Some Economics of the Helicopter — Present and Future*

By L S WIGDORTCHIK, A F R Ae S

A lecture presented to the Helicopter Association of Great Britain on Saturday, 24th September, 1949, 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

The subject of the opening paper for our 1948/49 Lecture Session is, I am sure you will agree, of prime importance to all of us in the helicopter industry To my mind there is no point in spending time, money and energy designing and constructing helicopters unless they can be operated economically, although for any specialized application economy may not be so important

MR WIGDORTCHIK has put a great deal of work in the preparation of this paper, and although he will only have time to read a summary this afternoon, examination of the full paper, which will be published in the Association's Journal, will be well worth while

MR WIGDORTCHIK is an A F R Ae S , and was a Wakefield Scholar to the College of Aeronautical Engineering in London He was commissioned in the Technical Branch of the R A F in 1940, and from 1943 was engaged in Research and Development in connection with aircraft, and subsequently helicopters, holding an appointment in the Ministry of Supply in this respect He joined the staff of B E A Helicopter Unit in 1948 and is still with that Corporation

The discussion following the paper will be led by MR N E ROWE and AIR COMMODORE PRIMROSE, and should prove most interesting, as it is more than likely that these two gentlemen and others may hold very different opinions from those expressed by the lecturer I will now ask MR WIGDORTCHIK to read his paper

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* Owing to lack of space a summary only of the paper, *Some Economics of the Helicopter—Present and Future* by L S WIGDORTCHIK, has been published in this Journal (together with discussion) The full paper however, has been printed separately, as a Supplement to the Journal and is available to members, price 2/6 each, on application to the Association Headquarters

MR L S WIGDORTCHIK

Mr Chairman, Ladies and Gentlemen

I wish first of all to signify my appreciation of the honour of being asked to deliver a paper, at this time, on helicopter economics I am very much aware of the responsibility of discussing what is virtually the life-blood of the helicopter, for, with its predominantly civil future, the helicopter must pay its way to a degree hitherto unknown in aviation

Bearing this in mind, I decided that I would approach the subject from the commercial point of view My aim was to adopt the viewpoint of an impartial businessman who would only back a sound proposition In this way I felt that I might get a little nearer the true prospects At the same time, I felt that such an approach would evaluate the helicopter on the basis that will control its development into the major vehicle we all believe it to be

On these bases, therefore, I have found that the future of the helicopter is reasonably defined over the next ten years In certain fields it will be possible for the helicopter to show a profit—in others, only the promise of future profitable operations will justify the subsidies which will have to be borne The helicopter will support itself *now*, in specialized operations such as agriculture and the carriage of mails In five to ten years, it will be able to support itself in certain passenger transportation activities, over particular routes This decade will, I believe, see the successful establishment of the helicopter in its fundamental roles, and in the end the " acid test " will be its economy

I would like, at this stage, to record my appreciation of the permission granted me by B E A to deliver this paper and my gratitude to all of my colleagues and friends, both here and in America, whose help has been invaluable I must also state that the opinions expressed are my own and do not necessarily represent the views of the British European Airways Corporation

COMMUNICATIONS IN THE DEVELOPMENT OF HUMAN SOCIETY

If we are to put our prospects of the next decade in their true perspective, we must try and visualize the magnitude and nature of the eventual development of the helicopter For we have in the helicopter a form of universal transportation to become as important to society as the ship, the train, the motor car or the bicycle

Let us consider how the United Kingdom has developed over the last one and a half centuries The country in 1800 was agricultural, with towns situated either on the waterways or the tracks across the flat land, for these were the only communications Early in the century the invention of the railway brought into being the system of communications that was to change the country from an agricultural land into the " Workshop of The World " The result was to create major lines of communication radiating from London In this way, small centres of industry sprang up at the sides of the railways, living by means of the communications that the railways afforded The towns grew into cities, and the almost universal characteristic of their social and economic picture was that their trade and commerce was carried on with London or any other city that happened to be on the same railway Communication, and therefore trade, with cities on other railway lines was difficult and so the whole nature of the cities developed around the railways' convenience, just like a tree with a stunted growth One envisages the country covered by a series of radial spokes, with the people living in belts on either side

In 1920, the impact of motor transport began to be felt and roads were built, mostly along the flat land, sometimes across the hilly country , but these were still difficult and slow Large communities separated by such terrain lacked a rapprochement of interests, as they still do to-day We are a nation that lives essentially on a lattice work of communications Some of the lines are railways, others are roads, but there are areas between the lines which are still undeveloped and which have to be made accessible The private motor car has gone a long way towards filling the holes, the helicopter has a chance of completing the picture

Such a major change cannot take place quickly because it will take a very long time for the cities to change their economy such that they no longer live *only* along the spokes but across them Eventually they will, however, with the aid of the helicopter And the traffic, now potential, will build up into steady streams across the country in all directions—*that* is the part I visualize for the helicopter It is man's *first truly universal transport* For it will be the first vehicle to provide not Lines of Communication, but Areas of Communication over the land If I may be allowed to re-quote some of my own words—" The history of vehicles shows that they become really economic when mankind evolves his society around their potential " When a country lives truly on areas rather than lines of communication, then the helicopter will have arrived

The Economy of Commercial Operations

I have already said that the acid test of a commercial operation is whether or not a profit is made, and, made in a constructive manner And so a person wishing to operate helicopters must analyze the proposition essentially from that aspect For in the end the source of capital, be it private enterprise or the Bank of England itself, will be concerned with the percentage return for the capital invested Now the commercial operation of helicopters comes under the heading of producer business The operations produce ton-miles, passenger-miles or pounds of insecticide per acre and so on, but all of them units of production Therefore, the picture is that of the prime producer on the one hand and the potential market on the other We have three factors which concern the planning of operations —

Firstly, we have the Cost Curves of the helicopter which establish the cost per ton-mile, as it varies with the different operating conditions

Secondly, we have the Operational Requirement which the helicopter has to meet, which determines the optimum type and humber of helicopters to be used

Thirdly, we have the Operating Efficiency of the operating company, expressed as the financial return for capital invested

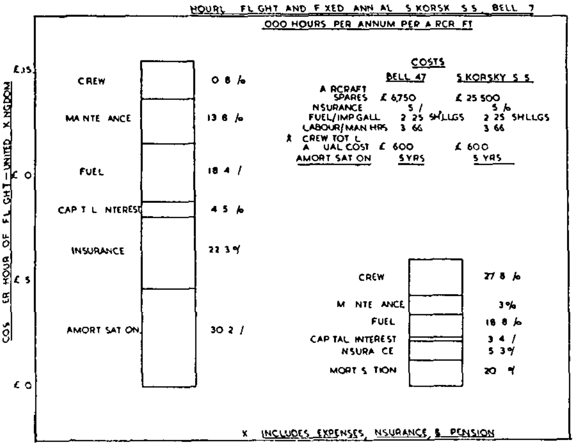
These factors are self-explanatory in definition but the operating requirement can bear further examination The man who wants to make paper, knowing what price he can get for it, examines various paper machines with a view to finding out which type will make the most money for the minimum outlay Just so with the helicopter , the cost curves have to be examined with the same object in view Analysis of this aspect immediately indicates that the rate of doing work combined with the limiting utilization will govern the yearly turn-over and through this, the profit Thus we have to consider the Cost Curves, the rate of doing work and the Capital Investment *against* the amount and nature of work required in the time concerned, the Limiting Utilization per helicopter per annum and the revenue per sold ton-mile

These are the basic principles of the economic analysis in my paper

The Experience of Helicopter Operators in Various Operations

The experience of helicopter operators is obviously of great importance in assessing future prospects In my full paper I have correlated and presented as much data as is available In this abbreviated presentation, however, I have space to

Fig 2



submit my findings only The evidence, I suggest, combines to demonstrate the following —

(1) The Sikorsky S 51 and the Bell helicopter possess a degree of mechanical reliability which permits them to be operated on scheduled operations and with utilizations of at least 1,000 hours per annum

(2) The target pilot-utilization of 900 hours flying per annum has been shown to be practicable

(3) The operating costs of these machines has stabilized to a known figure (see Fig 2), and there are fields of operation which can afford to pay the charges concerned

(4) The all-important need to extend permissible operations into IFR conditions is already well on the way to solution, as are the requisite ground aids

CHARACTERISTICS FUNDAMENTAL TO COMMERCIAL APPLICATION

The helicopter's characteristics are the key to the commercial applications There is first the physical ability to do the work There is secondly—the deciding factor—whether or not the work is worthwhile In most cases, the measure is whether or not the work is economically justified—does it pay ? There are other cases where the measure is the general service to the community

In order to facilitate an examination of the fields of application, I have created four types of helicopter and have analyzed their physical and economic performance The types are —

Type I, 200 h p , Type II, 500 h p , Type III, 1,000 h p , Type IV, 2,500 h p

Figs 3 to 10 present the basic operating and economic performances of these aircraft The curves shown in Figs 3 to 6 are based on principles established by MR PETER MASEFIELD* and are self-explanatory The curves in Figs 7 and 8 show the operating costs per hour for the smaller helicopters as they vary with utilization The curves in Figs 9 and 10 relate to the passenger-carrying helicopters and show the cost per capacity passenger-mile at various utilizations and with normal headwind variations

THE POTENTIAL OPERATING FIELDS

We must attempt to analyze prospects on the basis of what we have already experienced, the capabilities of the helicopters, and our own assessment of the potential business The fields which concern us are —

Commercial Passenger Transportation

The analysis concerns the provision of passenger services between city centres either within or out of the U K The vital characteristics are (*a*) Speed , (*b*) Reliability , (*c*) Cost , (*d*) Regularity , (*e*) Punctuality

These are the factors which govern the value of the service to the community

The vehicles in the passenger field and over which the helicopter has to show an advantage are (*a*) The bus , (*b*) The private car , (*c*) The train , (*d*) The train and steamer , (*e*) The aeroplane

Fig 11 shows a series of curves expressing Total Time against Distance Between City Centres Fig 12 shows the Total Cost against Distance Between City Centres

The helicopter is taken as having a scheduled block speed of 90 m p h and costing 7 7d per revenue passenger-mile between block distances of 75 and 200 miles This is an approximation on the performance of Type IV

THE POTENTIAL OPERATING FIELDS

Passenger Traffic

The helicopter can expect to find passenger traffic in two ways There is first of all *Existing Traffic,* which at present is carried by other vehicles Secondly, there is *Potential Traffic,* which will be gradually stimulated by helicopter services on routes where other vehicles cannot operate for geographical reasons

Existing Traffic In order to carry existing traffic the helicopter has to enter into *direct* competition with other vehicles Below 300 miles the helicopter is faster than any other vehicle But at the average figure of 7—8d per revenue passenger-mile, the helicopter is so expensive that it is only approached by the first class rail and steamer and the aeroplane out of the U K We can say, therefore, that the helicopter can compete on favourable grounds with the latter, but on internal routes, where it is at least twice as costly, the helicopter can only compete on speed How much, therefore, is the time saved worth ?

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* Some Economic Factors in Civilian Aviation Peter G Masefield, Journal R Ae S October 1948

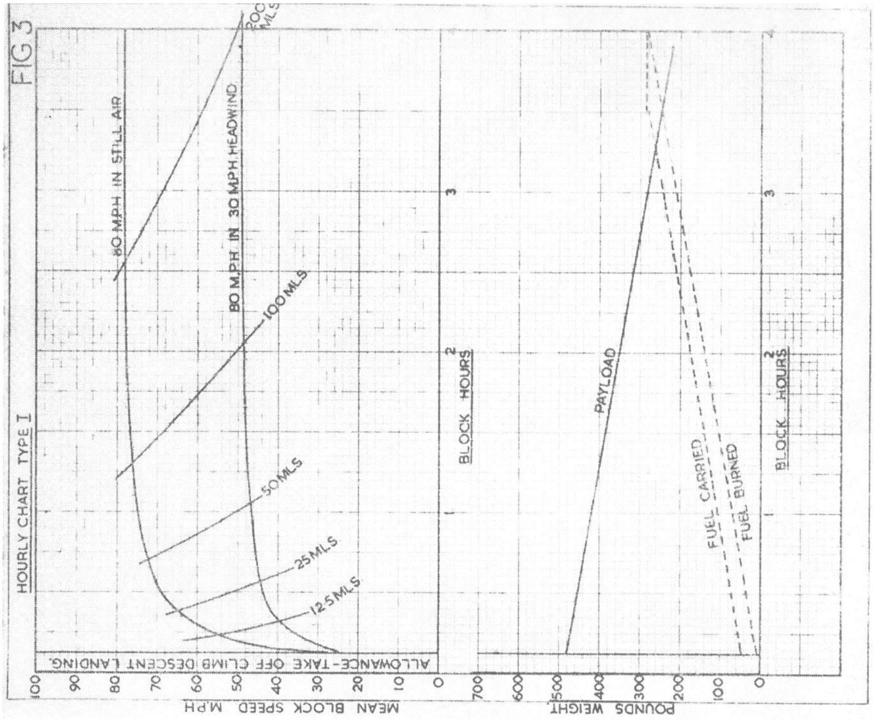


FIG 3
HOURLY CHART TYPE I
80 M.P.H IN STILL AIR
80 M.P.H IN 30 M.P.H HEADWIND
100 MLS
50 MLS
25 MLS
12.5 MLS
ALLOWANCE - TAKE OFF CLIMB DESCENT LANDING.
MEAN BLOCK SPEED M.P.H
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
BLOCK HOURS
PAYLOAD
FUEL CARRIED
FUEL BURNED
POUNDS WEIGHT
700
600
500
400
300
200
100
0

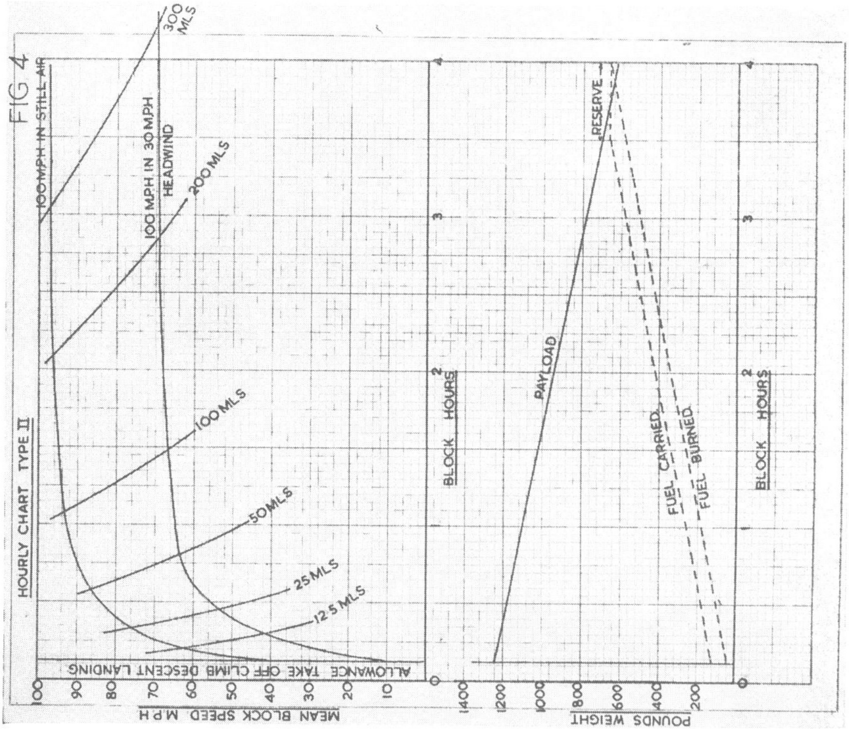
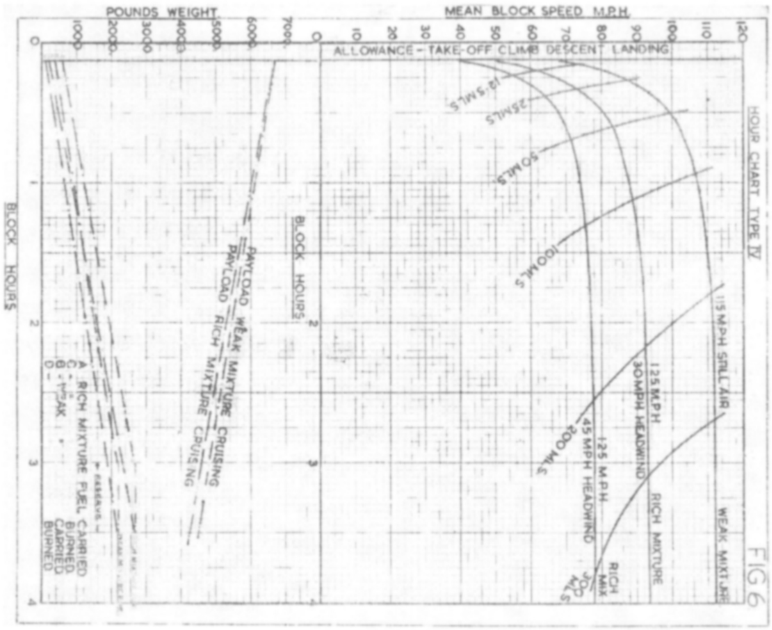
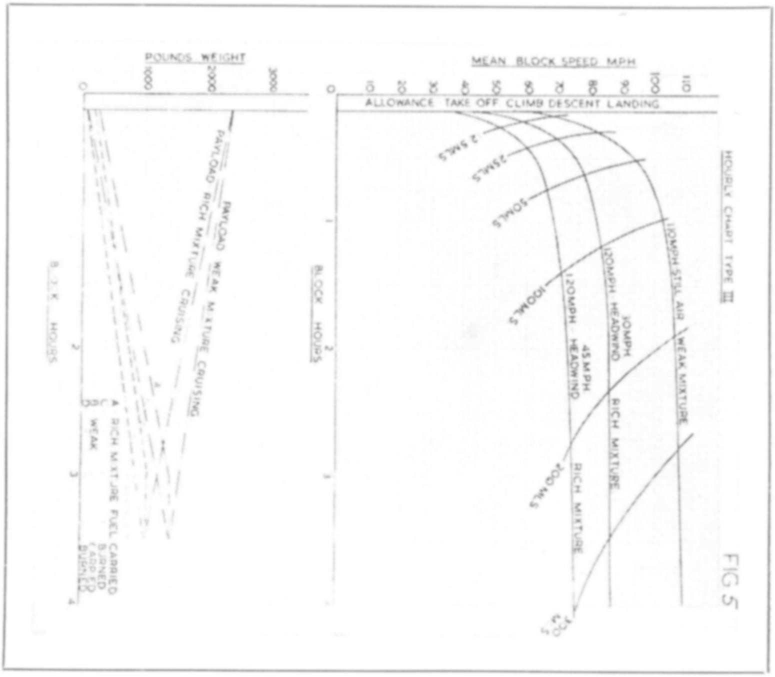


FIG 4
HOURLY CHART TYPE II
100 M.P.H IN STILL AIR
100 M.P.H IN 30 M.P.H HEADWIND
300 MLS
200 MLS
100 MLS
50 MLS
25 MLS
12.5 MLS
ALLOWANCE TAKE OFF CLIMB DESCENT LANDING
MEAN BLOCK SPEED M P H
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
BLOCK HOURS
PAYLOAD
RESERVE
FUEL CARRIED
FUEL BURNED
POUNDS WEIGHT
1400
1200
1000
800
600
400
200
0



HOUR CHART TYPE IV
POUNDS WEIGHT
0
1000
2000
3000
4000
5000
6000
7000
MEAN BLOCK SPEED M.P.H.
0
10
20
30
40
50
60
70
80
90
100
110
120
ALLOWANCE – TAKE-OFF CLIMB DESCENT LANDING
12·5 MLS
25 MLS
50 MLS
100 MLS
200 MLS
400 MLS
115 MPH STILL AIR
WEAK MIXTURE
125 M.P.H
30 MPH HEADWIND
RICH MIXTURE
125 M.P.H
45 MPH HEADWIND
RICH MIX
PAYLOAD WEAK MIXTURE CRUISING
PAYLOAD RICH MIXTURE CRUISING
BLOCK HOURS
A RICH MIXTURE FUEL CARRIED
B " BURNED
C WEAK CARRIED
D " BURNED
1
2
3
4

FIG 6



HOURLY CHART TYPE III
POUNDS WEIGHT
0
1000
2000
3000
MEAN BLOCK SPEED MPH
0
10
20
30
40
50
60
70
80
90
100
110
ALLOWANCE TAKE OFF CLIMB DESCENT LANDING
12·5 MLS
25 MLS
50 MLS
100 MLS
200 MLS
400 MLS
130 MPH STILL AIR
WEAK MIXTURE
120 MPH
30 MPH HEADWIND
RICH MIXTURE
120 MPH
45 M.P.H HEADWIND
RICH MIXTURE
PAYLOAD WEAK MIXTURE CRUISING
PAYLOAD RICH MIXTURE CRUISING
BLOCK HOURS
A RICH MIXTURE FUEL CARRIED
B " BURNED
C WEAK CARRIED
D " BURNED
1
2
3
4

FIG 5

FIG 7

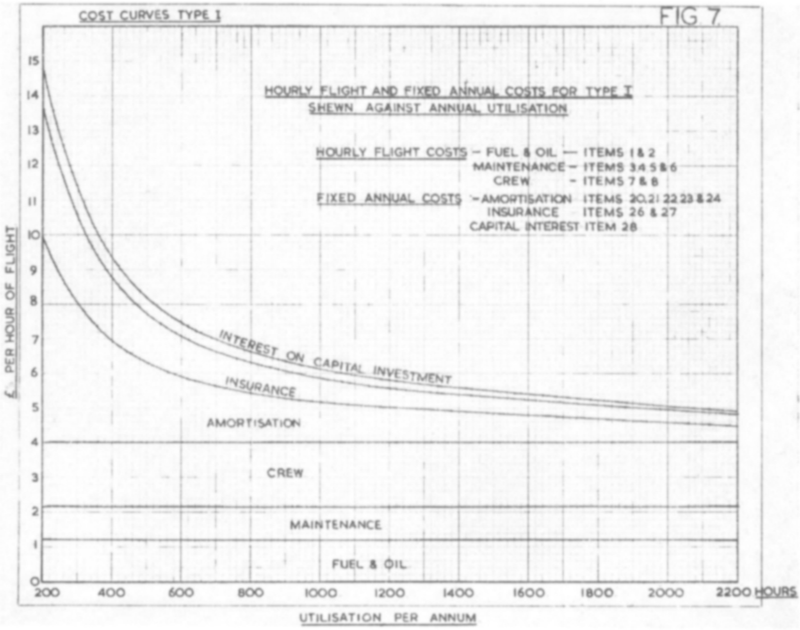

COST CURVES TYPE I
HOURLY FLIGHT AND FIXED ANNUAL COSTS FOR TYPE I
SHEWN AGAINST ANNUAL UTILISATION
HOURLY FLIGHT COSTS – FUEL & OIL — ITEMS 1 & 2
MAINTENANCE – ITEMS 3,4,5 & 6
CREW – ITEMS 7 & 8
FIXED ANNUAL COSTS – AMORTISATION ITEMS 20,21 22 23 & 24
INSURANCE ITEMS 26 & 27
CAPITAL INTEREST ITEM 28
INTEREST ON CAPITAL INVESTMENT
INSURANCE
AMORTISATION
CREW
MAINTENANCE
FUEL & OIL
£'s PER HOUR OF FLIGHT
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
200
400
600
800
1000
1200
1400
1600
1800
2000
2200 HOURS
UTILISATION PER ANNUM

FIG 8

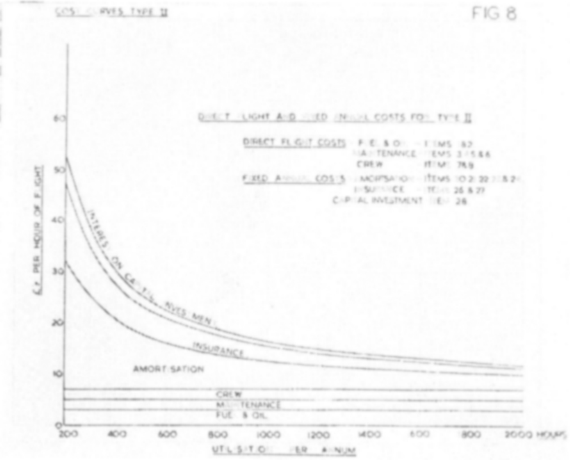

COST CURVES TYPE II
DIRECT FLIGHT AND FIXED ANNUAL COSTS FOR TYPE II
DIRECT FLIGHT COSTS – FUEL & OIL – ITEMS 1 & 2
MAINTENANCE – ITEMS 3,4,5 & 6
CREW – ITEMS 7,8,9
FIXED ANNUAL COSTS – AMORTISATION – ITEMS 20,21 22 23 & 24
INSURANCE – ITEMS 26 & 27
CAPITAL INVESTMENT ITEM 28
INTEREST ON CAPITAL INVESTMENT
INSURANCE
AMORTISATION
CREW
MAINTENANCE
FUEL & OIL
£'s PER HOUR OF FLIGHT
0
10
20
30
40
50
60
200
400
600
800
1000
1200
1400
1600
1800
2000 HOURS
UTILISATION PER ANNUM

FIG 9

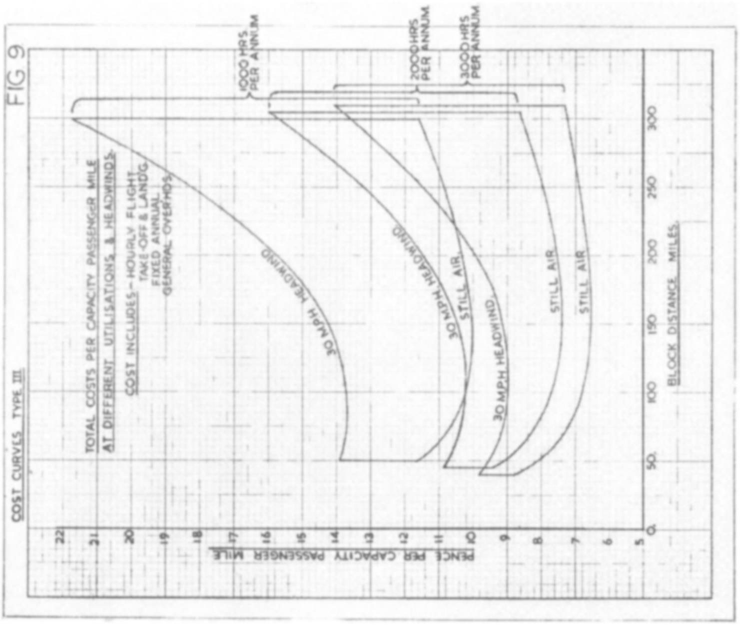
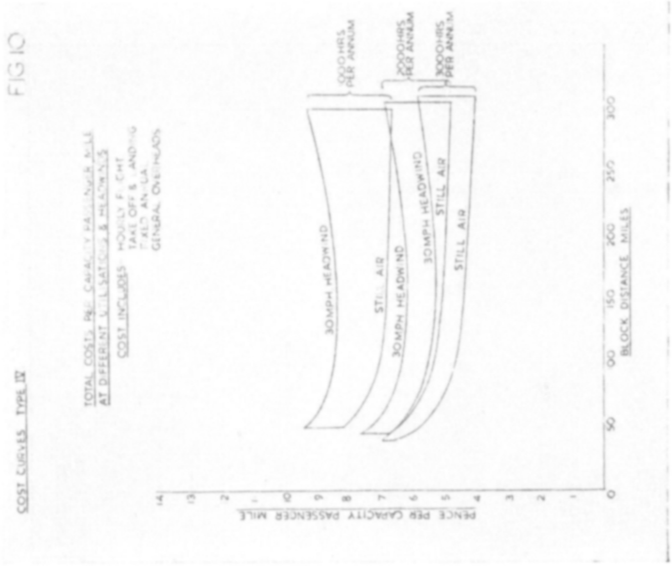

COST CURVES TYPE III
TOTAL COSTS PER CAPACITY PASSENGER MILE AT DIFFERENT UTILISATIONS & HEADWINDS
COST INCLUDES – HOURLY FLIGHT
TAKE-OFF & LANDG
FIXED ANNUAL
GENERAL OVERHDS
1000 HRS PER ANNUM
2000 HRS PER ANNUM
3000 HRS PER ANNUM
30 MPH HEADWIND
30 MPH HEADWIND
STILL AIR
30 MPH HEADWIND
STILL AIR
STILL AIR
PENCE PER CAPACITY PASSENGER MILE
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
0
50
100
150
200
250
300
BLOCK DISTANCE MILES

FIG 10


COST CURVES TYPE IV
TOTAL COSTS PER CAPACITY PASSENGER MILE AT DIFFERENT UTILISATIONS & HEADWINDS
COST INCLUDES – HOURLY FLIGHT
TAKE OFF & LANDING
FIXED ANNUAL
GENERAL OVERHEADS
1000 HRS PER ANNUM
2000 HRS PER ANNUM
3000 HRS PER ANNUM
30MPH HEADWIND
STILL AIR
30MPH HEADWIND
30MPH HEADWIND
STILL AIR
STILL AIR
PENCE PER CAPACITY PASSENGER MILE
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
50
100
150
200
250
300
BLOCK DISTANCE MILES

My analysis of the problem suggests that an extra cost of 6/8d per hour of time saved would produce fares which would attract traffic, but this would mean fares at a maximum of 4½d per revenue passenger-mile, which is well below present costs

Potential Traffic This exists only on routes between important centres where there are few and inadequate communications due to geographical reasons We have first of all to consider how much traffic we need to support the helicopter under its most economic conditions Taking the ultimate case of 3,000 hours per annum we find that over a 100 mile stage we need a minimum of 85 passengers a day for each Type III helicopter and 243 passengers for each Type IV Remembering that we are considering routes where there is as yet no traffic this means a very high traffic index indeed With this knowledge, we can examine specific routes We find that Potential Traffic is governed by —

Firstly The average frequency, time and cost of alternative transport

Secondly The size, distance apart and economic characteristics of the centres concerned

And finally—for the helicopter, the relationship between traffic and capacity passenger costs and the effect on cost of time saved

No investigation is required more urgently than one dealing with potential traffic for the helicopter within the U K

General Conclusions on the Use of the Helicopter for Passenger Transportation

In stating my conclusions, I must state that I believe that we should use the helicopter on those first applications which will permit it to earn a profit I believe this to be essential in order to establish the helicopter, because *Good Business* leads to more good business, a process which will establish the industry we all hope for Secondly, we must employ the helicopter on applications which will foster long-term business which may eventually predominate although being unprofitable in early stages The following conclusions therefore apply

On the availability of Type IV helicopters in a reliable and operable form, it will be possible to make a profit on all existing routes at present served by rail and steamer or aeroplane from the U K to the continent and up to 250 miles in length These will be the first routes to support themselves at existing costs

On the availability of Type III helicopters in a reliable and operable form, it will be possible to operate cross-country routes and eventually stimulate sufficient traffic to fully occupy them A subsidy will be required to bring the cost of passenger fares down to a rate of about 3½d and no more than 4½d per passenger-mile if sufficient traffic is to be attracted

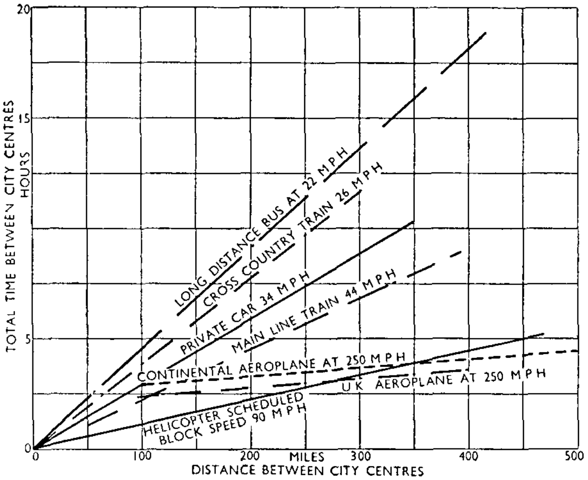


Fig 11

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Freight

The field of operations likely to be served by the freight-carrying helicopter can be defined as " The transportation of freight to places inaccessible to other fast mechanical vehicles capable of carrying similar loads " The helicopter will be paid for if, by its use, humanity and its hardware can be maintained in the inaccessible place where the resultant business is sufficiently good to pay for the process

A Type II helicopter can be flown for 1,000 hours, carry out 49,000 ton-miles and will cost about £16,000 per annum On the other hand a Type IV will fly 1,000 hours and carry out 427,000 ton-miles and will cost about £50,000 per annum This sounds very expensive, but when compared with aeroplane freighting charges in, say Canada, and considering the flexible reach of the helicopter, the costs are not disproportionate There is no doubt that the helicopter will come to be used for this work—in limited quantities

Mail

Mail is the only field in which we have experience of scheduled operations The field is split into two

> *Class A Mail Operations* which concern the expediting of local delivery through an urban area from a distributing centre
>
> *Class B Mail Operations* which concern the linking up of existing and separated networks of mail transportation, already rapid within themselves, but which for reasons of terrain or otherwise cannot be linked by any other means then by the helicopter Class A implies short range deliveries and Class B implies the transportation of mail over relatively long stages

Class A The speed of mail is largely controlled by the fact that as far as collection and delivery is concerned, half the day and 36 hours of the week-end are dead hours There are many areas in the world, of which perhaps Los Angeles is the best example, where, although mail may arrive in the centre in the morning, surface means of distribution to outlying post offices is not sufficiently fast to catch the last delivery of the day If the helicopter can catch the last delivery—then at least twelve hours will be saved There are other places where by expediting the mail an earlier delivery in the day can be made, which will permit a business house to get a reply out by the last collection and thus reach the original sender a day sooner

The same arguments of time saved apply to Class B, but here the mail is accelerated by large bulk movements which circumnavigate some previously slow stage of the journey by surface transport

The Cost of a Mail Service

Let us take a typical Class A operation with a fleet of five Type II helicopters, each operating for 1,200 hours per annum If the load factor is 33% and the average stage 25 miles, then 6¾ million lbs of mail will be accelerated by, say, 12 hours

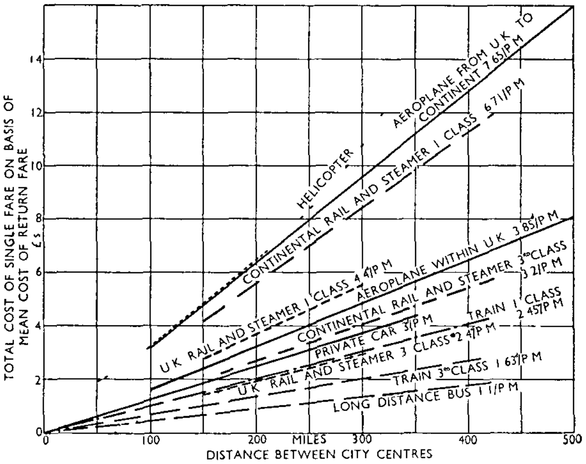

Fig 12

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The total operating costs will be about £110,000 per annum at a cost of one-fifth of a penny per letter This is within the price allowed by the average state post office and a profit will be made

Class II helicopters are of a suitable size and are sufficiently economic for the carriage of mails where the nature of the communities and corresponding mail services are such as to permit large scale expediting of mail

Social Services

Depending on how the helicopters are operated, it would be possible to establish a helicopter rescue and ambulance service at costs commensurate with existing costs for aeroplanes I find that a Type I helicopter, with its limited capacity for one passenger, would cost between £2,000 and £5,000 per annum, with a radius of operation from 75 to 125 miles A Type II, with capacity for three passengers, would cost between £6,000 and £9,000 per annum, with a radius between 125 and 200 miles These costs would permit between 100 and 200 flying hours per annum

Personal Transportation

I have included a note on this because I believe that one day a cheap helicopter might arrive which will be widely used by private persons But to examine present-day prospects I have considered a Type I helicopter at varying annual mileages and initial costs The best figure which can be obtained, but which assumes an initial cost of £2,000 and 40,000 miles or 500 hours per year, is 7 8d per mile To achieve 500 hours per year, the helicopterist would forego largely his motor car, which he would only do on the grounds of speed—certainly not convenience The cost would be 2½ times as much and considering a more realistic cost of £4,000 and 20,000 miles a year, the cost would be double These costs speak for themselves and only commercial undertakings will be able to afford—let it be said—these useful transports There will obviously be a small market here, for if aeroplanes can be sold then so can helicopters The best view to take of a personal helicopter is that it will only come along after many years and that when it does it will be more like a motor car than a helicopter

Agricultural Work

Of all the fields so far tackled by the helicopter, perhaps agriculture has yielded the most promising indications of success with contemporary types Certainly in America and probably in the U K spraying by helicopter is not much more expensive than by alternative means, and generally more effective However, the chief problem is to obtain a sufficiently high utilization to keep costs low This is difficult because the work is largely seasonal Amercian operators use their fleet in alternative fields—generally specialized—during the off season U K operators with the dominions to serve, can take their fleet to other countries in the off season and so obtain the necessary utilization The costs are as shown in the cost curve for Types I and II and from this and the prices prevailing for alternative methods I conclude that agriculture offers an existing and profitable field with contemporary types, always providing that the machines are reliable In order to give a rough impression, each Type II would have to turn over about £16,000 of business each year, or, in terms of spraying, about 7,000 acres

Flying Training

The best training helicopter is the Type I But with an optimum of 400 hours per year utilization, the cost per hour of tuition would be about £17 per hour Such costs will preclude *ab initio* training I therefore conclude that only professional pilots wishing to convert to helicopters will pay for training at these costs About twenty pupils will have to be found every year to support each machine, and for some time it is likely that training will be offered only by companies already operating their fleet in an alternative field, and who look on training as a sideline

This sums up the potential fields of operation

London-Paris—The Evaluation of the Helicopter against a Particular Operation

In order to present some methods of evaluating the helicopter against a particular operation, I have chosen, as an example, a helicopter passenger service between the centres of London and Paris Apart from the fact that it is a route on which the traffic potential can be assessed on existing experience, it is also a route which falls under the classification of Point I of my conclusions of the helicopter as a passenger carrier

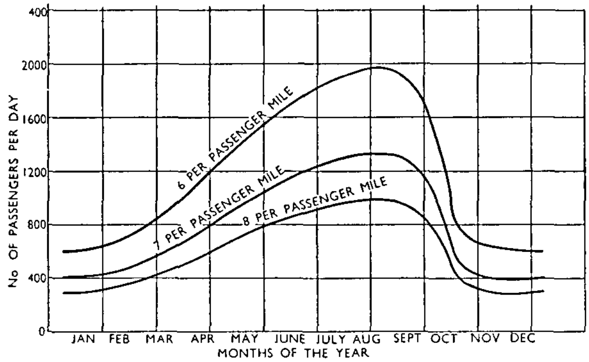

Fig 15

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It is not possible within the brief space of this paper to carry out a comprehensive study of the operation , I can only present the " bones " of the study, or rather those features which I believe to be the governing ones Since this precludes detail, I have done my best to be reasonable rather than optimistic The basic and, I believe reasonable, assumption is that there will be available a 2,500 h p Type IV helicopter of at least the same mechanical reliability as the contemporary S 51, and with the performance indicated in Figures 6 and 10 The second assumption is that terminal rotor-stations will be available in the centres of London and Paris, and that the cost of using these stations will be as in my figures for Take-off and Landing costs

The study breaks down into the three divisions quoted as follows —

(i) The physical performance of the Type IV helicopter between London and Paris
(ii) The potential traffic and price
(iii) The ability of the Type IV helicopter and the organization behind it to satisfy the market and its price

I have chosen the Type IV helicopter as the suitable class to examine, for, as will be seen, the potential traffic is such as to require a helicopter of this capacity I must also stress that any traffic figures quoted have been computed by myself from published figures, and are not intended to represent in any way the state of traffic or the opinions of the British European Airways Corporation

The Physical Performance of the Type IV helicopter, between London and Paris

Figs 6 and 10 give the basic operating and economic performance data of the Type IV helicopter upon which I will base this study

Scheduling

The scheduling depends on the known winds on the route Figure 16 represents the latest data available On this information, I have summarized the basic scheduling characteristics in Table XIX

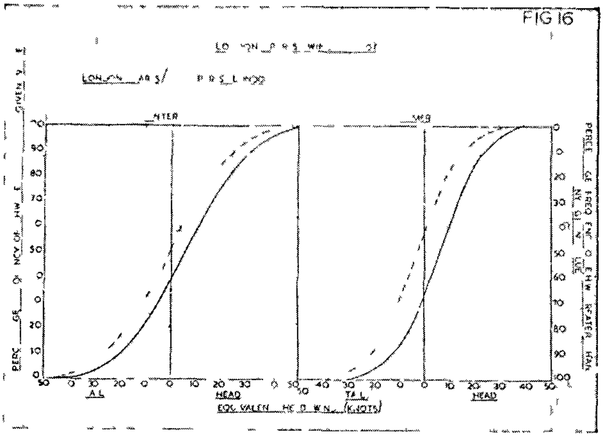

FIG 16

Table No XIX

LONDON-PARIS WINDS, SCHEDULE BLOCK SPEEDS, BOOKING CAPACITY, REGULARITY

Stage	*Vector Mean Wind*	*Schedule Block Speed*	*Regularity against Winds*	*Schedule Block Time*	*Booking Capacity per Flight*
Summer					
London–Paris	4 0 m p h tailwind	95 m p h	98 0%	2 hrs 15 mins	26 passengers
Paris–London	6 3 m p h headwind	95 m p h	98 0%	2 hrs 15 mins	26 passengers
Winter					
London–Paris	1 0 m p h tailwind	93 m p h	96 5%	2 hrs 18 mins	25 passengers
Paris–London	6 7 m p h headwind	87 m p h	96 5%	2 hrs 22 mins	24 passengers

The schedule block speed is obtained by assessing the cruising-speed range and setting it against the known vector winds of the route, so as to achieve the best balance between schedule block speed and punctuality This is based on winds not exceeding 75% of the occasions, which is possibly a little severe but necessary in order to obtain the high punctuality required for tight schedule gearing

This latter aspect is essential to obtain the minimum fleet size However, the vector winds for this route are well balanced throughout the year with the result that the schedule block time only varies slightly throughout the year The percentage regularity only refers to regularity affected by winds It will be appreciated that reductions in punctuality and regularity will result from other causes, the most important of which are

(*a*) Meteorological influence
(*b*) Traffic congestion
(*c*) Mechanical defects in the aircraft

The weather minima for helicopter operations of this type are still in question Based on the Type IV being twin-engined and fitted with radio navigational aids of the Decca characteristics, and also cleared for I F R conditions, I have assumed a minimum of 550 yards visibility, and a ceiling of 500 feet above the ground at the terminal rotor-stations This is possibly marginal, but even so, meteorological statistics for the route suggest that these conditions would not be worse on more than 4% of the occasions throughout the year There will be a further loss due to exceptional winds

Potential traffic congestion is an unknown, but referring to Mr Rowe's paper, " Helicopter Operations—Some Problems and Prospects,"* and assuming an allotted time of departure and arrival, it is assumed that there will be no loss of regularity but some loss of punctuality Mechanical defects again are an unknown factor and so I can only seek to draw an estimate between current experience with contemporary helicopters and aeroplanes This would suggest, on an established type, a figure of 1½% loss of regularity throughout the year, fluctuating from a peak in the summer with high fleet utilization and when reserves are low, to a low figure in the winter

The expected regularity, taking these factors into consideration, might be as shown in Table XX

Table No XX

LONDON-PARIS REGULARITY

Stage	*Regularity*	*Stage*	*Regularity*
Summer		*Winter*	
London–Paris	94 0%	London–Paris	91 0%
Paris–London	94 0%	Paris–London	91 0%

---

* Helicopter Operations—Some Problems and Prospects, N E Rowe Journal of the Helicopter Association of Great Britain—April, 1949

Maintenance

I have assessed the maintenance task and set it out in Tables XXI and XXII In the first I list the direct labour requirement on the aircraft, and in the second I list the work on the replacement components I have assumed that Sealed Servicing will be employed, which permits slightly less than half the overhauls to be carried out on replacement components

It will be seen that the engine has an overhaul life of 960 hours, which is justified on the characteristics of available engines of this class The direct labour on the aircraft has been assessed either on the basis of single or double shift work on the aircraft In the second case, the minimum time on the ground due to scheduled inspections is 19 days per cycle of 960 hours' flying Daily inspections are assumed to contain progressive 30-hour inspections and these and 60-hour inspections are carried out overnight, if necessary

TABLE NO XXI

TYPE IV DIRECT LABOUR PER 960 HOUR CYCLE—INSPECTION AND MAINTENANCE ON AIRCRAFT

Estimated on current experience and assuming flow maintenance and sealed servicing Labouring not included

Item	*Inspection*	*No of Unserviceable Days*		*Man Hours*		*Crew*	*Inspections per Cycle*	*Days per Cycle U/s*		*Man Hours per Cycle*	
		1 S	*2 S s*	*1 S*	*2 S s*			*1 S*	*2 S s*	*1 S*	*2 S s*
Complete Aircraft	Daily	—	—	17	—	4	142	—	—	2614	2614*
	60 hr	1	over-night	85	85	11	8	8	—	680	680
	120 hr	1	1	170	187	13	4	8	4	680	748
	240 hr	5	3	625	687	16	2	10	6	1250	1374
	480 hr	7	4	1080	1188	20	1	7	4	1080	1188
	960 hrs	8	5	1370	1507	23	1	8	5	1370	1507
Totals								39	19	7674	8111

* Included for Totalling *S* = Shift *S s* = Shifts

TABLE NO XXII

TYPE IV DIRECT LABOUR PER 960 HOUR CYCLE—OVERHAUL OF REPLACEMENT COMPONENTS

Item	*Frequency*	*Man Hours per Set*	*Man Hours per Cycle*
Rotor hubs and blades	480 hrs	571	1152
Gear boxes, clutches and transmission	480 hrs	900	1920
Radio	—	450	450
Instruments	—	350	350
Engines	960 hrs	Outside	Contract
Total			3872

The figures quoted should be capable of attainment if the aircraft has at least the same reliability and standard of maintenance as the S 51, with at least the same facility for changing components

The Potential Market and Price

For this example, I have chosen London-Paris because, firstly, it has a very good potential market and, secondly, it has not been too difficult to estimate the characteristics of that market I emphasize the word " estimate," for that is exactly what my figures are and so I am prepared for criticism Nevertheless, the figures represent my estimation of the potential market, as it might well be for the next ten years, international monetary exchange and control remaining as they are to-day

My estimates are based on the extent of traffic on existing carriers, that is to say, the aeroplane and the rail and steamer route The implication is that the market for the helicopter will be traffic already travelling on those carriers and with whom the helicopter will be in competition There will be two aspects, therefore

(i) The variation of market price , (ii) The possibilities of competition

Let us consider the first

The Variation of Market with Price

The aeroplane and rail and steamer services offer a range of prices for passenger fares between London and Paris, averaging the figures in Table XXIII

TABLE NO XXIII

AVERAGE PASSENGER RATES—LONDON-PARIS—AEROPLANE, RAIL AND STEAMER

Carrier	*Average Rate Pence/Pass Mile*	*Average Time for Journey*
Aeroplane	8 10	3 hrs 35 mins
Rail and Steamer—Pullman 1st Class	6 71	7 hrs 15 mins —Short sea route
Rail and Steamer—2nd Class	5 17	8 hrs —Short sea route
Rail and Steamer—3rd Class	3 45	8 hrs —Short sea route

Therefore, a background of traffic data for all services as experienced in the past and present, is available and with a price range varying from 3½d to just over 8d per mile From this we must first assess the potential market for the aeroplane against a varying price This will take in the aeroplane's speed advantage and the public's readiness to use air transport We know what the market for air travel by the aeroplane is already and at 8d per passenger-mile We must find out what it would be at 8d , 7d and 6d for the next period of five years How can we deduce this from our existing information ?

The Readiness to use Air Transport

The aeroplane at 8 10d per passenger-mile between London and Paris is in competition with Pullman and first class travel by rail and steamer averaging 6 71d per passenger-mile (Actually Pullman rates are nearer 7 8d and there is no free lunch !) Bearing in mind the fact that the aeroplane takes 3½ hours between centres to the rail and steamer's best time of 7 hours, I think it is safe to assume that all passengers travelling Pullman or first class rail and steamer would travel by aeroplane if they had the readiness or need to use air transport Or, putting it another way, of all the passengers who can afford to pay between 6 7d and 8 1d per passenger-mile, the ones who travel by air come under the following classes

(i) Those who have no fear of flight and wish to save time with at least equivalent comfort and convenience to rail and steamer travel

(ii) Those who have to save time for one reason or another and which over-rules any other aspect

On this basis, therefore, I have used the proportion of first class travellers* who use the aeroplane to those who use rail and steamer as a factor on which to assess the public's readiness to use air transport between London and Paris I have therefore applied this factor to the second class traffic travelling by rail and steamer and have produced the curves at Fig 15, and which are intended to show how the air

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* All passengers irrespective of vehicle who can afford to pay between 6 7 and 8 1d per passenger mile I take to be 1st Class passengers

transport traffic potential varies at 8d , 7d and 6d per passenger-mile The assumption is that the second class passenger potential to travel by air will be roughly the same as that of the first class passenger, as the aeroplane fare rate approaches 5 17d per passenger-mile, and at equivalent ratios of cost The curves show that the potential traffic peaks in September at just under 1,000 passengers per day and is down to 300 passengers per day in November and December for 8d per passenger mile The figures are roughly doubled for 6d per passenger-mile, and with the same seasonal fluctuation

The traffic potential at 8d per passenger-mile consists entirely of the existing proportion of first class passengers who have the readiness to use air transport for one reason or another As the price goes down, so the proportion of second class passengers who use air transport will rise steadily from virtually *nil* At the same time, the proportion of first class travellers who use air transport will rise with the inducement of cheaper travel It is this combined effect which doubles the traffic potential at 6d per passenger-mile (We must not forget, of course, the probable retaliating action on the part of the rail and steamer in the way of price reductions and in the face of this competition)

I have deliberately assumed that, initially, the helicopter would only have a potential traffic based on the public's " readiness to use air transport " as it applies to the aeroplane This factor implies the safety of the aeroplane, which I believe to be of an inherently lower order to that of the helicopter But I do not believe it wise to make business assumptions presupposing public attitude towards the safety of the helicopter, despite the promising beginnings, until we have had more experience And so we must now set the helicopter against the aeroplane in order to see how the passenger services would compare

The Helicopter competing with the Aeroplane—London-Paris—Cost Excluded

The purpose of this comparison is to ascertain whether the traffic potential for the aeroplane is available to the helicopter We must therefore compare the Speed, Reliability, Regularity, Punctuality and Convenience of the two vehicles

Speed

Present-day aeroplane summer services between London and Paris average 3 hours and 35 minutes between centre to centre Actually the passenger is requested to be at the city centre departure station fifteen minutes earlier than the advertised time of departure The helicopter summer scheduled time—doors closed to doors open—is 2 hours 15 minutes The passenger would be advised to present himself 15 minutes earlier to clear all formalities and an average time to clear formalities at his destination would be 10 minutes These figures are based on a series of time checks of existing experience His time, therefore, from entering the rotor-station at one end to leaving it at the other, would be 2 hours 40 minutes, against the aeroplane passenger's time of 3 hours 50 minutes And, further, the helicopter passenger, because his progress through formalities would be in his *own hands* and his own *responsibility*, would probably make time I emphasize this because the aeroplane passenger, once he presents himself at the city centre departure station, is geared to a schedule of bus, formalities, aeroplane, formalities, bus, which is the time of the average passenger and sometimes the slowest Thus, the helicopter service would be more like that of a train leaving at, say, 12 00 hours and arriving at 14 15 hours

It is true that faster aeroplanes will enter service on London-Paris in three years' time, but the saving on the time schedule will not be more than 15 minutes I would say, therefore, that the helicopter will save at least one hour over the aeroplane's time between London and Paris

Reliability

So far the helicopter has had a remarkable record of safety, although upwards of 500 production types have been constructed since 1942 Without going any further, I think it safe to say that the helicopter's reliability will be at least as good as the aeroplane's, if not very much better The chief reason for this is its ability to come to the hover, and descend slowly

Regularity

The regularity expected is of the same order as aeroplanes on the London-Paris route One factor can alter this—exceptionally high winds which seriously affect the helicopter and its low cruising speed whereas the aeroplane, with nearly double the speed, is at an advantage An exceptional season might lower the regularity considerably

Punctuality

Because of the importance of punctuality as it affects the gearing of one schedule to another, generous reserves have been allowed in the block speeds assumed The very high winds of an exceptional season, however, would affect punctuality, in the same way, to the advantage of the aeroplane

Convenience

The helicopter is the *only non-stop vehicle between the centres of London and Paris* There is no changing through three stages as required for the aeroplane, and any other vehicle There are no waiting periods in remote places Last-minute cancellations do not find the passengers out at airports thus wasting their time The very nature of the helicopter service lends itself to a relaxation of the passenger seat booking system With a reservation system and prior to flight ticket-purchasing availability, as well as the other factors I have mentioned, the convenience of the helicopter will be far in excess of that of the aeroplane

One last word about comfort The evidence, so far obtained on helicopters approaching the Type IV in size, suggests that the vibration and noise level need not be higher than that of contemporary twin-engined aeroplanes of similar power class The flexible nature of the rotor system acts as a shock absorber and the tendency to air sickness in the helicopter is much lower than that of the aeroplane

CONCLUSIONS

I The helicopter may not be able to equal the aeroplane in regularity and punctuality, but it should have a good chance of doing so with the generous time reserves allowed

II The helicopter will have at least the same reliability, *i e* , safety, as the aeroplane

III The helicopter has a *very great* advantage both in speed and convenience over the aeroplane

IV Points I, II and III indicate that the public readiness to use helicopter services between London and Paris is at least as great as their readiness to use the aeroplane The market potential, at Fig 15, will therefore apply to the helicopter as a minimum expectation

THE ABILITY OF THE TYPE IV HELICOPTER AND THE ORGANIZATION BEHIND IT TO SATISFY THE MARKET AND ITS PRICE

We have the characteristics of the helicopter and the market The next step is to assess the operating organization required and to estimate its cost The process divides as follows

(i) The design of a schedule with the optimum fleet size to meet the market requirement
(ii) The aircrew and maintenance staff to operate the fleet
(iii) The total operating costs
(iv) The Profit and Loss Account, and the return

(i) THE DESIGN OF A SCHEDULE WITH THE OPTIMUM FLEET SIZE TO MEET THE MARKET REQUIREMENT

The first move is to establish the order of things The cost curves of the Type IV helicopter imply broadly that the aeroplane's selling price of approximately 8d per passenger-mile could be met, with a utilization of 2,000 hours per annum and a mean load factor of at least 65%, taking the mean block speed and winds for the year On the preliminary assumption that we can meet the 8d per passenger-mile market, I have designed a schedule to meet the traffic at 8d per passenger-mile in Fig 17 This schedule is shown in Table XXIV

I shall also consider the requirement to meet a modified schedule set up to meet the traffic if the fare price is fluctuated with seasons The second part of

Fig 17 shows how a modified schedule might cover varying fare prices from 6d -8d , and it will be seen that the schedules are basically the same except that the summer schedule is now spread over February to October The following examination does not cover this case, but the costs which follow do present the appropriate figures

The major problem with this route is the very heavy seasonal fluctuation in traffic This results in the fleet having to be sufficiently large to meet the summer schedule and with the result that it is largely idle in the winter There is the associated point that in addition to the fleet, the entire organization and staff are subject to the same fluctuation, but fortunately they are a little more flexible than the helicopter

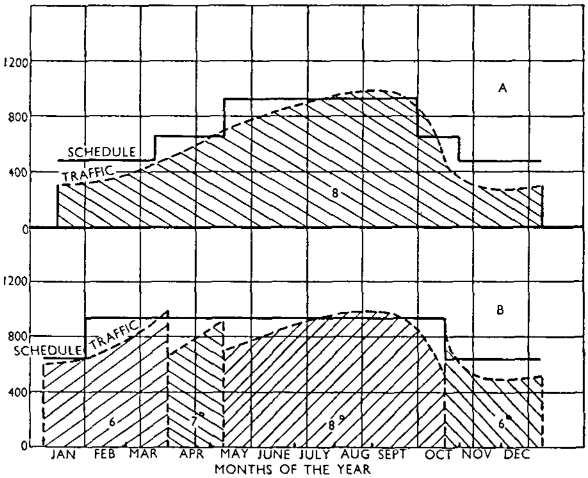

Fig 17
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The helicopter has a slow rate of doing work , it takes 5½ hours to complete a full return cycle between the city centres of London and Paris, whereas, for example, the aeroplane only takes 4 hours Since the length of the part of the day when passengers are to travel is, at the very most, about 16 hours, this means that one helicopter can effect a maximum of three return trips, whereas an aeroplane can manage four This is based on a turn round time of thirty minutes

The question arises as to what proportion of the peak and average potential traffic it is best to try to carry I do not know enough about the argument as to whether it is best to undersupply air transport demand or to saturate it Commercially, I would suggest that it was better to undersupply, but there is the question of convenience, and the unattractiveness of " not being able to get on the helicopter " whenever one wants to This affects any booking schemes However, I have tended to undersupply with the result that the schedule is designed to have a potential mean annual load factor of 90% This is not to be confused with actual load factor achieved

There is also the point which concerns the fluctuation of traffic during the day I have done my best to give good service to those who wish to make one-day trips, but again this is a debateable question

Bearing this in mind, the summer schedule runs for five months, and provides 36 flights per day and a booking capacity of 936 passenger seats per day It can *just* operate with seven operational aircraft, representing 81 flying hours per day It is interesting to note that a similar schedule based on a turn round time of fifteen minutes could be operated with six aircraft The latter turn round time would be possible if punctuality were better than 95%, but I have not considered this a safe assumption even in the summer

The daily requirement for seven aircraft, each with a mean flying time of 11 5 hours, plus serviceable reserves, governs the fleet size in conjunction with the maintenance cycle given

During the summer, a two-shift maintenance would be in operation and aircraft would only have to be withdrawn from service for 120, 240, 480 and 960 hour inspections Therefore each aircraft would fly, on average, ten days between inspections which would withdraw it from service, and so its operational life per cycle would consist of eight 10 operational day periods stretching over 80 + 19, or approximately 100 days in the shorter case The summer schedule extends for 153 days and so a high proportion of the aircraft in the fleet would complete a 960 hour cycle Using a graphical method, I find that, were the maintenance sequence to function, with no delays due to defects, modifications, or spares availabilities, it would be possible to have seven operational aircraft each day, from a fleet of nine aircraft, on all but eleven days in the period of 153 days The addition of two reserve aircraft, to be held at either end of the route, however, would provide seven operational aircraft on all days and would provide sufficient flexibility for the maintenance pool to have two aircraft to break maintenance sequence up to thirteen days simultaneously and for one to go considerably longer

Such theoretical methods are open to the criticism that there will be times when larger numbers of the fleet may be rendered unserviceable due to some suspected common defect, but I do not believe that it is reasonable to plan the economy on cases which are the exception I have, to recapitulate, assumed a helicopter of at least the same reliability as the Sikorsky S 51

And so I conclude that a fleet of eleven Type IV helicopters would be required to operate the schedule

(ii) THE AIRCREW AND MAINTENANCE STAFF TO OPERATE THE FLEET

Aircrews Before examining other requirements it is important to establish the number of aircrews which will be required On this particular operation, I have assumed that there will be two pilots and one steward in each crew The reason for two pilots is because it is intended to fly an intensive roster during the summer Crews will have a peak of nine hours flying per day, but will average 6¾ hours per operating day, being on duty a possible eleven hours altogether Due to the intensive summer work, they will average six weeks holiday a year, of which only two will be taken in the summer

Reverting to the schedule, and during the peak period, there will be 3¾ flights per day, requiring twelve crews, plus two reserves, each day Crews will fly, on average, for two days and will have the third day off Neglecting sickness, X, the minimum number of crews required to operate the schedule for the 153-day period, is as shown by the expression

$$X = \frac{d}{h \times w}$$

where X = minimum number of crews required
h = proportion of working days to period, *i e*, leave allowance
w = proportion of days on duty to working days
d = daily requirement of crews

$$X = \frac{14}{\frac{139}{153} \times \frac{2}{3}} = 23 \text{ crews}$$

composed of 46 pilots, 23 stewards Crews' flying time will average 875 hours per year

Table No XXV

ANNUAL COST OF AIRCREWS

Crew	*Salaries Expenses Item 7*	*Insurances Pensions Item 8*
46 Pilots 23 Stewards	£51 600 £18 400	£18 400 £6 900
Totals	£70 000	£25,300

Maintenance Taking the broad basis of flying hours per year, WA, the approximate number of direct man-hours required, will be

$$\frac{TA \times WM}{MC} \text{ where } TA = \text{Total flying per annum-fleet}$$

$$WM = \text{Man-hours per maintenance cycle}$$

$$MC = \text{Maintenance cycle}$$

$$= \frac{23{,}130 \times 11{,}765}{970} = \underline{283{,}500 \text{ man-hours per annum}}$$

or at a mean annual week of 50 man-hours, WW, one engineer's working year being 49 weeks,

$$\text{the direct labour force } L = \frac{WA}{WW \times 49} = \frac{283{,}500}{50 \times 49} = 116 \text{ men}$$

In actual fact there will be periods when a large number of men will work 60 hours per week due to uneven flow of aircraft, but the basis of 116 engineers will be assumed for the maintenance organization Of that number, approximately two-thirds will be employed on aircraft maintenance and one-third on the overhaul of replacement components I must mention that I take direct labour to include charge-hands as well as engineers, but not foremen or inspectors

Taking an average figure of 3/6d per hour to cover the total cost of labour, *i e* , all grades, expenses, pensions, benefits, etc , the total annual cost becomes Total cost of direct labour per annum = £49,612

The cost of material consumed is an intangible factor in the absence of operating experience with the type and so I take the figures quoted in paragraph 3 as the basis on which to work The question of engineering bases and their cost is a little more complex I have assumed that the maintenance of the aircraft would be carried on away from the rotor station, outside the city, since the cost of maintaining a base within a city would be very expensive A Type IV helicopter requires about 10,000 square feet of hangarage And so daily and maybe 60-hour inspections would be carried out at rotor-stations, but very little else It would be necessary to have hangarage for at least one aircraft at each rotor-station The amount of work during the peak period would require hangarage at the engineering base for at least four aircraft in the worst case—*i e* , 40,000 square feet Therefore the overheads are bound to be high and in general the installation will be at least as great as that required for a similar fleet of aeroplanes Accordingly, I have worked on that basis

Take-off and Landing Costs I have not attempted to discuss rotor-stations in this paper—for this is a subject quite apart and which merits the most serious thought and application For this operation, I have based my costs on my current impressions of cost as laid down in Table V I do not imagine that the terminal rotor-stations for the London-Paris service can be simple affairs for the very nature of the operations imply accommodation for all of the clerical staff associated with international formalities, as well as being able to handle peak passenger traffic of 1,000 passengers per day Restaurants, which might be leased to contractors, and waiting halls, would be essential as well as adequate facilities for getting the passengers away Land and rents in the centre of those cities are not likely to be inexpensive

General Overheads Again I have based my costs on Table X The overheads, if the engineering base overheads are subtracted, are not very high, as would be expected

(iii) TOTAL OPERATING COSTS AGAINST TRAFFIC

The total operating costs are computed initially for the schedule in Table XXVI and secondly for the schedule as modified to meet the second case in Fig 17 For convenience, I call the first Schedule A and the second B Both schedules are assumed to be mainly operated without any cancellations due to lack of traffic, but with the regularity factor applied I have chosen a mean regularity of 92 5% The general particulars of each schedule are

TABLE No XXVI

GENERAL PARTICULARS—SCHEDULE A AND B

	Item	*Schedule A*	*Schedule B*
1	Total Scheduled Hours per annum	23 130	27 247
2	Total Capital Required	£1 668 800	£1 668 800
3	Fleet Size	11	11
4	Number of Aircrews	23	27
5	Booking Capacity per annum	256 608	312,182
6	Potential Traffic at 8d per passenger mile	223 512	148 552
7	Potential Traffic at 7d per passenger mile		33 360
8	Potential Traffic at 6d per passenger mile		110 088
9	Total Potential Traffic	223 512	292 000
10	Total Scheduled Landings made per annum	9,462	11 157
11	Total Scheduled Hours Flown per annum	21 291	25 103
	Total Dead Hours per annum	426	502
	Actual Utilization of Aircraft per annum	1,935 hrs	2,282 hrs

The total operating costs are shown as annual costs, in Table XXVII It will be seen that the costs for Schedule A total £1,076,395, whereas those for Schedule B total £1,184,549

TABLE No XXVII

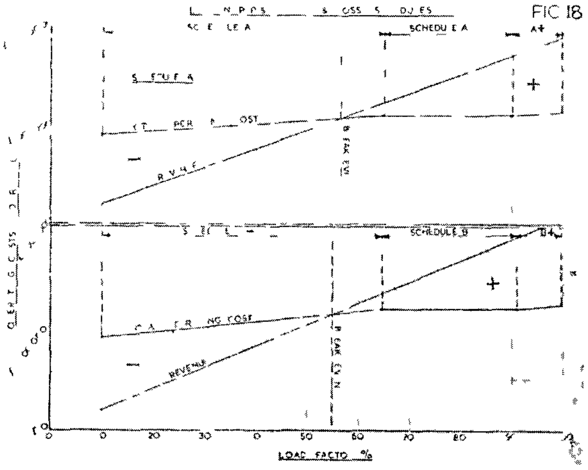
LONDON-PARIS ANNUAL OPERATING COSTS

DIRECT FLIGHT COSTS

	Fleet of 11 Type IV Helicopters	*Total Cost in £ s per annum*			
		Schedule A		*Schedule B*	
Item	*Description and Bases*	*Detail*	*Totals*	*Detail*	*Totals*
	Hourly Flight				
1	Fuel 162/ per hr, Continental Rate	183 958		207 401	
2	Oil 18 2/ per hr ,, ,,	20 672		23 301	
3	Maintenance Direct Labour	49,612		58 450	
4					
5	Material	54,355		63 962	
6					
7	Crew Salaries and Expenses	70 000		82 174	
8	Crew Insurance and Pensions	25 300		29 695	
9	Passengers Air Service	2 405		2 927	
10	Passengers Insurance	3 208		3,903	
11	*Total Flight Costs per annum*		409 510		471 813
	Take off and Landing Costs				
15	Landing Fees	54,407		64,153	
16	Passenger Ground Service	32 076		37 832	
17	Station Operation	81 610		96 229	
18	*Total Take off and Landing Costs*		168 093		198,204

Item	*Description and Bases*	*Schedule A*		*Schedule B*	
		Detail	*Totals*	*Detail*	*Totals*
	Fixed Annual Costs				
20	Amortization of Airframe	70 708		70 708	
21	Amortization of Engines	42 350		42 350	
22	Amortization of Rotors and Transmission	50 820		50 820	
23	Amortization of Special Equipment	4 895		4 895	
24	Amortization of Ground Equipment	1,408		1,408	
25	Insurance of Aircraft	91 630		91 630	
26	Insurance of Third Parties	506		506	
27	Insurance and Interest on Ground Equipment	1 265		1,265	
28	Interest on Fleet Capital Investment	39,160		39 160	
29	*Total Fixed Annual Costs*		302 742		302 742
	General Overheads				
30	Salaries etc Administrative Staff	40 041		42 858	
31	Headquarters Accommodation	9 471		9 471	
32	Administrative Office	10 120		10 120	
33	Out station Accommodation	5 060		5 060	
34	Research and Development	18 942		18 942	
35	Flying and Engineering Training	15,180		15 180	
36	Advertising and Publicity	18 942		25 256	
37	Traffic and Sales	8 228		8 915	
38	Engineering Base Overheads	70 066		75 988	
39	*Total General Overheads*		196 050		211 790
11	Total Flight Costs per Annum		409 510		471 813
18	Total Take off and Landing Costs		168 093		198 204
29	Total Fixed Annual Costs		302,742		302,742
39	Total General Overheads		196 050		211,790
	Total Annual Operating Costs		£1,076 395		£1,184 549

Fig 18



(iv) THE PROFIT AND LOSS ACCOUNT AND THE RETURN

We have now—the final step—to assess the profit and loss characteristics of the operation and then the return for capital invested The analysis must concern the following

(i) The Profit and Loss
(ii) The Break-even Load Factor
(iii) The Gross Return

The Profit and Loss The curves at Fig 18 are produced to show revenue and costs against load factor The construction of the curves is quite straightforward except that the annual costs are reduced, below 65% load factor by cutting services, and increased above 92 5% load factor by adding services Table XXVIII gives the characteristics

TABLE NO XXVIII

LONDON-PARIS PROFIT AND LOSS—SCHEDULE A AND B

Load Factor	Schedule A		Schedule B	
	Profit	% Profit to Turnover	Profit	% Profit to Turnover
40%	— £225,000	— 20 9%	— £225,000	— 19 0%
55%	— £25 000	— 2 3%	Break even	Break even
70%	+ £218 000	+ 20 3%	+ £262 500	+ 22 1%
85%	+ £493,750	+ 46 0%	+ £562 250	+ 47 5%

The interesting point is that the potential profit appears to be high in both cases, and with considerable flexibility This is to be expected considering the high traffic potential of the route

The Break-even Load Factor This factor, on Schedule A is 56 5% and 55% on Schedule B This is a low figure and suggests that the basic fare rate of 8d per passenger-mile could be reduced with a view to taking, at all times, a rather higher proportion of first class passengers than at present The low break-even figures do show that the market reserves on the operation are very high

The Gross Return As Table XXVI shows, the capital investment for both Schedules A and B is identical It follows, since that the volume of business, and profit, of the latter, is greater, that the return will be correspondingly increased Table XXIX summarizes the gross return as it fluctuates with load factor

TABLE NO XXIX

LONDON-PARIS GROSS RETURN—SCHEDULE A AND B

Load Factor	Gross Return	
	Schedule A	Schedule B
60%	3 0%	4 8%
65%	7 5%	9 4%
70%	13 1%	15 3%
80%	24 0+	28 4%
90%	34 5%	40 4%

The figures are self-explanatory and give an indication of the high potential gross return at quite moderate load factors The small increase in gross return, occasioned by the use of Schedule B, raises doubts as to its value

CONCLUSIONS ON THE LONDON-PARIS HELICOPTER SERVICE

I have outlined a preliminary assessment of the operation, for that is all that can be done within the compass of this paper The figures are based on premises, some of which are known, others of which are arbitrary From such a study, one cannot draw hard and fast conclusions, for there are many factors which can influence the situation I have done my best to point out the major issues and from these I believe that the following conclusions are justified

(i) Given Type IV helicopters, of the price and reliability stated, the route can be physically operated as outlined

(ii) Subject to (i), the helicopter, at the fare rates stated, is better in almost every respect to all other vehicles on the route It has virtually *no competition*

(iii) Subject to (i), the helicopter has a good chance of operating the route with a high return for investment It is probably the best helicopter passenger route in the world

(iv) Offering, as it does, a major profitable and unsubsidized operation, the London-Paris helicopter service will serve to establish and advertise the British helicopter industry before all eyes It can be the foundation of the future

SOME CONCLUSIONS ON THE ECONOMICS OF THE HELICOPTER

What makes the helicopter's economy what it is? Firstly, and most important, the helicopter has a low rate of doing work, or, in broad terms, it does not produce enough work for what it is We have only to consider a Type II helicopter, at £20,000, in terms of its ability to move half a ton ninety miles in one hour I realize that it is unfair to make such an unqualified statement—the service rendered should be considered, and when it is a difficult ninety miles by other vehicles, then perhaps the cost *is* justified But the trouble is that, in the inhabited parts of the world, there are just *not enough difficult ninety-mile stretches* to support the order of industry that we are hoping to create

Although the helicopter's service will always be worth a little more because of its inherent convenience, we must evolve an economy which is much nearer to that of its competitors than it is to-day It is true that even to-day's helicopters have good prospects but the fields of application are limited The future of the helicopter lies with to-morrow's helicopter and economy will be the deciding factor And so we must search out the answer to cheaper operations and this will be bound up with (1) The helicopter's rate of doing work, (2) The initial cost of the helicopter, (3) The external overheads

The first two are already well understood, but of the external overheads I must say this We have come to associate great ports with ships—because they are difficult to berth—great airports with aeroplanes—because they are difficult to land But, with the train, or with the 'bus—which require little to facilitate loading—what do we find? Occasionally, a large station, more generally small ones, and in terms of passenger flow—quite modest affairs And so it must be with the helicopter—for the helicopter has the same facility of landing and loading without *great preparations* And so the great invisible overheads, which are really behind so many of the other vehicles, can be avoided for the helicopter

I must stress most emphatically, therefore, that the keys to the economic helicopter and its future in society are (1) *Improved performance*, (2) *Reduced initial costs*, and (3) *Minimum external overheads*

To sum up, there is no doubt in my mind that the helicopter, of this decade, can be successfully operated at a profit in particular but limited fields This period will see the successful launching of helicopter operating concerns in the United Kingdom and the Commonwealth But, there are essential ingredients which will be required (1) *Creative intuition*, (2) *Business acumen, courage and drive*, and (3) *Technical skill*

In fact, the qualities which have been the mainspring of all commercial enterprises are just as, or even more, necessary for the helicopter Above all, success will only be achieved if everybody works We are in an early stage of development and for many years there will be setbacks and hardship, but this ten years will see the beginning

Some little while ago, when I was rather discouraged about the economy of the helicopter, Mr Sikorsky told me a story with a moral It seems that when he was a young man, his father pointed out an early motor car to him and said, " What good will they ever be—they are much more expensive to use than a railway train ! " I think that those words point the way to the future of the helicopter

TABLE No XXIV

LONDON PARIS OPERATING SCHEDULES — CENTRE TO CENTRE

BLOCK DISTANCE—213 5 miles

DESIGNED TO CARRY TRAFFIC IN FIGURE 17

TYPE IV HELICOPTERS

SUMMER SCHEDULES (MAY, JUNE, JULY, AUGUST SEPTEMBER)

	Flight	SA	SB	SC_1C_2	SD	SE	SF	SG	SH	SI_1I_2	SJ	SK	SL	SM	SN	SO	SP
London Paris	Depart Arrive	07 45 10 00	08 00 10 15	08 15 10 30	09 00 11 15	10 30 12 45	11 45 14 00	13 15 15 30	13 30 15 45	13 45 16 00	14 30 16 45	16 00 18 15	17 15 19 30	18 45 21 00	19 00 21 15	19 15 21 30	20 00 22 15

	Flight	S1	S2	S3	S4	S5	$S6_AS6_B$	S7	S8	S9	S10	S11	$S12_A12_B$	S14	S15	S16	S17
Paris London	Depart Arrive	06 15 08 30	07 45 10 00	09 00 11 15	10 30 12 45	10 45 13 00	11 00 13 15	11 45 14 00	13 15 15 30	14 30 16 45	16 00 18 15	16 15 18 30	16 30 18 45	17 15 19 30	18 45 21 00	20 00 22 15	21 30 23 45

Vector Mean Wind—London Paris 4 0 m p h tailwind }
Vector Mean Wind—Paris London 6 3 m p h headwind } Schedule based on block speed of 95 m p h giving 98 0% regularity
36 Flights per day, giving mean booking capacity of 936 seats per day
Seven aircraft required to operate all services each day
Flight with suffix 2 or B go out 5 minutes after basic schedule time

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SPRING AUTUMN AND WINTER SCHEDULES (JANUARY FEBRUARY, MARCH APRIL OCTOBER, NOVEMBER AND DECEMBER)

	Flight	WA	WB	WC	WD	WE	WF	WG	WH	WI	WJ	WK	WL	WM
London Paris	Depart Arrive	07 32 09 50	08 27 10 45	08 32 10 50	10 22 12 40	11 22 13 40	13 12 15 30	14 07 16 25	14 12 16 30	16 02 18 20	17 02 19 20	18 52 21 10	19 47 22 05	19 52 22 10

Flights WB WG, WL W2 W5 and W10 do not operate on Sundays, or during January February November and December

	Flight	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W14
Paris London	Depart Arrive	07 30 09 52	08 25 10 47	08 30 10 52	10 20 12 42	11 15 12 37	11 20 13 42	13 10 15 32	14 10 16 32	16 00 18 22	16 55 19 17	17 00 19 22	18 50 21 12	19 50 22 12

Extra flights can be added for Spring Schedule as WC_2 WH_2 WM_2 $W3_B$ WG_B and $W10_B$ booking capacity rising to 800 seats per day

Vector Mean Wind—London Paris 0 m p h Schedule based on block speed of 93 m p h giving 96 5% regularity
Vector Mean Wind—Paris London 6 7 m p h headwind Schedule based on block speed of 87 m p h giving 95 5% regularity
Spring and Autumn 26 Flights per day, giving mean booking capacity of 650 seats per day
Winter 20 Flights per day, giving mean booking capacity of 480 seats per day
Five aircraft required to operate all services in Spring and Autumn
Four aircraft required for Winter

DISCUSSION

N E Rowe, Esq , C B E , D I C , B Sc , A C G I , F R Ae S (*Member*)
I am very glad to have the opportunity of opening the discussion, because, as you know, Mr Wigdortchik is one of the team at the B E A Helicopter Experimental Unit, and I am sure you all join with me in offering congratulations on a most valuable paper which has been presented in an admirable way

The paper is both valuable and stimulating Its value rests largely on the display of factual data, such as we have not had the privilege of hearing before The stimulation comes from the way in which the lecturer has used the factual data to build a picture of the future, which I am sure can be taken also as a challenge to designers and operators alike to go and do better

However, it is important to remember that the facts, even although the lecturer has garnered the field very well, are still very slender The more we can reinforce them from real operational experience the better Incidentally—and this may appear to be " beating the drum "—the material presented demonstrates in a striking manner the value of an experimental operational unit such as that which the B E A is running with the full support of the M C A There is no doubt that without such operations many of the most interesting facts would not have been available Mr Wigdortchik has been energetic and enterprising in getting as much data as possible out of the operations

There are two main points I wish to make Firstly, it is clear that the helicopter must be worked *really hard* It is essential to have high utilization if the economy is to be satisfactory Machines must be designed to make it possible to do such hard work cheaply Operators, of course, are also concerned in this Secondly, the landing charges turn out to be a high proportion of the total costs Of course it is known that landing charges are likely to be much more serious in short-haul transport than in the long-haul, but the figures quoted in the paper are rather alarming I have roughed them out and they appear to be as follows —

For Type IV, taking a utilization of 3,000 hours and mean journey times of ¾-hour and 1½ hours, the landing charges are 37 6% and 23% respectively of the total costs , for 1,500 hours utilization and a journey time of ¾-hour, the corresponding figure is 30%

For Type III, again taking 3,000 hours utilization and journey times of ¾-hour and 1½ hours, the landing charges are 33% and 20% respectively of the total costs, and with reduced utilization of 1,500 hours, the figure is 27% for a mean journey time of ¾-hour

These figures are very high and it is clear that we must give very special attention to their reduction if the helicopter is to be made an economic form of transport In the paper I delivered to the Helicopter Association last January, I made the point that it is essential to keep rotor-station costs down, and this seems to be borne out by the figures adduced by Mr Wigdortchik It is interesting to note that in the operations of Los Angeles Airways data quoted in the paper shows a figure of only 4 7% for landing charges I shall be very glad to hear the lecturer's views on this matter

Air Commodore W H Primrose, C B E , D F C , A F R Ae S (*Member*)
Congratulations on an excellent paper It involves a painstaking study and careful analysis of the many factors which go to making the picture of the present and future possibilities for the helicopter from the economics angle

The study is so complete and detailed and has been prepared with so much labour and careful research, that a much longer time than I have had in which to examine it would have been required to do justice to it in discussion

My first impression on reading over the paper was one of disappointment at the pessimistic outlook for the helicopter as revealed by Mr Wigdortchik's analysis of the economics of its production and operation But that was on reading the paper from front to back On reading it over from back to front I got a distinctly more optimistic viewpoint

A general criticism is that at first examination the author in his detailed analysis prevents the reader from " *seeing the wood for the trees* " He presents a mass of snags in the way of tree trunks and stumps, which keep trapping one and obscuring one's vision and shutting out the fine vista that lies ahead This continues right up to near the end when one bursts through this thicket and is presented with the more pleasing picture of possibilities in the operating on the London-Paris route

It is, however, a very encouraging sign to see that the general reaction of helicopter addicts, as exemplified by the lecturer, is to study the problem from a realistic viewpoint rather than to be carried away by a foolishly optimistic outlook

Now for some points in the paper which strike one as requiring further examination

The lecturer is right when he states that the commercial operation of the helicopter is the problem of "*producing a commodity to meet a demand at a price that will stimulate demand*"

But cost descends in ratio to quantity produced And demand increases in ratio to reduction in cost The first is the seller, the second is the buyer

The question is—Will it pay the seller to fix a low price, which at the existing demand is uneconomic, in order to stimulate an increased demand which would enable the commodity to be produced economically at that low price ? Or must the reduction in selling price await a rise in demand because of the utility of the product The question is—Which comes first, the Hen or the Egg ? Do we Woolworth or do we not ?

On take-off and landing costs Again I think the lecturer makes his point very well and is so very right But I do think he is being over conservative in putting the cost for the helicopter at only one-third that of the aeroplane But he is right in drawing attention to the fact that only 50% of aerodrome costs are paid by the aeroplane

In dealing with freight, he omits the possibilities in freight-lifts direct from manufacturer's works to docks and ship, or aerodrome and aeroplane, for urgent dispatch to distant places And what about the crane-use in unloading from ships, etc ?

On the passenger traffic costs I think he would do well to remember that the helicopter to-day is only at about the same stage of development as the aeroplane of 1920, when 2/- per passenger-mile charge was proved to be uneconomic

The helicopter should develop at about double the rate of the aeroplane owing to the advance of technical knowledge

The lecturer evidently is of the opinion that the turn-round time of the aeroplane and the helicopter will be the same He puts this at 30 minutes I would suggest that owing to taxying time, etc , for the aeroplane, both in take-off and landing, the helicopter should have the advantage in this by at least 50%

I would like to submit that the lecturer has missed a point when he asserts that, in comparison to the aeroplane, the helicopter does not produce enough ton/miles to pay the costs The point missed is that—The helicopter takes you (right) there and brings you (right) back here Whereas the aeroplane takes you the aerodrome distance/time short of there and brings you the aerodrome distance/time short of back here, leaving other transport to complete the journey

J S Shapiro, Dipl Ing , A F R Ae S (*Founder Member*)

The helicopter designer will learn from this paper a number of lessons My own selection as applied to transport-helicopters is roughly as follows

(1) The economic advantage of large machines
(2) The importance of using engines of low specific cost and high overhaul period
(3) The importance of a wide forward-speed range with reasonable fuel consumption
(4) The operational limitations to high utilization
(5) The great benefit from fast turn-round at the terminus
(6) The fact that blind flying and night flying and night landing are essential
(7) The benefits of vertical take-off and landing

Such lessons are essential steps in the final development of a practical design They can only be derived from detailed planning of operations Mr Wigdortchik, in his London-Paris schedule, has provided a highly valuable example He has emphasized that an airline is governed by many kinds of accountancy and all the books have to balance It is high time that this process of imaginative planning is carried on in even greater detail to furnish further lessons for designer, operator and business planner The lecturer has given an example of the way in which knowledge in a variety of transport fields can be skilfully used to furnish many necessary data in this new field of helicopter transport

Coming now to figures, I am concentrating on the lecturer's Type IV helicopter, which closely corresponds to the Cierva Company's twin-engined Air Horse project (W 11 T)

The following is a list of a number of assumptions where the lecturer has introduced what I consider to be an excessive reserve without good reason

(1) *Aircraft Weight* The lecturer allows 2,100 lbs for passenger equipment to seat 27 against our allowance of 1,100 lbs for 32

This figure can be verified by comparing with recent Dakota conversions specifically designed for short-haul service, bearing in mind the availability in the helicopter of a hot air supply for heating and ventilating Assuming that this discrepancy contains a general reserve for increased weight, I would say that our weight estimates have the authority of an already existing forerunner of the type Indeed, considerable weight-savings are envisaged arising from increased acquaintance with the type of machine which will offset the usual weight increases inseparable from flight development to operational standard Finally, All-Up Weight is only arbitrarily fixed and provides a further reserve for weight increases

(2) *Fuel Consumption* W 11 T Engines are oversize This is the cause of some excess weight but is partly countered by benefits such as larger r p m -range and larger equivalent altitude-range for given power, greater reliability, high forward speed for maximum range

The lecturer has retained oversize engines, but in his consumption figures has used powers nearer to powers available rather than powers required The difference is no less than £2 10s 0d per hour cruising

I would like to emphasize that our estimates of power required already include a reserve margin of 4% Furthermore, our figures for specific consumption are not test bench results but include a further margin of 10% to account for the usual operational departures from the optimum arising from the condition of the engine, difficulties of precise governing and navigational errors Such a margin is firmly established in experience but further savings are possible through technical improvements such as a special supercharger gear ratio for the route in question and fuel injection

(3) *Maintenance* is often considered the most difficult in estimating

In all, the lecturer's estimate of £6 16s 8d per flying hour compares with £6 3s 0d according to our method I believe it will be appreciated that the lecturer's estimate, based on a small helicopter and making no allowance for improvements in rigging methods, is bound to be conservative

(4) *Crew Remuneration* It is difficult to understand why the lecturer has thought it necessary to include a handsome reserve in this rather straightforward item In accordance with the S B A C publication on standard aircraft costing, issued in September, 1949, the total crew cost for a crew of two, including expense allowances, insurance and pensions, is £2,220 for 900 hours, making £2 9s 0d per hour against the lecturer's £3 15s 5d

(5) *Insurance* We assume a rate of 8% against the lecturer's 10% I would like to say that even 8% is an exaggeration and 10% quite fantastic Such average rates correspond to at leat 10% and 12 5% actual rates based on book value 12 5% p a means an expectation of total loss in every 16,000 hours Does anybody seriously think that to run a passenger airline under such conditions is a practical proposition ? Insurance at such a rate is not insurance at all, it is the rate at which a non-risk taking organization can be persuaded to gamble At such rates it becomes apparent that " accident reserve," as I would prefer to call it, should be split between hourly cruising cost and the " landing cycle " cost and not count as fixed annual cost at all, because there is after all little risk in standing on the ground

The second class of differences in detail concerns cost items which must at this juncture constitute pure guesses Both the lecturer and myself have taken some guidance on take-off and landing-cycle costs and on general overheads, from Mr P Masefield's well-known lecture to the R Ae Society

Landing and Take-off Costs The lecturer assumes one-third of fixed wing costs, but gives no detailed information on the basis for this estimate Translating into terms of the London-Paris service on the basis of the lecturer's schedule the

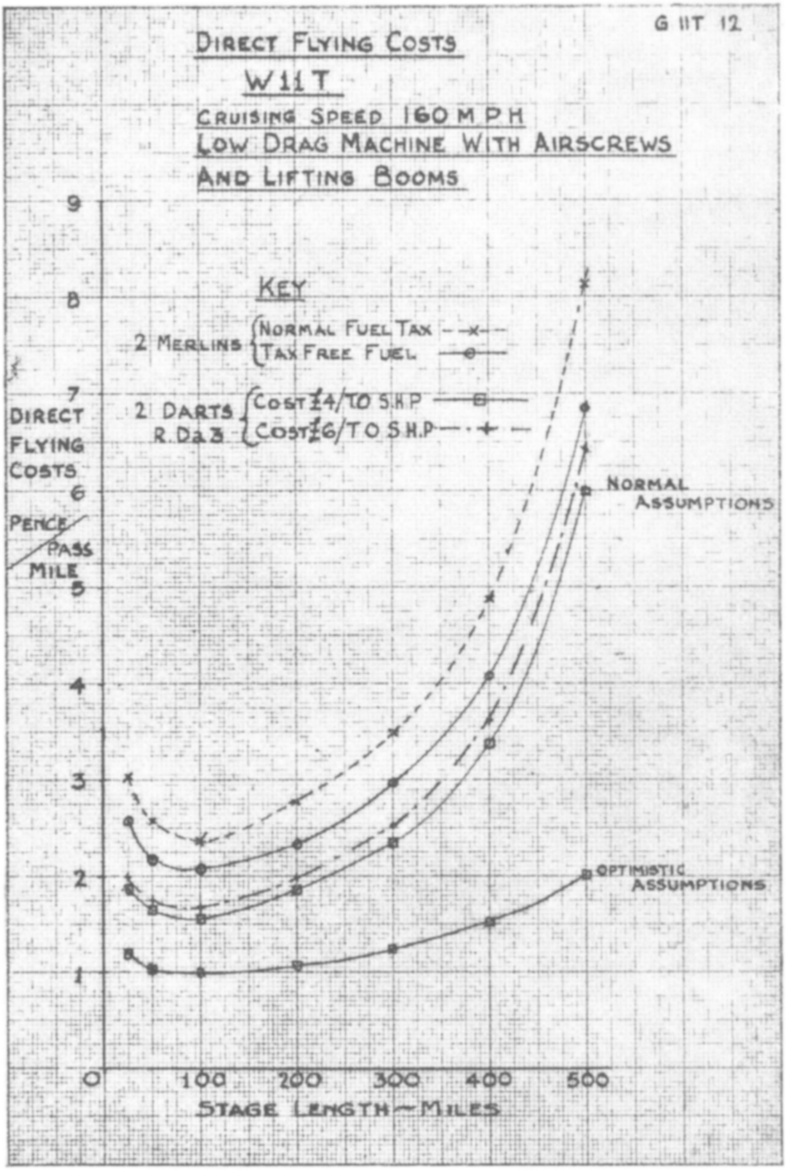

Fig 1 (*Contribution to Discussion by Mr J S Shapiro*)

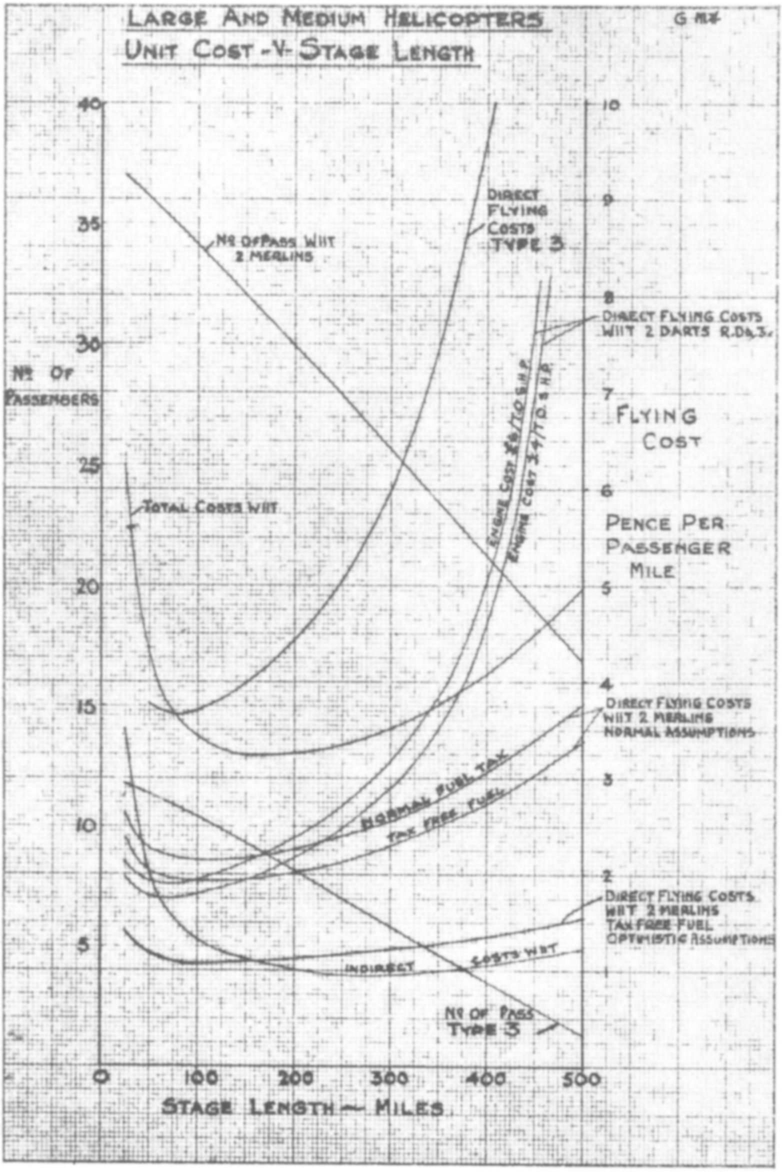

Fig 2 (Contribution to Discussion by Mr J S Shapiro)

cost per annum of running a rotor-station for this one line is £100,000 *at each end* I believe £60,000 is a more realistic figure, in which £40,000 are capital charges less revenue from rents, etc , and £20,000 are running costs, representing the time of 40 employees receiving an average annual remuneration of £500 each This brings us near to the figure of £10 per landing quoted by MR N E ROWE in his lecture to the Association

General Overheads We have cut the lecturer's estimates on administration throughout to half the figures given by MASEFIELD and eliminated the lecturer's increase in training and research expenditure over MR MASEFIELD'S estimates

In other respects our assumptions are rather similar to those of the lecturer, thus we equally assume a utilization of 2,000 hours per year and 30 lbs luggage per passenger

With regard to fuel reserves, the lecturer allows a total of 38 minutes at cruising consumption for all manoeuvring, stand-off and flight to alternative landing ground Our allowance is 27 minutes

On the other hand, all our estimates include a fuel reserve based on a 40 m p h headwind and we regard the construction of " Hour Charts " a premature refinement at this stage

Fig 1 shows the direct flying costs *vs* stage length of the W 11 T For comparison with Fig 10 of the paper, attention should be directed to the curve marked *piston engines, taxed fuel*

It can be observed that in the region of stage lengths of 200 miles the total costs are of the order of 3 25d per passenger-mile per capacity-seat A load factor of 72% leads to a cost of 4 5d per passenger-mile

The third heading of my criticism is that the lecturer, whilst dwelling at length on the higher limit of estimated costs, does not present the lower limit, and therefore fails to demonstrate the great potentialities of helicopter transport

Apart from what I would like to call our standard estimates I have included further graphs in Fig 1 First, a graph showing the effect of remission of fuel tax which already operates on cross-channel routes, and, we hope, will one day be generally applied

Further, another curve is shown labelled " optimistic assumptions," which is based on the following savings

(1) Reduction of first cost by 10%
(2) Reductions of fuel consumption by 10%
(3) Increase in obsolescence period from 5 to 8 years
(4) Small reduction in stand-off fuel allowance
(5) Small reduction in maintenance allowance
(6) Increase of A U W to 26,800 lbs (7 2%)
(7) Reduction in insurance rate from 8% to 5%
(8) Increase in utilization from 2,000 to 2,500 hours per year

None of these improvements requires breaking really new ground except perhaps reduction in first cost Direct costs are reduced to just over 1d per capacity passenger-mile Nothing more need be asked of flying equipment and further savings must come from the ground organization

Speed is the only unique commodity sold by the air transport operator Within its range the speed of a helicopter is more effective than that of a fixed-wing aircraft On the London-Paris route an increase in fixed-wing speed by 30% will reduce centre to centre time by 10% A similar increase in helicopter speed will improve centre to centre time by 22%

The Cierva Company's plans include further development of the W 11 T The aim of this development is to achieve a weak-mixture cruising speed of 160 m p h Our researches indicate that the combination of turbine power, airscrews, and some fixed-wing area produce such a cruising speed *without calling for any basic advances in aerodynamics*

Fig 2 shows the direct cost per passenger-mile of a helicopter developed to this stage It can be seen that increase in speed does not mean an increase in cost The scheduled time for the London-Paris journey is 1 hour 32 minutes, centre to centre Again, a similar set of optimistic assumptions reduces the direct cost to 1d per capacity passenger-mile

In conclusion I wish to assure the lecturer that in spite of much disagreement in detail I am the first to appreciate that he has performed a great service to the helicopter world by calling attention to the prime requirement in any useful art—a respect for arithmetic

O L L Fitzwilliams, B A (Cantab) (*Founder Member*)

He congratulated the lecturer on his paper and admired his courage for persisting in his own beliefs In spite of the allegedly conservative attitude of the paper, the lecturer had still managed to show that a profit could be made The work was based on fact and on what was believed to be possible, avoiding construction upon optimistic hopes Even then, we should have to work very hard to do as well as the lecturer suggested The paper was a basis for calculation

Mr Wigdortchik had introduced a new yard-stick for measuring efficiency —the rate of doing work This seemed an advance on earlier conceptions, but he did not believe this to be a final measure and care had to be exercised in its application He was rather dismayed at the number of spare components that the lecturer held were necessary for intensive passenger operation Could not a method of servicing be used where the manufacturers held spare components—overhauling and replacing to customers' requirements ?

R Hafner (*Member*)

He welcomed the lecturer's conservative approach and said that the paper presented a datum, whilst he also looked forward to the possibilities shown by Mr Shapiro's optimism He was coming more and more to the belief that for some time we should have to accept a limiting cruising speed of 130 m p h , in view of the vibration problem presented by the stalling of the retreating blade The lecturer had called for lower initial costs—he believed that this would only be achieved by higher rates of production and the application of different types of power plants—either pure jets or propeller turbines Manufacturers must obviously show vision in trying to assess the intersection of the supply and demand curves in relation to prices He stressed the importance of saving manpower and not horsepower as sound economics

L D Tyrrell, M B E , A R Ae S (*Founder Member*) (*Contributed*)

Whilst I am a firm believer in the future of rotary-wing aircraft, I am of the opinion that your paper (and subsequent speakers) painted an altogether too optimistic picture, and was little more than an expression of wishful thinking

It is assumed that any study of the economics of helicopter operations should be based on its use for passenger transportation, this sphere having by far the most promising commercial possibilities

If the helicopter is to be considered primarily as a machine for spraying crops, life saving or carrying mail, the obvious limitations of these applications would leave the helicopter with a doubtful future, and the restricted financial returns would make development costs prohibitive

It is assumed that helicopter operation is both safe and reliable, although this is far from being an established fact at the moment

Considering, therefore, the helicopter as a vehicle for passenger transportation, we must compare our present helicopters with the alternative means of transport, determine what advantages (if any) the helicopter can offer, assess the value of these advantages, and compare the costs

It may be reasonable to base our comparisons on projected helicopters likely to be built and proved in the immediate future, but it would be quite unfair to base our comparisons on imaginary conceptions of the distant future In the first place we have no real assurance that the design performance will be achieved, and secondly, we are neglecting the fact that our alternative means of transport—particularly the aeroplane—will also have made improvements in the interim period

As a fast passenger transport, and in comparison with the aeroplane, the helicopter has the peculiarity of its ability to fly slowly and hover, and this peculiar property gives the helicopter its *only* advantage, that of being able to take up passengers from confined spaces where they are most likely to congregate This is only an advantage if it can be proved to save time, and only a commercial proposition if the cost is competitively relative to other transportation time-savers

My own calculations show that, by comparison with alternative means of passenger transport, the present-day helicopter is grossly inefficient Its relative efficiency is so low as to suggest that normal development improvements will have little effect and that nothing short of revolutionary changes in the conception of the machine will bring it up to a competitive commercial basis

I think that to use present-day helicopters for public transportation is quite hopeless as a commercial proposition, and is likely to remain so for a long while to come

Unless some very radical changes are made, affecting the economy of the machine, its future must remain as a piece of highly expensive agricultural, life-saving or aerial photographic equipment with the remote possibility of some day becoming the private owners' flying machine, and this latter, I think, is the helicopter's most promising future

MR WIGDORTCHIK'S REPLY TO THE DISCUSSION

My immediate reaction to the speakers' comments this afternoon is to remind them that my paper has been written on the basis of what can be reasonably expected in the *next ten years*, based on experience, facts and a normal expectation of progress I have not allowed myself to make constructions or aspirations or hopes where these cannot be argued The work is therefore a datum and not necessarily a target We might be able to achieve much more, but then again we shall have to have our fair measure of luck and we will have to work very hard even to do as well Ten years is a short time and we are still at the beginning of rotary-wing development Some of my readers, enthusiastic as indeed they have to be in this hard field, may feel that I have been conservative, but others, equally knowledgeable on aviation matters, certainly think the reverse

The speakers have raised many points of query and one point of principle I shall do my best to answer them

MR ROWE has mentioned the high cost of the landing and take-off charges as shown in my paper They cannot be applied to all types of operation since they refer only to passenger operation of the pattern described in the London-Paris service MR SHAPIRO has queried the cost of rotor-stations and the two problems are, of course, interdependent The cost of rotor-stations depends on the nature of the service One might establish a rotor-station in a provincial town, for cross-country services, on parkland or waste, for a nominal capitalization of £3,000 But the type of rotor-station for a London-Paris service handling up to 2,000 passengers per day, with all the amenities that such an installation would require, would probably involve a capitalization of £150,000 The effect on landing fees and associated costs would be further affected by density of traffic, but, as can be seen, the limits are very broad And so I must refer MR ROWE to Part 8 0 of my paper, where the effect of small rotor-stations on operating costs are shown, and again, the experience of Los Angeles Airways is with mail operations only, there are no passenger-handling costs involved

With regard to AIR COMMODORE PRIMROSE'S point concerning the small quantity of ton-miles produced by the helicopter and whether or not they can be paid for, it is true that the added convenience and safety and, perhaps, regularity, will be an inducement to the passenger to bear higher costs, but how much higher ? In fact, it is a question of degree, but one in which, I feel, the helicopter of the next ten years will have to be worked very hard

The turn-round time of 30 minutes refers only to the London-Paris service, where it was chosen in order to allow sufficient reserve to maintain punctuality It is true, however, that a turn-round time of 15 minutes is a practical proposition, where schedules are not so interwoven

I agree with AIR COMMODORE PRIMROSE that the helicopter is, to-day, where the aeroplane was in 1920, except that a strict comparison of 2/- per passenger-mile then would give an equivalent cost of 6/- to-day This is rather higher than 8d , which I suggested I would say that the Type IV will do for helicopter transport what the Handley Page 42 did for aeroplane transport and after, roughly, the same lapse of time

Coming to MR SHAPIRO'S points, I must first of all emphasize the value of his contribution When one writes a paper of this length and scope it is gratifying that someone else should produce—in length—the other point of view, for that is just what MR SHAPIRO has done, and with great perception His criticism of principle is that he believes that I have shown the higher limit of estimated costs and not the lower limit, thus failing to demonstrate the great potentialities of helicopter transport My answer is that I have shown what I believe to be the lowest average of costs which we can hope for reasonably within ten years and that the lower figures, which he quotes, will only be achievable later As I point out in my paper, the true promise can only lie with to-morrow's generation of helicopter, and economy will be the key

With regard to Mr Shapiro's points of detail there is, firstly, aircraft weight in relation to my Type IV It is true that the figure of 2,100 lbs for 27 passengers is high, but it does include a galley The general weight reserve which it includes should have been shown separately I suggest, however, that the all-up weight for helicopters is by no means as flexible a reserve as it is for aeroplanes, where take-off performances can be, to some extent, sacrificed against the provision of suitable runways

The question of power required for cruising is largely a question of estimation and it may well be that the Cierva W 11 T, which approximates to my Type IV, is more economical My own calculations, based on existing types, however, have given the figures quoted in Table IX of my full paper However, I look forward to the improvements that he expects The operating reserves—that is the reserve against engine performance deterioration and faulty cruising drill—are similar to those used by Mr Shapiro

It is suggested that my maintenance estimates do not allow for an improvement in rigging methods—in fact I have banked on such an improvement In this respect I have assumed that these types will only require half the amount of rigging man-hours, in proportion to their weight, that are required for existing types

The question of crew remuneration is perhaps explained in that in the figures quoted by Mr Shapiro, my figure of £3 15s 5d per hour refers to two pilots, whereas his, I believe, refers to one pilot and one steward However, the large item in my costs of the aircrew pension fund is approximately £400 per annum—which figure is in fact being paid on behalf of all airline pilots in the United Kingdom to-day

I would now like to refer to insurance rates at 10%, and as raised by Mr Shapiro, and which he believes fantastic It is unfortunate that even airlines are now having to pay 6% for aeroplanes, and we have to face the fact that insurance companies are not likely to give the helicopter such a rate until the helicopter has proved that it is capable of deserving it It is quite true that insurance at such a rate is not insurance at all but, as Mr Shapiro says—the rate at which a non-risk taking organization can be persuaded to gamble It is only demonstrative of the fact that insurance companies are not in business for philanthropic reasons There is much to be recommended in his suggestion that perhaps the risk should be borne by the operator—and this is actually being done by certain operators of Type I helicopters in the U S A Perhaps we shall have to do something on these lines—at least until the helicopter has found its level

The total costs of 3 25d per capacity passenger-mile as calculated by Mr Shapiro for the Cierva W 11 T, are not so very much lower than those calculated for the London-Paris service, but I question the assumption that a load factor of 72% is achievable Obviously the question of what can be charged to the passenger is a complex matter and, as suggested in my paper, it is this which largely determines the best business-promoting price But his later and, as he states, optimistic calculations are not realistic as far as the next ten years are concerned, however attractive they may seem They do show how the entire economic picture can be changed by slender margins in the parameters governing costs, and how adherence to detail and fact, in assessing these parameters, can give us an awareness of the importance of fighting each point There is no room for slack-mindedness in business

I agree with Mr Fitzwilliams that the yardstick of " rate of doing work " cannot be applied without due consideration of the many other facts, but it does seem to be the major parameter at this stage Much might be done to reduce costs if manufacturers can hold stocks of replacement components so that operators can call on them when engaged in intensive operations But it must not be forgotten that wherever these stocks are held, they will represent capital expenditure which will have to be amortized and the operator will have to pay his share

Mr Tyrrell has expressed the view that my paper and the attitude of subsequent speakers is indicative of an altogether too optimistic picture and is little more than an expression of wishful thinking !

I think that we all have to ask ourselves from what viewpoint we assess the helicopter's possibilities I have always believed that the future of the helicopter depends on its economic potential standing on its own feet—quite unlike the aeroplane, which has always had its over-riding military application to justify its existence and finance its development I think it is a false and dangerous belief that subsidies will always have to be employed, subsidies beyond the nursing period are incentive destroyers and creators of false values—almost a confession of defeat before we start

Finally, and with reference to criticism that I have been conservative, I would say that it is too easy to imagine a rosy future with no problems The future of the helicopter is a battle of economics and in battle it is fatal to belittle the enemy I have done my best to set the problem in its true light and I find that the helicopter has a bright future—providing we keep our eyes open

Closing Remarks by Mr N E Rowe

I think that in that short time our lecturer defended himself well, and I think we have all listened to a most stimulating and interesting discussion

Air Commodore Primrose made several very good points in his talk In drawing out attention to what was happening to the aeroplane in 1920, and in comparing the high costs of operation then with the operational cost of the helicopter now, I think he gave us a good perspective I strongly support the possibility of using a synthetic trainer for helicopter training , I think this might reduce costs of training pilots very considerably

Several speakers referred to the rather cautious line which was taken by the lecturer and we have heard from Mr Shapiro particularly about the costs he would expect to have in the years to come Well, on that point I think that we all have our own judgment and we can look forward to the 4½d per mile which Mr Shapiro has promised us ! In the meantime, I think that the point made by the lecturer himself that the costs he assumed were based on current experience as to maintenance with the S 51, is very relevant

In thinking about the presentation of the discussion as a whole, we have to consider what can be expected in the intervening years, till say 1956/7, in terms of development and improvement , both Mr Shapiro and Mr Hafner, and Mr Fitzwilliams on the small aircraft, were quite certain we could look forward to real improvements which would help to reduce some of the figures that the lecturer has taken If we can have them, well, that is all to the good

I listened with great interest myself to what Mr Fitzwilliams had to say about the small aircraft and indeed Mr Shapiro made the same point The question of the maintenance and spares supply being done by a central body would make a very great deal of difference, and if the lecturer could spare the time to make the analysis suggested by Mr Fitzwilliams, this would be extremely valuable I thought that Mr Hafner in giving us a figure for future cruising and calling our attention to vibration as a limiting factor was putting his finger on a very important point

The lecturer himself in his written paper referred to the part played by communications in helicopter development and I think that it has a very important bearing on getting our perspective right in this matter I suggest that communications throughout the ages have really been subsidized in one way or another Nowadays all transport concerns have a subsidy of some sort or another In some cases it is hidden as in the case of the road-users of this country The system of roads has existed for centuries , their maintenance, improvement and development has been supported by local and county rates This is the hidden subsidy enjoyed by the road-user We must also remember, I think, that in the helicopter we are dealing with a new vehicle, and a new vehicle is bound to find a great deal of trouble in its introduction To start with, it seems only fair to me on this general question of communications which has been touched on by the lecturer and was referred to here by Mr Hafner, that consideration must be given to whether it is going to advance our business If it will enable a new economy to be built up, allowing of a more economic way of using our time, I am sure it will be found to be economic as a vehicle

Vote of Thanks to Mr Wigdortchik by Mr B H Arkell on behalf of the Association

I think we can agree that we have had a very interesting afternoon It has been a very good meeting to open our Winter Session for 1949/50 We have heard a very stimulating lecture which has needed a considerable amount of preparation by Mr Wigdortchik, and also a very lively discussion The lecturer, as Mr Rowe remarked, defended himself very admirably in the face of some quite severe criticisms I think if we might use the lecturer's own words and regard this paper as a basis and not as a target, it does then assume very considerable importance, and I think that we owe a great debt of gratitude to Mr Wigdortchik for its presentation I will ask you to signify our approval in the usual way (The vote of thanks was heartily accorded)