that a lot of money would be available and that there would be plenty of pilots and passengers with money to spend The problem of the first regular helicopter flight in this country, from London to Birmingham about five years ago, was in fact one of price The service had been run with considerable success Mr BALE had been on one of the first flights But the cost of the journey was twice the cost of an ordinary flight from Croydon, in spite of which the helicopter operators claimed that they were losing money The Croydon flight—London to Birmingham—was twice the price of a good railway journey with refreshment car included

**Mr Bristow** expressed himself as shocked that Mr WILSON had never heard of him ! Nor had he heard of Mr Wilson ! Mr Bristow said that he had been in the helicopter business for a very long time and, as an operator, was fully conscious of the considerations which had to be taken into account in any futuristic studies, or even present studies, of space requirements for helicopter landing sites in cities The question which the Corporations and Councils must ask themselves was—will it pay to provide such elaborate facilities for a helicopter service ?

He pleaded with representatives from local authorities to provide space in the cities now That was the first step towards the introduction and development of any inter-city helicopter service There was so much to learn about the whole business of operating helicopter services into built up city areas that he thought it was too early to try and draw up hard and fast requirements for such sites The Authors, he felt, had gone too far and had been too ambitious and had ended up by presenting an unrealistic concept

He was asked by the Chairman what would be the position in a vertical descent if one of the engines stopped He said that it would largely depend upon the point at which the engine stopped—assuming that there were only two engines—but he could not answer the question in detail without giving the matter a lot more thought

A MEMBER asked what would happen if two helicopters came in to land at the same time, and Mr BRISTOW commented that the Authors had been talking about a frequency of operations which had left him dumbfounded

**Mr T F A Manning** (*Bartlett School of Architecture*), said if they were assuming a helicopter which was landing and taking off vertically in the most difficult conditions of visibility and weather, why must they necessarily choose the most difficult place for it to land—a roof top site ? Were there not a great many places in all cities where they could find a strip of land 70 feet wide by 250 feet long which would do as well, if not better, for such a machine ?

**Mr Wilson,** in reply, said that if Mr MANNING was suggesting that the helicopter should land on the ground he must recognise that that land would be sterilised for any other building purposes and that a very high price would have to be paid for it In central areas the price would be fantastic In addition, it would increase the problems of noise The important point was that by using a roof top site they were enabling the land to be used for its normal organic purpose It would not then be necessary to create a large space around an otherwise completely unused site, which would have been out of the question financially when bearing in mind the cost per square foot of a site in any city centre

The **Chairman** commented that if a site could be restricted to 70 by 250 feet, and if vertical take-off and landing could be achieved, they might get away with a ground site in a city centre, but he was sceptical about that

Mr **Wilson** said it would probably still cost more than a roof top site

The **Chairman** added that as soon as ascent and descent had to be other than vertical, and as soon as they had to obtain a site bigger than 70 by 250 feet, the ground site looked most unattractive in any highly developed city

**Mr Shapiro** said that a ground site with equivalent capacity to a roof site 250 by 70 feet would need to be an area at least four times as large because of the clearance area needed The comparison must be made between a roof top site 250 by 70 feet and a ground site at least four times as big

**Mr Wilson** agreed that this was so by the time the reception area had been added

**Mr J C Lister** (*Associate Member*), asked for the Authors' opinion on the use of the tops of ordinary rail stations for helicopter services This was a wide space available in most city centres

**Mr Wilson,** in reply, said station roofs were commonly thought of as being one of the most sensible places for helicopters and he drew attention to Mr Peter Masefield's suggestions on the subject There were about 10 lines going out of London and the rail lines and stations could possibly be taken as a basis for immediate purposes The main lines had an underground system linked with them which would fit into the pattern He did not know whether the actual roof of a station would be sufficient for take-off now It might not be ideal because of reasons of circulation

**Councillor T Meffin,** who said he was a member of both the Planning Committee and the Transport Committee in Coventry, said they had considered the need of good inter-city transport and also transport from the centre of the city to the perimeter Some time ago he had heard Mr SHAPIRO speaking on this subject at a Planning School and the audience on that occasion had rather been carried away Coventry had already provided the flat roofs and also had some open spaces, so that it was wrong to accuse them of lack of imagination

But after travelling that afternoon from Coventry to London in 1½ hours and then hearing all the trouble likely to be associated with Mr Shapiro's plan, he wondered what was the use of such a helicopter service In the near future the Birmingham rail journey would be shortened to one hour and 20 minutes—a journey made in comfort and without the risk of being left up in the air !

In his opinion, train travelling was the best form of travelling in this country and he had to be convinced otherwise When asked to attend this meeting of the Association, he had said that he had no objection provided his journey was really necessary In fact, he had enjoyed the meeting very much , it had been very good entertainment

The **Chairman** commented that if the rail services could be improved to such an extent so that the travelling time to Birmingham could be cut to one hour 20 minutes, and the time to Coventry to 1½ hours, then the helicopter would be hard pressed to justify itself in direct inter-city competition on these and similar routes It would always score in transport across to the Continent, however, because of the long time involved in any sea crossing The landing problem at the end of journey would, of course, remain the same

**Miss S MacPhee** (*Companion Member*) (*British European Airways*), said she would bring the discussion back to the immediate present There were two things which fare-paying passengers would not tolerate—noise and lack of heating She had been told that the problem of noise in a helicopter cabin was a difficult problem, and although she regarded that as a poor answer she would not press the point

Last week she had been flying on schedule trips in a helicopter in preparation for carrying the Prime Minister, and one point which had worried her was the lack of heating It was freezing in the machine That might be all very well on a 15 minute flight, but it would not do for a service She had asked why there was no heater and had been informed that the helicopter manufacturers had promised delivery of one the previous June !

**Mr O L L Fitzwilliams** (*Member*) (*Westland Aircraft Ltd*), intervened to comment that a heater had been forced on him by the Ministry , it weighed 150 lb and the operator had refused to have it

**Miss MacPhee** said she did not think they would get fare-paying passengers over a distance unless these things were put right

The **Chairman** said that was certainly among the engineering aspects of helicopter bus operations

Although people might disagree violently on the views expressed by the Authors, they had been given food for thought in a most stimulating evening A few months ago, Mr Hough, of Liverpool, had put forward more conventional proposals for roof top sites and on this occasion there had been another line of attack They should not throw these things out simply because they were difficult and because the helicopter was difficult to fly , they must allow for the inventor That was not easy because they did not know what he would invent, but 10 or 20 years ahead was quite a long time and much could happen in it

He believed that elevated sites, rather smaller than people were considering at the moment, would be used, although perhaps not quite as small as those they had been discussing during the evening

Members owed a debt to the speakers and he asked the meeting to express its thanks in the usual way

The thanks were accorded with acclamation

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## Mr Shapiro's written reply to Councillor T Meffin, Coventry

Since I had no chance of replying to you in the discussion on the 10th February I am doing so in writing

As I see it, the searching questions which you put should really have been the beginning of the discussion rather than the end of it Until then the discussion took an illogical course The operators instead of putting operational questions and discussing the operational assumptions made by the lecturers, usurped the role of engineers and questioned the solutions presented in terms of their engineering practicability

Our thesis is that a certain pattern of operations makes public transport by helicopter buses extremely attractive Existing helicopters and existing equipment cannot follow this pattern, but engineering development, without new discoveries, can produce the helicopters and their equipment which will make this desirable pattern a reality

In each field, an expert with knowledge of development possibilities had something to say in support of this proposition In each case concrete engineering solutions were presented These solutions must be scrutinised, but valid criticism can come only from those whose experience endows them with judgement on engineering

development Operators as such can state what they want but are not qualified to judge the practicability of specific solutions Their job is to provide the specification which must be met Instead of this, operators delivered criticisms which amounted to saying that they had not yet seen the engineering solutions proposed and those they had seen did not work in the way we require to accomplish the pattern envisaged If something cannot be found in a shop, it cannot be created

The accompanying pretence of solid practice restraining reckless imagination has so often been demolished in the recent past as to require no further comment The discussion on such lines was therefore futile and must remain so

You mentioned that, when conducting discussion groups at the Town and Country Planning summer school at Bangor in 1952 I was in some way responsible for convincing you of the future of the helicopter You have now come to question not only the reality of this future but also its desirability Undoubtedly the two questions are inter-related for in matters of technical planning the future is what we make it and we make it in accordance with what we believe to be desirable

I may assure you that the lessons which I took away from the same Summer School left an equally profound mark on me I was most impressed with the dilemma of the Town Planner who has of necessity to think in terms of 25 years ahead, whereas he cannot safely rely on currently prominent trends of development in transport engineering for a period longer than perhaps 5 or 6 years This is particularly true of aviation where the town planner has continually been outstripped by progress

It is natural to seek a way out of this dilemma if we wish to inform planning authorities of the broad trends of the future The way out lies in adopting a degree of basic thinking and ignoring the views of those concerned only with immediate sales and immediate promotion

Indeed the questions you put proved once more that the mere study of present day helicopters and equipment yields nothing more than a negative result If the helicopter is operated in the manner of a high lift airplane, it becomes nothing more than an expensive high lift airplane True enough, the high lift airplane allows a pattern of operations very different from that of the conventional air liner and so enables the town planner to envisage a compromise between the vast and distant airfield outside the city and the small roof top " helicopter stop " right in the business centre My own conclusion is that, broadly speaking, there is room for this compromise only in isolated cases

Either we must forgo the advantages of air services into the centre of cities or we must have a pattern of operation roughly as described that evening With few exceptions, there is no room for an intermediate solution You ask what are the advantages of air services into the centre of cities when you can travel from Coventry to London in $1\frac{1}{2}$ hours ? The answer is that in the middle of the 20th century the distance between London and Coventry can be covered in about $\frac{1}{2}$ hour, by the kind of fast helicopter that is possible today In $1\frac{1}{2}$ hours travelling by a modern transport airplane you should be not in London but in Rome Of no less importance is the fact that helicopter services would be frequent and so would not oblige you to adjust your own timetable to that of the few good trains It is this infrequent train service which makes in many cases the road more attractive than the train, although there is no other justification for the road either in economy or speed and the motorcar is really a vehicle appropriate for families to roam about in comfort

The object of the series of lectures and other contributions from development engineers given on the 10th February was to show that a pattern of operations is possible which will accomplish the 35 minute journey between London and Coventry at frequencies of departure of 5 minutes in the rush hour and whatever the traffic will require at other times The essence of the proposition is that these services can be established at a cost roughly of 1st class rail travel No *railway* project can possibly approach this quality of communications *at the same cost*

One speaker has asked whether the rooftop helicopter stop could be put on the roof of a railway station Our object was to show that the rooftop station can be narrow enough to be put anywhere It I am asked whether I believe in helicopter stops on top of railway stations, my answer is that I do not believe in railway stations under helicopter stops

Moreover, the introduction of helicopter passenger services in this country with all their equipment and civil structures will demand a capital expenditure of about 100 million pounds This is the cost of two or three trunk roads, and 1/10th of the railway modernization cost It is difficult to understand how this country which must seek ways and means of improving its efficiency and amenities with the minimum

capital expenditure can possibly ignore such a promise, or even wait until the armed services have made up their mind

If you follow this argument you will perceive that once we change the airline approach into rotorline operations we achieve immensely improved communications at reasonable cost You will realise that whatever preparation you have made in Coventry will not in the long run be in vain

Indeed, if I may rely on your sense of humour I am sure you will appreciate in this context the story of the little boy who was told by his mother to go and wash his face because Uncle George was expected The little boy replied with great resentment " I know what is going to happen, Uncle George won't come and I shall be sitting here like a fool with a washed face "

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## Written Contribution received from Mr P A Hearne

In compiling these papers, Mr SHAPIRO had let his very fertile and optimistic imagination swamp his objective assessment of the possible developments in this field Since 1948, British European Airways, in conjunction with the Ministry of Transport and Civil Aviation, had been studying the field of all-weather helicopter operations and, as a result of a great deal of scientific effort and experimental flying, had made some very practical contributions to it

It would be unfortunate if Mr Shapiro were to assert that his own *opinions* were of greater value than other peoples *achievements* It was undoubtedly true to say that vertical approach under completely blind conditions could be achieved but the means of doing so would be far more complicated than those required for the low forward speed approach Moreover the possibilities of equipment failure would be higher and, as would be obvious to all who had read the lecture, a missed approach and landing would mean total destruction of the aircraft and its occupants due to landing half off the roof or striking the side of the building

In a different vein, the lectures had either minimised or ignored some very real objections to small roof sites in general Briefly some of these are

1 Off-schedule arrivals and departures will cause prohibitive congestion on the roof or else entail appreciable stand off periods

2 Mechanical failures, *e g* , engine failure, mean that some major engineering operations will have to be undertaken in quite unsuitable conditions Coupled with (1) above, even minor mechanical delays, *e g* , radio failure, would dislocate the site's operation

3 Any form of accident might be far more serious due to the possibility of the aircraft falling over the edge and the lack of adequate crash facilities

4 The loading and unloading of baggage will take more time than that quoted in the paper

5 International helicopter operations will form a major portion of any civil helicopter activity and will necessitate full customs facilities at the site

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## Mr Shapiro's written reply to Mr Hearne

I am able to deal rationally only with the factual points raised by Mr Hearne

1 This matter has been considered at some length in conjunction with the Navigational Aid A detailed examination would demand a lengthy discussion but the result of our tentative planning of operations is that there is no cause whatsoever to fear more than 15 minutes of stand-off periods Congestion on the roof is of course impractical just as it is in a tube station The spare space is for emergency only

2 Mechanical failures are either truly minor in which case operations are continued or they are such as to withdraw a machine from operation If so, the machine is flown away to a base site The machine can be safely flown away when unloaded even with one engine inoperative If the rate of withdrawals of London tube trains is achieved, we can be satisfied I see no reason why this should be impractical

3 The operation into the heart of cities must be either safe or inadmissible

Of all the operations so far planned the operation proposed in the paper is the safest This is unchallengeable in principle for two reasons

(*a*) The machine remains within a zone of a possible accident for a shorter portion of its journey than in any other type of operation

(*b*) The machine is always guided in the same manner and affords to the pilot the greatest familiarity with ground features

The discussion of safety in rhetorical terms without the objective means of judgement indispensable for the evaluation of very small probabilities is not only futile, as I pointed out already, but a positively irresponsible exercise First impressions can be most misleading Road safety statistics show that there are more accidents per vehicle mile on straight runs than in curves, more by day than by night and more in good weather than in bad Safety cannot be discussed at all in terms advanced by Mr Hearne

4 The figures for loading and unloading quoted in the papers were those observed under circumstances where *real* operations take place which have some similarity with those discussed in the papers Mr Hearne's objections are entirely imaginary

5 The difficulty in Customs facilities lies in the nature of the operation of which they form part The Customs clearance in circumstances which approach the type of operation envisaged here is known from *experience* to present no problem at all

The introductory part of Mr Hearne's written contribution cannot be treated seriously As between comedians, readers will have to decide whether Master Shapiro must write 100 times " People with new ideas should be seen and not heard or Master Hearne 200 times " I must gladly suffer Shapiro and other fools to believe that their opinions are of greater value than my achievements "

Railways came about because at one point some people thought that their opinions were of greater value than the achievements of the stage coach It is not for me to judge whether this comparison is disrespectful to the stage coach or to the B F A helicopter services

Operators gain knowledge from experience Helicopter operators have gained a little knowledge from a little experience A little knowledge is proverbially dangerous It is true that proof of the pudding lies in the eating, but if you eat all your puddings you have proved nothing



https://doi.org/10.1017/S2753447200003954 Published online by Cambridge University Press