Helicopter Noise Suppression

by

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A paper presented to The Helicopter Association of Great Britain in the Library of the Royal Aeronautical Society, 4 Hamilton Place, London, W 1, on Friday, 8th May, 1959

Professor J A J Bennett *(Chairman, Lecture Committee), occupying the Chair*

Introduction by the Chairman

The Chairman, in opening the meeting, said that after all the comment in the Press in the last few days concerning the noise of helicopters flying over London and in view of the possibility of further comment in the immediate future because of the existence now of a heliport in London, it was opportune that the Association should be having a lecture this evening on " Helicopter Noise Suppression " from one of its members, Mr H B Irving, who was a leading authority on the subject

By 1939, surprising as it may seem, Mr Irving had already completed 25 years of scientific work at the National Physical Laboratory, Teddington, before going on to the Royal Aircraft Establishment, Farnborough, where he worked during the war He then spent eight years at the Ministry of Supply as Assistant Director of Scientific Research (Air) and three further years as consultant to the Ministry of Supply on noise He was now Consultant on Noise to the Westland Aircraft Company, and also to Bristol-Siddeley, Ltd

Mr Irving had been Chairman of the Aerodynamics Data Sheets Committee of the R Ae S , and President of the Low Speed Aerodynamics Research Association He was now Chairman of M A P A C (the Man-Powered Aircraft Committee), which was associated with the Royal Aeronautical Society, and recently was appointed Chairman of the Noise Research Committee of the Aeronautical Research Council It was very fortunate that Mr Irving was now applying his long experience and scientific outlook towards the problems of helicopter noise, and members were looking forward to hearing his paper

H B IRVING

I must apologise for there not being any printed paper circulated before the lecture It is something like eighteen months since I promised to give this lecture At the time I promised, 8th May, 1959, seemed a very long way ahead and I thought there would be all sorts of developments by that time As is usual, however, things moved more slowly than we expected, and it is only within the last few months that much information has come along With the late coming of that information and also my own many activities, I have not been able to prepare a written paper beforehand

The title of my talk is " Helicopter Noise Suppression," but it is much more in the nature of further discussion of Professor Richards' lecture on " Problems of Noise in Helicopter Design," which was given as far back as April, 1955 However, my further discussion takes account of the recent developments and reviews them in relation to the noise problem

What are the chief developments that we have had in the last few years ? They have been chiefly in size of helicopter and type of power plant We now have the Westland Westminster coming along with a fairly big advance in size, and there has also been the change-over from the piston engine to the gas turbine As well as that, we have the mixed type of helicopter I am thinking of the Fairey Rotodyne, with its pressure jets for take-off and landing

Looking to the future, I think we can take the piston engine as being obsolescent and that we shall get further increase in size, but whether that increase in size will mean still larger rotors or whether we shall go over to multi-rotors, I should not like to venture any prophecy Certainly, the rotor of the Westminster strikes one as a very massive achievement

Also in the future, I think there is a fair chance of helicopters coming along in much simplified form with rotor tip turbines I will not say much about them now, but I would like to refer to them a little more later That is a distinct possibility of a great simplification in the helicopter in that it virtually gets rid of the tail rotor It offers the hope of doing that and so of cutting out at least one source of noise

As always, of course, progress in one direction raises all sorts of difficulties, and if we got rid of the tail rotor we would be faced with the problem of the noise of the little tip turbine jets That problem, however, would probably not be as serious as for the pressure jet type

There is no doubt that future developments will raise new problems and accentuate existing ones, as regards both internal noise and external noise , internal noise as affecting passenger comfort and external noise determining whether helicopters are to be allowed to operate in congested areas As I go along, I shall try to give my views on the most serious of the various problems and indicate where developments are needed and also where pioneer work is needed

Before I come to the main body of the lecture, I ought to say a little about the units of noise measurement This seems to be the stock-in-trade of any noise lecture, a little bit about decibels and so on These units are objective units and subjective units The objective measurements of noise measure the pressure or the energy that is conveyed by the noise It is a definite physical measurement There is no question about it

We all hear of the decibel, but I rather like to start with the bel

Originally, I believe, it was thought that the bel should be the unit, but it was found later that it was a rather large unit for convenience and so the decibel came into more common use

Thinking of the bel, an increase of one bel in noise intensity is a step to ten times the noise energy A decibel is not just a straight one-tenth of that, because we are working on a factorial or logarithmic scale When one thinks about it, therefore, a step of one decibel corresponds with a factor of 1 26 , each decibel increase in noise is an increase to 1 26 times the noise energy It comes out at that figure because 1 26 × itself ten times brings us up to the factor of 10, *i e* the bel If we multiply 1 26 by itself three times, we get the factor of 2 That is to say, three decibels corresponds to twice the noise intensity

Thus we get the common example that if two engines are running, each making 100 db noise, and we cut one out—*i e* , halve the noise energy—the reduction is only 3 db That is to say, the 100 db drops down to 97 db It also follows simply that, due to the spreading of noise as distance from the source increases, a doubling of the distance results in a reduction of 6 db in intensity This, it should be noted, is an effect quite distinct from atmospheric (or other) attenuation So much for the objective units

Now we come on to the subjective That brings in people, and people differ Therefore, subjective units can only be statistical, based on trials with a large number of ordinary people The commonest and best-known subjective measure of noise is the phon Briefly, my definition of the phon is as follows

The intensity of a noise in phons is that of a 1,000 cycle per second pure note which the average listener judges to be of the same intensity or loudness as the given noise

If the given noise were, say, 100 db and of rather high pitch, we should find that the average listener would want the pure note of 1,000 cycles per second to be adjusted to be rather more than 100 db to make it sound the same intensity as the noise *i e* , for high pitched noise, its intensity in phons is somewhat more numerically than its intensity in decibels

That is a very important fact to remember If the content of the noises which we are concerned with tends to have a great preponderance in the high frequency range, the number of phons—subjective value—will always be greater than the number of decibels The difference might be 5 db or 10 db and it varies according to the nature of the noise with which we are concerned

More recently, the Americans have brought in a new subjective noise level, which they call the Perceived Noise Level (PNdb) I am not sure that I understand it very clearly yet , it is just a bit subtle I understand, however, that there may be a distinction between loudness and noisiness in their tests In addition to that fact, they use as their standard of comparison, not a 1,000 cycle pure note, but a band width of 600–1,200 cycles per second that is, the octave band width They make their comparisons in octave band widths

That means that the perceived noise level is rather similar to the phon, but on the whole it tends to put more emphasis on the high-pitched notes, so that there is a bigger difference in perceived noise level between decibels and PNdb, as they are called—perceived noise level decibels—for noises like jets, where the difference may be something of the order of 10–15 db

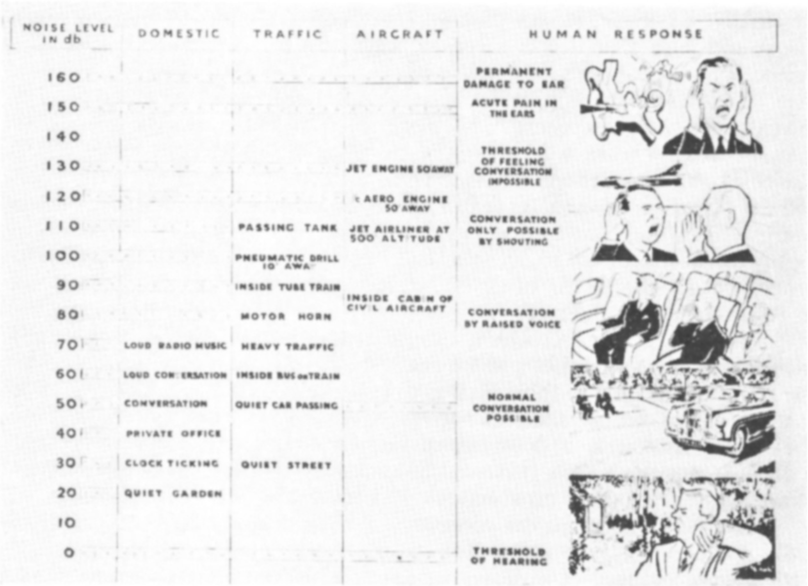

Fig 1 Human response to noise

That is to say, if we are thinking of a noise of 100 db, the PNdb might be as high as 110–115 for a jet, particularly a jet which has a silencer fitted which has a lot of little tubes which put up the preponderant frequency So much for our noise units

Another thing I would like to say before coming on to the actual experiments and data which have been collected recently is something about the effect of distance on noise comparisons When given figures of noise comparisons, it is always important to bear in mind at what distance they were made The importance arises from the simple fact that high-frequency noise is attenuated more rapidly with distance than low-frequency noise , so that it is very important to specify the distance, because comparisons for near and far might even be reversed in sense

I am indebted to Mr Greatrex for Fig 1, which is reproduced from an article of his Here is a scale of noise level in decibels on the left, starting at 0 and going up to 160, giving the various categories of noise They range from 20 db for a quiet garden to 70 db for loud radio music , traffic noises vary from a quiet street at 30 db to a passing tank at 110 db , and for aircraft, 110 db for a typical jet airliner at 500 ft altitude to 130 db for a jet engine only 50 ft away

Next come some rather descriptive little pictures of human response The threshold of hearing is 0 db Normal conversation is possible at up to 50 db and with a raised voice at 80 db When we reach 110 db, we can only make each other heard by shouting At 130 db we have the threshold of pain, with conversation impossible Permanent damage to the ear comes at about 160 db

For Fig 2, which relates to noise criteria, I am very much indebted to

Dr G E Bell It is of rather generally similar nature to Slide 1 but is put in a rather different way, the loudness level being given in phons Some useful criteria are given A broadcasting studio should be no more than 50 phons , a schoolroom might be 55 phons, and flats and offices 50–55 phons Here we can think of phons as being fairly close to decibels, but the difference between the two will depend on each individual case

I should explain that the letters S I L at the head of the last column stand for " Speech Interference Level " The range of frequency of most speech is from 600 to 4,800 cycles per second, so the S I L is usually taken to be the arithmetic mean of the three frequency bands 600–1,200, 1,200–2,400 and 2,400–4,800 c p s

Fig 3 relates to the effect of distance on the noise spectrum This is taken from a figure given in *Noise Control* on the comparison between the noise of the Boeing 707 and the Super Constellation Curves of decibel level are here plotted against the different octave band numbers The standard practice is to take the noise of eight different octave bands The first band, however, being usually taken at rather more than an octave, namely 20–75 c p s , the next 75–150 c p s , and so on up to 4,800–10,000 , the last band being again more than an octave width

Loudness Level (S S Stevens)	*General Situation*	*Telephone Use*	*Conversation*	*S I L*
Phons 110				85
100	Intolerable	Not Satisfactory	Voices very loud at 1 ft Shouting at 2-3 ft	75
90	Unpleasantly Noisy		Voices raised at 2 ft Very loud at 4 ft Shouting at 8 ft	65
80	Noisy but Acceptable	Satisfactory	Normal at 3 ft Voices raised at 6 ft Very loud at 12 ft	55
70	Moderately Noisy		Easy and natural	45
60				
50	Quiet to Very Quiet			
40				

USEFUL CRITERIA (Based on data in this Table)

	Phon	*S I L*		*Phon*	*S I L*
Broadcast Studios	50	20	Houses (sleeping)	50–60	25–35
Schoolroom	55	25	Hospital	55	30
Flats and Offices	50–55	25–30			

Fig 2 Noise criteria

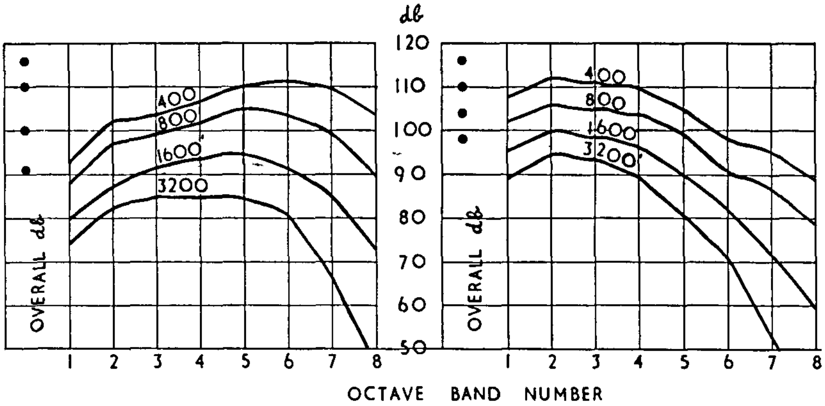

Fig 3 Effect of altitude (distance) on noise spectrum

It will be seen that for a Boeing 707, at the nearest distance and the lowest height given (400 ft) the noise level rises to a maximum at the sixth octave band and then falls, whereas with the propeller aircraft, the Super Constellation, it starts falling much earlier These two spectra correspond to the same overall decibel level of about 116 Each of the dots gives the overall level corresponding to each of the curves As the height increases, the shape of the curve alters until at a height of 32,000 ft the curve for the jet approximates much more nearly to the propeller aircraft

Notice, too, that the overall level of the Boeing 707 is falling with distance at a greater rate than is the case with the propeller aircraft, so that at the 32,000 ft height we have 91 db for the Boeing 707 and 98 for the propeller aircraft They started equal at a height of 400 ft

That is all very simple and straightforward, but people are apt to forget that and to speak as if a comparison at one distance is the final comparison and that that settles it, whereas, in fact, one has to consider where the communities live Some communities are quite a long way from an airport or heliport and others are quite near

I want now to say a little about the internal noise of helicopters First, I would like to state my opinion that I think the present civil helicopter is quite a long way short of the civil aeroplane as regards standards of internal noise I do not think that anybody would be inclined to disagree with that Comparisons vary, of course, between different aircraft and helicopters, but on the whole we have quite a long way to go as regards reducing the internal noise in helicopters and making them really comfortable It is a very difficult problem Since the lecture I have seen the most interesting and useful account given by Miller, Beranek and Sternfeld in " Noise Control " for March describing the elaborate measures taken to make the noise inside the Vertol 44 commercial helicopter comparable with that in current large commercial fixed-wing airliners

A number of years ago, the R A E laid down a standard for the noise inside helicopters It started at 95 db for octaves Nos 1 and 2 and then, at the high frequency end, it falls right down to 50 db If we look at the noise spectrum of most modern helicopters, we find that they are well above that In fact, the position is very little different now from what it was when Richards gave his paper four years ago Comparatively little progress has been made

How are we to get the noise level down inside the helicopter ? I think that the only way to do it is by the classical method of finding where the noise comes from, how it is created and how it gets inside the cabin of the helicopter The classical method of doing that is narrow band spectrum analysis Westlands have been doing a certain amount of work on this for a Whirlwind for a variety of conditions, both of the aircraft and of flight

Fig 4 is merely a reminder of the general arrangement of a Whirlwind, with its three-blade rotor and the engine down in the front with a sloping axis driving to a reduction gear at an angle The shaft cuts across the front corner of the cabin There is a big gearbox just above the passengers' heads The figure shows different positions in which measurements were made

Fig 5 shows the noise spectrum, with decibels plotted against frequency What a lot of different peaks there are The first peak at just below 50 cycles per second could correspond either to twice the tail rotor frequency or to the engine frequency I should mention that we have two curves The full line is for level flight and the dotted line is for auto-rotation On the whole, the noise level is less under auto-rotation This is all inside the cabin, of course, but at this particular frequency (*i e*, just below 50 c p s) auto-rotation makes next to no difference Therefore, we conclude that that peak is due, in the main at any rate, to the tail rotor noise

The next peak at 100 c/s corresponds to twice the engine frequency As can be seen, there is quite a reduction when the engine is cut off for auto-rotation, so that evidently a lot of the noise is due to the engine Then there is a whole series of peaks corresponding to various multiples of the

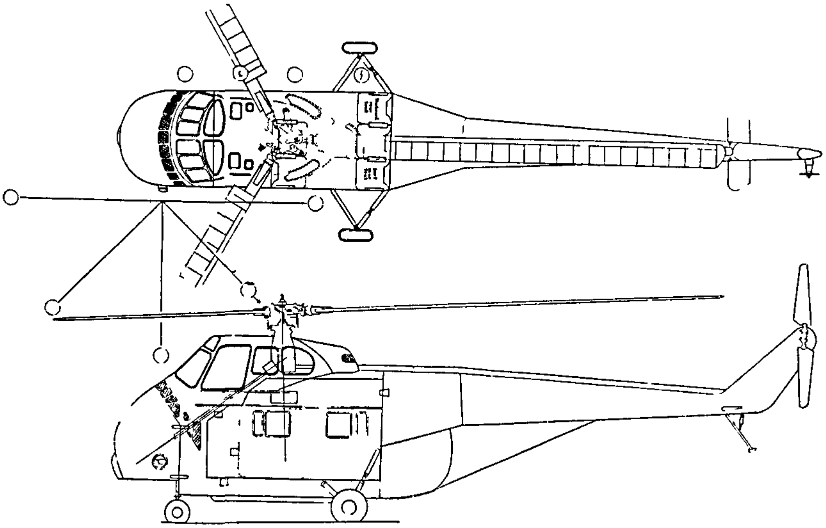

Fig 4 General arrangement of Whirlwind

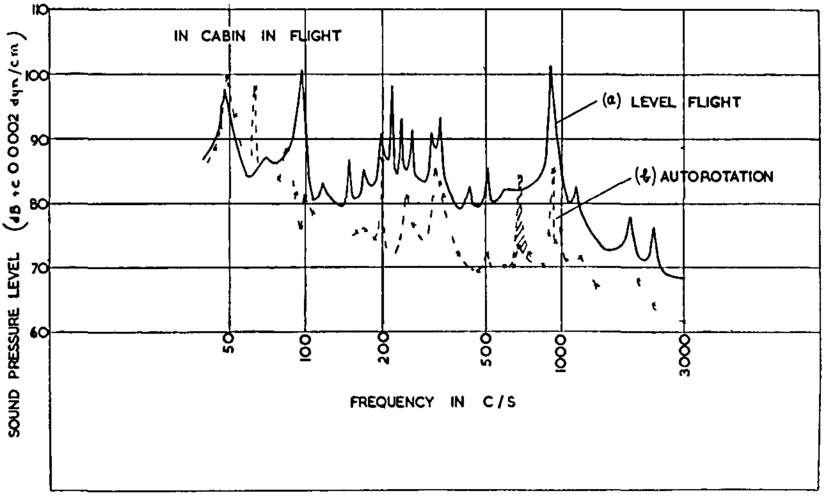

Fig 5 Spectrum of noise inside Whirlwind G-AOCZ with standard furnishing

engine frequency Again, there is a reduction when the engine is cut Lastly, there is a peak a little below 1,000 c/s which corresponds to the gear noise frequency, in the first stage, epicyclic, just above the cabin roof That is a very striking peak

Fig 6 shows a little silencer that was tried on the Whirlwind It made little or no difference to the noise inside I remember, before we did these tests, being told by somebody that he was quite certain that the way to quieten the Whirlwind inside was to have a silencer , it was quite obvious (to him) that most of the noise in the cabin came from the exhaust I remember also Mr Fleming, of the National Physical Laboratory, telling me wisely that one should not come to any conclusion about that sort of thing until measurements were available and that appearances with regard to noise could be most deceptive We shall see how right he was

Fig 7 relates to an interesting experiment Mr C E P Jackson, of Westlands, suggested that we should throw light on the exhaust noise business by putting a long exhaust pipe, about 20 ft long, so that the exhaust noise was removed to some distance outside The results of doing that are most illuminating Fig 8 shows the results The full line is the normal condition , the dotted line relates to the extended pipe There are two sets of curves, the upper set for the noise outside and the lower for the noise inside Looking at the outside noise, which we are thinking of now as the source of the exhaust noise getting inside, there is considerable effect, amounting to 10 or 20 db in the mid and high frequency range But the important thing is that the noise *inside* has been very little affected, except just in one little region of frequencies , and presumably, just over that comparatively narrow range of frequencies, the exhaust noise is oscillating the cabin plating in such a way that a certain amount of noise is getting in from the exhaust The general conclusion, however, is that the noise inside is hardly affected by the noise outside The overall effect came to only about 1 or 2 db In the front wall of the Whirlwind cabin there is a panel giving access to the clutch and fan assembly Fig 9 is a forward looking view with the panel removed while Fig 10 gives the noise spectrum inside

Fig. 6.
Small silencer fitted to Whirlwind G-AOCZ.

Fig. 7.
Whirlwind fitted with long exhaust pipe.

the cabin with and without the panel in place. Note the large increase in noise on removing the panel, particularly in the high frequency region.

Fig 11 is a picture looking up into the ceiling, showing the casing where the oblique drive up to the rotor cuts across the top corner of the cabin. The

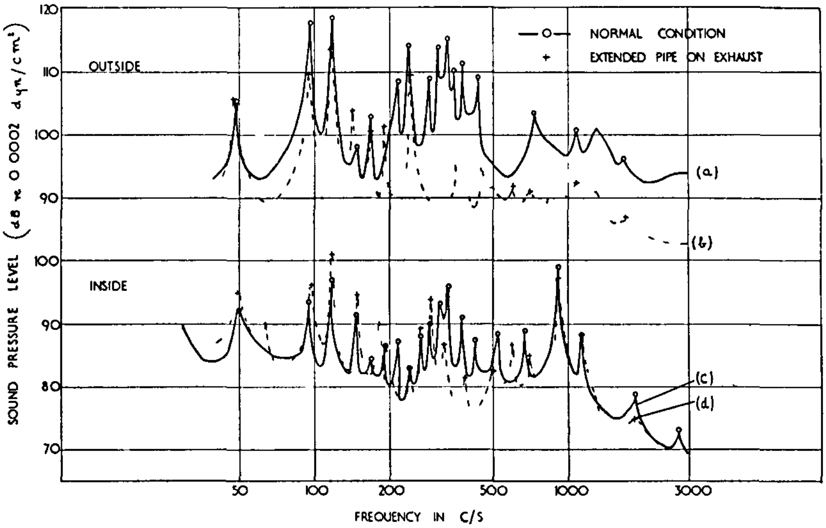

Fig 8 Effect of long exhaust pipe on spectrum of noise inside and outside cabin

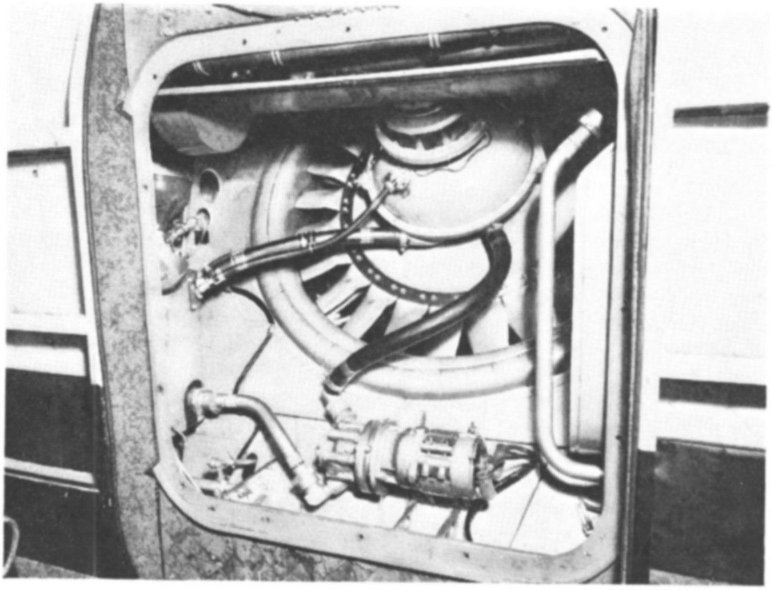

Fig 9 View looking forward through fan access panel (removed)

slide shows an oil catchplate just under the main reduction gearing in the top of the cabin In the ordinary way there would be a big ceiling panel, which has been removed for the purpose of taking this photograph, covering the catchplate and the surrounding region With this ceiling panel on, the effects of treating it with Aquaplas damping tape, and with fibre glass in addition, as well as removing the panel, were found The results, which are given in Table 1, showed that the modifications had comparatively little effect on the noise inside the cabin This is for a machine with standard furnishing of the cabin , for a machine with unfurnished cabin, however, it had been found that the band of the noise spectrum corresponding to the

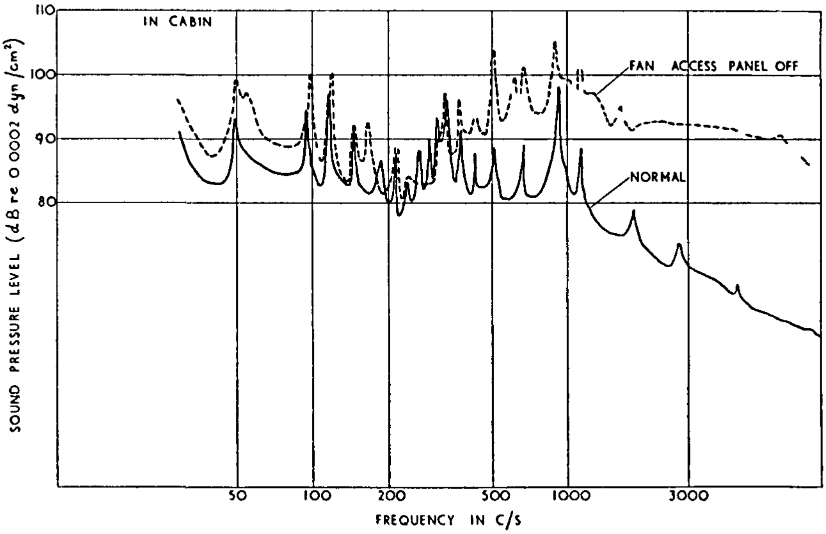

Fig 10 Effect of removing fan access panel on noise inside cabin

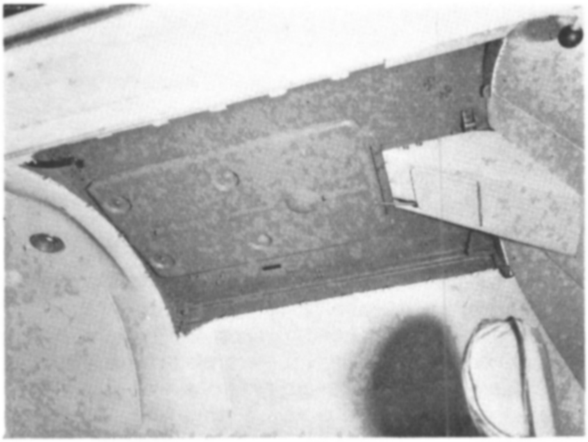

Fig 11

View of Whirlwind cabin ceiling with cover below main rotor reduction gear removed

TABLE I

Effects of modifications to ceiling panel on Whirlwind G-AOCZ with standard furnishing Engine r p m 2,900 , boost 30 in mercury Measurements made at port rear seat position

Mid-frequency of octave band	*Sound pressure level in octave band (db re 0 0002 dynes/sq cm)*			
	Normal cabin	*Ceiling panel off*	*Aquaplas treated ceiling panel*	*Same with fibreglass*
53	99	102	103	101
106	101	100	99	100
212	99	99	100	100
425	101	100	99	100
850	103	106	104	102
1700	93	97	94	92
3400	82	90	84	83
6800	76	85	80	80

Fig 12 Sound absorbent head shield (2 ft × 2 ft × 2 ft) and other components used in Whirlwind cabin noise tests

gear for frequency was very pronounced It was accordingly concluded that the gear box noise was being mainly transmitted to the cabin through the framing and plating

Fig 12 shows various bits and pieces that were tried during the experiments, including the exhaust silencer and the ceiling panel just referred to Also shown in this photograph is a sound absorbent hood which was placed at the position of the head of a seat in the cabin and found to be quite reasonably effective Although it gave no improvement at low frequency, it gave something like 5–10 db at medium to high frequencies It is helpful to have something like this and it might be useful where there is difficulty in communication in a service helicopter For ordinary passengers, however, I am afraid that it is ruled out by the possibilities of ladies wearing picture hats, and so on, and for Royalty going on their occasions

As already indicated, one thing that became quite clear from all these experiments was that a lot of the noise getting into the cabin was structure-borne noise I have shown the ceiling panel, below the gearing in the roof Experiments on the effect of removing it showed that it really did not make very much difference From the various tests that were made, it became clear that the way that the gearing was producing noise in the cabin was not directly by noise being radiated from that access panel down into the cabin, but by the noise being structure-borne all round the cabin framing and vibrating the cabin plating and so getting in all round the cabin The only cure for that was to put sound insulation all round the cabin walls Westlands are in process of doing that experimentally on a Whirlwind I am sorry that they do not yet have the results and I hope they will be successful

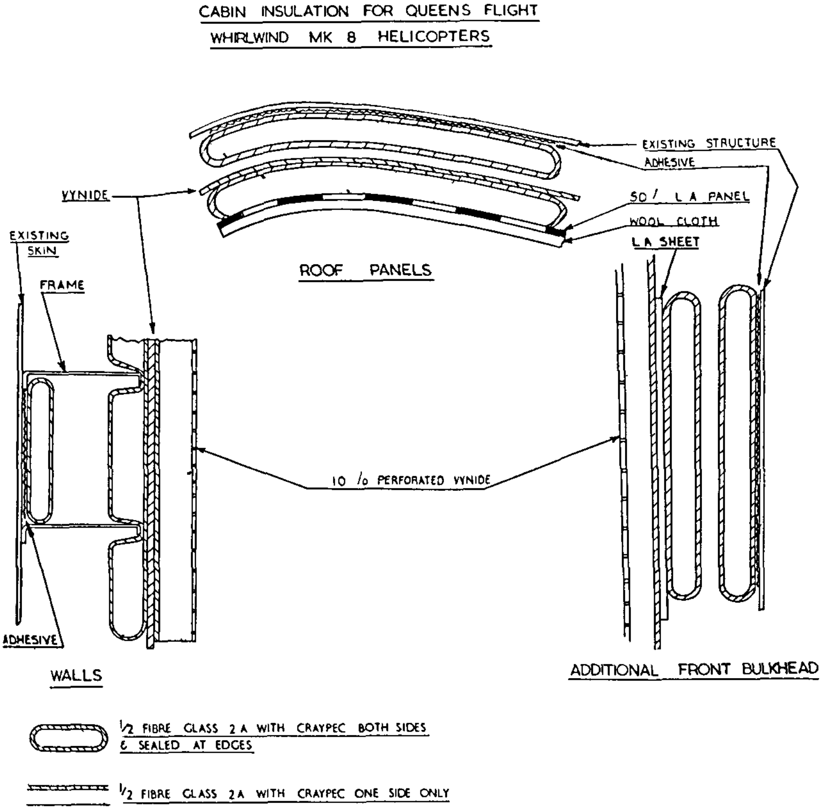

Fig 13 Cabin insulation for Queen s Flight Whirlwind, Mk 8 helicopters

Fig 13, however, gives some idea of the lengths to which they are going in trying to get it quiet On the left one can see the scheme for the outside skin of the cabin and the framing There are bags of fibre-glass in a very light coating of Craypec, which will keep any condensation moisture out of the fibre-glass and so keep it dry There is a solid skin of unperforated Vynide inside the two outer layers of fibre-glass, and finally, more Craypec and fibre-glass , and the innermost coat is of 10 per cent, perforated Vynide The general idea is that there is noise in the cabin Solid Vynide, which was used at first for the internal lining, only reflected the noise backwards and forwards across the cabin and did not absorb it With 10 per cent perforation, however, most of the noise is absorbed , it gets into the fibre-glass and is absorbed by it Similarly, noise transmitted from the outside is absorbed The intermediate solid Vynide tends to reflect back out any noise that gets to it from outside, and any that gets to it from the inside is thrown back into the fibre-glass It is an elaborate and quite expensive arrangement and it all costs weight

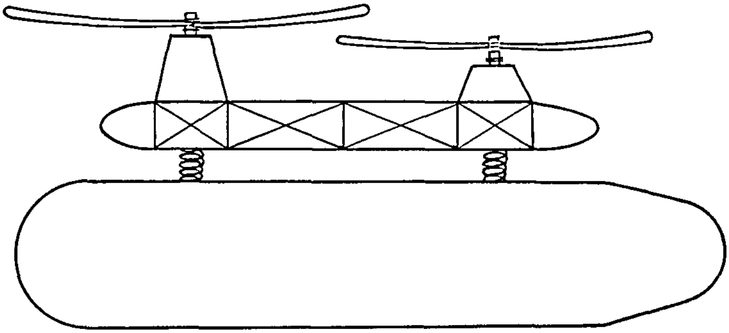

Fig 14 Rough sketch of type of helicopter suggested by Dr A J King

The figure shows on the right the similar arrangement for the front bulkhead leading to the engine and a similar arrangement in principle on the roof, except that the final covering is a wool cloth over the roof It will be interesting to see how all this works and what it does Preliminary results to date (7/7/59)—so far only with ground running—are encouraging It is greatly to be hoped that at a later date Westlands will give a full account of them One is led into an awful lot of trouble, however, by this structure-borne noise , one thing that helicopter designers must think about very hard is how they are to get rid of it

I must not talk, however, as if designers of helicopters have not thought about structure-borne noise They have, of course, done so Undoubtedly, it is one of their big bugbears The difficulty, however, is how to mount something like the main reduction gear in such a way that it does not transmit noise to the whole structure of the aircraft or helicopter Similarly, the tail rotor drive also transmits structure noise

I talked to Dr A J King, of Metropolitan Vickers, about this problem some months ago and asked him how he would deal with it I talked to him because I knew that he felt strongly about structure-borne noise, and he has a very telling demonstration, that he takes round with him on his lectures, of the effects of cutting out the structure-borne noise He has a gearbox which he can enclose or have open, and he can either have it resiliently mounted in a way that does not transmit the noise or he can have it rigidly mounted The results he gets are that with the enclosure open with the rigid mounting, there is a reduction of 3 or 4 phons With the resilient mounting and without the enclosure, he also gets 3 or 4 phons If, however, he does the two together and cuts out the structure-borne noise, he gets a 28 phons reduction His demonstration is very striking

Dr King said that he would make a helicopter something on the lines sketched in Fig 14

The passengers' cabin would be suspended underneath with resilient suspension It would probably be impossible to make the structure sufficiently rigid and the whole thing would tend to be very heavy, but is it not possible to develop this idea by cutting out some of the structure and making it merely a framework inside which the cabin is suspended by resilient mountings, or even put a smooth cabin outside the framework so as to streamline the whole thing ? I may be talking hot air about this, but the whole problem is so serious that it is worth quite considerable thought

On a visit to U S A since the lecture I was told that a vibration mounting for the main transmission gear of a well-known helicopter had been designed but not proceeded with , it would have cost an extra 60 to 70 lbs weight

After all, if one thinks of the fixed-wing jet aircraft, the noise problem has been the cause of fundamental changes in the layout of aircraft The French showed us the way in the Caravelle They were the first to stick their jets on right at the tail Although a lot of people scoffed at it originally, it is the case now that nearly everybody is doing it

There is another possibility Again, I am only a novice on helicopters generally, but what about the possibilities of multi-rotors ? We have had, side by side, McDonnell and tandem helicopters A short time ago, Professor Bennett lent me a nice little book on helicopters In that book, " The Aerodynamics of the Helicopter," I looked up what Gessow and Myers had to say about multi-rotors They say

> " Helicopters with many rotors have been proposed for special uses and generally for large machines Three or more rotors offer simplifications in control system design inasmuch as control in all directions may be achieved by simply increasing the thrust of one of the rotors relative to the others For large machines, use of multi-rotors offers the further advantage of influencing a large mass of air without having blades of unwieldy dimensions "

I should think, particularly if the increase of size is to continue, that the question of multi-rotors will have to be considered seriously

Now, a few words about air-to-ground noise It is hard to say which is more important, the internal noise or the air-to-ground noise If the internal noise is not sufficiently low, the people will not fly anyway , and if the external noise is not low enough, the helicopters will not be allowed to fly In this connection, I would like to say a little about experience at the rotorport and heliport enquiries that I attended in connection with the two applications for heliports, one opposite the Tate Gallery and the Westland one at Battersea, which is now in existence

I attended both those enquiries thinking that noise would be an important subject, but I and others had our eyes opened about the enormous importance that was attached to noise by a lot of people The people, in this case particularly, were firms who either had offices, or were thinking of building offices, in the vicinity of the Tate Gallery They went to the length of employing Queen's Counsel to talk about decibels and the awful nuisance that noise would be I was amazed at the fluency and intelligence with which they talked about decibels, although probably they had never heard of them until a few days beforehand The Tate Gallery proposal was rejected, and I do not think we have been told the grounds on which it was turned down, but certainly noise featured very largely in the arguments put forward by Counsel representing the National Coal Board and Vickers, who are to build their great skyscraper offices near there, and a group of insurance companies who did not want their employees to be disturbed by noise It is, therefore, an important issue

As the Chairman remarked, *The Times* has just written a leader about it—" All this and helicopters too " They think that people should not be allowed to cruise up and down the Thames in helicopters just for pleasure and making a horrible noise Perhaps it will not be as horrible as they think I am not sure that it will be all that horrible I have an idea that people are rather getting it into their heads that it is worse than it is

At the Westland enquiry, however, the firm had very wisely taken the precaution of getting the National Physical Laboratory to do some actual noise measurements in the vicinity of the heliport as a Whirlwind came in and did a typical landing and take-off That report was handed in as evidence One must not quote merely small extracts of N P L reports, because by so doing one might quote merely those parts which are to one's advantage and leave out other bits , but the report was handed in as evidence and the facts spoke for themselves They showed the positions (one just outside a school) where the records were taken and how a motor cycle or a lorry could come along and swamp the noise of the helicopter It was a fairly obvious case that there would be little or no nuisance for that particular site

When I say that, I am thinking of the daytime Night-time, of course, is a rather different matter In the daytime, however, there is so much traffic and factory noise going on round about that there is very little prospect of annoyance being caused I do not know whether anybody would like to say anything about any reactions in the light of the experience of the working of that heliport since it started I would be pleased to hear, because I have not been there since the enquiry

I had better come on to a few examples of the air-to-ground noise of some recent aircraft, including the Westminster Before I show the diagrams, however, let us hear the sound track which Mr Jackson and his assistants at Yeovil have kindly arranged, giving the actual noises of different aircraft in fly-overs at 500 and 1,000 ft These include a Whirlwind with the de Havilland turbine engine (*The recording was then played back*)

The amplifying gear was calibrated before tonight's audience arrived so that it would give about the correct level in the room, but the audience has introduced a certain amount of absorption and I am not sure what effect that has had

A Representative of Westlands The sounds were all correct to within 2 db—*i e* , plus or minus 1 db

Mr Irving I would have liked to have for comparison a sound track which has come over from the Port of New York Authority giving the noise of various propeller and jet aircraft taken at New York Some of you may have heard the sound track Certainly, the general order of noise was much higher and nastier than what we have been hearing tonight Perhaps we may feel that the jet engines do the helicopters quite a lot of good by producing something nastier—unless, as Mr Greatrex may tell us, some huge jet engines are coming along that will be very quiet

Fig 15 gives the spectrum of the noise on the ground below fly-over

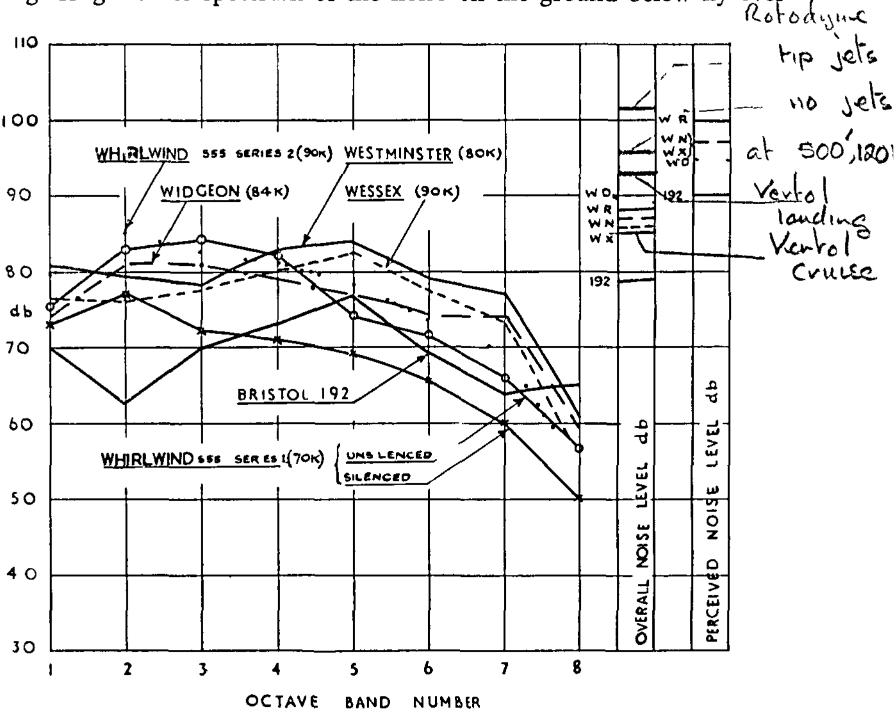

Fig 15 Noise on ground below flyover at 500 ft height

at 500 ft, showing decibels against octave band number for a number of helicopters including the Whirlwind, the Westminster, the Wessex (following the same general trend be it noted, as the Westminster, both helicopters being turbine engined), the little Widgeon, and the Bristol 192 In addition, on this diagram the overall decibel level is shown, as well as the perceived noise level, by the short horizontal lines on the right of the figure Perceived noise level is, generally speaking, of the order of 10 db above the overall decibel level

At the top of the perceived noise level column is the Westminster, with 100 PNdb, corresponding to an overall decibel level of 88 Notice that in the overall decibel level, the Whirlwind is above the Westminster That is to say, in spite of the increased size and power of the Westminster, it is not making quite as much noise intensity as the Whirlwind, although in terms of perceived noise level it is higher than the Whirlwind, the figures being 100 for the Westminster and 95 for the Whirlwind

The difference in the comparison of overall decibel level and perceived noise level comes about for this reason The spectrum lines for the piston-engined craft reach their maximum at fairly low octave band number and then go plunging down, whereas the turbine-driven machines keep on gently rising up to a later stage before they fall off rapidly That leads to the greater perceived noise level relatively for the turbine-engined craft

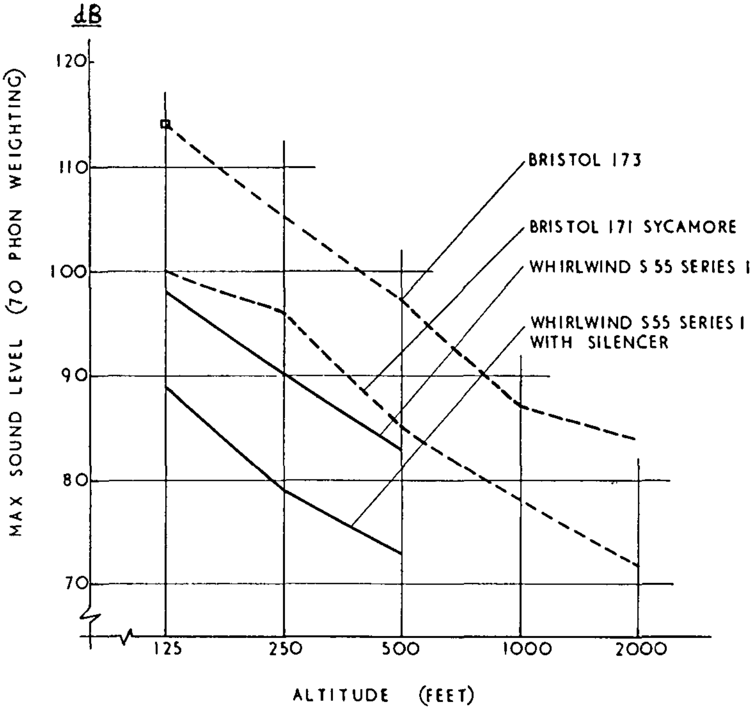

Fig 16 Noise on ground during level flight overhead variation with altitude

The Bristol 192 comes out of this well for its size It is the lowest apart from a silenced Whirlwind It has twin rotors and it has got rid of the tail rotor I wonder which of these factors contributes most to the lower noise level The noise of twin or single rotors is a complicated question, and I expect that Bristols have gone into it

I understand, however, that the noise *inside* the bare helicopter is not low, a provisional figure being 103 db, bearing out what has been said about structure borne noise In the commercial version the cabin noise will of course be reduced in a manner which may well benefit from Vertol's and Westland's experience

Fig 15 relates to a constant altitude of 500 ft Fig 16 is a collection of information on the noise of the Bristol 173 and 171 and the Whirlwind S55 at different altitudes, the curves for the last showing the effect of fitting a silencer The figure shows the reduction in noise that would be expected with increase in altitude and it follows fairly closely the expectation of a reduction of 6 db for each doubling of the height or distance

Fig 17 shows the effect on noise of the mode of take-off The take-off is either done normally, in perfectly safe fashion, or as steeply as the pilot

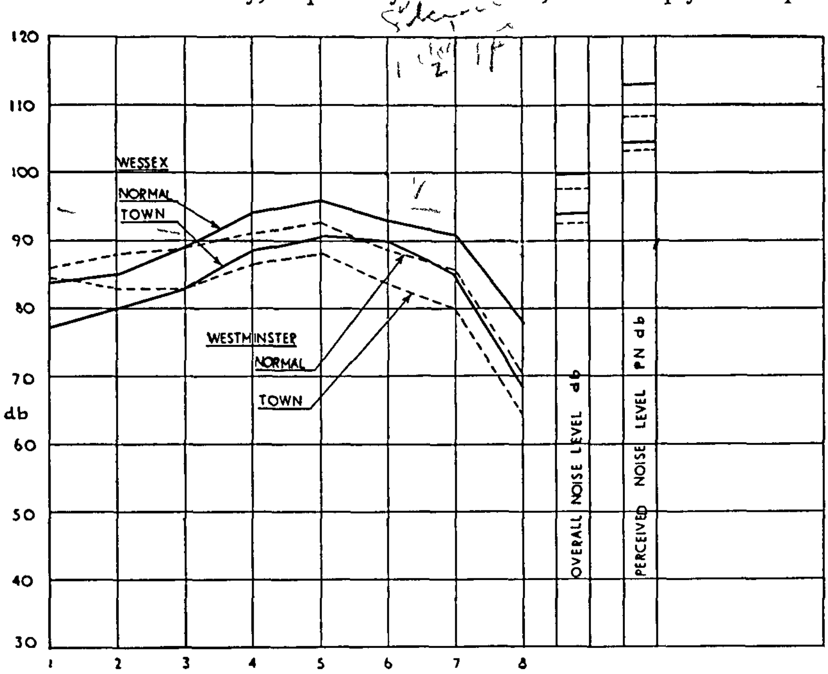

Fig 17 Take-off (Normal & Town operation)—Wessex and Westminster

TABLE II —Noise of various helicopters landing condition, 500 ft from pad , Microphone below flight path

Helicopter		*db*	*PNdb*
Widgeon (Mean of 3 , altitude 250 ft)		92	99
Whirlwind		97	103
Wessex (Mean of 2 , altitudes 180 and 200 ft)		97	104
Westminster	Normal landing	100	109
Westminster	Town operation	96	105

thinks he can get away with in the event of an engine-cut The difference can be seen both for the Wessex and the Westminster There is a reduction of the order of 5 db in each case by going up more steeply

Table II gives the noise for the landing condition, 500 ft from the pad with the microphone under the flight path The heights, where known, are given , in some cases they were not known

Table III is an illuminating one relating to the hovering condition The microphone was as before 500 ft away from the pad and the helicopter was hovering over the pad and pointed to the four points of the compass The table shows the overall decibel level and the perceived noise decibel level, the figures for the Wessex being 87 for all three cases other than when the nose of the machine was towards the microphone in which case the figure was only 80 Unfortunately, the Westminster was not recorded with its nose towards the microphone, but the Bristol 192 also shows some reduction for this conclusion Thus there is a useful indication that, for these

TABLE III —Noise of various helicopters
Hovering condition , 500 ft from microphone

Condition	*Widgeon*		*Whirlwind*		*Wessex*		*Westminster*		*Bristol 192*	
	db	*PNdb*	*db*	*PNdb*	*db*	*PNdb*	*db*	*PNdb*	*db*	*PNdb*
Port side towards microphone			93	99	87	95	93	100	78	87
Starboard side towards microphone			89	95	87	94	95	99	79	89
Nose towards microphone					80	88			74	84
Tail towards microphone					87	92	92	96		

TABLE IV

Helicopter	*Horsepower*	
	Take-off (maximum power)	*Cruise (Estimated for all-up weight of noise tests)*
Widgeon S 51 Series II G-ANLW	525	380
Whirlwind S 55 Series II G-AOCZ	750	480
Wessex XL 722	1450	900
Westminster G-APLE	5000	2800
Bristol 192	1500	1100

particular aircraft at all events in taking off in a congested area, the nose should be pointed towards the people one wants to annoy least In connection with the foregoing figures and tables of external noise it will be useful to know what power was being produced in the various tests Table IV gives information on this as well as specifying the particular mark of helicopter concerned

What conclusions can we draw from our latest information ? On the whole, they are encouraging , at least, they are not as frightening as we might have imagined them to be You have seen the results and heard samples of the noise of the huge Westminster It is not all that bad No doubt there will still be a serious noise problem and we must do all we can about it, but we can be very hopeful about the whole thing Compared with the jets, I think we are well in the clear

I should like to express my grateful thanks to Westlands, not only for arranging the noise demonstration, but also for permission, given similarly by the Bristol Company, to present these results on their new helicopters It is very public-spirited of them to allow them to come out at this comparatively early stage

Discussion

The **Chairman** invited Dr G E Bell, of the Ministry of Transport and Civil Aviation, to open the discussion

Dr G E Bell (*Ministry of Transport and Civil Aviation*), who said that most of the points associated with the noise of helicopters had been at least touched upon by Mr Irving in the course of his talk, expressed his intention of underlining the extreme importance of the outside noise In the case of fixed-wing aircraft at airports, as everybody knew from correspondents all over the world, the problem had grown to be very acute and it was generally agreed that the aircraft that were now flying had just about the limit of noise level that the general public would endure This was the experience in certainly the United States, England, France, Australia, Germany and Holland There was a difference between the reactions to the fixed-wing aircraft, to which people were accustomed, and to helicopters, which were not yet fully operational in any real sense of the word

When London Airport was opened, in 1947, and for a few years thereafter, the predominating aircraft were the comparatively small DC 3s and Vikings and there was no serious measure of complaint Post-war developments had brought the bigger aircraft and ultimately, in 1952, the original Comet made its appearance, providing a rather sudden step from the comparatively small and quiet aircraft, apart from the Constellation 749 and the like At London Airport, the Comet was the instrument which began the campaign against noise Subsequently, other aircraft had come along and if the original Comet were to be introduced today, it was fairly certain that nobody would really worry, at least when the aircraft was in flight

It was important, if possible, to accustom the public to this sort of thing in a peaceful manner in gradual stages If the helicopter was to serve the purpose for which it was intended, it must operate from city centres or somewhere near city centres It also must have fairly few restrictions on its path It was no good making it fly by circuitous routes if that could possibly be avoided This meant that the noise must be cut down as much as was ever possible This raised the question, " It is all very well, but what should it be cut down to ? " For a brand new noise such as the helicopter represented, this was a difficult question to answer

It was a common and fallacious argument that cities were noisy and the addition of the helicopter was unimportant Even in a city like London, although the busy streets were noisy, as soon as one got away from the main streets London could be surprisingly quiet One of the quietest places he had ever measured, for example,