Some thoughts on the operational future of the Transport Helicopter

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NORMAN HILL, A M I MECH E , A R AE S
in the Chair

Introduction by the Chairman

It is the custom of the Association for the Chairman to introduce to you formally all its lecturers In the case of our lecturer this evening, there is no such necessity to do so, for we all know full well the name PETER MASEFIELD and the work that he has done and is doing in all branches of commercial and other aviation and doubtless some of us would wish to know something more of his background than is already available

In 1945, Peter Masefield was appointed by the Minister of Civil Aviation to be the first British Civil Air Attache at the British Embassy in Washington In 1946 he was appointed Director General of Long Term Planning and Projects at the British Ministry of Civil Aviation in London He led the British delegation to the South Pacific Air Defence Council in 1948 in Wellington, New Zealand In January, 1949, he joined British European Airways and was appointed Chief Executive and member of the Board in October, 1949, Lord Douglas of Kirtleside having been appointed Chairman a short while previously

It is of great interest to me, as I know it will be to you, that he holds a current pilot's licence and is a member of the Guild of Air Pilots and Navigators I consider this occasion is one for congratulation in that we are now able to add the name of Masefield to the already impressive list of our Association lecturers The subject of his paper will be known to you and is entitled " Some Thoughts on the Operational Future of the Transport Helicopter " I will now call upon Mr Masefield

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MR PETER G MASEFIELD

Helicopters—newest recruits to the ranks of passenger carriage—offer one major contribution to the field of Air Transport That contribution is their ability to operate successfully from small areas without the need for acres of prepared runways to get them into and out of the air This attribute may well bring the helicopter—and its developments—to the proud position of one of the world's leading transport vehicles

The helicopter's take off and landing characteristics are, at present, its only outstanding quality It has, in fact, no other advantage for air transport In its present stage of development it is slow It is complex It has difficult vibration characteristics It is potentially noisy It is expensive to buy and run And as yet it is small—too small to be economic

In due course the handicaps of slow speed and of small size, the vibration problems and the economic difficulties, all will be overcome Only the complexity—and perhaps the noise—are likely to remain But then man-made contrivances, in search of perfection, have been evolved in steadily more complex directions, in detail at least, ever since the Industrial Revolution began

ECONOMIC TRENDS

The potential of the helicopter as a serious means of transport—rather than a taxi, an airport 'bus or an " odd-job-man "—has been canvassed only in the past few years Its economics—as are those of any vehicle—are the essential foundation on which a case for the use of the helicopter in commercial transport must be based The practical advantages of the helicopter for short-haul transport between city centres are obvious What is not so clear is whether the helicopter can be used in this field on a truly commercial basis—that is to say whether, in its future developments, its operating costs can be less than the revenue it can earn in fares appropriate to the service offered

After a good deal of study, based on experience with existing types, the conclusion we have reached in B E A is that the helicopter is capable of development to a commercial stage during the next decade Its field, however, will be of a specialist character where the substantial saving in time which the helicopter can offer, compared with any other form of transport up to about 250 miles, will be worth the additional fares necessary to " break-even "

We believe that during the next ten years a large and relatively fast transport helicopter can be produced which will be able to cut train and air times by more than half at non-subsidised break-even fares about double those of first-class domestic rail travel to-day—or at fares on short international passenger services comparable with luxury surface travel

Later on, the economics of the large helicopter are likely to improve so that break-even fares more nearly match those of internal surface travel When this is achieved, the helicopter will be able to realise to the full its enormous potentialities as a short-haul vehicle That is, however, not likely to happen within the next ten years

Lest this should be considered an unduly pessimistic view, one must take into account another aspect which may well have a profound influence in speeding up the helicopter's development as a transport vehicle The fact is that the take-off and landing characteristics of the helicopter make possible important savings in airport costs, compared with the transport aeroplane These savings are potentially enormous But they cannot be defined with precision because of the impossibility of foreseeing as yet how many—or how large—airports would still be required for longer range air transport if the helicopter were to take over all air routes up to 250 miles stage distance In the late 1960's the development of the helicopter might well mean that London could be served adequately by only two major fixed-wing airports—Heathrow and Gatwick—instead of at least four which will be necessary if present traffic trends continue These potential economics which the helicopter may bring must be taken into account in any comparison of the relative economics of the helicopter and the aeroplane

THE TAKE-OFF AND LANDING PROBLEMS

Thus the protagonists of the helicopter can look for its success in offering a solution to the major transport requirement over which the fixed-wing aeroplane has failed Indeed, ever since man first achieved flight in heavier-than-air-machines—now nearly half a century ago—the major impediments to the most convenient, regular and economic use of air transport, as a service to the community, have been the problems of take-off and landing These problems apply with special force over short or medium distances

Such pre-occupation with starting and ending a flight is fundamental A highly desirable feature of any means of transport is that a journey should start from the most convenient point and should proceed safely, quickly and without change of vehicle to its destination And, against that background, the failure of the fixed-wing aeroplane to triumph over its earth-bound environment offers the helicopter its chance (Fig 1)

Present developments in air transport have led to a situation where there are now more than 2,000 major civil airports throughout the World At a rough estimate, the capital investment sunk in hard runways and taxi tracks at these airports (leaving out of account their radio installations and airport buildings and traffic aprons), amounts to not less than 1,000 million pounds What is more, the average surface journey-time taken from city-centre to airport is not less than 30 minutes—at the present stage of air transport representing a useless expenditure of about a million passenger-hours on road conveyance every week, at a mean speed of only some 20 m p h

If, from the early days of air transport, a means of achieving satisfactory flight could have been developed using some means of vertical take-off and landing, the saving in fixed installations would have been tremendous—quite apart from the intangible advantages in enhanced safety, in the avoidance of the sterilisation of valuable land and in the speeding up of journey time

As things are, the fixed-wing aeroplane is certain to be here with us for very many years to come It will develop in speed, in size, in economy and in safety as each year goes by And with all that, the major transport aircraft of the future will continue to require runways of up to 2,000 yards long to achieve its phenomenal performance

Probably, in the long run the characteristics of the helicopter and of the jet aeroplane will be combined to provide a vertical take-off and landing —although whether that will be achieved with rotors is, in my view, doubtful Elimination of the rotor, with all its troubles, should certainly be the eventual aim—and with it, the achievement of " helicopter performance " at take-off and landing as simply and as cheaply as possible

I am not concerned in this study, however, with either ultimate developments of simple jet thrust for vertical flight and descent—or even with the

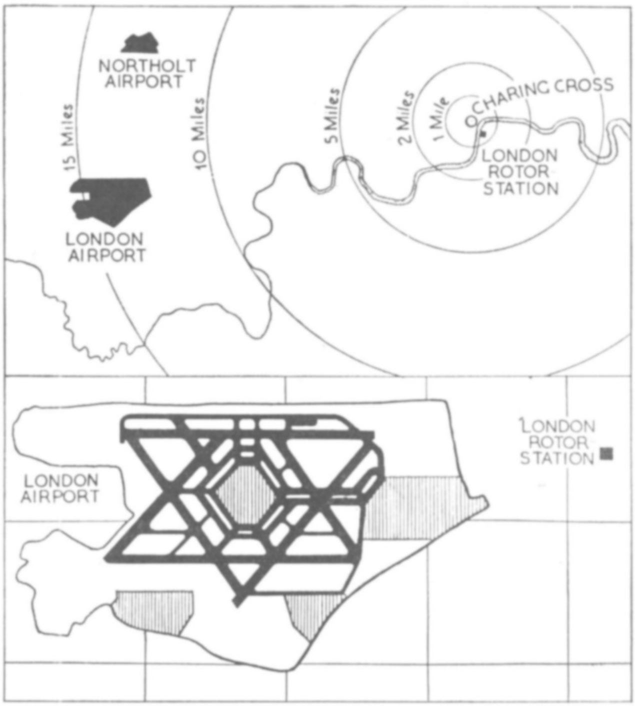

FIG 1 ROTORSTATION *v* AIRPORT

Geographical advantages Comparisons in terms of distance from City centre and of area (lower sketch)

(*By courtesy of Flight*)

so-called " convertible aircraft " or " convertiplane," probably an unhappy, and anyway transitory, compromise I am concerned here only with the helicopter and its direct development—probably with wings and propellers —in the field which one can foresee for it—however dimly—over the next 10 to 15 years

So, today we find that—alongside the active work which is leading us to the 600 m p h juggernauts of a few years on—there is developing, although all too slowly, a new means of transport through the air which overcomes those inherent take-off and landing deficiencies of the fixed-wing machine This solution, the helicopter—its serious beginnings dating, after Cierva's

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FIG 2 THE FOCKE-ACHGELIS Fw61

inspiration, from the Focke-Achgelis Fw 61 (Fig 2) which first flew on 26th June, 1936, and the VS-300 (Fig 3) of Igor Sikorsky which first flew on 14th September, 1939—opens up new vistas for the future At the same time it brings with it serious problems of its own

I must emphasise that throughout this analysis of the capabilities of the helicopter, I have confined my studies to the specialised case of the high competitive, low-price, operation of the transport vehicle In this category the helicopter has to compete with other, established, means of transport which set high standards of reliability at relatively low fares There is also another aspect of helicopter operation, although it is a side which I have not taken into account here It includes both transport operations overseas, where conditions may be quite different from those I have analysed in this study and also the other many uses for the helicopter outside the field of scheduled transport There are certainly manifold opportunities for the helicopter overseas, where it can perform duties which no other vehicle can attempt

In these directions, the helicopter can achieve results which will justify much higher operating costs than those which are acceptable in the highly competitive field of European transport

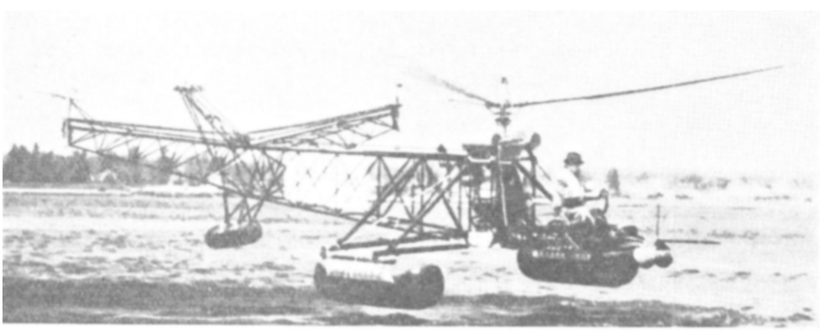

FIG 3 THE VS-300 OF IGOR SIKORSKY

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Against this background of alternative use, the British products already show up remarkably well There seems little doubt that the British Aircraft Industry, producing such machines as the Bristol 173, is on the right road and has ideas which are more advanced than any at present forthcoming elsewhere Furthermore, such operating experience as is available so far, shows that these British helicopters are entirely practical and rapidly approaching high standards of reliability On the competitive economies a comparison between the Bristol 171 and the Sikorsky S 51 shows a very marked advantage to the British machine

BASIC NEEDS

To be successful as an economic means of transport in the future the helicopter must be large and it must be fast Lower limits for these two qualities, in the immediate future, can be set at not less than 40-passenger seats and not less than 150 m p h cruising speed Even these minima will result in a helicopter substantially more expensive to operate than the equivalent fixed-wing aeroplane

No helicopter exists today which can offer either one of these two qualities—although several are in the offing Until a machine is built which combines both qualities satisfactorily—and with them a reasonable standard of exterior quietness—the major field of activity for the helicopter must lie outside the realm of commercial air transport

The large, fast, and reasonably quiet helicopter is still a vision of the future But it is entirely capable of achievement And so my belief is that, although the helicopter has so far reached a stage in scheduled civil passenger transport work not yet equivalent to that achieved by the fixed-wing aeroplane in the early 1920's, and although at present there is no large passenger transport helicopter in service anywhere in the World, nevertheless the passenger helicopter will, during the next 20 years, assume a major role not only in short haul air transport but also as a major factor in all forms of transport for all distances between about 50 and 400 miles

In spite of this bright future which opens before the helicopter in the transport World there is, as yet, no general realisation of the amount of work, money and time which is needed before the helicopter can be regarded as a developed and economic vehicle, adequate for the tasks which it will have to perform A vast amount of effort is needed, particularly on power-plants, transmissions, and rotor systems, together with much expensive, and time consuming, proving and development flying The design and the production of a large, fast, passenger-transport helicopter remains a major engineering task comparable with that of the Comet or Britannia airliners in the United Kingdom or of the Super-Constallation or Stratocruiser in the United States

THE DEVELOPMENT PATTERN

Helicopter development can in fact be seen as evolving in three stages —

(1) The present phase of building up operational experience with small, single-engine, single-rotor machines not capable of economic service or of operating safely into built-up areas as a regular procedure

(2) The interim phase in which medium-size, multi-engine helicopters—such as the developed Bristol 173—can be brought into service Such types

will be the first to achieve scheduled operations on any scale and will be the first which will be capable of operating safely into built-up areas They will nevertheless be limited severely by their economic characteristics, which leave a great deal to be desired

(3) The beginning of the use of the helicopter in its fundamental role—that of short and medium stage commercial air transport between city centres That phase cannot begin until a multi-engine helicopter with a speed of at least 150 m p h and a capacity of not less than 40 passenger-seats is available, so that the operating costs per seat-mile can be reduced to an acceptable level without the need for a heavy subsidy Even so these aircraft are likely to be substantially more expensive to operate than equivalent fixed-wing types In my opinion this third phase cannot begin before 1960—and is likely to be still further delayed

PRESENT EXPERIENCE

Up to the present time operational experience on scheduled services with the helicopter is confined almost entirely to two operating companies in Europe and two in the United States They are, in Europe, British European Airways and Sabena, the Belgian Airline, and in the United States, Los Angeles Airways and Helicopter Air Service Inc of Chicago In addition, in the United States the Skyway Corporation of Boston, Massachusetts, operated a shuttle service between the International Airport at Boston and a garage roof in that City between April and July, 1947

The privilege of operating the World's first regular scheduled passenger helicopter service fell to British European Airways with the start of the scheduled operation between Cardiff and Liverpool on 1st June, 1950 Between that date and 31st March, 1951, a total of 1,086 hours were flown in completing 741 scheduled journeys during which a total of 819 passengers were carried

From the 1st June, 1951, the service was transferred to the Birmingham-Northolt-London Airport route and between then and 5th April, 1952, a further 809 hours were flown completing 1,212 scheduled flights, carrying 1,166 passengers This service is still being continued on freight operations while additional research work is done B E A remains the only operator which has so far flown serious passenger services for more than a very short period (Fig 4)

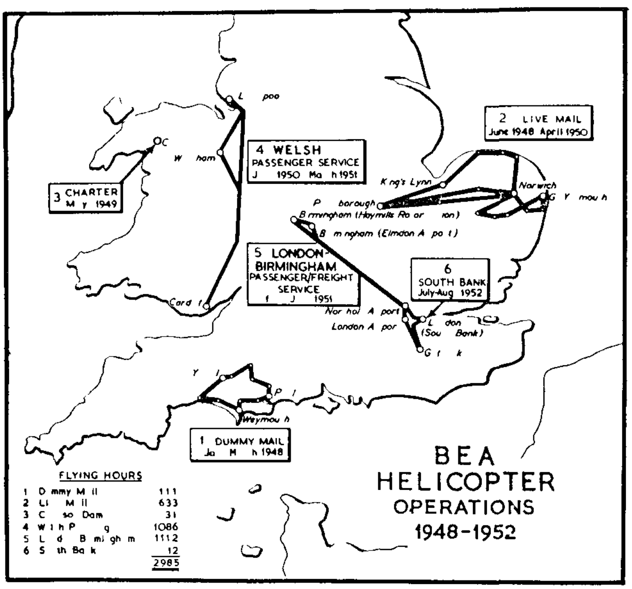

FIG 4

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Sabena has been operatıng hıghly successful scheduled aır maıl servıces sınce September, 1950 As Mr Anselme Vernıeuwe of Sabena recently descrıbed before the Helıcopter Assocıatıon of Great Brıtaın, a total of about 2,000 hours have been flown wıth Bell 47 helıcopters over a route cırcuıt of 266 mıles wıth nıne ıntermedıate stops

In the Unıted States the operatıng experıence can be summarısed as follows

(a) *Los Angeles Aırways* has, sınce October, 1947, buılt up some 24,000 flyıng hours wıth S 51 helıcopters, carryıng maıl ın the greater Los Angeles area Los Angeles Aırways ıs now ın the process of acquırıng the larger S 55 aırcraft

(b) *Helıcopter Aır Servıces Inc* has flown approxımately 16,000 hours ın the Chıcago area, carryıng maıl, sınce August, 1948 Bell 47 helıcopters have been used

In addıtıon, New York Aırways ıs about to start maıl servıces ın the New York area, especıally lınkıng New York's aırports wıth Manhattan, usıng S 55 helıcopters New York Aırways plans to fly passenger servıces after ınıtıal experıence wıth maıl

Many other operators are ambıtıous to enter the field

All these operatıons, wıth comparatıvely small sıngle-engıne sıngle-rotor machınes, do not represent as much as one day's servıces by the World's aırlınes There have been suffıcıent, however, to ındıcate that the helıcopter can now be made ınto a relıable and acceptable—although uneconomıc—vehıcle for passenger transport over short and medıum dıstances

What we have to do now ıs to use what lıttle experıence we have as a guıde to the soundest possıble plannıng for the future These plans must state a requırement for the vehıcle and try to determıne both ıts method of operatıon and the pattern over whıch ıt can perform ıts most satısfactory servıce to the communıty

BROAD REQUIREMENTS

Samuel Butler saıd " Lıfe ıs the art of drawıng suffıcıent conclusıons from ınsuffıcıent premıses "

That statement ıs all too true of the requırements for the helıcopter today We have no experıence of large, multı-engıne, helıcopters upon whıch to draw, yet we must try to guess what we can achıeve wıth them ın framıng an operatıonal requırement for the future

Too conservatıve an estımate eıther of performance or of sıze wıll lead us, after a great deal of expensıve experıment and development, to a vehıcle whıch cannot be used satısfactorıly or economıcally ın servıce On the other hand too optımıstıc a guess wıll lead us to a " whıte elephant " lıke the " Great Eastern " too far ahead of ıts tıme to be used ın servıce

As I have already stated, my belıef ıs that the best compromıse wıll be found by lookıng forward to a large multı-engıne helıcopter capable of cruısıng at not less than 150 m p h and that we should plan to achıeve a vehıcle of thıs sıze and speed by 1960 I belıeve that such a helıcopter—known to as ın B E A as the " BEAlıne Bus "—offerıng between 40 and 70 passenger seats ıs just wıthın the technıcal capabılıtıes of today's knowledge Such a sıze should just be suffıcıent to make the helıcopter a practıcal commercıal vehıcle for lımıted operatıons yet ıt ıs not so far ahead that ıt would be lıkely to lead to an expensıve faılure

FIG 5   THE BRISTOL 173

There is, however, an essential step on the way towards this commercial helicopter of the 1960's That essential step may be partly filled by the development of the Bristol 173 helicopter, now flying

The Bristol 173 is the first twin-engine passenger helicopter to fly successfully (Fig 5) And although it is too small, in its present form, to offer economic results on regular passenger routes with good ground communications, nevertheless it represents an important step forward in size and capabilities compared with the single-engine types at present in service

If we are to achieve the development of the helicopter in passenger transport to which we are all looking, work on the development of the Bristol 173 must be pressed forward, supported by adequate financial backing

We in B E A —led with enthusiasm by our Chairman, Lord Douglas of Kirtleside—believe that the Bristol 173 could form the basis for a helicopter development from which useful results could be gained and for which—as an act of faith—the Corporation would be prepared to place a production order

Not only will the developed Bristol 173 make possible the starting of experimental scheduled operations into city-centres but it will make possible also the building up of further essential operating experience on the basis of which the truly commercial helicopter can be developed

Although we in B E A hope to receive for intensive assessment and testing, the second prototype of the Bristol 173 with two 550 h p Alvis Leonides engines, during the Spring of 1953, this early version has not the payload capacity to make it acceptable for serious operations

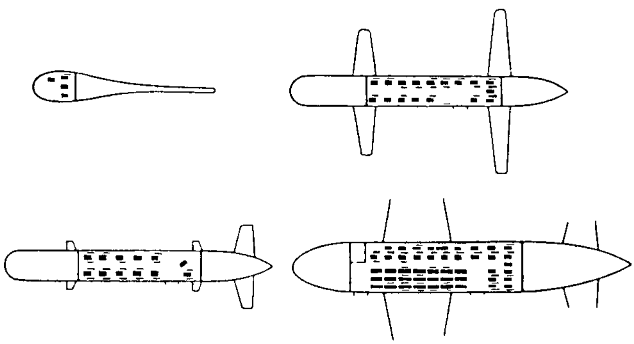
Increased power from the installation of two 870 b h p Leonides Major engines and the addition of stub wings to unload the rotor during cruising flight and to increase the speed, are essential to the use of the developed Bristol 173 (the Mark 3 version) as an interim commercial type

If work was pressed forward with despatch, and adequately supported by funds, we believe that a prototype or pre-production version of the

Bristol 173 Mark 3 helicopter could be delivered to B E A in the Autumn of 1954 Development flying could be pressed forward with this aircraft in preparation for a start on scheduled freight—and later passenger transport —operations with production Bristol 173 Mark 3 helicopters These scheduled operations unfortunately could hardly be expected to begin before 1957 because of the need for gaining a full Certificate of Airworthiness and because of the position on engine production Nevertheless, by the time a large helicopter was available in the early 1960's, some years of scheduled operating experience would have been built up, including service into rotor-stations situated in city centres

Cruising at about 115 m p h (100 knots) and offering 18 passenger seats in simple 'bus form over a stage distance of approximately 115 miles, the developed Bristol 173 Mark 3 should have a total operating cost of about 9 5 pence a seat mile, which, although high, could be tolerated commercially over certain key routes Were mail contracts gained the passenger fares could be usefully reduced

If such a programme is to be attained there is no time to lose and work on prototypes of the developed version of the Bristol 173 will have to start without delay If production aircraft are to be delivered to B E A by the Spring of 1956 for passenger service in 1957 the first prototype of the developed (Mark 3) version with stub wings and Leonides Major engines will have to fly not later than the Autumn of 1954, two years from now It is a tight schedule, particularly because the essential Leonides Major has still to be produced and type tested



Bristol 171
4 Passengers

Bristol 173 Mk 3
18 Passengers

Bristol 173
13 Passengers

Possible layout for
" BEAline Bus "
48 Passengers

FIG 6 FUSELAGE CAPACITY
(*By courtesy of 'Flight*)

The Bristol 173 may be considered as an essential step towards the future large helicopter At present only two prototypes of the original version are being produced (of which one will come to B E A), plus three, additional and improved, non-civil, machines which will be capable of taking the larger 870 b h p Leonides Major engines

Such numbers are, of course, quite inadequate for the work which must be put in hand The development and type testing of the Leonides Major engine will require a high priority We in B E A believe that production of an initial number of Bristol 173 Mark 3's with Leonides Majors and stub wings will be justified as soon as satisfactory initial trials are complete —in 1954

Experience with the Bristol 173 Mark 3 will lead us to the true commercial helicopter with which to extend the commercial use of the helicopter to a network of short haul services

The various stages in the development of representative British helicopters up to this " BEAline Bus " of the 1960's are set out in Fig 6

THE B E A SPECIFICATION

In October, 1951, B E A issued a specification of requirements for a large helicopter and this specification has been the subject of design studies now in course of preparation by five British manufacturers

A primary object behind the B E A requirements for a helicopter much more advanced than anything contemplated at the time it was issued, was to stimulate thought on what would be needed to bring the helicopter to a commercial stage and to make constructors think seriously on how to meet the requirements It has, I am sure, succeeded in that first objective—and as a result there will be a truly commercial British transport helicopter at a much earlier date than there otherwise would have been—even though that date cannot be soon

The chief features of the B E A Specification of requirements, as originally laid down, were as follows —

(1) In its initial form, a requirement to carry 30 passengers (or 7,000 lb of payload) over a stage of 115 miles In its finally developed form, to carry 35/45 passengers (or 10,000 lb, of payload) over a 230 mile stage

(2) Fuel tankage to permit operation on a 230 mile stage against a 46 m p h headwind

(3) Both the above to be achieved with fuel reserves for 45 mins stand-off

(4) A commercial cruising speed of at least 138 m p h (120 knots) at 2,000 ft using either maximum weak mixture power or 50 per cent METO power, whichever is the lesser

(5) A vertical rate of climb at sea level and maximum power of at least 600 ft per minute without ground effect and at zero forward speed

(6) Cruising speed, with critical engine inoperative, of at least 115 m p h at 5,000 ft Rate of climb at best forward speed, with critical engine inoperative, of at least 200 ft per minute at 5,000 ft

(7) Ability to operate from an area 400 ft in diameter, with upstanding obstructions all round, contained below a cone with a slope of one in two from a circle 300 ft in diameter centred on the landing area It should be possible to operate in such a manner that, in the event of engine failure at any stage of the flight, the helicopter can return safely to the take-off point or continue its flight and land elsewhere

(8) Ability to make an autorotative landing over a 100 ft screen within 150 yards

(9) The importance of safety, mechanical reliability, good stability and handling characteristics and the ability to operate in all weathers were particularly stressed, as was the importance of low operating and engineering cost

(10) Other features asked for included ability to permit indiscriminate loading full dual control, complete instrumentation with all necessary aids to all weather operation, blade folding, provision for rapid turn-rounds, low vibration characteristics, air conditioning in the cabin and low external and internal noise levels

These outline requirements, now more than a year old, have been modified and extended somewhat in the course of discussion and developed thinking—although their broad characteristics remain unaltered

Like all forms of aircraft, a helicopter is essentially dependent on its power plant for determining its size and performance Possible power units for the large " BEAline Bus " might be

(a) Two Bristol Centaurus piston engines 2 × 2,625 b h p)
(b) Four Bristol Hercules piston engines (4 × 1,660 b h p)
(c) Two Bristol Proteus turbo-prop engines (2 × 4,000 e h p)
(d) Two de Havilland Ghost turbo-jet engines (2 × 5,000 lb static thrust)
(e) Four Rolls-Royce Dart turbo-prop engines (4 × 1,525 e h p)
(f) Four Armstong-Siddeley Mamba turbo-prop engines (4 × 1,475 e h p)

If any of the four latter engines were to be used a requirement for a pressurised cabin might well result although the wind speeds at height and the effects of blade-tip Mach number and tip-stalling may delay such developments The short stages flown by helicopters would also militate against operation at more than moderate heights Nevertheless high rates of climb and descent from even moderate heights may dictate cabin pressurisation as a requirement

With any of these power units the large helicopter would come out at a gross weight varying between about 35,000 lb and 62,000 lb , with seating capacities for between 45 and 90 passengers Commercial cruising speeds might vary between about 150 m p h (130 knots) and 200 m p h (175 knots) according to the weight and type of propulsion used A reasonable, and not too optimistic, " guesstimate "—ahead of the submission of design studies to the specification requirements—would be a helicopter having a fuselage with a capacity for up to 64 passengers in high density form for very short stages (25 miles) falling to 48 seats for 250 miles, 48,000 lb gross weight, a practical mean cruising speed of 160 m p h and a rotor diameter of about 72 ft

The original conception of starting with a minimum of 30 passenger seats and 130 m p h cruising speed for a minimum of 115 stage miles and going up to 35/45 passenger seats for 230 stage miles, is now seen to be too small and too slow for acceptable economy in service A revised requirement would call for a minimum of 40 passenger seats for a practical operating distance of 230 miles, with an upper figure of around 70 passenger seats A minimum acceptable cruising speed would be 150 m p h —anything slower, being too uneconomic

What the large " BEAline Bus " type helicopter will look like I do not pretend to forecast here The design studies now being worked upon will undoubtedly bring forward a number of quite different solutions—some with two engines, some with four, some with single rotors, some with more Certainly, a number of the projected aircraft will have propellers to help the attainment of a relatively high forward speed—and most of them will have wings —stub or not-so-stub—so as to unload the rotor in cruising flight and help to raise the cruising speed as well as provide somewhere to stow the undercarriage

On the subject of accommodation, one must not forget that the transport helicopter is likely to be required for a variety of roles—from that of the high-density 'bus over distances as short as 50 miles to the luxury lunchtime B E A " Silver Wing "-type service over international stage distances involving nearly two hours of flying This implies varying standards of seating and of such items as catering equipment and stewarding

Certainly on the London-Paris route exacting standards will be required Axiomatic to any expanding form of transport is the principle that an obsolete vehicle can never be replaced by a new vehicle of smaller size And present London-Paris aircraft have 47 seats —or more

The helicopter may also have important uses in short haul freight transport Its application to such specialised tasks as car-ferrying is possible and again will dictate a sufficiently large size of aircraft

The sales of such a vehicle are not likely to be confined to this country If produced in time and to the right requirement it can command export sales which will be no less widespread than those of the Comet, the Britannia, or the Viscount

Nor must we forget that work on large helicopters is already in progress in the U S A Several types of large military helicopter are well advanced and their advent will mean that the United States will be in a strong competitive position in the commercial field

If the United Kingdom fails to make a determined effort now in the continued development of the Bristol 173 and in pressing on towards the commercial vehicle of the size of the " BEAline Bus," we are likely to lose the World market for this class of aircraft in much the same way as we lost the export market for the transport aeroplane 20 years ago

AN ESSENTIAL DEVELOPMENT PROGRAMME

So much for the outline requirement To achieve that requirement much work, time and money are essential And there is, unfortunately, still too little realisation of the scale of activity which is needed if the helicopter is to be developed to the stage of a practical and relatively cheap form of everyday transport within the next decade

The cost of developing such a vehicle must be reckoned in millions of pounds rather than in hundreds of thousands The prototype cost of a helicopter is likely to run at approximately the same rate as that of a fixed-wing type—which, in these times, works out, including design, at approximately £40 per lb of gross weight for two prototypes Assuming a gross weight of about 50,000 lb (48/64 passenger seats) two prototype " BEAline Buses " would cost about £2,000,000 excluding engine development

Engine development is, of course, an expensive business The adaptation of an existing engine for work in a large helicopter, plus development work on the necessary ducting, coupling and gearing—and the type testing thereof—could not add up to less than about £1,500,000

Thus two prototypes, complete with engines, up to the stage of their first flight would be likely to cost approximately £3 5 million—not less

Much ground test work would be needed with such a radically new vehicle Ground running, together with test rigs and so forth would be likely to absorb about £300,000

Finally, a necessary provision would be flight testing The Air Registration Board is, I understand, likely to require several thousand hours of test flying before a fully commercial Certificate of Airworthiness would be granted to passenger service with such a large new vehicle Such an amount of flying would take very many months were only two prototypes available and undoubtedly presents a strong case for an additional prototype—or pre-production aircraft—at a further £400,000 or so Whether a third prototype is built, or not, 3,000 hours of test flying at about £120 an hour would cost £360,000 Some of these hours might be piled up on experimental freight services so that some revenue could be arned Even so, the test flying is bound to be a very expensive item

Adding all these up, we arrive at the following figures

(*a*)	Two prototypes at £40 per lb gross weight	£2,000,000
(*b*)	One additional pre-production aircraft at £8 per lb	£ 400,000
(*c*)	Engine and transmission development	£1,500,000
(*d*)	Ground test rigs and running	£ 300,000
(*e*)	3,000 hours of flight testing (less revenue)	£ 300,000
	TOTAL cost up to start of production	£4,500,000

Then there comes the stage of jigging and tooling and of production cost Comprehensive jigging and tooling for a 50,000 lb aircraft of this sort would cost not less than £1,500,000 Obviously the bigger the production order the cheaper the individual aircraft will be However, the direct cost of materials, labour and overheads for construction of production aircraft would be likely to average £3 per lb of gross weight (Fig 7)

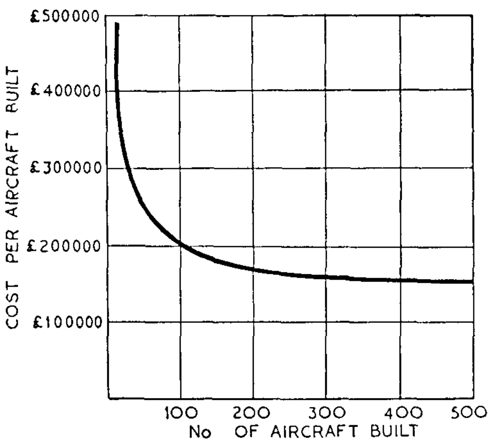


FIG 7 " BEALINE BUS "
Cost of Manufacture per Aircraft
(By courtesy of 'Flight)

That means that, with development and jigging and tooling costs of £6,000,000 a production run of various number of 50,000 lb helicopters would cost the following amounts for each machine, covering all development costs incurred

20 aircraft	£450,000 each	£9 0 per lb)
50 aircraft	£270,000 each	£5 4 " ")
100 aircraft	£210,000 each	(£4 2 " ")
200 aircraft	£180,000 each	(£3 6 " ")
500 aircraft	£162,000 each	(£3 2 " ")

The scale of jigging and tooling which I have envisaged in the figure of £1,500,000 is of an order suitable for the production of large quantities of aircraft If only small numbers were to be produced the tooling bill could be reduced substantially, with some useful effect on selling price Against this, a point which is becoming increasingly obvious in the field of fixed-wing aircraft production, is that time is the essence of any manufacturing contract The rate of production as well as the total numbers produced must, of course, be taken into consideration in judging tooling costs

My personal belief is that, if the large helicopter came up to the performance estimated, not less than 200 would be sold At £180,000 each they would be thoroughly competitive in prime cost with the sales price of current fixed wing aircraft of similar gross weight

A programme of the sort outlined above could not take less than about seven years to bring to the stage of C of A trials It would mean a capital outlay of about £21 million, spread over ten years or so to bring 100 aircraft into airline service All that money would be recovered provided the machine was a success—as could be determined relatively early in the expenditure programme

Such a project requires the fullest possible Government support—not at present obvious From the point of view of bringing Great Britain to the forefront in this new field of technological and commercial endeavour, its importance cannot be over-stated And time is slipping by

HELICOPTER ECONOMICS

A programme of this magnitude must of course be founded on a sound economic basis, combined with detailed traffic estimates related to the likely fare structure

As nearly everybody knows, the present small helicopter is utterly uneconomic For instance, the total operating cost of B E A 's three-passenger S 51s in low-intensity service, works out at about £100 a flying hour or 24 shillings a mile The cost per aircraft mile is thus about 2½ times that of a 27-passenger Viking, although this comparison is not entirely fair to the S 51 as these costs are incurred over a wide range of experimental applications

Cost estimates have been made by B E A for four helicopter developments These estimates compared with that for the 32-passenger Pionair, are set out hereafter , in each instance the figures being for the " Aircraft Type Costs " which are those directly associated with the aircraft type These costs together with the normal airline and promotional costs, make up the total costs to the operator of using each type of aircraft For the Bristol 171 and 173 Marks 1 and 3, the operator's Total Costs are estimated as amounting to some 180 per cent of the respective Aircraft Type Costs For the " BEAline Bus " the ratio is estimated at 170 per cent , while for the Pionair, on present achieved costs, the ratio is 200 per cent

Total Costs arrived at in this manner while representing the costs of operating a particular type of aircraft from the Operator's point of view, do not necessarily give a complete picture of the comparative overall economics of the helicopter and the aeroplane Landing fees, paid by operators of fixed-wing aircraft for the use of airports, navigational aids and air traffic control facilities, although they make a reasonable contribution to the direct cost of providing such facilities, do not cover to any significant extent the enormous national investments made in this vital field all over the World Obviously they should not be expected to do so because of the impossibility of establishing how much of such an investment is justified on grounds of national prosperity and prestige or to meet essential military requirements

The same arguments will, no doubt, in due course apply also to the provision of rotorstations, navigational aids and air traffic control for helicopters Although the cost of control facilities and navigational aids are likely to be similar for both the aeroplane and helicopter, there can be no doubt that the cost of providing rotorstations will be much less than that of building airports This is the factor which represents the main unknown in any comparison between the overall economics of the aeroplane and the helicopter Although its effect cannot be assessed at this stage, it will clearly mean that, from the taxpayer's point of view, the helicopter will offer substantial economies in capital investments when the shift comes from the aeroplane to the helicopter for the short haul services

As an example of this sort of saving, present traffic forecasts indicate that the volume of airline passenger traffic between London and the near cities on the Continent of Europe is likely to grow to such proportions that, were all air travel to be performed by aeroplane, four or even more airports of the size and cost of Heathrow would be required to serve in the London area alone This fact will undoubtedly lead to the development of very much bigger transport aeroplanes in order to keep the numbers of aircraft movements within bounds However, if the greater part of the short-haul traffic were to move by helicopter from a number of small, and relatively cheap, rotorstations, the savings in airport costs by themselves might more than outweigh the development costs of the large helicopter

Leaving these intangibles out of account, the relative Aircraft Type Costs for domestic operations in the U K work out as follows

	Bristol 171 (1952)	*Bristol 173 Mk 1 (1953)*	*Bristol 173 Mk 3 (1955)*	*BEAline Bus (1960)*	*B E A Pionair DC 3 (1951)*
1 Basic Annual Costs (per annum)	£6 660	£13 170	£16 400	£43 800	£6,150
2 Hourly Cruising Costs (per flying hour)	£11 95	£21 60	£26 35	£62 20	£33 50
3 Take off and Landing Costs (per Landing)	£1 00	£2 10	£2 40	£8 00	£9 30
Assumed Power Plant	One Leonides	Two Leonides	Two Leonides Major	Two Turbines	Two Twin Wasp
Gross Weight (lb)	5,300	10 600	14 000	48 000	28 000
Rotor Diameter (ft)	48 3	48 3	48 3	72	—
Commercial Cruising Speed (m p h)	92	104	115	160	167
Assumed Passenger Seating Capacity	4	10	18	48/64	32
Assumed Revenue Utilisation (hours per annum)	2 000	2 000	2 000	2,000	2 000
A Cost per Aircraft Mile					
At 50 statute miles	4 48s	7 64s	8 82s	19 64s	11 95s
At 100 ,,	3 94s	6 54s	7 34s	15 41s	7 95s
At 200	—	—	6 75s	13 32s	6 38s
At 300	—	—	—	—	5 70s
At 400 ,,	—	—	—	—	5 44s
At 500	—	—	—	—	5 17s
A Cost per Available Seat Mile					
At 50 statute miles	13 40d	9 75d	5 88d	3 87d	4 48d
At 100 ,, ,,	11 80d	9 62d	5 30d	3 36d	3 02d
At 200 ,, ,,	—	—	6 34d	3 54d	2 39d
At 300 ,, ,,	—	—	—	—	2 14d
At 400 ,,	—	—	—	—	2 08d
At 500 ,,	—	—	—	—	2 07d

These derivatives illustrate a number of important points which are best shown by plotting the Aircraft Type Costs per seat-mile against stage

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lengths, in Fig 8 The curves for the 32-passenger Pionair and 48-passenger Discovery (V 701) provide a basis for comparison

These curves indicate that the Bristol 171—while substantially more economic than the S 51—is too expensive for any serious scheduled commercial services The Bristol 173 in its present form (the Mark 1) is some 25 per cent cheaper per seat-mile at its optimum stage distance of 80 miles,

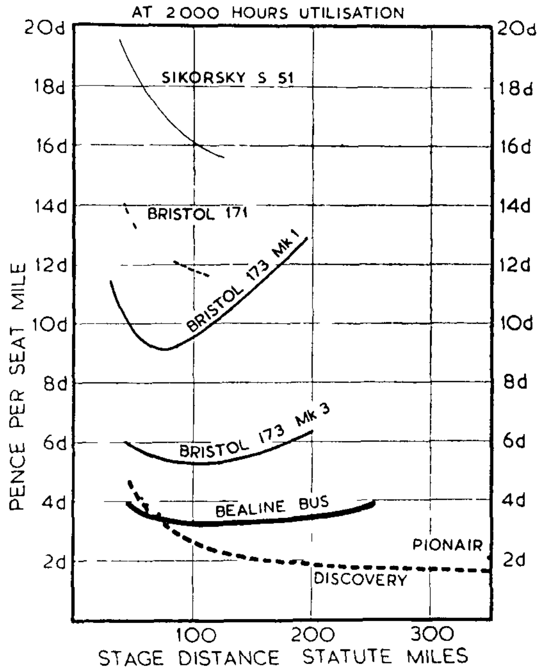

Fig 8

Aircraft Cost per Seat Mile

but is not commercially possible for scheduled operation without heavy subsidy The developed Bristol 173 Mark 3 shows a marked improvement compared with the present version—a reduction of 44 per cent at an optimum stage distance of 100 miles At a total cost of about 9 5 pence per seat-mile, the developed 173 Mark 3 will be some 60 per cent more expensive than the Pionair per seat-mile It will be worth operating commercially, on a limited scale over routes where its characteristics offer competitive advantages or where possible savings in aerodrome costs would be sufficient to warrant the higher airline costs—such as in Scotland, by about 1958

The 48/64-passenger "BEAline Bus" is a much further advance, halving the seat-mile costs and bringing them within reasonable distances of the fixed-wing standards over useful stages Even so the "BEAline Bus" —as a 48/64-passenger aircraft—does not achieve as low costs as the 32-passenger Pionair, except on very short stages, leaving out of account potential savings in aerodrome costs To achieve comparable seat-mile costs a still larger and faster helicopter would be required—and that may be beyond the practical possibilities of the time

In Fig 9 the cost per seat-mile is plotted against gross weight at a stage distance of 100 miles From this we can see that on present trends, a total

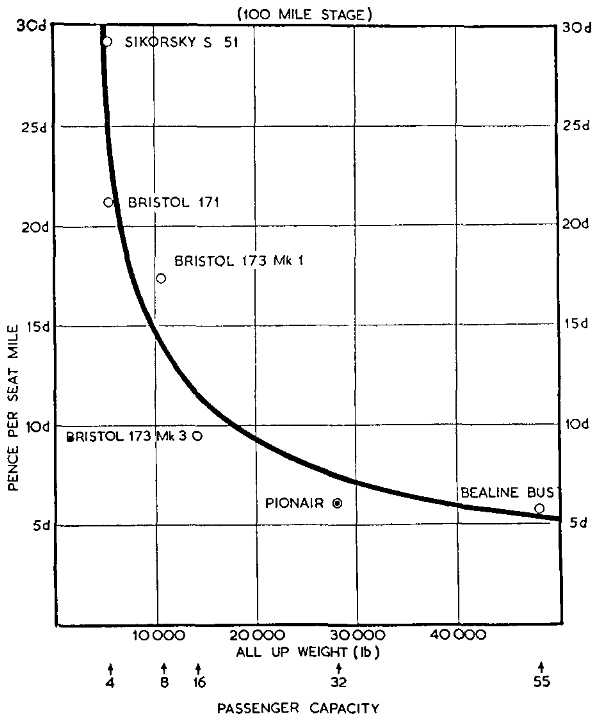

FIG 9
TOTAL COST
PER SEAT-MILE
v
ALL-UP WEIGHT

(By courtesy of " The Aeroplane)

cost per seat-mile of fourpence cannot be gained until we can produce a helicopter of some 80,000 lb all up weight with a capacity of about 100 seats

Fig 10 indicates that, again on present trends, a speed of some 220 m p h will be needed to achieve a total cost per seat-mile of fourpence

These figures indicate that we cannot hope, in the next decade, to achieve unsubsidised helicopter fares which will be below those of fixed-wing aircraft—except for very short stages where the aeroplane serves no useful purpose As an indication of the return fares required to break even on total costs at a 75 per cent load factor, the following figures are of interest (Fig 11) —

Sector	*Distance Miles*	*Existing First Class Return Surface Fare*	*To break even at 75 per cent Load Factor*		
			Bristol 173 Mark 3	*BEAline Bus*	*Pionair*
London Birmingham	90	£2 8 10	£9 14 0	£5 12 0	£6 13 0
London Manchester	152	£4 0 6	£17 10 6	£9 10 0	£8 17 0
London Jersey	180	£6 19 7	—	£11 12 0	£7 17 0
London Paris	224	£14 6 8	—	£15 11 6	£8 18 0

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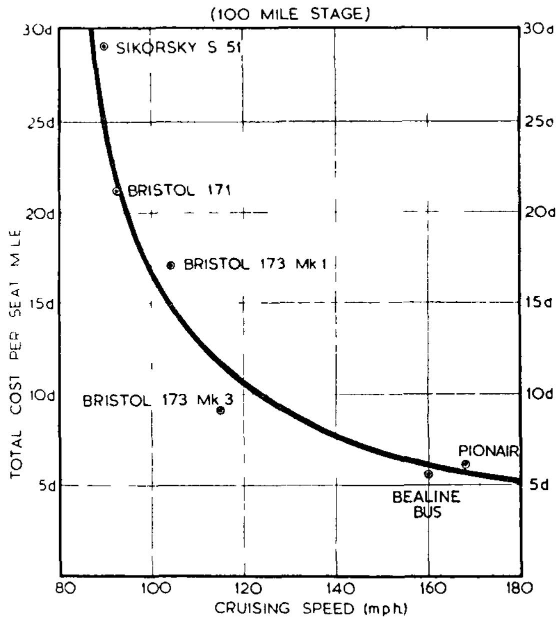


FIG 10
TOTAL COST
PER SEAT MILE
v
CRUISING SPEED

The Bristol 173 Mark 3 would be able to show a saving of 1 hr 8 mins between London and Birmingham compared with the fastest train, and of 2 hrs 12 mins between London and Manchester It could not operate with adequate reserves to Jersey or to Paris The higher cost of this helicopter to Birmingham and Manchester represents a price at the rate of over £6 an hour saved compared with the train—a high figure

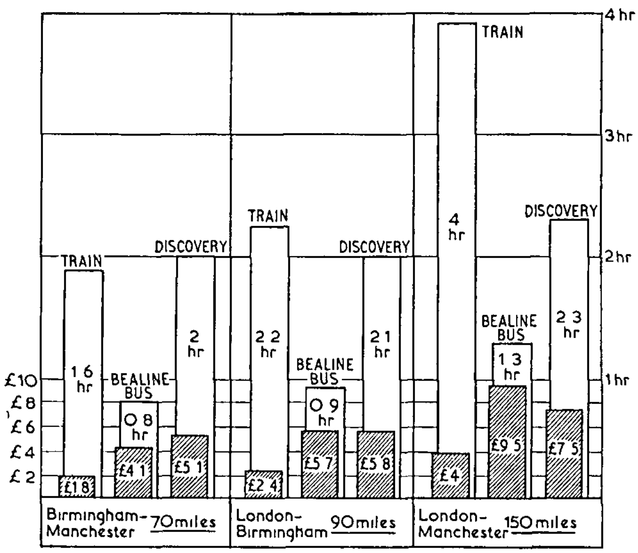


FIG 11
HELICOPTER—
AEROPLANE—
TRAIN

Time and Fare Comparison

Fares assumed Train, first-class return 1952 Helicopter and Discovery, estimated rate-even return

(By courtesy of "Flight")

The " BEAline Bus " would save 1 hr 20 mins to Birmingham and 2 hrs 30 mins to Manchester, compared with the train—savings working out at the rate of £2 37 an hour to Birmingham and £2 19 an hour to Manchester

In these circumstances a 160 m p h 48/64-passenger helicopter would probably be worth operating from London to Birmingham and to Manchester at about double the first-class rail fare Between London and Jersey and London and Paris the competitor is not so much the train and boat as the aeroplane Here the savings in time are again probably worth the extra fare—leaving the cheap, tourist travel to the fixed-wing machine This is a most important point The helicopter becomes, over the longer range (150 to 250 miles) the luxury vehicle and its break-even fares must be judged against this fact and its saving in time

Indeed, on these facts, the " BEAline Bus " may well find its most favourable application on international short-haul services where the fares which are required to cover costs more nearly match existing surface rates

THE IMPORTANCE OF SPEED

Let us now turn to the question of speed A point which is not generally realised is that cruising speed is of the utmost importance not only in the economics but also to the competitive ability of the helicopter

In assessing helicopter speeds we are, of course, interested primarily in the total journey time between city-centres Because of the time taken by surface transport from city-centre to airports for fixed-wing aircraft, a 500 m p h jet transport flying for a stage distance of 100 miles will have a total journey speed pulled down to only some 47 m p h A 160 m p h helicopter would arrive 71 minutes earlier over such a distance—in other words it will more than halve the journey time compared with the 500 m p h jet

Although problems of drag, of power, of rotor blade stalling and, possibly, of vibration, will set an economic limit on the cruising speed of helicopters in the next decade, there is a lower economic speed limit also

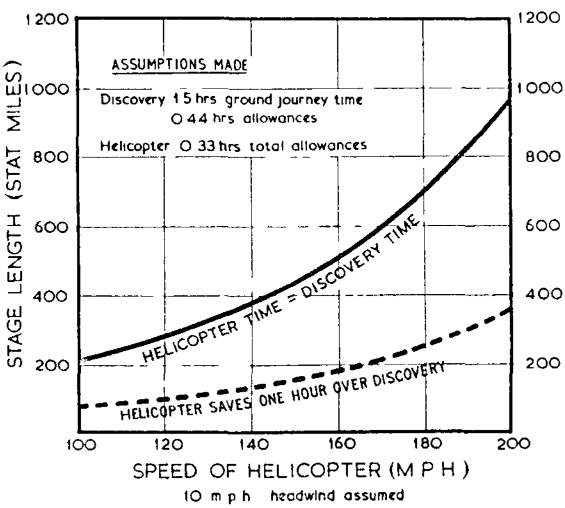


FIG 12
HELICOPTER
v
AEROPLANE

The effect of increase in Helicopter speed on its ability to compete with the aeroplane over longer stages (City centre to city centre)

If the helicopter is too slow it cannot succeed as an economic commercial vehicle Too slow a speed means that the vehicle cannot maintain either punctuality or regularity against moderate headwinds Fuel reserves have to be higher for a slow machine Furthermore, the stage distance at which a helicopter can compete with the fixed-wing aeroplane is reduced very much —and with it the utility of the helicopter—as the speed is reduced

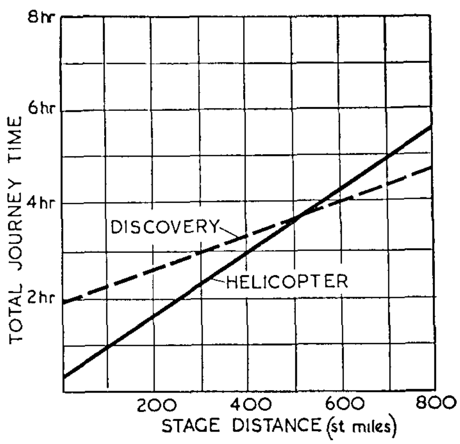
As things stand today, the lower economic limit on the speed of a large transport helicopter can be set at about 150 m p h A helicopter slower than that speed could not be considered as a serious transport vehicle for other than limited use

Obviously the faster the helicopter the better its competitive ability For instance an increase in speed pushes up usefully the distance over which the helicopter can show an improvement in journey time compared with the fixed-wing aeroplane Thus (Fig 12) a 120 m p h helicopter can achieve the same practical journey time between city-centres as can a 290 m p h aeroplane for a stage distance of 300 miles—except that the helicopter's punctuality will be low against headwinds But a 160 m p h helicopter can achieve the same journey time as a 290 m p h aeroplane over a stage distance of 600 miles—vastly extending the competitive field of the transport helicopter Unfortunately the 160 m p h 48/64-passenger helicopter will be

FIG 13
TOTAL JOURNEY TIME
(City Centre to City Centre)
Discovery *v* " BEAline Bus "

A speed of 291 m p h is assumed for the Discovery, and of 160 m p h for the Helicopter, an allowance being made in each case for a headwind component of 10 m p h

(*By courtesy of " Flight*)



too expensive to operate commercially beyond about 250 miles over which distance it saves nearly an hour's journey time compared with the 290 m p h aeroplane

In Fig 13, total journey time for the 290 m p h Discovery (V 701) aeroplane is plotted against that for a 160 m p h " BEAline Bus " helicopter The helicopter is faster between city-centres up to a distance of 500 miles —well beyond its practical range The total journey speed for the helicopter and aeroplane are plotted in Fig 14 This illustrates the fact that the helicopter can achieve a journey speed of 100 m p h between city-centres at a stage distance of 100 miles, whereas the turboliner aeroplane can do so only over a stage distance of 300 miles

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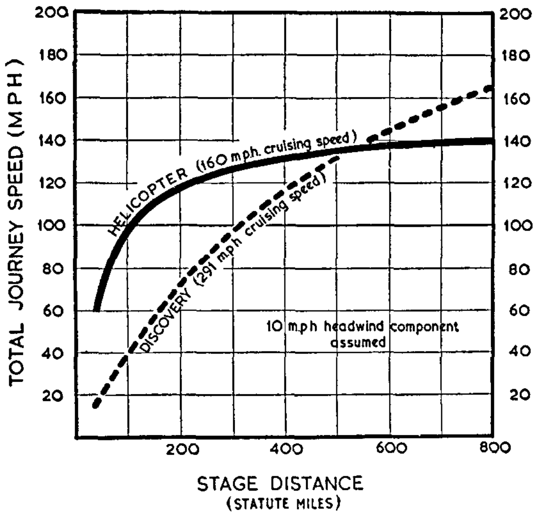


FIG 14
TOTAL JOURNEY SPEED
(City Centre to City Centre)
Discovery *v* " BEAline Bus "
(By courtesy of The Aeroplane)

AN OPERATIONAL " GUESSTIMATE "

Let us now turn from the economics and the speeds to consider what can be achieved by a large helicopter in active airline service

We may assume for the purpose a " BEAline Bus " with the following characteristics

Passenger capacity	48 seats for 250 miles
	64 seats for 25 miles
Normal cruising speed	160 m p h (allowing a margin to increase speed to meet headwinds while maintaining schedule)
Gross weight	48,000 lb
Rotor diameter	72 feet

Such a helicopter will have an optimum stage distance of about 120 miles, at which the total cost per seat-mile would be about 5 56 pence—rising to 6 56 pence per seat-mile at 250 miles

A possible route network for such a " BEAline Bus " is shown in Fig 15 This hypothetical network links all the major traffic centres in the United Kingdom and joins them with the nearer major Continental cities —Paris, Brussels and Amsterdam

A 160 m p h " BEAline Bus " would replace—in terms of journey speed—fixed-wing aircraft on all domestic routes within the United Kingdom with the exception of the three major trunk routes London to Edinburgh (327 miles), Glasgow (339 miles) and Belfast (319 miles), where the fast turboliner would still show advantages both in city-centre journey speed and cost

I understand that the Post Office may possibly be interested in a helicopter network radiating out of Crewe—a historic junction point for surface mails If so there would have to be developed a helicopter " mail van " either to fly direct to other postal centres such as Newcastle, Norwich and Bristol in the " wee sma' hours " or to link with the existing passenger helicopter network Any special helicopter " mail van " is likely to prove very costly

The network shown, however, is not intended to do more than illustrate possibilities for direct links and the sort of schedules which could be planned It is by no means comprehensive nor exhaustive but it does indicate likely major trunk routes where high frequency helicopter services would be possible London to Manchester would, for example, be capable of being scheduled at 1 hour 16 minutes, city centre to city centre, compared with today's fixed-wing schedule of three hours between city-centres and the fastest railway time of 3 hours 30 minutes The longest sector shown is London-Amsterdam which is 221 statute miles, taking 1 hour 48 minutes

The London-Amsterdam stage distance is at the upper end of both the economic scale and practical range for the " BEAline Bus " as projected here The fare necessary to break-even at a 75 per cent load factor would be about £15 4s 0d , which is rather less than today's standard air fare and which compares with the first-class return rail fare of £11 19s 0d The " BEAline Bus " would, however, take only 1 hour 48 minutes between the city centres compared with 2 hours 48 minutes by Discovery and 11 hours 10 minutes by train and steamer The helicopter's time saving over surface transport could therefore be priced at 3/6d an hour while, compared with

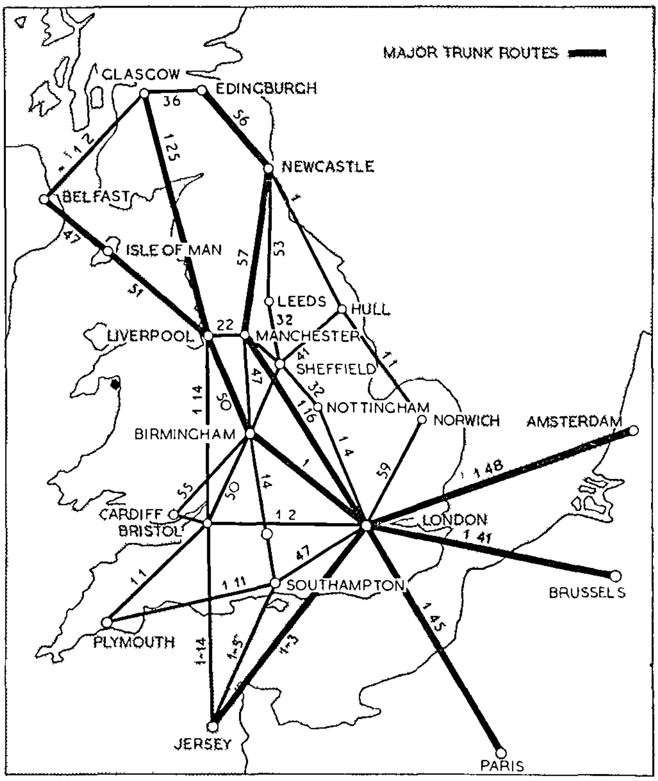


Fig 15
Potential "BEALine Bus" Routes (196?)
160 m p h , 48-Passenger Helicopter
Figures represent journey time for each route in hours and/or minutes

(By courtesy of Flight)

todays' aeroplane, the helicopter will save an hour's journey time and at the same time offer a slightly reduced fare

From all this we can conclude that, on such a route network, the primary role of the transport helicopter is to operate directly from traffic centre to traffic centre In my view, the helicopter-taxi over very short stages, such as between airports and city centres, is not likely to prove a practical—or an economic—proposition A taxi operation from London Airport to the Waterloo Air Terminal would require a one-way fare of about 16 shillings for the " BEAline Bus "—not likely to prove attractive

The route network outlined does not preclude, however, the possibility of brief stops at major airports to set down and pick up interline traffic Certain Manchester-London helicopter services, for instance, might well call at both Ringway and Heathrow for two-minute halts, to offer connections with long-distance fixed-wing services

Such a network operated by " BEAline Buses " at economic " break-even " fares would probably attract a substantial amount of the first-class traffic over these routes, besides creating new helicopter traffic of its own In this connection it is interesting to note than some 60 per cent of B E A 's annual passenger traffic today—amounting to some 750,000 passengers—travels on sectors potentially within the operating range of the " BEAline Bus " However, if the helicopter is to carry this traffic, it must offer not only fares which can be afforded but also standards of safety, of regularity, of punctuality and of comfort acceptable to the travelling public as a whole

Safety is, of course, the first requirement It depends on three major factors

(*a*) Mechanical reliability
(*b*) Air traffic control procedures
(*c*) Airline operating standards

Mechanical reliability can be attained only by meticulous attention to detail in design, in construction, in flight testing and in airline maintenance A helicopter is, fundamentally, more complex mechanically than is a fixed-wing aeroplane and may require more engineering man-hours to keep it serviceable An intensive pattern of helicopter services means that a carefully worked out system of air traffic control will be essential, including integration of helicopter services with that of fixed-wing aeroplanes

The airline operating standards, including the crew training, to which large helicopters will be operated, are a further fundamental to safe operation

OPERATING STANDARDS

Helicopter operating standards are, of course, as important as are those for fixed-wing aircraft, when both are used for the carriage of fare-paying passengers

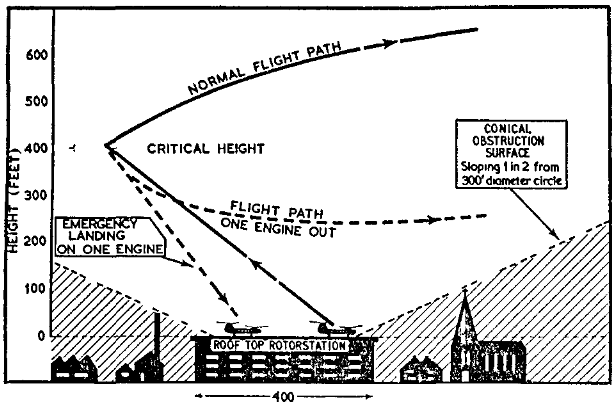
Operating standards apply to every phase of flight For illustration, those applying to take-off and landing and to en route performance may be taken specifically

Safety at take-off from small rotorstations is essential It means that techniques must be worked out carefully and that the helicopter concerned must possess a satisfactory performance with one engine out

A take-off technique, which may well prove to be the most satisfactory, is backwards at an angle of about 40 degrees (Fig 16) Such a technique means that the pilot can keep his alighting area in view all the time, Should an engine fail below the " critical safety height," he can reverse his direction and come down again, along a steeper flight path, to alight safely within his take-off area " Critical height " in this sense may be defined as the height at which the helicopter can safely translate climb into level flight with one engine out without such loss of height that a forced landing will result At or above safety height, the backwards ascent would be translated into a normal forwards climb on course Then, if an engine failed, the pilot would not, normally, attempt to get back to the rotorstation but would fly to a convenient nearby airport and probably make a runway landing

FIG 16
HELICOPTER
BACKWARD
TAKE-OFF
PROCEDURE

(By courtesy of " The Aeroplane)



In the interests of economy in operation, the ability to hover with one engine out is probably best eliminated Indeed, so long as a satisfactory take-off performance is achieved with all engines operating, the minimum speed to maintain level flight with one engine out can safely be relatively high Landings with one engine out would then be made, like a fixed-wing aeroplane, at airports Two other considerations will, however, influence the performance required after an engine has failed The first of these is the problem of landing at a rotorstation in low visibility The second is the en route performance required to clear specific obstacles, such as mountains

In bad visibility a helicopter has the great advantage over an aeroplane of being able to approach both steeply and at low speed With adequate radio aids and high intensity lighting, a helicopter should be able to approach and alight safely with lower minima than a fixed-wing aeroplane—until satisfactory automatic blind landing for fixed-wing types is achieved

But account must be taken of the sequence of events should an engine fail below critical height during a blind approach In fact, the regulation will probably have to be that no helicopter is allowed to continue an approach below critical height unless the landing area is visible from that height

The regularity of helicopters in bad weather will thus be governed by their critical safety height, which itself is a function of their performance with one engine out If, for example, a helicopter could always climb away after one engine had failed, then the critical height could be ground level But such a helicopter would be sacrificing useful payload to achieve such a phenomenal performance and could more economically be operated at a higher gross weight

These facts may well lead, in their turn, to the requirement for operations at a lower gross weight in bad visibility than in VFR conditions—thereby improving the engine-out performance

When we turn to the en route case, the requirement is, obviously, the ability to clear the highest point on the route by an adequate safety margin after engine failure Such a requirement, on particular routes, may limit the safe all-up weight In certain circumstances it may have a greater influence than the requirements for take-off and low-visibility landings

There is also no doubt that the development of an accurate and reliable navigational aid either semi or fully automatic, will be as essential to commercial helicopter operations as an adequate system for low visibility approach and landing The two aids would be complementary and might, indeed, be provided by one set of equipment

There is one further point—fuel reserves

There has been a tendency in some quarters to suggest that a transport helicopter will not need much in the way of fuel reserves Much as one would like to endorse that view, in the interests of payload, I am afraid that it is not likely to be attainable in the interests of both safety and economy

Fuel reserves are of four sorts

(*a*) Those required to combat unexpectedly adverse headwinds
(*b*) Those required to enable the vehicle to " hold " in the landing pattern
(*c*) Those required to enable the vehicle to divert to an alternative landing point
(*d*) Those required to meet increased consumption such as may occur after engine failure with turbine power plants

Regular helicopter transport services in bad visibility will, inevitably, slow down the rate of landing at any rotorstation We must expect and plan for high frequencies of operation and a high landing rate at peak periods Helicopters must therefore be capable of " holding " like fixed-wing aircraft and, if necessary, diverting to alternative alighting points in bad weather when the rate of landing is reduced The suggestion that a helicopter should merely pop down at any convenient point and wait its turn to come in, is not realistic In low visibility at night a helicopter will be almost as dependent on landing aids as an aeroplane A blind descent into an open field (possibly laced with high tension cables) is not really a practical proposition, even with an uneconomically high one-engine-out performance

Adequate fuel reserves will certainly be necessary and the requirements of 45 minutes' stand off reserve, plus ability to complete a flight against a 46 m p h headwind, as agreed in the latest B E A Specification of Requirements, is certainly not over stringent

QUICK STOPS

An additional point in the operating pattern will be the vital need for quick turnrounds and transit times at rotorstations

The basic reasons for this need are that

(1) Rotorstations, by their very nature, will be of restricted area with strictly limited parking space There will, therefore, be a serious limitation on the number of helicopters which a rotorstation will be able to accommodate simultaneously

(2) Helicopter services, because they are short-haul, will be of high frequency This means that there will be rapid air traffic control saturation of rotor-stations unless the time taken for the landing and take-off is brief
(3) Helicopters will have high standing charges because they are basically complex and expensive vehicles This means that their utilisation will have to be high for economic operation Rapid turn-round is essential for high utilisation on short-haul services

Design for quick entry and exit of passengers and for rapid loading and unloading of baggage, mail and freight is thus essential High speed pressure refuelling is also a requirement For maintenance and overhaul the large helicopter will probably fly to a major airport where it can share Base facilities with its fixed-wing brethren Apart from such breaks in the operating programme the need will be to cut ground stops to an absolute minimum

NOISE

One of the awkward—but " must-be-solved "—problems which faces the helicopter is that of noise For some reason, as a people, we, the British, seem to be particularly susceptible to—or specially intolerant of—noise from the air, judging from the volume of residential protests which arise from those who live in the neighbourhood of the approach paths to busy airports

We must all have sympathy with these views Modern aircraft are noisy—especially the jets And, as there is a strong probability that future large helicopters will be propelled by turbine engines, the problem of noise at city-centres is very real

Recent tests at the South Bank site with B E A 's S 51 and Bristol 171 helicopters have been made so that the M C A could measure noise intensities No report has, as yet, been published, but I understand that a good deal of concern is felt officially about the level of noise measured—especially with the Houses of Parliament well within earshot There may be occasions when the noise level in the House may drown the helicopter—but one cannot plan on that

The fact is that if we cannot solve—or divert—the helicopter noise problem, then we shall have to start thinking again about the transport helicopter If it were banished from city-centres on account of noise the whole advantage of the helicopter would be lost and the money required for the development of the large helicopter would be more usefully spent on improving the fixed-wing aeroplane

A real effort is needed Even though the suburbs are now the dormitory areas, hotels and hospitals as well as business houses—and even learned Societies—inhabit city-centres and demand reasonable quiet, despite the thunder of buses and the rocket of pneumatic drills

Roof-top sites for rotorstations can help to keep the noise from street level A parabolic shaped " crash barrier " around the perimeter of the roof site can do something to reflect noise upwards away from neighbouring buildings But the maximum amount of silencing tolerable from a payload point of view must come from the detail design of the aircraft Noise might possibly rule out the use of straight jet engines or tip-jet units on the rotors —although some bleeding of air round the jet engines may bring about some degree of silencing Something can be done to dispose the engines and their exhausts to reduce noise, especially with a stub wing to act as a blanket

A rapid rate of climb at a steep angle—and equally rapid and steep rates of descent—can also help very much towards reducing the menace of noise

The problem must be taken seriously The fact is that unless we can make the helicopter tolerably quiet in service its use as a transport vehicle will be jeopardised I cannot over emphasise the importance of this fact But the problem is not insoluble

ROTORSTATIONS

Finally, in the operating picture, comes that essential, the traffic stop —the " rotorstation "

I use the word " rotorstation " advisedly It was originated some three years ago by Mr N E Rowe when, as " Controller of Research and Special Developments " in B E A, he was in charge of the work of the B E A Helicopter Unit The word rotorstation says what it means the word " rotor " being a generic term for helicopter and the word " station " being recognised universally as a term for " the stopping place of a public service vehicle "

On the other hand " air stop " means nothing at all It certainly does not come in the category of " bus stop " A bus stops at a " bus stop " but the air fortunately continues to flow at an " air stop "

I hope that use of the etymological monstrosity " air stop " will be abandoned swiftly, along with those other terms of illiteracy, " helidrome " and " hoverplane "

In my view the desirable qualities for a rotorstation are that

(*a*) It must be at, or very close to, the city centre, or centres, so that a minimum of time is wasted by passengers in reaching their destinations

(*b*) It should be situated on a roof-top so as to avoid the air turbulence associated with ground sites near large buildings, so as to avoid sterilising valuable building land, and so as to reduce the noise at street level

(*c*) It must have refuelling points built-in (with adequate safeguards) so as to reduce journey times The helicopter cannot afford to fly off to refuel

(*d*) For safe and satisfactory operation on a busy route the size of alighting area should be not less than 400 feet square, including essential parking space

(*e*) The building should house, if possible, airways offices and town terminal and might well incorporate an elevated garage (In London an ideal site for the main rotorstation would be on the roof of a rebuilt Waterloo Air Terminal, incorporating hotel, shops, bus station and underground station)

(*f*) The roof would not need to be strengthened significantly beyond normal practice but would have to be rendered impervious to petrol and oil (The extra cost of fitting the roof of a new building for helicopters has been estimated at rather less than 20 shillings per square yard or about £17,000 for a roof of the size required)

The problem is, of course, to find or to erect, buildings of adequate size to act as the basis of rotorstations in cities already congested The most obvious possibilities seem to be to adapt buildings designed as multi-storey garages, railway stations, omnibus stations, warehouses, or exhibition halls

The soundest approach to the problem would appear to be to start operations from surface rotor stations in less crowded areas and then, after experience has been gained, transfer to suitable roof sites as near as possible to traffic centres and distributive transport services

Some parking and refuelling at city-centre rotorstations is, in my view, essential For the helicopter to compete effectively on short-haul routes against surface and fixed-wing transport, it will have to operate non-stop between traffic points Technical stops for refuelling at surface rotorstations outside cities would conflict with this fundamental requirement However, whenever traffic stops are made at an airport, advantage could obviously be taken of such landings for refuelling This would reduce congestion in the city-centre rotorstations

ACKNOWLEDGMENTS

Such is a broad review of some of the major problems and possibilities as they appear today And here I want to acknowledge the assistance given to me by many people in discussing ideas which are incorporated in this paper First and foremost stands my Chairman, LORD DOUGLAS OF KIRTLESIDE, whose practical enthusiasm for the development of the helicopter is well known all over the World I am also grateful to Messrs B S SHENSTONE, P W BROOKS, R A C BRIE, G S HISLOP, R H WHITBY, W O THOMAS, N E ROWE, J G THEILMAN and R E G DAVIES, all of whom have read proofs and made practical suggestions

In particular I want to express my appreciation for the work of the B E A Helicopter Experimental Unit which has put in the basic work on which the future can be built

CONCLUSION

In conclusion one can sum up as follows —

(1) The helicopter has a vital part to play in World communications if it can be made large enough, fast enough and quiet enough—and hence economic and acceptable in operation

(2) The objective to make possible economic results in the next decade must be a speed of not less than 150 m p h and a capacity of not less than 40 seats More speed and more seats are highly desirable to cut costs

(3) A 160 m p h helicopter with 48/64 passenger seats should be capable of being produced by 1960 on the basis of technical progress which can be forecast today Its development, however, will be dependent on large-scale Government support—of which, as yet, there is little evidence

(4) One hundred such aircraft would cost about £200,000 each and have a total operating cost of about 5½ pence per seat-mile for an optimum stage distance of about 120 miles That means a fare of about £4 for a journey of 120 miles in order to cover all costs at a 75 per cent load factor

(5) If a 48/64 passenger " BEAline Bus " helicopter is produced during the next eight years, it will be able to provide important improvements in short-haul transport at costs to the operator—and hence at passenger fares—consistent with the level of service offered

(6) The field of use of the transport helicopter in the next decade will be up to a stage distance of about 250 miles At the longer stages the helicopter could provide international luxury services at fares on a level with those of luxury surface transport although higher than those of the fixed-wing aeroplane The helicopter will be able to cut about an hour off journey times between city centres 250 miles apart, compared with the aeroplane

(7) When potential savings in capital expenditure at new airports are taken into account, the development of the large helicopter may well prove to be a most valuable national investment

(8) To be effective the commercial helicopter must operate into city centres If it is banned from city centres because of noise most of the case for the transport helicopter falls to the ground Tackling the noise problem is thus a major task

In brief, the large and relatively fast transport helicopter has a clear commercial potential—a potential which can begin to be significant to the pattern of national and international transport about ten years from now—in the early 1960's It will not, however, be in the mass travel field by then The 1960 "BEAline Bus" will almost certainly be more expensive to operate per seat mile than either the fixed-wing aeroplane or the train, but its savings in time and in other directions mean that it is a "natural" for development

If it has done nothing else, perhaps this lecture has served to highlight the importance of reducing the cost per seat-mile which at present appears likely to evolve for the transport helicopter If by the concentration of designers on this point better figures can be achieved than I have set out in this rather conservative forecast, then the range of application for the large helicopter in the early 1960's will be vastly extended That must be our aim

In my view, the commercial helicopter is bound to come Already it has captured the imagination of the public—and, no less important—the Press

What it needs is the continued support and enthusiasm—and faith—of its protagonists

Well may we say, with Tennyson —

"Not in vain the distance beacons Forward, forward let us range,
"Let the great World spin for ever, down the ringing grooves of change"

The Chairman My earlier words are more than confirmed We have had an excellent paper delivered in the true and delightful Masefield style

I have a list of names of those who have notified their wish to participate in the discussion and I propose to call upon them in the order in which I have them here

I have been advised that unfortunately Captain Forsyth, of Fairey Aviation Ltd, is unable, through illness, to be present, and Colonel Hodgess is taking his place

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Discussion

Mr R Hafner (*Member—Bristol Aeroplane Co Ltd*) It gives me very great pleasure to begin the discussion on Mr Masefield's paper There is, indeed, tremendous scope for discussion, a good deal of controversial material, something to get one's teeth into, in short—a typical Masefield effort

I think my best policy will be to commence with the punches and then to lead on to the more complimentary part of my comments, which will make for a happy ending

I am afraid I cannot escape the impression that one of the themes in this paper is to show how primitive all helicopters have been, especially Bristol Helicopters, in those dark ages before that important event that brought enlightenment to the people, namely, the birth of the B E A Specification This arbiter elegantiarum then produces the great "BEAline Bus," which is the cat's whiskers Thus goes the story