The Navigation of the Helicopter

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A Lecture presented to the Helicopter Association of Gt Britain, 25th September, 1948, in the library of The Royal Aeronautical Society, London, W 1

H A MARSH, A F C , A F R Ae S , IN THE CHAIR

Introduction by the Chairman

Ladies and Gentlemen,—As you know, this is the first lecture of our 1948 49 Session—a series which I am sure you will find both interesting and instructive It is also the first time we have been privileged to use this room for our Meetings and our thanks are due to the President and Council of the Royal Aeronautical Society for granting us this facility

Our lecturer today has chosen a subject which is becoming of very great importance now that Helicopters are being used in a definite operational sense Mr Usher is peculiarly well suited to talk to us on "Navigational Aids to the Helicopter" as he is qualified as a R A F Advanced Specialist Navigator, and has some experience of Helicopter Pilotage He is a Fellow of the Royal Meteorological Society and an Associate of the R Ae Society and, needless to say, a Member of our Association and also holds the Bachelor of Science Degree and Diploma of Education—both of London His present appointment is with the Ministry of Civil Aviation as a Member of the Examining Staff for Personnel Licences, and as such will obviously have a very close contact with Navigational problems

A cordial welcome is extended to our visitors, also to those new members who have not previously attended our meetings

Mr R W USHER

Introduction

The helicopter is designed to provide air facilities which fixed wing aircraft cannot supply, *i e* , short range trips with the minimum amount of inconvenience to passengers, and the maximum speed of transit It has been variously estimated that the helicopter is more efficient from the point of view of the time factor than other forms of transport over distances between 250 and 400 statute miles Making an allowance for the optimism of the enthusiast and for adverse weather conditions, which affect

The author wishes to thank the Director of Meteorological Services for the courtesy to utilise the above figures and for the valuable criticism of this paper made by members of his staff a resume of which is available in the full paper

helicopter operations more seriously than fixed wing aircraft, it may be assumed that the estimated distance for the efficient transit of passengers and/or freight is 200 statute miles

For the United Kingdom helicopter operations will first assist fixed wing operations, and eventually supersede them completely within a relatively short period, when the larger type helicopter is available The purpose of any paper on Navigation will thus be to review the present method of internal transport, and then put forward the basic requirements for the helicopter to do, at first, precisely the same work, and eventually to increase this work, as the fixed wing aircraft What is more, the criterion must be that the use of helicopters for internal transport will be more efficient than fixed wing aircraft

From the figures issued by the British Division of the British European Airways the initial target becomes —

Passenger load factor 63 4%
Revenue load factor 53 4%
Average passenger load 6 9 persons
Average freight load 1,289 lbs
Annual utilisation 1 156 hours
Percentage regularity of service 95 2%
Average length of stage 102 st miles
Average length of hauls 137 st miles passenger , 150 st miles freight , 130 st miles mail

Note The figures quoted are for the period April, 1947, to February, 1948

Stage Distance It has been shown that up to 200 miles, or even further, the helicopter is more efficient than the aeroplane Thus nearly every one of the stages completed by B E A British Division fall within this category

Load Helicopters are in the prototype stage which will carry either

(i) 3 passengers or 750 lbs
(ii) 12 passengers or 4,200 lbs
(iii) 24 passengers of 8,500 lbs

These latter two types will be able to handle the average loads as stated in the above figures

Annual Utilisation is an engineering problem, and outside the scope of this lecture It seems possible that the helicopter will become as mechanically efficient as the present aeroplane

Regularity of Service The average figure of 95% is the initial target, and it is with this figure in view that the main thesis of this paper is concerned To arrive at a reasonable statement of the problem the paper is set out in the following form —

Part II The need for a navigation aid
* Part III The navigation aids that are available
* Part IV The requirements for helicopter navigation and the aids that meet these requirements, at least in part

Before discussing the subject of Navigation is it advisable to examine the present position in the U K and at the same time remember that the provision of navigation aids for the helicopter, if required, should not greatly increase the present telecommunications system Also, it is submitted, that

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Parts III and IV were not delivered as part of the Lecture but are available in the Association Library for reference helicopter operators should bear in mind when ordering navigation equipment, or asking for its provision by the State, the initial cost of installation, operation, and maintenance, and compare this with the increased services that such systems would provide It may well be that the cost of installing such navigation aids will far outweigh the benefits that will accrue from their utilisation

The present situation Most of the flying taking place in and over the U K does so during daylight hours In fact is it questionable that night services in this country bear any advantage over rail transport when the important question of passenger comfort is discussed

It would appear that there is little call for night services for passenger traffic at least in the U K internal services Thus it may be established that the majority of the civil flying in the U K will take place during the daylight hours

To accommodate this traffic, which is a substantial proportion of the total air traffic into the U K , a vast organisation has been created

> *Aerodromes* There are 132 aerodromes in the U K available to civil aircraft Of these 62 are civil aerodromes, 50 are R A F aerodromes, and 20 private aerodromes Of this total 71 have no facilities for night flying and 5 have limited facilities Of the civil aerodromes, 34 have no facilities, 5 have limited facilities, and to this list must be added 18 private civil aerodromes which also have no facilities This substantiates the assertion that much of the air traffic in the U K is solely in the daylight hours
>
> *Telecommunications* To assist this air traffic and provide information for control purposes a comprehensive network of radio stations and installations is available Details of this may be found in " Notice to Airmen," No 16048 and Amendments

Note Not all these systems and aids are used exclusively for internal net-works It is difficult to separate the utilisation of the telecommunications net-work of the internal and international routes But if it can be shown that the helicopter can replace the aeroplane on all internal routes, then the country will require about eight major airports to handle the international traffic, and a number of small landing areas to handle the inter-connecting helicopter services These landing areas can be situated close to, or inside, the towns, thus increasing the over-all speed of passenger and/or goods transit There are further considerations —

(*a*) There would probably be a reduction in the telecommunications net-work
(*b*) There would certainly be a reduction in the number of airfields available for civil aircraft, and, as a consequence,
(*c*) The land could be returned to use for the production of food

The Problem of Navigating the Helicopter

THE NEED FOR A NAVIGATION AID

Purpose

The purpose of this paper is to attempt to study the need for a navigation aid for helicopter operations, and the advisability of introducing ground aids To date, it has been assumed that the helicopter must be equipped with a blind flying panel and a reliable navigation aid before it can operate commercially with safety and regularity This paper attempts to show that, except for certain limited areas at definite periods of the day, the helicopter can operate during *daylight* hours with up to 98 per cent regularity of service without any additional equipment

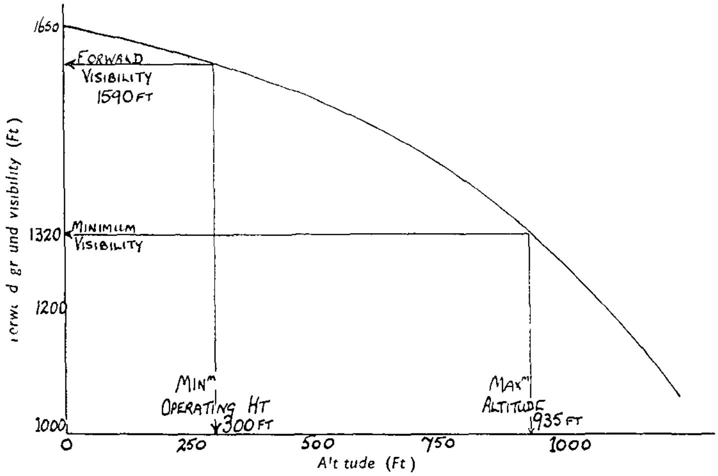
Factors preventing regularity of service

The phenomena which may interrupt any air operations of aircraft are —

Weather

Reduced visibility It has been reliably stated that the helicopter can operate in reduced visibility conditions of 440 yards with safety, and still maintain a schedule Thus at an altitude of 1,000 feet above the surface, to obtain a forward ground visibility of 440 yards, the slant visibility will

DIAGRAM 1 The visibility condition is 550 yards



have to be 550 yards Diagram 1 shows the relationship between forward ground visibility and slant visibility The figure of 1,000 feet altitude is taken because it seems unlikely that the helicopter will operate at much greater heights than this The number of occasions when the visibility is less than 550 yards is determined in the following paragraphs

The consideration of visibility must also include a mention of night flying The basic need for night flights must be

(*a*) increased stability of the machine ,
(*b*) a blind flying panel ,
(*c*) a navigation aid

These problems still await a solution, and although the Americans have granted Certificates of Airworthiness to the S 51 and the Bell 47 for operation at night the number of occasions when this will be possible will small, and at any rate too unreliable to assess for use with scheduled operations But because these problems have not been solved, there is no need to halt the commercial development of the helicopter for daylight operations

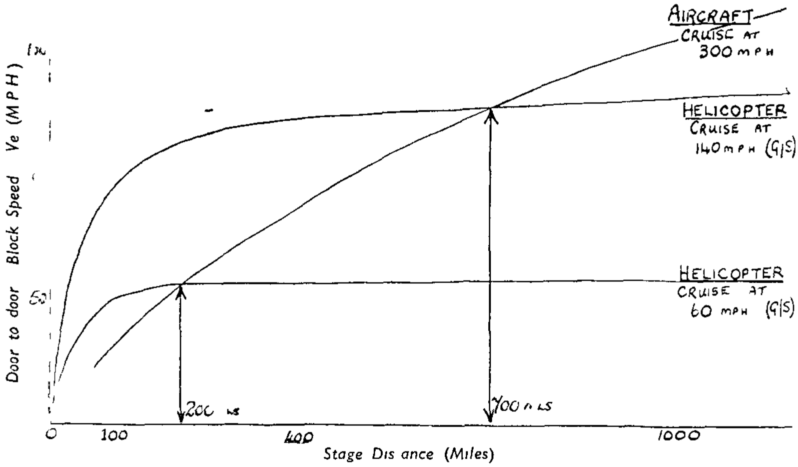
High winds It is inadvisable to operate the helicopter in high winds for two reasons —

(*a*) Starting and stopping the main rotor blades is complicated by the buffeting they will receive, which is likely to damage the blades

(b) From the point of view of this paper, the effect of the wind on the ground speed of the helicopter is more important If the limit of operation of the helicopter is in winds of 40 m p h , then with present-day machines, assuming an air speed of 80 m p h , the ground speed will vary between 40 and 120 m p h , depending on the assistance the machine is receiving from the wind of otherwise This will increase the cost of a single operation over a particular route, and will have to be allowed for in the final analysis of costing helicopter operations It would, for instance, have a considerable effect on the figures given for the comparative speeds of different transport systems (Raoul Hafner Lecture and article in " American Helicopter ") This is shown in Diagram 2, when the figures postulated by Hafner are subjected to a head wind of 40 m p h For interest, the same analysis is given for a tail wind component of 40 m p h in Diagram 2

Although this wind effect should be noted, the number of occasions when the wind exceeds this maximum figure is less than 1% of the total observations For the purposes of this analysis this item can be ignored

DIAGRAM 2



Low cloud base When the cloud is too low to offer a prospect of flight under contact conditions with safety then once more operations will have to be suspended This low height limit is taken to be 500 feet above the surface of the earth The number of occasions when this occurs as an isolated phenomena is small Usually, low cloud covering the high ground in the vicinity is associated either with high wind and/or rain Thus these occasions will be included in the reports for lowered visibility, and there is no need to make a special study here of this effect

From Diagram 2 it would appear safe to say that for distances up to 200 statute miles the helicopter is more speedy than any other form of transport This figure is also supported by Chawla, an American economist, who postulates a maximum figure of 250 statute miles, and our President, Mr Marsh, who also has estimated this distance as 200 statute miles

Rain Rain generally lowers the visibility to approximately half that prevailing in clear conditions at the time Thus the occasions when this phenomena is likely to interfere with helicopter operations by lowering the visibility will also be included in the visibility figures It is assumed that the helicopter will be able to operate in light rain which does not reduce the visibility to less than 550 yards, although at the present time it is feared that the main rotor blades will suffer damage by pitting The introduction of blades made by substances other than fabric will overcome this problem

Snow No known information is available on the behaviour of the helicopter under icing and snow conditions In any case snow reduces the visibility below 550 yards and is thus included in the visibility figures Icing is not assumed to present a difficult problem as the helicopter pilot will not enter ice-forming cloud The problem will be overcome for the present by default rather than solution

Comment These weather phenomena can all be included when a study of the reports of visibility is made The number of occasions when one of the above phenomena occur and *at the same time* the visibility is greater than 550 yards is assumed to be negligible

Mechanical Unserviceability

This effect will also reduce the regularity of helicopter operations but is overcome by the introduction of reserve machines This problem does not fall into the compass of this paper, but is one that should be discussed when the ecomonics of operating the machines is studied

Provisional Target

The helicopter is to augment and finally supersede the air transport services at present available in this country Thus the first target is to equal the figures issued by the B E A British Division for passengers carried, freight carried, utilisation, and regularity of service The relevant details are —

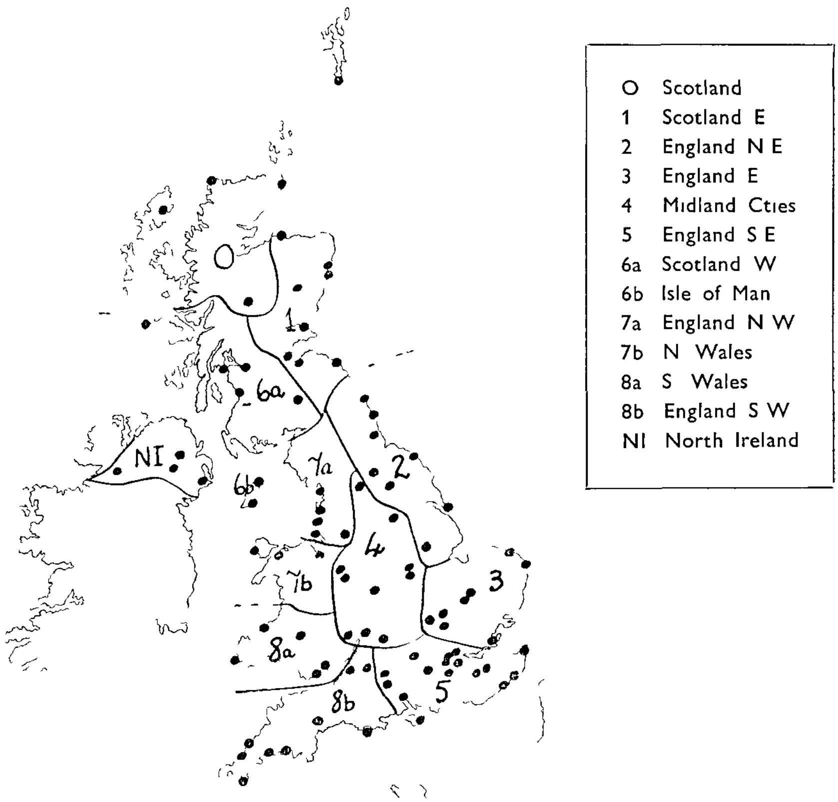
Passengers carried per aircraft-trip 7
Freight carried per aircraft-trip 1,289 lbs
Average length of haul 133 statute miles
Annual utilisation 1,156 hours
Percentage regularity 95%

As it is anticipated that the helicopter will operate over short distances, less than 200 statute miles per stage, and the new machines, at present in the prototype stage, will be designed to cope with the above passenger and less than 200 statute miles per stage, and the new machines, at present in freight loads, the two factors left for comparison are the annual utilisation, and the percentage regularity of service The former will be studied in any analysis of the economics of operation of the helicopter The latter is the basis of study of this paper, and the figure of 95% regularity of service is taken as the minimum requirement for this initial stage

Method

The British Isles was divided arbitrarily into thirteen areas corresponding with the division of the Meteorological Office (see Diagram 3) A number of Reporting Stations were selected for each area and the endeavour made that the area was adequately covered for synoptic information This was accepted on the premise that the helicopter will operate, in the main, either local services of a radius of 80 statute miles from the base to augment and

DIAGRAM 3 REPORTING STATIONS AND AREAS



feed other air services, or direct stage distances of not more than 200 statute miles This latter would cover two of the areas and both would have to be studied to obtain a reasonably accurate estimate of the regularity of service that may be expected on such a route Despite this arbitrary choice of areas and Stations it is felt that any change in this division of the country would not materially affect the final conclusion

The synoptic reports from these Stations for each of the areas was studied for the period 1942-46 inclusive A five-year period was considered the minimum to obtain reliable results The visibility reports only were studied, as explained on page 32, and in order to standardise these readings, the reports given at six-hourly intervals were considered to be issued in the middle of such an interval, *e g*,

Report at 03 00 hours valid for 00 00-06 00
Report at 09 00 hours valid for 06 00-12 00
Report at 15 00 hours valid for 12 00-18 00
Report at 21 00 hours valid for 18 00-24 00

Also for the years 1942-44 reports were issued at 07 00 and 13 00 hours These were considered to be virtually the same as the 09 00 and 15 00 hour reports, and were included with them In order to conform with para 1, page 27, the reports were split into day and night, day being considered to last from 06 00-18 00 hours This would have the effect of making the results of the analysis conservative, as the figures would include part of the winter night hours when flying would be restricted by conditions other than the visibility, and they would exclude the periods in the summer months when good flying weather is experienced up to 22 00 hours

From the reports sub-divided in this manner, the visibility conditions were compiled for each of the meteorological code figures, and the results tabulated From these figures the percentage of the occasions when the reports gave a visibility Code 2 or less (550 yards or less) were taken for each of the areas

Note The Tables on which the final Table I was constructed are included in the full paper in the Association Library

These percentages were then summarised for the five-year period see Table I

In the preliminary Tables used to construct Table I the figures are given for the night observations although no detailed analysis is made of these figures Both the S 51 and Bell 47 have been given Certificates of Airworthiness to operate under contact conditions at night, *i e*, provided that a natural horizon is available In order to obtain an approximate figure of the expected regularity of service of such an operation the minimum condition for the visibility is taken as 2 25 statute miles, *i e*, Code figure 6 This approximate figure will not consider the effect of moonlight on such operations

Results

Day From Table I it will be seen that over the five-year period the number of occasions when a helicopter, as at present equipped, cannot operate varies with the area, and in no case exceeds 5% Thus at the present time the helicopter can give a 95% regularity of service

This means that any navigation aid will have to increase the regularity of service from 1-4%, assuming that the best figure to be obtained for regularity of scheduled operations if 99%, which is high when compared with other forms of air transport

Because of the very small increase in regularity that must be attained, the navigation aid may not be of a universal nature, such as GEE, because the aircraft utilisation of this aid will be so small as to make the actual cost of operation in terms of improvement of service quite high

Thus the aid required will have to be of a local nature, providing homing facilities with light equipment in the aircraft This is to allow the aircraft to have maximum payload, and not have to carry a navigation aid* which will occupy space and weight, when the number cf occasions on which it

*_Note_ It is proposed to discuss the navigation aid required on another occasion

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is to be used will be small, and thus increase the actual cost of operating the equipment per occasion used

The regularity of service compares favourably with the figure achieved by B E A British Division Also it should be noted that the helicopter will be able to achieve a better door-to-door time for each of the stages of the flights This factor of 95% can be improved in the near future

The B E A helicopter operations should, according to these tables, have achieved a regularity of serv ce of 98% in the Yeovil area The figure obtained was 96% regularity of service during the worst flying months of the year For the Norfolk area, with operations taking place in the better flying weather, June-August, the figure should be better than 97 7%

The helicopter, as it is equipped at present, can achieve a better figure for reliability of service than the fixed wing aircraft without the aid of a blind flying panel or a navigation homing aid This is true of *day flying only*, but the majority of British internal services operate during the day

TABLE I

OBSERVATIONS SUMMARY, YEARS 1942-46

The following Table is a Summary of the results for the period concerned The percentage of the occasions when the visibility is below the prescribed minimum of 550 yards is tabulated against the areas concerned, and an average taken over the five-year period

AREA	1942	1943	1944	1945	1946	Minimum Average
Scotland, N	1 2	1 2	2 0	1 0	1 9	1 5
Scotland, E	1 1	1 2	1 3	1 4	1 5	1 3
Scotland, W	1 6	1 5	1 0	1 8	1 3	1 4
Isle of Man		0 2	0 9	1 7	0 6	0 9
England, N E	2 4	4 1	2 9	2 4	2 8	2 8
England, E	1 8	2 6	3 2	2 0	1 8	2 3
Midland Cities	4 6	4 9	4 5	4 9	3 0	4 4
England, S E	2 7	3 1	2 5	3 4	1 8	2 7
England, N W	3 6	3 6	3 0	4 5	2 4	3 4
N Wales	1 2	1 8	0 9	1 0	0 3	1 0
S Wales	2 4	1 2	1 8	3 1	1 3	2 0
England, S W	1 7	1 5	1 6	3 8	1 4	2 0
N Ireland		1 2	1 1	2 2	1 2	1 2

Anomalies in the Observations

There are a number of places which have reported throughout the year minimum visibility conditions of less than 550 yards for more than 5% of the total reports These places are listed in Table II At first glance this looks a formidable list covering large sections of the British Isles But in all cases except three the reports show that the reduced visibility is due to morning local fog which clears rapidly by mid-day All these mid-day figures show a reduction to less than 5% of the observations which falls below the prescribed limiting figure The places which report persistent minimum visibility of 550 yards on more than 5% of the observations are coastal areas away from populated areas, and the conditions are produced by persistent sea-fog

Note The full Table II is available for inspection in the full paper in the Association Library

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TABLE IA

The following table is a summary of the results of the same period when the visibility conditions are less than 1,000 yards Code 3 The figure for the expected percentage of occasions when the helicopter will be unable to operate owing to reduced visibility is nearer to the average in Table I than in Table IA An estimate is made of the expected figures by weighting the results obtained This is given in Table IA

AREA	1942	1943	1944	1945	1946	Maximum Average	Estimated Percentage
Scotland, N	2 6	1 4	2 4	1 5	2 5	2 1	1 6
Scotland, E	3 3	2 6	2 0	2 8	2 2	2 6	1 6
Scotland, W	3 6	3 0	3 0	3 6	2 6	- 3 2	1 8
Isle of Man		1 2	2 0	3 4	0 9	1 5	1 0
England, N E	5 0	6 5	5 2	4 8	5 2	5 3	3 3
England, E	3 6	5 0	4 8	4 0	3 4	4 2	2 7
Midland Cities	9 0	9 0	8 5	9 2	5 5	8 2	5 2
England, S E	5 4	5 0	4 0	6 0	3 6	5 4	3 3
England N W	7 2	7 2	7 0	8 0	7 0	7 3	4 2
N Wales	2 6	4 0	1 2	2 4	0 9	2 2	1 2
S Wales	3 6	2 0	3 4	3 8	2 4	3 0	2 3
England, S W	2 6	3 0	3 0	4 8	1 8	2 3	2 3
N Ireland		2 0	1 9	2 6	1 8	2 1	1 4

The table was weighted by allowing a balance of four times the average in Table I to one of the average of Table IA This purely arbitrary method of estimation is designed to bring the results near to the proscribed visibility minimum of 550 yards

This table also allows for a 20% error in the observations made under Code 3, *i e*, on 20% of the occasions that Code 3 was reported it was in fact so near the limiting figure of 550 yards as to preclude helicopter operations

To assist helicopter operations into these areas, the correct scheduling of aircraft would achieve the desired end It may be that some form of ground aid would also be desirable

Congested Areas

It is thought improbable that single-engine helicopters will be allowed to operate into towns unless the track follows a route which provides suitable landing areas in case of emergency These landing areas should be of the order of 300 by 150 feet, and spaced approximately half a mile apart Inspection of a number of towns will prove that few can offer this facility The figure of half-a-mile is derived —

The normal operating height will be 1,000 feet above the highest point on or near the track

The normal descent in autorotation will be at 1,200 feet per minute at 45 m p h indicated forward speed

Thus the time of descent will be 50 seconds plus time for " flare-out " and landing, during which time the helicopter will have travelled five-eighths mile Allowing a factor for wind, turning into wind, etc , the optimum figure becomes half a mile If the disc loading on helicopters is decreased, which is away from present development trends, then the glide may be made more shallow and the distance between landing areas increased

Thus the operation of single-engine helicopters into congested areas will be precluded

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TABLE II ANOMALIES OF THE OBSERVATIONS

A number of individual stations report less than 550 yards visibility on more than 5% of occasions These are listed below to show, except in three cases, this is only true of the morning or the evening reports, but that the phenomena causing the low visibility clears before mid-day and in the afternoon, allowing operations under the conditions that have been proposed

These stations are listed below, and the Table gives the morning, mid-day, and evening reports to show the clearance This is an important point, if it is proposed to schedule helicopter services into these areas

Place	1942			1943			1944			1945			1946		
Time of Obsvtn	9	15	21	9	15	21	9	15	21	9	15	21	9	15	21
Bidston Obsy										5	—	—			
Birmingham	10	1	2 5	6	3 5	4 5	7	2 5	3 5	7	—	—			
Boscombe Down				6	0	5	7	2	2	7	1	3			
Cape Wrath				6	6	6	8 5	5 5	5				5	4	2 5
Catterick	9	2 5	4 5	12	4	5									
Cranwell				9	2	2 5	6	2	2 5	5	1	4			
Croydon				8	3	7 5				5	2	2 5			
Driffield				5	2	2 5	5	1	1 5						
Dunstable	6 5	1 5	2 5	6 5	1	2	9	1	2						
Durham										7	8	3	6	1	4
Eskdalemuir										5 5	1	4			

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Place	1942			1943			1944			1945			1946		
Time of Obsvtn	9	15	21	9	15	21	9	15	21	9	15	21	9	15	21
Felixstowe							5	1 5	1						
Finningley							11	1 5	2 5	7 5	1 5	1	4 5	1	2
Greenwich	5	—	—	10	—	—	6	—	—	6	—	—	4 5	—	—
Harrogate				10	—	—	7	—	—	6	—	—	8 5	—	—
Kew	6	2 5	2 5	10 5	2	3	6	3 5	3 5	7 5	2	4 5			
Little Rissing							10	3	5	10 5	3	6			
Larkhill										7	1	0			
Linton on Ouse				9	1 5	1 5	8	2	3						
Littlehampton										7 5	—	3			
Lizard										8	7	7			
Lympne	5 5	1 5	2				9	2 5	3	7 5	2	5 5			
Manston				5	1	2									
Mildenhall				8	1	2 5	6 5	2	2						
Nottingham	13 5	—	—	13 5	—	—	13	—	—	11 5	—	—	8	—	—
Oxford	6	—	—	7 5	—	—	5	—	—						
Ross on Wye	6 5	1	1 5							6 5	1	3 5			
Renfrew	5	2	2 5							6	3	3	5 5	—	—
Ringway										6	2 5	2 5			
Rhayder										6	—	—			
S Farnborough	6 5	0 5	3	9	1	1 5	6	2	5	5 5	1 5	4 5			
Scarborough				7	—	—	6 5	—	—						
Scorton							5 5	2	2 5						
Sealand	5	1 5	1 5												
Southampton	5	—	—												
Southport	5	5	1 5							6	3	—			
St Ann s Head							6	4 5	5	6	5 5	6			
Tern Hill				5 5	1 5	2	8	1	1 5	7	1	5			
Thornaby				5	2	2 5									
Upper Heyford				8	3	2									
Wisley				7	—	—				6	—	—			
Honiley				10	2 5	3	7 5	1 5	2 5	7 5	2	4 5			

§ Where the spaces are vacant in the table, then the observations for that year do not exceed 5% for the number of times that the visibility is less than 550 yards

— indicates that the reporting station does not give returns for the times indicated

§§ for the years, 1942, 1943 and 1944, the reporting times were actually 01 00, 07 00, 13 00 and 18 00 hours instead of the 03 00, 09 00, 15 00 and 21 00 hours respectively They have been grouped with the nearest time

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From these figures it has been shown that the helicopter can operate with safety and a higher degree of regularity than the fixed wing aircraft over the British Isles The need for a navigation aid exists, and although it is an imperative requirement, it is subsidiary to the solution of the problems of greater stability of the machine, and the provision of a blind flying panel Apart from reasons of economy, if a navigation aid is required to facilitate expanded helicopter operations by day, it will require to be cheap, simple, light-weight, and easy to maintain both for air and ground installations To illustrate this point From any of the sets of figures in the tables used to construct Table I, assuming that the safe minimum visibility for fixed wing aircraft is 2 5 miles for contact flight, then there are approximately between 12 7% and 39 6% of the occasions when some aid is required As this figure is large, it is economically sound to spend a large sum of money on some form of instrument and navigation aids This is not true of helicopters, and the above observations are made

The form of the navigation aid which *may* be required for day operations is to be discussed in Part IV of this paper, but outlined it will probably be

A ground aid into congested areas, when allowed to operate, marking a safe track by lights every 400 yards or so, preferably leading from a homing beacon outside the congested area The helicopter will home to a beacon and then proceed in on a specified track, guided by ground installations *Or*

VHF D/F Homer A small light installation for homing on to a low power beacon with restricted range The same frequency can also be used for voice transmission

A radar homing aid This has the disadvantage of no speech transmission, but provides the helicopter with range and bearing from a fixed ground installation

Conclusions

1 The commercial development of the helicopter can be undertaken with as high a degree of reliability of service as at present given by the fixed wing aircraft, without the installation of any further instruments or aids

2 Ground aids can be introduced, in the first instance, at specified points only to assist operations into areas where the reduced visibility conditions tend to lower the regularity of service

3 During the interim period the problems of stability and of blind flying can be tackled and overcome

4 Useful data on the operation and economic servicing of the helicopter can be obtained in this period

5 Given para 3, the helicopter can be provided with navigation aids which will give it, for this country, a regularity of service and speed of operation which the present form of air transport cannot hope to achieve, even with the introduction of " all weather flying "

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MR A MCCLEMENTS VOTE OF THANKS TO MR USHER

It gives me great pleasure to thank Mr Usher, on behalf of the Association, for presenting to us today part of his paper on " Navigational Aids for the Helicopter "

That Mr Usher has chosen for his paper a subject of the utmost importance is obvious, and it is gratifying to us all to know that a man of his calibre is giving intensive thought to the overall problem We look forward with interest to reading the remainder of his paper which, I am sure, will be a contribution of the utmost value

From the discussion we have just heard, it is apparent that we have a long way to go before we reach a solution to our navigational problems acceptable to us all Nevertheless, so pressing is the need for an early solution, that we must proceed vigorously in our researches It is my impression that the technician must provide, before long, an aid which is both simple in presentation and accurate If he does not, commercial exploitation of the helicopter will be seriously handicapped because full utilisation by flying under bad weather conditions during day and night will not be possible as soon as we wish

I think it only remains for me to thank Mr Usher again and to request you to signify your appreciation in the normal manner

* * *

DISCUSSION

The Discussion following Mr Usher's Lecture will be reproduced in the next issue of the Journal