Discussion

Mr Shapiro It is now time for us to start the discussion, and I would like to ask Mr SHENSTONE to open it

Mr B S Shenstone (*British European Airways*) Regarding the comment on the lectures, all of which I found very interesting indeed, I was a little confused about Quantity B in Mr MCCLEMENT'S lecture Quantity B I think is the amount of time the aircraft could be engaged in revenue flying and he said he thought it had got nothing to do with engineering I have tried that on our traffic people as it concerns them If the available time for flying is not at the right time, such as at midnight, it is no use to traffic people If engineering can produce it when it is wanted, it is welcome and can be used Hence Quantity B can have quite a lot to do with engineering

In connection with Mr SHIPPEY'S lecture I noticed he made some remarks about licensed engineers and unlicensed inspectors on overhaul work He gave the impression that any person might inspect on overhaul, *i e*, a man without proper training This is a theoretical possibility but any Chief Inspector who appointed an Inspector with no background and no knowledge to do the job wouldn't be Chief Inspector very long and I think that although we do recognise there are certain great advantages to licensed men, it does not mean to say that the unlicensed man is out He may have particular virtue in dealing with the very thing he is doing He may be able to do it better than anybody else Many Inspectors are licensed so I don't want you to get the idea that just because an unlicensed man is inspecting that there is something wrong there—it might be the opposite ! I noticed that Mr Shippey said we've had no trouble with fans and cooling fans and other things in connection with the engine on the Bell helicopter I was talking to the people in Sabena recently and one trouble that they were experiencing with the Bells was the cooling fans in the engines Sabena manufactured cooling fans themselves with heavier gauge and they worked perfectly

Mr W Tye (*Member—Air Registration Board*) I did not come this afternoon to talk but rather to listen As I have been caught unawares, the only thing to do is to mount one of my favourite hobby horses, and to suggest to you that the trouble with helicopters is that there are far too many things that whizz around and wiggle about It seems to me that such moving parts are very much more prone to fail than things which stand comparatively still As a very rough guess, parts which move—whether they are instruments, mechanisms or engines—probably fail about once in every thousand flights On the other hand, solid pieces of structure are not likely to fail more than once in every million flights I may be wrong about the odd nought on these figures, but the point which I want to make is that the fixed structure is perhaps a hundred, perhaps a thousand, or perhaps ten thousand times more reliable than parts which move

Now the helicopter vitally depends on parts which move to keep it up So it seems that the overall reliability of such moving parts, particularly the hub and rotor blades, must be developed to a degree more on a level with the fixed structure of an aeroplane You may feel that I am unduly pessimistic about the reliability of moving parts, but to quote an example only, with modern aeroplane engines, the propeller and reduction gear are still liable to fall off Thus, there is a very big job ahead of making the broadly comparable parts of the helicopter a great deal more reliable than previous good practice has achieved Usually I direct the question to the designers -what are you going to do about it ? It is more appropriate to-day to address the question to the members of the audience who are Licensed Aircraft Engineers and to ask them what special attitude to their work they are going to take so as to ensure that those slight faults (which in the aeroplane do not cause catastrophic result) are totally eliminated from the helicopter

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Cdr (E) R H Webber (*R N A S, Gosport*) Firstly, I am glad to have had some dispensation from a previous speaker, to permit me to be on the safe side, and tell you that any opinions that I may express are not necessarily those of my Lords Commissioners of the Admiralty Secondly, I must say that my qualifications to speak on this occasion and before such an acknowledged crowd of experts are perhaps a little nebulous, but, as an engineer officer in the Royal Navy, I am not entirely uninterested in the rules appertaining to the granting of ground engineers' licences —not only do I hope to learn enough today to be able to advise Aircraft Artificers, and Air Engineer Officers who may be leaving the Service from time to time as to their qualifications for employment in Civil Aviation, but, you never know, I might get the sack myself, sometime The Navy has operated helicopters for a number of years now, and in the course of operating them a large number of officers and men have been trained and given experience in their maintenance Some of these officers and men have been employed on duties which are entirely comparable with those for which ground engineers' licences are issued to civilian personnel Although I am not by any means offering you all the helicopter trained personnel of the Navy I would like you to realise that there is such a body of men in existence, some of whom appear from time to time on the open market, and many of whom are, to my mind, well qualified to possess "A" and "C" licences for helicopter maintenance, and by virtue of their experience in the Service can render good service "outside"

Mr McCLEMENTS opened his paper with the statement—"It is a good thing occasionally to lift our sights from the job in hand and focus our attention on the broader purposes of our actions" I would like to apply that to the procedure for satisfying an "Airworthiness Authority" as to the safe scrap life of a helicopter's components, as formulated by Mr Le Sueur When a new helicopter has been produced, and the powers that be require it to be subjected to excruciating tests, the desire and ambition of the designer and his sponsors must be for their aircraft to pass those tests without any trouble at all But when, as is perhaps inevitable, a component fails its test, or is shown by the tests to be a critical part, what should be the reaction ? The designers must certainly not stop at fixing upon a safe life for the part Consideration must be given to a design alteration to achieve an increase in the life of the part Design effort must be directed towards improving all parts of the aircraft so that maintenance work is reduced to a minimum Now such design work, after tests have brought to light weaknesses, is always duplication of original effort and, therefore, is likely to be unpopular—because it costs money The proper time for design effort to be expended in producing an aircraft on which maintenance requirements are a minimum is before the prototype aircraft or its components are subjected to tests

Unfortunately, designers have not, in my opinion, yet learned that they must incorporate easy maintenance in their product—I was told recently, by one senior servicing engineer of a firm which does not, perhaps happily, produce helicopters, that he had the greatest difficulty in holding the attention of his firm's Chief Designer for more than a few seconds at a time, whenever he talked to him on the subject of "Design for Maintenance" (I might say I would prefer to use the phrase "Design for NO Maintenance") This senior servicing engineer told me that his Chief Designer had no idea at all of what the Service did when it carried out an Inspection He was trying to arrange for his Chief Designer to come and witness an inspection as carried out by the Service I must say I think it would be an excellent idea if all Chief Designers were made to carry out an inspection themselves Then perhaps one would not find, for example, an engine fitted into a helicopter so tightly that the manufacturer's service engineer had to confess that whenever they had to change a set of plugs they "always left that one in, it was such a job to get it out"

There is a real need for design effort to be directed towards reduced maintenance requirements Mr McClements has demonstrated most ably the economics of the matter from the operator's point of view He has also listed, under headings (*a*) to (*e*) those things which go to make up the maintenance requirements of an aircraft Items (*a*) to (*c*) covered the ordinary fuelling, greasing and cleaning of the aircraft, while (*d*) and (*e*) were the visual inspection of each part of the aircraft at stated intervals of flying, and the removal, overhaul and replacement of components when their lives are up Items (*a*) to (*c*) will always be with us although reductions in the time and manpower requirements associated with such daily servicing work should be sought and could, without difficulty, be found—but (*d*) and (*e*) are where reduction to an absolute minimum must be achieved And here the licensed engineer comes in Mr McClements has given a list of some of the aspects on which the experience of the maintenance staff should be sought by the designer We won't achieve an aircraft

which, in prototype stage, is perfect for a long time yet—after all it is all a matter of experience , but the necessary experience is gained first by the ground engineers

It takes the best class of detective to maintain a low crime rate in any form of society and similarly, as aircraft are improved, I suggest the quality of the ground engineer will have to improve too If a defect is obvious to anyone, anyone can report it, but if defects are less obvious and less frequent in occurrence, their timely discovery and rectification will require a good quality engineer

I would like to make one more point I have heard arguments put forward from time to time, both to the effect that helicopters are different and must be looked after and operated only by those who are familiar with their ways, and also to the effect that helicopters are just the same as any other type of aircraft and 'why all the fuss" I have heard the same person use both arguments, according to his requirements at different times ! So far as the maintenance engineer is concerned, I do not think that the helicopter should be looked upon with awe as something different from all past experience Certainly the need for a reduction in maintenance requirements is not limited to helicopters

Mr J Leason (*British European Airways*) These remarks are certainly my own First, I would like to intervene in the discussion between Mr SHENSTONE and Mr SHIPPEY on the points they made about the approved Inspector and the Chief Inspector Probably what Mr Shippey had in mind was the Chief Inspector Mr Shenstone said that if the Chief Inspector were to appoint an irresponsible Inspector he would not be a Chief Inspector long Well, there may be some food for thought here, as there might possibly be a Chief Inspector even without a licence—that anomalous situation does exist in a number of instances today The second point I would like to make is that with regard to the standards of maintenance being kept up I feel that one of the blows that have been dealt to the upkeep of standards lately has been done by the Air Registration Board in withdrawing their supervision of Licensed Aircraft Engineers In the past it has been their practice every six months to keep a check on Licensed Engineers by submitting a satisfactory or adverse report on their activities which I think has been a very good thing Now they have withdrawn this practise and knowing human nature what it is, I feel that it has the tendency for a certain amount of apathy to creep into the outlook of the Licensed Engineer, in so much that they will now not keep up to date with regulations and some developments as they should do I say this with some conviction because recently (before these reports were discontinued), a Surveyor came along to our Unit and did a six monthly check on a number of Engineers and during the course of his interviews he found that an engineer was not up to standard on his regulations This was mainly because the Engineer in question was not actually engaged on the schedule operations but was more concerned with general overhaul and the supervision of labour The Surveyor thereupon withdrew the Engineer's licence for a temporary period On doing some revision the Engineer became fully conversant with the requirement and was re-examined after a few weeks I can now say that this Engineer, is, and always will be, now fully conversant with the regulations and schedules under which his firm operate I feel I may be "shot at" by my colleagues from the Licensed Aircraft Engineers and the Air Registration Board for making this point but I do feel that the six monthly checks on Engineers should be retained and this will then give the Engineer more confidence to know that The Air Registration Board is behind him and that he is answerable to them as well as being an employee of his company and thereby keeping the standards of maintenance to a high level

Mr Carter Representing as I do the private operator, I must say I feel a slight sense of loneliness as I believe it is still correct to say that my firm is the one and only private operator of helicopters in the country I should like to give you a few details of our operating experience up to date Over the past $5\frac{1}{2}$ years we have operated seven helicopters of three distinct types and have accumulated 4,700 flying hours A considerable amount of this flying has been completed in nine separate overseas expeditions to different countries and types of territory I know that in comparison with any other operators these figures mean very little but, as they have been carried out often under very difficult conditions, they represent no small measure of effort on the part of our pilots and engineering staff The subjects of maintenance and the licensing of personnel is of vital importance to an organisation such as ours

both from economic and operational efficiency aspects It is due to overseas contracts that we have been unable to attend your lectures and discussions in the past The maintenance principle as outlined by Mr McCLEMENTS form the basis of a most acceptable method With certain detail differences it closely resembles the line we ourselves have followed for some time To apply any system of planned maintenance it is essential to have a planned or at least a known programme of the future operational requirements With our particular type of work this is not always possible as so much depends on the behaviour of our weather and the often erratic happenings of nature At the most we know the usual pattern of the seasons but often the maintenance cycle must be adjusted by bringing the work forward to give a useful overhaul free life for urgent requirements overseas, or away from base A recent appeal for help in flood relief found our aircraft under overhaul, in what is usually an ideal period for this work We just could not get there in time, this is most regrettable and we have lost a useful job, but it does show the difficulty of planning ahead for the private operator Mr McClements suggests a closer liaison with the manufacture at an early stage of the design with reference to advising on the operational and maintenance problems I, for one, would gladly welcome such an arrangement but up to date we've had no invitation but surely the first move must come from the manufacturers themselves ? Our maintenance schedules are compiled using the manufacturers recommendations as a basis and adapting to the requirements of our particular type of operations We find it more suitable to carry out the necessary checks as and when they occur—using all available periods of non-flying time Mr McClements period " B," the second period of time—well he said that this was not of importance to the maintenance engineer—well, I am afraid I cannot fully agree Such periods for us usually mean the aircraft is in transit or being prepared for or assembling after transit, also of course there are periods of non-flying due to weather and state of growing crops We can use much of this time to carry out such maintenance as possible, including, of course, night work It is our policy to have an experienced ground crew with each aircraft fully equipped with the necessary schedules and equipment to carry out intermediate inspections For major inspections the aircraft are returned to base

Mr SPAULL gave us a very careful review of the requirements of the licensing of helicopter maintenance engineers and I note that it is not the intention of the Board to consider the issue of " B " and " D " licences in respect of helicopters and their engines (I had rather hoped that Mr Spaull would say " for the time being ') If we assume that the regulations covering the certification of similar engines when installed in fixed wing aircraft, equally apply to the " D ' licence Does this mean the Board are prepared to consider the approval of an Inspection Organization for the overhaul of helicopter engines without the services of a " D " licensed engineer ?

Mr LE SUEUR s remarks—I think Mr Le Sueur's remarks on fatigue problems should be appreciated by all who design, build and operate helicopters An operator having purchased his helicopter for a very large sum of money now endeavours to operate it for his own particular business with the object of obtaining the maximum amount of revenue flying with the least amount of compulsory grounded time, with its associated maintenance and material expenses It does not seem compatible that the operator should be called to bear the additional expenses of a large number of lifed parts It is to be hoped that the designers and manufacturers together will discover and eliminate by suitable design changes, as many as these items as possible by extensive type and endurance tests If any lifed parts are passed on to the operator they shall have at least an economically useful life On the maintenance side I feel there is much we can do to alleviate the fatigue problem We should keep suitable records of all component parts whether lifed or not, so that action can be taken if subsequently required We must eliminate all flight vibrations by careful rigging and balancing of rotors The required incidence setting of a rotor or control surface is usually given as x number of degrees Almost universally the tolerance is allowed is plus or minus half degree Presumably this is arbitrarily fixed by the Designer, but we have always found that by careful levelling of the helicopter and use of the adjustments provided it is possible and desirable to work much closer to the required setting, also each rotor blade is carefully checked and matched together This simplifies the tracking adjustment and results in improved flight characteristics We also double check all rigging figures—sometimes three times The limits of a rotor assembly for being out of static balance is usually expressed in inch ozs again we have in all cases by the exclusion of all draughts, correct adjustment of the blades in a spanwise direction been able to obtain nearly perfect state of equilibrium We also take the

precaution of renewing all hinge bolts and pins in the control linkage directly connected to any rotor blade We have had failures of various parts most of them have been discovered on detail inspection Modification action has been taken in most cases, but there are cases where our particular failures have not been experienced by any other operator, which, indicates the need for vigilance at all times I think we at least appreciate that scrap lives are not a whim or fancy, but still hope the manufacturer will take all possible corrective action promptly when the occasion arises Thank you

Mr N E Rowe (*Founder Member—Blackburn General Aircraft Ltd*) This is a discussion of course on maintenance engineering, about which I know nothing at all I have given some thought to the matter from time to time, and to the various factors involved One thing which impressed me very much when I was with B E A was the effect which random unserviceability that is unplanned unserviceability, had on the economics of the operation There is no doubt that such unserviceability leads to pronounced dis-economy It involves the possession of large numbers of aircraft to do a given task, or inability to fulfil the task adequately, and therefore inefficiency in operations I think all would agree that the elimination of random unserviceability would be a very great contribution to efficient operation of air transport

I was greatly impressed by a number of points made by the last speaker , one of his points had a bearing on something that Mr McCLEMENTS said, which was very wise, namely that the ground engineer should co-operate with the designer at early stages of the design The particular speaker had never been asked to do this sort of thing Well, bearing in mind the very wide scale which his operations have covered, I should have thought that it would have been to the benefit of the helicopter business in this country to ensure that he co-operated with designers and gave them the fruit of his wide experience of maintenance of helicopters under a wide variety of operational conditions

He also made the point that designers should do their utmost, by type testing and so on, to give the operator the best information they can about the scrap life of parts I think now, as I have thought for a long time, that it is essential to do work which will give this information at the earliest stage in the life—not only of helicopters, but of fixed-wing aircraft as well Obviously if one can devise a means of laboratory or ground testing which would determine the lives of all the parts of the aircraft, including auxiliary equipment, then a great deal of maintenance inspection could be eliminated We would also obtain very much earlier knowledge of the parts requiring re-design to improve their life, we would be able to do real planned maintenance which is not possible now, and the choice of spares could be made on the most economical basis This is idealistic of course However, I think that the attempt should be made, especially in rotary wing work I think it would give rewards even greater than those clearly possible in fixed-wing operations Action is probably being taken by the Ministry of Supply on these lines

The point of greatest importance is that the maximum possible determination of the lives of critical parts should be made in the safe conditions of ground use or running We should try to simulate the critical flight conditions in ground running tests and in that way safely determine the lives of parts

As Wing Commander BRIE says, the maintenance engineer is an essential element in the organisation of operations, but he can only maintain what is given to him to maintain I think that we probably do not take anything like enough trouble to feed back to the designer the experience of the man in the field in two directions—that is the items included in the Schedule of Maintenance which are constantly giving trouble, leading to inefficiency and even to the loss of life, and secondly things which are included in the Maintenance Schedule which never go wrong and which should, therefore, not be in the Schedule at all I think that any designer would agree that the Maintenance and Spares Schedule he puts out for a new type is very largely guess work, erring on the safe side so far as he can judge it, but there are many things which he cannot judge at all, some that will not go wrong and others that give a great deal of trouble, much more than he expects I think that in this way a great deal of time is wasted in operations that could be saved if we had this much better liaison between the man in the field and the designer May be this Association, by some sort of organisation for getting people together, could put the situation right to some degree, and I suggest that the Association should give this matter serious thought because it could bear great fruit in the future

Mr Shapiro I would just like to endorse one point made during the discussion by Mr TYE—I think that very few of us are yet sufficiently alive to the point he made, namely that this moving rotor on which we depend is something completely new in terms of an airworthiness authority It's neither an engine nor a fixed wing It must have the safety of a bridge yet it is moving Now I don't think that the fatigue conception expresses this difficulty In fact, I am on record, as the Americans say in stating that the whole discussion about fatigue is completely misleading—it takes us away from the real subject Fatigue is one of the set of factors which operate on structures, it's study is one of the methods by which we try and *eliminate* the uncertainty of the future To some extent, I would say to a very large extent, we have succeeded in doing so, provided that what we are dealing with is really fatigue strength, namely the ability of structures and mechanisms to withstand fluctuating loads Now, the difference between a fixed wing and a rotor blade or rotor hub is not that the rotor hub is more subject to fatigue The fatigue stresses needn't even be higher, however, the main difference is that the rotor is moving and the other is not I believe that there is an answer to this , there are indications that we are going to overcome this trouble I for one think that one of the reasons that the engine is less reliable than the airframe is not so much due to its motion but to another set of trials and tribulations namely temperature and the associated chemical processes At any rate I really would like to see this problem placed in the centre of attention in all aspects—design, maintenance and perhaps even operation, although I must say that the idea that the operator should keep some kind of fatigue accountancy is something which I do not personally believe to be a very practical suggestion I think the operator should be given a very simple set of instructions which would tell him whether it is right to operate in certain circumstances or not The design stage is better suited for precautions against fatigue than many people like to admit, at least this is my impression from studying fatigue failures I have seen only too often that there have been very definite omissions on the part of the designer to heed warnings which had already been given A lot has to be done in maintenance and inspection For instance, we still have no process for crack detection of aluminium alloys comparable to the Magnaflux process for steel This is only one example but altogether a new standard of inspection should be developed Having said my piece I would like to ask the lecturers if they have anything to reply to the discussion, May I ask Mr McClements first ?

Mr McClements (*in reply*) I have been picked up on my Quantity "B" by Mr SHENSTONE He doubts if the Engineering Group can dissociate itself from those periods when aircraft are available for revenue earning but are not in use , he rightly points out that, even if the utilisation offered were high, nothing much would be gained if the aircraft were not serviceable when the operator wanted to use them What I meant was that it was not the business of the Engineering Group to keep the aircraft occupied , it was, however, very much the business of that Group to arrange its methods so that all maintenance was done when the aircraft "was not required for revenue flying," and I suggested that the best way of achieving this was to aim at doing all maintenance during the period of the 24 hours when maintenance could be done without affecting operational demands It seems to me that the best way of reaching this goal is to adopt the progressive system of maintenance since it opens the way to effective use of the "operational" standing time Hence I do not think we disagree at all

I was interested to learn from Mr CARTER that Pest Control had been using progressive maintenance methods while engaged in non-regular scheduled operations I think that is quite an achievement (especially in as far as record keeping is concerned), and, as leader of the Engineering Team, I think Mr Carter should be congratulated on making the system work under conditions which must often have been difficult

Mr Carter agrees that close liaison between the Users and the Designer is a good thing during the early stages of a project, but he points out that it is not his experience to be asked to co-operate with the Designer I do not think he should feel put out over this The thing is not to be shy in letting the Designer know that he has a lot to gain by building in the practical points which the Maintenance Engineer knows he will want If the approach does not come from the Designer then let it be made by the Maintenance Engineer

Mr SHIPPEY, in his excellent paper, refers to the progressive maintenance done in the B E A Helicopter Unit I do not agree with him on one point, namely that "it is doubtful if there would be any advantage in progressive maintenance unless

there were scheduled turn round times away from Base of 3 hours or more" In saying that, I think he must be considering operations and maintenance all carried out during the hours of daylight In the practical sense, the utilisation requirements are likely to be for the bulk of the flying to be done by day, hence night maintenance seems to be indicated Then, of course, progressive maintenance could be applied with facility at Base

Mr ROWE mentions our attempts at the ground simulation of flight loads You probably know that quite a lot of work has been done with this end in view While ground simulation is a subject on its own, it would seem to have a useful bi-product, namely the maintenance and defect information thrown up at an early stage in the life of a new machine as a result of much ground running If used properly, such information should make the early maintenance schedules for the type of machine in question much more realistic

Mr SHAPIRO mentions fatigue This, of course, is a very important aspect of design but it does not finish there The chances of fatigue failure depend, *inter alia*, on the magnitude of the loads applied and the number of applications While the maintenance engineer has no control over the number of applications, he has quite a lot of control over the magnitude of the loads applied from, say, the rotor system Hence roughness is not only a matter of comfort, it goes far deeper than that since it can affect airworthiness by aggravating fatigue In all this the contribution of the Maintenance Engineer is obvious, *i e*, he must pay the closest attention to control and rotor systems with the object of minimising the magnitude of the low frequency helicopter vibratory loads

Mr Spaull (*in reply*) I would like first to clear up something in case there should be any misunderstanding I understood from Mr SHIPPEY's paper that he put the examination for the Bell helicopter and the Boeing Stratocruiser on the same level I would like to make it clear that the written examination paper for an initial "A" and "C" licence for the Bell helicopter takes something in the order of 2½ to 3 hours to complete, whereas the Boeing Stratocruiser "Type" paper for the addition of this aircraft in Category "A" is in two parts, each of 3 hours' duration Should the application be for the category initially, then there is an additional 3 hour "Basic" paper, thus making a possible 9 hours for Category "A" Similarly, for Category "C" for the Wasp Major, a further 9 hours written examination might be necessary Thus, it will be appreciated that, in the extreme, an "A" and "C" for Stratocruiser including engine, could be an 18 hour written examination, as against 2½ to 3 hours for the Bell helicopter

Mr LEASON expresses concern at the discontinuing of the supervision of engineers by the Board, and I want to allay his fears in that respect Because he is not required to complete a supervisory report every six months, he should not assume that the supervision of engineers has ceased The supervision still goes on, acting on the assumption that engineers are satisfactory all the time unless we learn otherwise—in which case we have an adverse report It should always be remembered that the licensed engineer who is using his licence for the purpose for which it was issued is constantly under the Board's supervision If, however, he is working with a firm which is not concerned in any respect with the duties for which he is licensed, then he is not using his licence and, therefore, he cannot err as a licence holder When he goes back to work within the limitations of his licence, the Board considers the integrity of the engineer such that he will make himself *au fait* with the Regulations at that time, and that he will "put his own house in order" before using his licence for certification One can rest assured that the supervision is no less than before, and the Board considers that by discontinuing the six-monthly report it has enhanced the licensed engineer's position by removing any suggestion that he is not competent to hold the authority granted him unless he is checked every six months to ensure that he still knows how to use it

With reference to Mr CARTER's query regarding "B" and "D" licences for helicopters, where an engine is common to any aircraft and not one exclusive to helicopters, it would be in order for an engineer appropriately licensed in Category "D" to certify the complete overhaul of the engine The point in combining "A" and "C" categories is concerned with installation problems of a particular engine in a helicopter which may also be installed in a fixed-wing aircraft

With regard to the question of certification under approved inspection or by a licensed engineer, one of the problems, it seems to me, is that of the engineer being able to obtain adequate experience and knowledge to cover the full syllabus Take

Category " B," for example Many instances have occurred where engineers have not been able to qualify for this category because their experience has not covered the full syllabus , yet in respect of, say, six items of the syllabus they are quite satisfactory This is principally due to the fact that these items are subjects with which they are dealing in their day-to-day work, and thus they render their employers good service Three such people, with limited experience, may well cover the full syllabus between them, and as a team under an approved inspection can expedite the maintenance routines, thereby returning the aircraft to service as quickly as possible and thus helping to meet Mr McCLEMENTS' point of reducing the time which aircraft spend on the ground

Mr Shippey (*in reply*) I don't seem to have been under fire quite as much as I expected after all—I might even believe that my views are the same as everyone else's With regard to the point about the Bell fan, I believe Bells issued two or perhaps three types of fan for cooling the engine, each one having a different pitch of the blades which can be used at different temperatures, a fan of higher pitch blades for use in warmer conditions and if Sabena don't know about this, well, I can't understand why, as it is listed in Bell's spare parts catalogue With regard to Mr McCLEMENTS' point about the night maintenance, when we get more helicopters B E A will be able to introduce night tourist rates, so that we have to do our maintenance during the day—I am not looking forward to night work myself I don't think there are any more points I should answer Thank you

Mr Le Sueur (*in reply*) Cdr WEBBER mentioned that the designer would realise that there were certain deficiences in the helicopter rotor blades if he found that critical stresses appeared in the strain gauging, and therefore he would improve the design If I wanted to buy a helicopter, I would agree with Cdr Webber, but speaking on behalf of the Airworthiness Authority and not the operator, I am more interested in the helicopter being safe rather than economic , so, whereas we would all like to see the design improved as far as possible, if the designer cannot improve it, or such improvement would be too expensive and there is still a possibility that under a certain regime of flight critical stresses may arise in some part of the rotorcraft, then obviously a scrap life must be agreed

Referring to Mr. CARTER's contribution, he also mentioned lifed parts He suggested that the operator ought to be reimbursed for the return of the scrapped part Is there any assessable value for a scrapped part which has reached the end of its safe life ? It is possible that the parts could be returned to the manufacturer to be further tested with a view to extending the existing agreed scrap life or to check whether the part is as fatigued, if at all, as was estimated in the original assessment I agree with him that a history of all occurrences of excessive vibration should be kept and that if there is much out-of-balance when tracking blades and in operation, then these are vibration conditions which may affect the fatigue life of that part

Referring to Mr McCLEMENTS who also mentioned out-of-balance, I would say that there is already a requirement in B C A R , Chapter G3-7, para 4 and Recommendation 3 which says that the rotors should be spun at an extended speed with " the inertia axis of the blade 01 of the mean chord aft of the most aft position after allowing for manufacturing tolerances " Such a test should show whether or not the out-of-balance due to bad tracking is likely to have any effect on the fatigue life

Mr SHAPIRO mentioned that fatigue is not the real difference between fixed wing aircraft and helicopters, but that the wing moves about its own axis instead of floating through the air I agree, but the point is that until we can find out what the real essence of that difference is, we must accept some method of assessing these aspects of fatigue

Mr ROWE mentioned ground simulation of flight conditions with which I would agree if such were possible as I have already mentioned—but I don't know how many of you here heard Mr HAFNER and what he had to say during his lecture on this very subject—I obtained the impression that he had proved conclusively that such simulation was impossible Referring to his diagram relating actual flight stresses to simulating stresses there was a drop in the latter in the middle of the rotor blade which would indicate that the shear distribution was entirely different, and so although the maximum bending stresses were approximately the same, the different shear distribution would nullify any comparison The only way to obtain flight conditions is to fly the helicopter