If through-flight, Station master communicates number of vacant seats to flight-lift operator

Woman flight-announcer can act as attendant in cases of sickness, etc

COSTS

A INITIAL OUTLAY

Mechanical Equipment			
Lifts		£10,000	
Transmitters		£12,000	
Fire extinguishing		£2,000	
Petrol and Pumps		£2,500	
	TOTAL	£26,500	
Building 234,500 *cu ft*			
Superstructure at 1/3d cu ft		£12,000	
Finishes and General services		£40,000	
15% for all fees, etc		£7,800	
	TOTAL	£59,800	
	GRAND TOTAL		£86,300

B RUNNING COSTS

Renewal, maintenance, ins interest		
Building at 10%		£7,800
Equipment at 25%		£6,500
Staff		£8,000
Power, light, rates		£2,700
Contribution traffic control		£2,000
	TOTAL	£27,000

3

SOME PROPOSALS FOR HELICOPTER APPROACH AIDS

By L J WARD, B Sc (TECH), A M I E E

I am going to describe some proposals for landing helicopters on restricted areas under conditions of zero visibility, using radio techniques

There is a natural tendency when considering a problem of this kind to extrapolate from earlier techniques In this case, say for those techniques evolved for fixed wing aircraft This is not necessarily the best approach I consider it important that one should start without too many pre-conceived ideas based on current techniques

The particular problem which I am going to discuss was originally put to me as follows —

Would it be possible to devise a vertical radio beam such that a helicopter fitted with a suitable receiver and indicating device, could be guided vertically down the beam, to land ultimately on a very restricted area The answer which I am giving to this question is " Yes, the design of such a set down system is in essence a very simple problem " I will describe presently how this can be achieved In my opinion the largest unknown in the system is not the set down process but whether or not an intermediate navigational system is required to transfer the aircraft from its normal navigational aid (which might be Decca for example), to this set down beam

From the limited investigation which has been carried out so far it is difficult to say with certainty whether or not this intermediate aid would be required It is quite likely that further research on the possibility of extending the cover of set down beam to obviate this intermediate phase would be successful

I do not propose to describe a possible intermediate aid, but will now concentrate on the proposed method of operation of the set down system

For those who are familiar with auto-follow radar the principle is somewhat similar to the conical scanning process We start with the small aerial on the ground the directivity of which *i e*, polar diagram as is shown in Fig 1

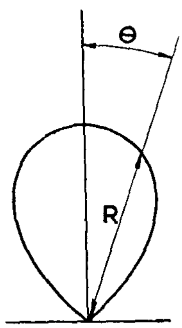

FIG 1

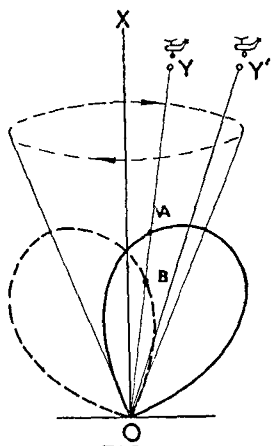

FIG 2

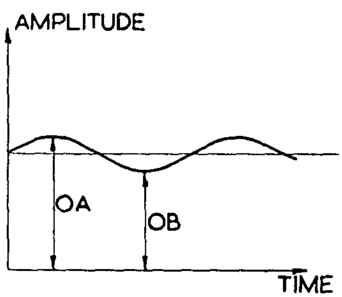

FIG 3

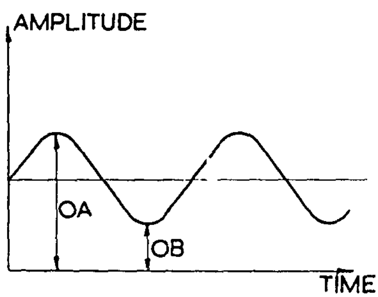

FIG 4

Since small aerials are more convenient than large ones, and since we shall want to rotate it as will be seen in a moment, we are forced to use high frequencies This follows from the fact that for a given polar diagram the higher the frequency the smaller the aerial

I am proposing that we use wave lengths in the centimetric region, and if time permits I will discuss frequency allocation at the end The aerial diameter at these frequencies will be of the order of only a few inches The associated electrical equipment could probably be accommodated in a 3 ft cube The aerial system would be protected by an electrically transparent window flush with the level of the landing deck

This aerial will be arranged to rotate about a vertical axis, and at the same time its electrical axis will be tilted so that the axis of the beam will describe a cone about a vertical axis as seen in the next diagram (Fig 2)

It is now not difficult to see how such an arrangement can be used to form the basis of a set down aid

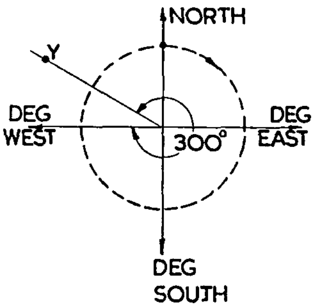

FIG 5

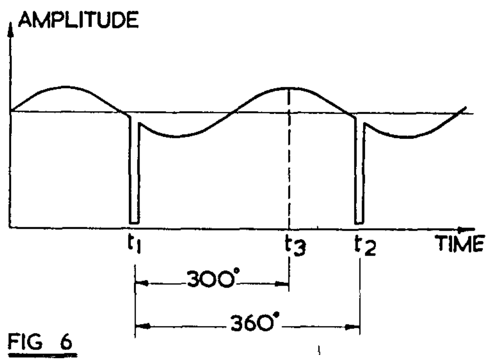

FIG 6

The ultimate object of the system is to guide a helicopter down the vertical axis OX If a helicopter is situated somewhere off this axis at Y′ then a suitable receiver in an aircraft would receive a fluctuating signal The signal would be maximum when the beam is to the right and of magnitude proportional to OA and the minimum when the beam is to the left, and of magnitude proportional to OB, thus the output of the receiver would be of the form shown in Fig 3

When the aircraft is still further away from the axis OX say at Y′ the depth of modulation of this signal would be even greater, as shown in the next diagram, Fig 4 As the aircraft moves towards the axis OX depth of modulation decreases until when it is on the axis there is no modulation at all Thus we have so far devised a means which can be used to tell the pilot how far away from the desired vertical axis he is However, we are still in difficulties because there is nothing as yet, to tell the pilot in which direction he must move to approach the axis He is simply told he is off axis, but has no idea at all in which direction he must fly to reduce his distance, *i e*, to reduce the depth of modulation of this received signal

This difficulty can be overcome as follows —

Referring to the next diagram, Fig 5, this is a diagram of the beam seen looking down from above The two co-ordinates are degrees of axis OX Thus the dotted circle represents the path of the beam axis Suppose an aircraft is at Y, *i e*, at a bearing of approximately 300° relative to the scan axis Distance OY is a measure of the angle between the line joining the aircraft and transmitter and the vertical If we now arrange to indicate to the pilot in some way the instant when the beam is pointing due north, say for example, by suppressing the beam for a very brief instant, then the signal which would be detected in his receiver would be as seen in Fig 6

On this diagram the instants of time t_1 and t_2 are when the beam is pointing due north, the time between t_1 and t_2 being that time that the beam takes to make a complete revolution, and the instant t_3 where the signal is the maximum corresponds to the instant when the axis of the beam passes through the aircraft

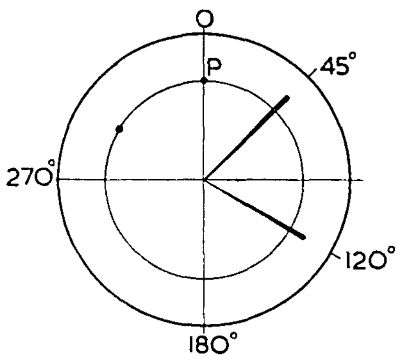

FIG 7

If the pilot were able to see this last diagram he could deduce from it his bearing relative to the scan axis, and make the necessary flight corrections (assuming he knew his aircraft heading)

Thus as drawn since the distance between t_1 and t_2 corresponds to 360°, T_3 will correspond to say 300° approximately, *i e*, the aircraft bearing relative to the scan axis as is shown at Y in the previous diagram

As described so far, the system has no practical utility, until we devise a successful means of presenting all this information to the pilot in such a way that he can easily interpret the information and act accordingly

The way in which I suggest this could be done is as follows —

The main display would consist of a small cathode ray tube say 3″ diameter, on the face of which the spot will be caused to rotate continuously (see Fig 7) This spot will be synchronised with the received signal so that it executes a complete revolution each time the radar beam makes one revolution, and it passes through the point P each time the beam points due north

This is easily achieved by extracting the zero strength signals from the main signal and synchronising the spot to them (Rather like the T V synchronisation process)

Next, the instant that the signal strength is at maximum can be detected This corresponds to the instant t_3 on the previous diagram, and can be used to cause the spot on the cathode ray tube to temporary increase its brilliance Thus we have on the end of the cathode tube a display corresponding to the diagram which I showed previously representing a view looking vertically down the beam To complete the picture we need only now provide on the face of the cathode ray tube an indication repeated from the magnetic compass showing the direction of heading of the aircraft

This can be presented in a variety of ways A convenient method would be to draw a radial line to act as a pointer The pilot can now see exactly what he has to do to get his aircraft on to the axis of the set down beam

Thus as drawn the aircraft heading is 45°, the pilot has therefore to increase his bearing to 120° to enable him to fly on to the scan axis As he increases bearing the radial bearing line turns in a clockwise direction and when it reaches 120° the pilot knows he is on course As can be seen from the diagram the pilot does not have to do any mental arithmetic—the necessary course being given when the radial compass line points away from the spot as shown

As described so far the system is capable of giving the pilot *directional* information only Or in other words, in the servo terminology we have devised an error indicator which gives sense only The system still lacks an essential feature, a feature necessary for all servo systems After all the system which I have described is only a servo system with a human error detector and controller The missing feature is an indication of the magnitude of the error Without this the system is liable to hunt—in other words the pilot will be over correcting, since he will have no idea of his distance to go and will therefore be unable to anticipate and reduce the rate of correction as the error diminishes

This last requirement is easily met by making the diameter of the circle which the spot on the C R T makes proportional to the depth of modulation of the received signal (as seen in Figs 3 and 4) and therefore proportional to the distance of the aircraft off the scan axis

The sequency of operation would therefore be as follows —

The pilot navigates by means of his "navigational" aid till he is as near to his destination as his aid will take him At this point he switches over to his set down aid (we are assuming an intermediate aid is not necessary) and he sees the circle at full diameter (unless he is remarkably lucky and is exactly over the spot where he should be) and he sees the brightened spot somewhere on this circle He now alters his aircraft heading until his compass line is in line with, and opposite to this spot and he proceeds on that bearing, as he does so the diameter of the circle will shrink and the spot will approach the centre of the tube face until he is exactly over the transmitter The spot will then be exactly at the centre of the tube face If he now over-shoots the spot will continue in the same direction over the tube centre and eventually lie somewhere on the compass line The pilot now reduces the over-correction as desired Presumably in the case of the

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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