darkness The flying rate achieved in phase 1 has been extrapolated to a total of 1,000 hours (Fig 7) and an allowance made of one month for a major inspection Under these conditions it will be seen that a total of 1,000 hours is possible in about 9 months This time could, of course, be improved if the task were undertaken by a flight whose sole duty was the conduct of intensive flying

The trials so far have been discussed on the basis of temperate flying only, but it is desirable that some of the time should be spent under extreme climatic conditions and it is considered that by careful timing it should be possible to conduct part of the trial, say 150 hours, at the Tropical testing unit and a further 150 hours at the Sub-arctic unit without much delay in the general programme

Since a lot of the information required from trials of this nature is statistical it would be an advantage if more than one aircraft could be tested and consideration could be given to one or two production aircraft subsequent to the trials aircraft being subjected to a modified form of intensive trials under full service conditions

Conclusions

It is concluded that an operational reliability trial on a new type helicopter will do much to eliminate the snags which arise during the early service life of the aircraft While the flying hours are building up and showing up early defects and difficulties, tests can simultaneously be made with portable instrumentation to check that production type systems function similarly to those tested on the prototype Roles may be checked during the trials It is recommended that the duration of the trial should be 1,000 hours and should be conducted in the quickest possible manner

Experience gained from the trials will be of value to the designer in the development of subsequent types of helicopter

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The opinions expressed in this paper are those of the Author and do not necessarily reflect the official views of the Ministry of Supply

Thanks are due to author's colleagues who have carried out the tests from which the recommendations have been made

Discussion

Mr T G G Newbery (*Ministry of Supply*) (*Member*), in opening the discussion, said they had heard a very interesting talk, and there was a great deal in the paper which could lead to argument and discussion At times, opinions were expressed concerning the usefulness of the testing establishment at Boscombe Down Tonight, the Author had given a slight insight into some of the work done at the establishment and he had made a case that at least some of it was useful Mr Newbery added that before making his comments, he should explain that any opinions he expressed were simply his own personal opinions and not necessarily those of the Ministry

In the paper, the Author said it was assumed that the engine development would be carried out in parallel with the helicopter development, so that the engine arrived at the production stage at the same time as the helicopter One of the problems which had faced engine designers and manufacturers in connection with helicopter

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installations was the fact that so far there had not been a helicopter flying test bed With fixed wing aircraft, it had nearly always been possible to devise some form of flying test bed so that the engine maker could get experience of the functioning of the engine under flight conditions sufficiently realistic to sort out many of the engine problems So far, this had not been possible with helicopters His own feeling was that many of the engine problems which arose in helicopters could be solved if the engine manufacturer could have a flying test bed Did the Author agree with this opinion ?

Much could be said on the first two sections of the paper, but the main point of the paper was the engineering assessment carried out during the operational reliability trials and the intensive flying trials This raised a question on which it would be helpful to have clarification Throughout the paper reference had been made to " the " helicopter, as if to imply that Boscombe Down was carrying out all the work on one aircraft If everything which had been outlined was to be carried out, however, the work would seem to involve two distinct requirements On the one hand there was the technical assessment, carrying out all the measurements and using all the instruments which had been described , and on the other hand there was the engineering reliability, the intensive flying If both these functions were to be carried out in a reasonable time, at least two aircraft would be required, one for the technical assessment and another for intensive flying The technical assessment included the assessment of the various roles, and this alone would take up quite a large part of the flying time

One endorsed very much the phrase in the paper that the operational reliability trials should be made under as near operational conditions as possible At Boscombe Down, how near was it possible to reproduce operational conditions ? There were two aspects of this One was the point of view of the pilots At Boscombe, the pilots were above the average standard, which meant that the helicopter would be handled rather better than it would be by many of the Service pilots This in itself could make quite appreciable differences in the reliability and in the results of endurance The other aspect was the actual conditions that were met during the flying

In Service operation, very tricky conditions were liable to be encountered In a Naval helicopter operating in very rough weather, for example, the pilot might find himself in a condition in which he had to carry out quite violent manoeuvres Similarly, an aircraft operating in jungle clearings might come up against some tricky conditions Under those conditions, the pilots were liable to treat the aircraft far more roughly than a skilled pilot operating under normal conditions such as might be experienced at the Establishment

In addition, there was the question of the different roles that one particular helicopter might be called upon to perform These could cover a wide range of operating conditions The anti-submarine helicopter would spend most of its time hovering quite close to ground level , an Army support machine might be doing short flights of 10 or 20 minutes continuously, whilst the transport helicopter would spend nearly all its time on long flights How far did the Author consider that all these conditions could be covered on the trials, particularly if only one aircraft was available ?

In the technical assessment, it was noted that the vibration levels were measured as near as possible to the crew seats, to assess the effect on crew comfort or, conversely, crew fatigue Would it be possible to broaden this method somewhat and make measurements at selected points where the vibration level might increase as a result of wear and tear ?

The Author had mentioned that the helicopter normally would be measured up before it started the trial and that periodically throughout the trials checks would be made to assess the wear and tear It would be useful if, in parallel with that, information could be obtained on variation in vibration level at various points—for example, on the gear boxes or on the controls

The question of the duration of the trials involved many factors and provided scope for a great deal of argument Three points called for brief mention First, in the overall programme of the helicopter development—*i e* , between the time when the first prototype started flying and the time when the helicopter began general operation in service—where would the trials at the Establishment be fitted in ? This brought with it the question of the elapsed time available in which the flying could be carried out

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The second point was the rate at which the flying could be carried out bearing in mind all the factors which affected that The third was the range of the conditions to be covered, the question of the various roles and the number of aircraft which would be available to cover all these conditions

Figs 13 and 14 in the paper gave graphs of rates of flying and it would be interesting to see them combined into a single graph Taken separately, they gave a rather different picture than if the two were put together The rate at which it was intended to carry out the flying was 30 hours per week (five days each of six hours) and the rate at which the flying was actually carried out was 24 per week, but after 240 hours there was a break of six months before the flying continued at 6 hours per week In Fig 14, where the Author suggested the rate at which the trials could be carried out, the curve went up to 600 hours, with an interval of a month before restarting

What rate was really practicable ? The figure assumed was the maximum achieved over a short period Thinking in terms of 1,000 hours' flying, it was too much to expect that that rate would be maintained, unless, as the Author suggested, special arrangements could be made This could involve additional expense and all the other consequent additions

Taking a line in between the two achieved rates a rate of 12 hours a week was suggested Instead of the 600 hours to first overhaul, if one assumed 400 hours, which would be a good start for a new helicopter, one then faced the question of how long the break would be The first one was six months, the Author assumed one month, but a more realistic period would be two months

To maintain a rate of 12 hours a week to 400 hours would occupy 33 weeks There would then be eight weeks' break and to reach the 1,000 hours would take 91 weeks—in other words, a year and three-quarters This gave an indication of the elapsed time that was likely to be required for a trial of anything like 1,000 hours, even on optimistic assumptions

If the initial rate of flying could be increased from 12 to 18 hours a week, a saving of 11 weeks would be made on the initial stage If, as the Author had suggested, one started off with a good rate and then eased off after doing the first inspection, one came back to the foregoing suggested picture It would therefore take something like two years to achieve the aim of 1,000 hours This explained the question of where it would be fitted in the overall programme

It was doubtful whether two years would be available between the time that an aircraft was sent to Boscombe for trials and the time that the Service started its own flying On the other hand, if when the Services started using the aircraft they carried out a period of intensive flying themselves, there would be that amount of additional time in which Boscombe could complete their intensive flying

Mr O L L Fitzwilliams (*Westland Aircraft*) (*Founder Member*) said that at Fort Rucker, with the S 56, a fairly large new helicopter, the United States Army had taken 82 days to do 1,000 hours

Mr Newbery remarked that that was exceptional

Mr Fitzwilliams added that the U S Army had done 500 hours on another aircraft in the same period

Mr Newbery added that another aspect was the amount of flying that should be done by the aircraft constructor before the machine went to Boscombe, because the rate at which the flying could be carried out at Boscombe would depend to a large extent on the amount of flying completed and the background of experience built up before the machine got there

Mr Newbery had not checked this and was therefore making his assessment from general impression, so was open to be corrected by the helicopter firms He suggested that in the past, by the time an aircraft went to Boscombe, the flying on any one aircraft had been of the order of not more than 100 hours and the total flying of all the helicopters of that type at the firm had been not more than 200 hours

Did the Author agree that before Boscombe started intensive flying an aircraft should have done 240–250 hours' intensive flying at the firm ? Before they started on the 240 hours, they would probably want to do a 100-hour programme, so the programme at the firm would be 100 hours, then a strip and inspection, and then 240 hours, on one machine The total amount of flying which should have been accumulated before Boscombe took over, he suggested, should be of the order of 750 hours rather than 200 hours

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Mr Webb, in reply, agreed that the use of a test bed was very desirable before reaching the final combination of the airframe and the engine that was destined to go with it Helicopter engines, however, seemed to be installed at such peculiar angles in the airframe that this would be a problem for many years to come, unless there was either a purely horizontal or a purely vertical engine The inclination of engines had a big effect on the subsequent functioning, particularly in the lubrication of, and hence the wear and tear of, the moving parts This was a real problem that should be tackled at an early date concerning the development of the engines The paper specifically did not deal with engines, precisely because of this difficulty It was assumed that the engines would be in a reasonable condition by the time that tests were started

It was all the more important to carry out the operational reliability trials because at this stage the completed engine was not available The trials so far done had given much valuable information on engine functioning and engine controls

On the question of the instrumentation affecting the rate at which the trials could be conducted, it was pointed out in the paper that the instrumentation had been made portable and easy to handle , and as such, the standard tests that had been carried out on temperature studies, pressures and cabin conditioning did not affect the rate of the trials in any way The role trials could have an effect upon the rate, but that was mainly due to changes of roles during the trials All this could, however, be done outside flying hours, during times of darkness, if it was desired to maintain the high rate of flying

Mr Webb agreed, and the paper stated, that more than one aeroplane should be used for trials of this nature One machine specifically could be used for intensive flying and nothing else The point to be stressed was that these trials should be made on a production aircraft, and not on a prototype The trials done at Boscombe were official acceptance trials Therefore, any intensive trials which could be done at an earlier period at the firm should, in fact, be carried out They would, however, be mainly on early prototype pre-production batches or on something that was not strictly representative of what the Service would eventually get Any amount of flying whatsoever that could be done at the firm before Boscome started the official trials should be done

One of the pieces of equipment illustrated in the paper for measuring vibration was the modified de Havilland equipment, which could be put in at any specific place on the aircraft where a vibration study could be made, and continuous records, or records every 20—30 hours, could be kept At the moment, the main interest was in the effect of vibration on the crew, and for this reason vibrations had been measured only near the seat positions of the crew A specific investigation had recently been conducted on some amplifiers and the results were quite successful It was considered, therefore, that continuous vibration records could be taken at any position in which the technicians were interested

The example given in the paper of the rates of flying was the result of Boscombe's first effort in the helicopter sphere The 30 hours per week could be maintained easily if a special effort was made to do so It would, however, involve overtime and a special section to do the work, with servicing at night and a good spares backing , but it was quite easy to maintain 30 hours a week

That would make the case, which Mr Newbery had suggested, for having at least two aircraft for the work, one of them simply for " bashing up " the hours at this rate and building up the 1,000 hours in the six months or in the 80-odd days which Mr Fitzwilliams said had been done in America Mr Newbery was quite right to suggest the use of more than one aircraft An extremely heavy programme had been piled upon the one machine at Boscombe It would be much better for all concerned to spread it out over two or even more aircraft, and the Author had recommended that complementary intensive trials should be done in the Service

Concerning the timing, he had stressed that the machine must be a production aeroplane , and this would fix the time If the first production aeroplane, or the first two or three machines, were used for these operational reliability trials and at least one was done at the high rate, the information that was required would probably be obtained It should, however, be emphasised that at least one aeroplane should always be ahead of any aircraft that was being used under the real Service conditions

Among those present at the meeting tonight was Mr Backhaus, from Boscombe Down, who was in charge of the intensive Flight on fixed wing aircraft, and possibly he would be able to amplify the rates and methods of control of intensive flying when there was a special department to do it What had been described in the paper had

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been fitted into the normal helicopter Flight and no special provision had been made to conduct these trials

Mr E C A Backhaus (*Boscombe Down*) said that the real question was whether one could afford the number of hours The important thing was to build up an excess of hours over service of not less than 250, and ideally this should be maintained throughout the service life of the aircraft Fatigue problems would arise at some time during the life of the machine, whether it was a fixed wing, civil or military, aircraft or helicopter There should be an aircraft whose trials were being watched all the time and which was always kept sufficiently ahead of any aircraft in civil or Service use so that any failures would occur on it

Boscombe Down had been forced to agree to operational reliability trials as short as 150—200 hours because that was all they could persuade the Ministry to afford The actual rate of flying varied With bombers and big transport machines, once they could be got into the air, it was possible to get between four and ten hours in a stretch, and if the machines remained serviceable, the hours could be built up quickly so that more than 30 hours per week was possible

In this country, with the present state of financial backing, it was difficult to get anything better either in flying rate or total hours It was true that the Americans were always ahead in this direction, but they had almost unlimited facilities, tremendous spares backing and staff, pilots and everybody else, whereas Britain always had to do these jobs on a shoe-string

In the case of the rotor blade failure described in the paper, three rotor blades were shown Two did almost meet the target life but the third one seemed to fail far more frequently Was there any installational reason for this ? Was it because of the particular root end fixing of the blade ?

Mr Webb replied that the blades always failed in the same area There was cracking of the trailing edges, which could be repaired by repair schemes They were, in fact, repaired and put back on the aircraft at a later date

Mr Backhaus said he wondered whether the right way to obtain the 250 hours lead was to take a production aircraft, get a certain amount of flying at the firm first and then ensure that, if the flying on this aircraft was not continued in an experimental establishment, it should proceed to a Service Unit and continue to keep a 250 hour lead by intensive Service flying A special Flight would be necessary whose Service task would be to keep up the hours and ensure that that aircraft kept in the lead If it crashed, the aircraft with the next longest hours should take its place It was difficult otherwise to see how it could be arranged The alternative was for a large team in a proving establishment to do the work and the cost of keeping the aircraft, helicopter or otherwise, airborne would be prohibitive This was really the only way of ensuring that failures ultimately did not occur under conditions that could not be controlled

Mr Webb remarked that among the audience was Squadron Leader Price, the pilot in charge of the intensive flying trials described in the paper Was it his opinion that the rate of 30 hours a week could be maintained ? Secondly, as a qualified test pilot, what comparison would he make with the "raw" pilot in the Service ?

Squadron Leader J L Price (*H Q , Coastal Command*) (*Member*), giving his own views which might not correspond to the official views of the Royal Air Force, said that the aim of six hours flying a day, quoted by the Author, was to allow for long periods of unserviceability of the aircraft The task was, in fact, 240 hours, to be completed at the rate of 100 hours per month No public holidays were worked and the period of 71 days included nine week-ends of which only two were spent servicing the aircraft No flying was done at week-ends

The major factor in achieving the rate was good administration and co-operation with the firm, coupled with the enthusiasm of the ground crew For example a clutch sustained a fairly major failure at 4 p m one Thursday, by 5 p m another clutch was loaded onto an aircraft at Yeovil, by 6 p m the clutch was at Boscombe Down and by 10 p m the machine was ready for flight When this kind of service is available for parts requiring a long repair time, the rate of 100 hours per month can be maintained Naturally any repaired part should be refitted as soon as possible, but to wait for each part to be repaired would cause unreasonable delays

To maintain 100 hours a month not more than two pilots need be used in any one day, although many pilots were used to get a wide consensus of opinion With two pilots assigned to the task the rate could be maintained

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Two complete ground crews were used, one week working overtime and the next returning to normal flight duties not connected with the trial This method was adopted because it is reasonable to allow for sport and general morale when using Service personnel Generally it was considered that the crew should not be worked continuously with overtime for more than seven consecutive days

Comparison of pilots' ability to control a helicopter was a thorny problem However, it was thought safe to say that when a pilot was working in a jungle clearing, any violent manoeuvre would be disastrous Over the sea one could not imagine a pilot getting himself into a very awkward position, except, possibly, when approaching the deck in violent weather In general it was considered that the manoeuvres carried out at Boscombe, *i e*, low speed manoeuvres, quick stops, hard turns, etc, were adequate to cover the rough handling in service A certain measure of representative treatment was also thrown in by inviting visiting pilots to fly the aircraft

Mr Newbery had spoken of the conditions that were covered in the trial With the existing amount of financial support, it was impossible to cover all the conditions It was a question of whether the Services wished to spend the money first, or to chance the effects later Certainly the winter trials had proved worthwhile, although there had not been an intensive helicopter trial until last year

From the Service point of view it was suggested that, if a batch of only 20 aircraft were ordered, it would be impossible to afford more than one for intensive flying trials lasting more than 240 hours Even one machine would represent a loss of five per cent at the outset

It had been suggested by Mr Newbery that the firm should do intensive flying trials as soon as possible Squadron Leader Price's view was that the sooner the service, *i e*, Boscombe Down, got an aircraft and started flying it, the better Although the engineering side could be covered by a trial at the firm, a representative of the firm could cover the engineering at Boscombe and visitors from Service squadrons could "have a go" at it This would provide a good concensus of opinion, while a general flow of Service visitors to a firm in an intensive flying trial would probably be an embarrassment Therefore the first machine, after the C A clearance trial, should go to Boscombe for intensive trials

Captain E C Beard (*Ministry of Supply*), who declared that he was interested in the finished product as seen by the Service, said that the operational reliability trials of which the Author had given such a clear description were merely one link in the chain between the finished building of an aircraft and its receipt into the Squadron Having decided to buy an aircraft, the Services wanted it as quickly as possible The manufacturers also were committed to producing aircraft at a certain rate

Living in Utopia, there would be no reason whatever for the operational reliability trials or any subsequent trials The firms would produce the aircraft which the Squadrons would love from the moment they had them Unfortunately, however, that was not possible because of a variety of reasons, the majority of which were perhaps the outstanding demands that were often placed upon the firm

How was the task tackled ? The firm flew their original aircraft as quickly and as fast as they could As soon as it was possible, an aircraft was given to Boscombe Down, very largely for the purpose, in the first place, of checking what the firm had done By this means, the aircraft could be released so that it could go to a squadron By this time, however, several aircraft were starting to pile up at the end of the production line Therefore, it was very much better, both from a Service and from a Ministry point of view, that the aircraft were given to an intensive flying squadron in the Service where, in addition to having the ordinary Service pilot, they were subjected to ordinary Service maintenance After all, in the long run the aircraft was judged by what it did in the squadron, with a squadron pilot and with squadron maintenance

Without in any way belittling the excellent work done by Boscombe Down, Captain Beard suggested that to increase up to even one year the interval before which the intensive flying could be done in the squadron would be a very retrograde step

The Chairman recalled the comment in the paper that the machines that went to Boscombe Down were those destined for use in the three Services On the other hand, those destined for civil use went to an operator He wondered whether there was anyone present from B E A who would like to speak

Mr H D Henniker (*B E A*) prefaced his remarks by making it clear that he

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was not a helicopter man and any comments he made were based entirely on the background of fixed wing aircraft

In the paper, the Author made the assumption that " things can be put right at a later stage " Detail design could be, and very often was, put right at a later stage, but the basic design philosophy could not be put right later It was the basic design philosophy which decided whether the failure of a single pipe clip could cause catastrophic results

On the question of building up hours quickly, his own experience was that if the object was also to build up hours on the components themselves, it was not always a good thing to whip them off at the first sign of trouble but to leave them going, by a system of special inspections, as much as possible, so that at the end of the reliability trial one would have the maximum hours on a maximum number of components The alternative, presumably, was a good backing-up organisation in which it was possible to take off the parts, have them remedied, adjust the defect very quickly and refit the parts back on to the original aircraft

It was not clear whether in the intensive flying trials the Author anticipated the normal check periods, whether he expected to include the same recommended check periods, or whether he had a system of accelerating them in order to gain experience on the checks also The check periods would otherwise come right outside the intensive flying trials if these are limited to about 250 hours

The next question concerned modifications to the aeroplane which was being used for this purpose Any attempt to keep it up to the latest modification standard would reduce time on components if the modification was done by introducing modified components partway through the trial The thing to do, therefore, was to have the aeroplane at the highest modification standard at the beginning and to avoid doing any modifications that would limit the experience on certain parts

On the duration of reliability trials, his experience of fixed wing aircraft in civil operation was that the 150—200 hour period that was talked about as being a satisfactory figure did not begin to reveal anything In fact, it gave some most misleading information On four new aeroplanes introduced into service after very short proving flight periods, the following indications of trouble were given simply by a figure of log entries in the technical log per 100 flying hours For one type, during the first 150 hours the rate was 370 entries per 100 flying hours At the end of 1,000 hours, it was 65 Any forecasting of reliability, spares assessment, and so on, based on 150 or 200 hours, would have been completely misleading on the aeroplane in question

On each new type that was brought in, the experience was that it took approximately 1,000 hours to settle down into a defect rate approaching the one at which it stayed for the rest of its life In other words, the aeroplane was down to 65 entries in 1,000 hours and after 10,000 hours it was only 30 Another aircraft began with 105 entries at 150 hours, dropped to 50 in 1,000 hours, and was down to 30 after 10,000 hours One thousand hours seemed to be the pointer, as far as B E A was concerned, as to how the aeroplane would really behave A great deal of the explanation was that apart from the aeroplane settling down, the people maintaining it had to settle down

What faith had the Author been able to place on reliability trials based on something as short as 200—300 hours ? It was difficult to follow his argument that whereas 200 hours was considered satisfactory for fixed wing aircraft, because a helicopter had so many more moving parts and vibrated so much more it required so much longer to bring things to light One would have expected it to be the other way round

In intensive flying, did the Author attempt to simulate a typical flight plan of the same sort of duration as the aeroplane would have in service, or did he try to accelerate many of the factors that would wear and tear certain parts of the aeroplane, related to flight cycles and not related to hours ? More and more one was being forced to realise that a tremendous amount of maintenance was related much more to flight cycles than to hours flown Therefore, the pushing up of a fairly large number of hours, if it was achieved by doing very long flights, would not necessarily give the right answers

Mr Webb replied that in deciding whether to replace defects immediately by another item, one should use discretion If a simple repair scheme could be done to the defective item immediately, it would be done, as in the case of the starter When exhaust pipes and exhaust pipe flanges had cracked, they had been allowed to go on flying and were watched through the inspections, as Mr Henniker had suggested

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Boscombe Down used the provisional check or inspection periods that had been fixed or suggested by the firm during the early prototype trials They were, indeed, discussed with the Ministerial Service Departments to see whether they fitted in with the user requirements They were used as a basis and were commented upon as necessary, alterations occasionally being suggested

Concerning the modification state of the aeroplane, the Establishment started off with the aeroplane in the latest possible modification standard—*i e*, the state in which the aircraft was to be delivered to the Service The modifications which the Establishment put in later, and which the Author suggested should be put in in batches to avoid the periods of delay and keeping the machine out of flight, were a classification of modification in the Ministry which was called a "B" Class *i e*, they were essential and should be put in as early as possible Thus it was only the really important modifications that were incorporated

As Mr Backhaus had said, the figure of 150—200 hours for fixed wing aircraft was settled by financial reasons Mr Backhaus had suggested that the idea was to keep on building up the hours, and the suggestion made by the Author was that the particular aeroplane tested at Boscombe Down should continue its life in the Service and should be made a special case and watched and all the information collected as time went by

In the flight plan and the actual duration of flights, the initial phase should be the building up of hours, and this could only be done by the longest possible flights of maximum duration That was how the trials were conducted in the early stages In the meantime, however, the programme was discussed with the user and the pattern of flying which would be used in service was then carefully studied, and later, when the role trials were reached, the pattern that would be used by the Service was followed This was one of the reasons why the rate tended to drop off as time went by

Mr J Leach (*A & A E, Boscombe Down*) said that the discussion had covered a great deal in connection with policy concerning the types of trials From the Service point of view, in the case of a helicopter that was to have wide application probably in all three Services and would have a fairly long service life, it was worth while doing the job properly The ideal arrangement would be to have one aircraft at Boscombe Down doing the trials slightly ahead of a Service squadron, with three or four aeroplanes which could operate in the various roles that the aeroplane was to fulfil

That type of trial had already been done with the Navy and the results were very good There had been very good co-operation The only essential requirement was that the technical control should be from the Establishment, mainly because their job was testing aeroplanes and they had a little more know-how on that sort of thing On the other hand, the general service conditions in a squadron, and probably the conditions under which operations were done, were not as ideal as at Boscombe The Establishment had lots of concrete outside the hangars, whereas a squadron might have to operate from fields and would not have the same facilities For these reasons, deterioration of the aeroplanes over a period in squadron service would probably be higher than in the case of Boscombe

In operating trials of this kind, there was very good morale, the team spirit was good and the men would press on The only danger was that they considered it more important to keep the aeroplane in the air than to find the defects It was necessary to watch them, otherwise they would improvise and do things when one's back was turned, so that it was impossible to catch up on some of the things that went wrong

The **Chairman** pointed out that one of the subjects which had not been much discussed was airworthiness certification In the case of civil aircraft, the Air Registration Board was involved A number of years ago, he had been a member of an S B A C Airworthiness Panel and the intention then was to try to co-ordinate the requirements of the Service with those of the operators Possibly Mr Shapiro could speak on the present state of affairs and say whether this had been done and how the Service aircraft were certified, whether in accordance with A P 970 or its equivalent as established by the A R B

Mr J S Shapiro (*Servo-Tec Ltd*) (*Founder Member*) said it was asking too much of him to cover the airworthiness angle, but at least he had a few remarks to make which might have some bearing on it What struck him particularly about the paper was that much of the work seemed to be based purely on opinion Perhaps, however, it had to be so, or perhaps it was not even very important

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He had tried to work out how important a subject was being dealt with from the point of view of finance His conclusion was that when talking about a helicopter that was kept in the air for 1,000 or 2,000 hours, one was talking of a sum which was not far from the amount necessary to design and build the first aircraft In other words, the subject that was being discussed tonight was roughly equal, financially, to all the subjects that had been discussed over the years with all the *X*'s, and yet there was no *X* in it

The B E A representative had put the point in a way which could hardly be improved upon, but the Lecturer's answer was not altogether satisfactory If it was impossible within 150 hours to get information bearing on reliability—*e g* , if one did not discover the significant levelling out of the failure rate—then the answer that it was not possible to do more because the money was not available was not a very good answer, because the 150 hours did not reveal anything

That had been shown quite clearly by the remarks of the B E A representative, who had also spotted an inconsistency in the paper, which seems to emphasize this point of view If something was shaking more, it did not take as long to find out the defects as it would do if it were shaking less

That situation led to a number of fundamental questions What was the correlation between intensive flying, operational reliability trials and airworthiness, whether for military or civil purposes ? Was there a correlation at all, and was there a body of knowledge from which it could be deduced that there was a certain number of hours that was useful and gave guidance on the degree of reliability and the airworthiness of the aircraft ? If not, was there a way in which to assess whether a sufficient number of hours had been done ?

It seemed that the B E A method was to count the number of the pilot's entries in the log book One did not know whether this was a very good way It might be that the man had a bad cold One did not know to what extent the number of entries was a very good criterion, but it was interesting to see that such a criterion was adopted and did, in fact, exist

To be objective, a criterion must be based on observations which had at least some degree of instrumentation Was it possible to devise or to think up forms of instrumentation which might at least help to discover failure rates, or even devise means to accelerate failure rates ? This was possibly the most fruitful avenue for reducing the cost of tests Was there some method of accelerating operational reliability trials ?

It was not suggested that operational reliability trials were a simple duplication of airworthiness trials Airworthiness trials were conducted under certain given conditions which the Airworthiness authorities had agreed to regard as simulating operational conditions, whether civil or military The very purpose of operational reliability trials, however, was to find out the difference between the simulated and real conditions This included the difference in the attention that the aircraft received, or the love and care that was lavished upon it Here, therefore, there seemed to be a virgin field

Was there any possibility of probing into the mystery of what made operational flying different from airworthiness flying ? The Author, it seemed, had tried to include simulating everything that happened, only to discover that he had not One always looked forward to somebody putting an advertisement in the "Personal" colum of *The Times* saying "Fool required to test foolproof equipment" Was it possible to devise a fool ? Could a squadron or individual be found, or a special team selected, who would give this accelerated form of operational reliability testing ?

To summarise, there was not very much that could be said on operational reliability from the airworthiness viewpoint except that one would like to see something on the lines mentioned by the B E A representative such as a decreasing and a levelling out of rate defects Secondly, it would be highly desirable to find out what made the difference between airworthiness trials and operational reliability trials If this could be discovered, it might be possible to save a great deal of money, perhaps as much as the whole design in helicopters or any other aircraft

Mr Webb replied that he had intended to comment, but had forgotten to do so, on the question of the accumulation of defects over a given flight time He had hoped to bring figures from the Establishment's trials but he was not able to get them worked out in time In any case, on their first operational reliability trial they were only up to 400-odd hours and on the second type they were up to only 300 hours Consequently, it might be some time before the long-term trend revealed itself

He had hoped to show the number of defects arising in unit time against accumu-

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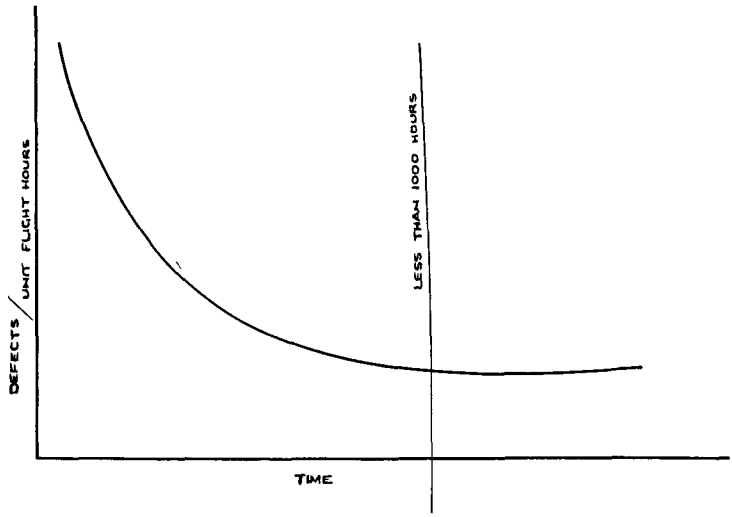
lated hours, a defect being anything which stopped the aircraft flying at any given time It was hoped that it would show a decreasing rate and would then become constant, and that the 1,000 hours which he had suggested as being a reasonable time for the trials would be somewhere on the flat part of the curve At least, it should be at such a time as to show that the steady state of the aircraft had been arrived at



If, then, as Mr Backhaus had suggested, the particular aircraft could be sent to a Service squadron to find out what happened during its whole life, the level would probably continue reasonably constant for, say, 10,000 hours Then, when age began to show, it would start going up again and one would arrive at the end of the useful life of the aeroplane

That was the hope Mr Webb had not yet seen the figures that were being compiled, but that was probably the type of statistical evidence that Mr Henniker intended should be collected

Mr Backhaus said that the fixed wing side of the Establishment had perhaps and a little more experience in that they had been undertaking operational reliability trials on their conventional types for more years than on the helicopter We were only getting information on the early teething difficulties, but this was all that one could hope to do in the first 150 hours Even this, however, was of great value to the Services

Experience showed that when starting a squadron of seven or eight aircraft, 80—90 per cent of the defects that would be encountered in service showed themselves during the first 150 hours of flying one aircraft We do not find the average total number of defects per hour for the aircraft life What we do find, however, was 80—90 per cent of all the possible defects that would come out in service This meant that modification action could be taken on those early enough without having the difficulties of modifying five, six or more in a batch, which would greatly increase the cost and length of time before the defect was known and modification action taken

Concerning the airworthiness side, the real difficulty was that very seldom was an aircraft that was on any other trials except operational reliability trials completely equipped Most of the defects that arose were in the interaction of one system with another, *e g* , heavy surge loads in the electric generating system caused by radar, etc , affecting radio compasses, vibration due to airloads or gun firing affecting functioning of equipment, etc Up to the stage of an operational reliability trial, aircraft on test did not include all the items that would be fitted when the Service took it over This was why the defects came out at that stage if that was the first time fully equipped aircraft flew

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As for fatigue, there was no other answer but to continue flying for so many hours that nobody could afford it—except in the manner suggested earlier, *i e*, to keep one aircraft 250 hours ahead

Mr Webb, in reply, said he thought Mr Backhaus was right What one was looking for in the operational reliability trials were all the minor defects that stopped the aeroplane flying and were not connected basically with airworthiness

In an endeavour to get some kind of guide of what was happening in the basic structure, he had discussed the matter with Mr Wood, at R A E, who had in mind some kind of instrumentation to put in this type of aeroplane to give an idea of what was going on in the structure

Mr F S Wood (*Structures Dept, R A E, Farnborough*) said that on the general question of airworthiness his idea might be thought rather biased, because this was his bread and butter There were two kinds of airworthiness to consider One of them had crept into the discussion once or twice—there had been reference to fatigue That was basic structural airworthiness, which had nothing whatever to do with operational reliability trials of helicopters, even if it might have some connection in the case of aeroplanes The other category was what might be called operational or secondary airworthiness—things that might happen to the equipment and so on that would ground operational aircraft but which did not endanger either the aircraft itself or its occupants

The basic structural airworthiness—particularly fatigue—must be ironed out separately from the operational reliability on a helicopter On an aeroplane, it might be permissible to have a fail-safe design on which one could rely on inspections to pick up a crack here or an odd defect there which could be used to indicate that a component was approaching the end of its useful life or needed modification The helicopter was different, however (except perhaps in secondary structure or bracketry, or conceivably in parts of the airframe in which there might be found to be a fail-safe structure, but one must not rely on the operational reliability trials to show it) On the moving parts of the helicopter, it must already be proved that there was sufficient fatigue strength for the specified life and operational role before trying to achieve that life The life established from fatigue tests should never be exceeded One should try to get a virtually infinite life, if possible, and then everything would be all right If the fatigue test caused any suspicion that virtually infinite life might not be reached, there would be a finite life assigned, and it would be wrong to rely on the operational reliability trials to show whether this could be exceeded This was generally understood by people concerned primarily with helicopter airworthiness Those concerned mainly with aeroplanes might tend to be misled sometimes into thinking that operational reliability trials could be relied upon to establish the fatigue properties of components They could not be relied upon to do so on the helicopter

Mr Backhaus said that it was surely only a matter of time On a helicopter, it was a far shorter period, presumably On bombers and other military aircraft, it was often longer than the service life of the aircraft In a civil aircraft, it would undoubtedly fall within the useful life of a type in full use and presumably it was well within the flying life of a helicopter

Mr Wood replied that on the helicopter it was very short

The **Chairman** invited a contribution from somebody in the industry

Mr O L L Fitzwilliams said that he wished to contradict what had just been said concerning short component fatigue lives in helicopters These had been and still were a common feature, but mainly because of inadequate development They were not an inherent feature of the helicopter On the contrary long, or unlimited, fatigue lives appeared in some respects easier to establish for helicopters than for other types of aircraft, provided adequate development resources were available

He was concerned about the part which Boscombe Down would play in the future and doubtful if Mr Webb was correct in assuming the Boscombe could play a large part in the engineering development of the helicopter

The past was somewhat misleading in this respect in that early helicopters had

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very little development, of which that part contributed by Boscombe might be considered significant The Contractors' development programmes are however now so extensive that Boscombe could not expect to contribute significantly to fatigue or endurance testing Mr Webb's example of a rotor blade was in this respect misleading The fact that Mod 331 (which cured this trouble) was introduced after the Boscombe engineering report had been studied, did not mean that Boscombe had fixed the blades In fact their observation was merely one of many during the long period of time required to get this Mod accepted by the N A M C

He thought that Boscombe might help in organizing operational trials by the Services but would not themselves be able to run full scale operational trials in a representative manner Boscombe's main job has always been, and presumably would remain, to check an aircraft against a Specification If a future Specification called for 1,000 hour overhaul periods, would Boscombe be involved in establishing compliance ? Here was a problem for Boscombe to settle for the future

The **Chairman,** in closing the meeting, said that time did not allow the Author to reply at once to the last speaker, but he would reply in writing after considering it A controversial note was an appropriate one on which to end the discussion The Association was very grateful to the Author for his paper on this very important and highly-specialised subject

The vote of thanks to the Author, proposed by the Chairman, was accorded unanimously by acclamation and the meeting then ended

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Mr Webb's Written Reply to Mr Fitzwilliams

Mr Webb, in a written reply to Mr Fitzwilliams, said that he wished to emphasise the part which Boscombe Down played in the development of a modern aeroplane, and that is to underline what Mr Fitzwilliams has already said namely a completed aeroplane is sent to the Eastablishment and it is checked against a specification It is the function of the Establishment to find out any specification short-comings in order that the Service could apply such limitations as were necessary for its operational use

Part of the check is the engineering assessment and it is to this feature that the present paper has been devoted

With regard to the question of blade failure raised by Mr Fitzwilliams the Establishment did not claim to have " fixed the blade " The trials emphasised the rate at which the blades failed in order to add to the weight of evidence to support modification action It should also be pointed out that the failure can hardly be regarded as minor as the operators are required to carry additional sets of spare blades to enable the aircraft to remain serviceable—a very expensive item

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