

Operation—*i.e.*, the fitting of all public transport aircraft with a Turn and Slip Indicator and a gyroscopic directional indicator. In the B.C.A.R.'s, the budding helicopter engineer is faced with the problem of having to take both his "A" and "C" licences at the same time.

In the distant future we can foresee many more problems coming our way, with pulse-jets, twin and multi-rotors, but we hope that some of the lessons learned in the past will be of benefit in the way of simplification of design, easy maintenance, adequate accessibility and a high standard of interchangeability between parts. All of these will contribute to the destruction of that bogey of helicopter operations—high maintenance cost.

You may not agree with all I have said, ladies and gentlemen, but I hope that some of the points I have made may promote further healthy discussion on this subject later on today.

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## DISCUSSION.

**Mr. J. Norman, M.B.E., F.R.Ae.S. (Air Registration Board):** I understand that my duty in opening this discussion is to deal with the problem of laying down standards which must be met by maintenance engineers before they can be licensed. But I must first make it quite clear that the possession of a licence does not mean that the holder is competent to do a particular job. It does mean, or at least it should mean, that the holder is competent to judge whether in the doing of a particular job the correct procedure has been followed and whether the final result is satisfactory.

This aspect of the licensing system cannot be stressed too often, particularly as one often hears it said that, although so-and-so has a licence, he could not do the job in a hundred years. In the majority of cases a statement such as this may be perfectly true, and as an example I would say that only a small proportion of the holders of an airframe licence are able to scarf a glued joint, but there is no doubt that the majority are able to judge whether the correct drill has been followed and whether the result is satisfactory. Another example is the manufacture of (say) a gear wheel, in that I do not know any holder of a "D" licence who would be able to undertake the job; but if in the capacity of an inspector he follows the job through the various processes, then he would be able to judge in the end whether the gear wheel meets with the drawing and specification requirements.

Every new type of aircraft introduced into public air transport is another problem for the operator as well as for the licensing authorities. The problem is serious enough so far as the orthodox or not so orthodox aircraft is concerned, but the introduction of the helicopter presented an entirely new one because, for licensing purposes, and for other reasons which are obvious to us all here today, its engine could not be treated as a separate entity, as in the case of the aeroplane.

In any examination it is essential that the examiners should know more about the subject than do the persons being examined, and as a general rule

the Board's surveyors have the advantage in that they are able to follow an aircraft through all stages of production, so that examination papers are already prepared by the time the candidates have obtained enough practical experience on the type to be able to sit the examination.

The helicopter was an exception to the general rule because some were imported and operated by the Services before production was started in this country, and long before they were taken over by civil operators. It is probable, therefore, that when some of the present licence holders were first examined on helicopters, they knew far more of the subject than did the examiners, the Board's surveyors. Quite recently two helicopters of a type not yet seen in this country have been registered here and sent direct from the country of manufacture to the field of operations abroad, and the Air Registration Board was asked in all seriousness by the operator to arrange for the type to be added to the licences of the air and ground crews he employed. It is true that the operator was good enough to send the Board copies of the Flight Manual and the Maintenance Manual, in the hope that it would be able to conduct examinations on the basis of the information given in the manuals.

If a licence is to be of any value at all, then it must be granted on the satisfactory result of a proper examination, properly conducted; and you can take it from me that the Board will not in any circumstances permit examinations to be conducted on the basis of what its examiners learn from publications. It does and will continue to insist that its examiners acquire their knowledge in a practical way, knowledge which can be obtained only by a physical check on the aircraft concerned, supplemented in some cases by publications.

The present requirements for the grant of a category "A" licence (aeroplane less engine) and a category "C" licence (engines) are based on many years' experience in the examination of candidates for those licences, and they appear adequate, irrespective of the size and complexity of modern aeroplanes, except perhaps in the case of aircraft of the size of the Bristol "Brabazon."

When drafting the requirements covering the grant of the combined category "A" and "C" licence for helicopters it was quite clear that any experience candidates may have had in their inspection and maintenance must have been of relatively short duration; therefore, to have insisted on long experience would have delayed the use of the helicopter in public air transport. It is for this reason that the experience necessary for the grant of a helicopter licence is, at the present time, less than that necessary for an aeroplane of comparable size. But we have learned quite a lot since the requirements were drafted, and there is no doubt that in the not too distant future the helicopter licence requirements will be stiffened up fairly considerably.

**Mr. R. L. Davis** (British European Airways Helicopter Unit, Society of Licensed Aircraft Engineers): It will be obvious from the accounts of the previous speakers that the helicopter is a form of conveyance which has brought more than its fair share of maintenance problems. These appear to be more numerous partly because they are so very different from those generally encountered in aviation spheres. The airframe comprises but a small part in which there is similarity; at least, it may be of tubular or stressed skin construction. The undercarriage or alighting gear has been

retained, giving us the usual servicing that goes with the oleo leg and wheels. The power plant is similar, but is usually in an unfamiliar attitude, giving a modified oiling system and services to suit. At this point the helicopter leaves the conventional type and travels its own problem path.

A newcomer to rotary wing aircraft will have to acquaint himself with gearboxes, swashplate controls, free-wheeling units, centrifugal clutches, control jacks and couplings of all types. None of these devices are new, but their application may be.

He will find that the rigging of flying controls is a strange procedure which varies considerably on each type and design of machine. During the overhaul of components he will spend more time with a torque wrench and a set of feeler gauges in his hand than he has ever had to do previously.

During periodic overhauls the checking of components must be rigidly adhered to at the correct stages of assembly, to ensure their fullest life.

As on a major inspection, when each unit or part of a unit is stripped down to the last split-pin, it will be appreciated that the engineer at work must be able to understand each sign of wear revealed during the dismantling. He will have to familiarise himself with evidences of deterioration in bearings and gears, discolouration of oil and grease due to friction, corrosion caused by the weather, and other attendant defects liable to occur during service.

On the aircraft itself he must be expected to diagnose the reason for roughness in flight—probably bearing trouble in the main rotor head, a damper not functioning, a worn control jack or a blade out of track. These indications have a meaning which can be interpreted only through experience.

Since the general use of the helicopter the manufacturers and operators have each compiled lists, both published and unpublished, of faults peculiar to those machines, and in some cases a cure for them. These have been useful in the past ; but as the helicopter is becoming more involved, these lists will increase.

All this may seem to present a dismal picture ; but I must confess that, the more I am with helicopters, the less I agree with the idea that a motor mechanic can maintain one. It is a very specialised branch of aviation and will remain such until the manufacturer can design a helicopter simple enough for the average handy-man to maintain.

To give an engineer, accustomed to working on fixed wing machines, instruction on helicopter maintenance is not casting suspicion on his capabilities, but is helping him to approach a new branch of aviation without having to grope about in the dark in search of the light.

A lot could be taught without actual contact with the machine. Obviously more could be taught with that contact, but a course covering the generalities to be found in their maintenance would be invaluable. All types do not possess all the same peculiarities, but there are many that do. Doubtless I shall be told later that in the future helicopter these peculiarities will be ironed out. They may well be, and it is to be hoped for, although at present bearing wear fatigues, short lives of components and once-per-revolution bounces are still with us ; and they may always be with us.

Any engineer who thinks he will become proficient in respect of these aircraft in a few months is doomed to disillusion. He will find that he will continue to learn more of his charge, as we at the Helicopter Unit have

done and are still doing. I feel that those who have knowledge should impart it to those who do not, in the hope that when operations on helicopters become more general we shall have engineers in other spheres of aviation who have at least a grounding in the problems of helicopter upkeep. A series of courses should be set up, dealing with the main components which comprise the major portions of a helicopter. Samples of those components should be made available to be dismantled, explained and re-assembled, pointing out the pitfalls that an engineer may encounter. Surely, in the cause of progress, manufacturers could yield enough useful scrap to construct a number of those valuable and instructive articles.

A main gearbox, complete with services, could be dismantled by an instructor, and a suitable sheet could be drawn up, giving each stage step-by-step. Those receiving instruction could then be allowed to take over the dismantling and re-assembly, dealing with each component in turn, until a fair knowledge of the work is obtained. Towards the end of the course a paper should be set to test the knowledge gained by a man who has completed the set schedule. The practical course could be interspersed with theoretical talks on flight, rigging, ground handling, fault locating (trouble shooting). No one particular machine should be singled out, but a cross-section of as many known types as is possible should be embraced in those courses.

Some manufacturers are making a start on these lines. In the U.S.A. such arrangements have been going on for some considerable period; but engineers have not been afforded that opportunity in this country.

Much theory has been poured forth on the subject of helicopters—in my humble opinion, too much—most of this theory being over the head of the average engineer, who requires to know more of the practical side, of what does happen, rather than what ought to happen.

Comprehensive manuals and instructions should be aimed at, settings and clearances laid out in understandable lists, for no other reason than that it is easier that way whilst overhauling units.

In conclusion, let me express the hope that in the future the helicopter will take its place not, as it has been, as a fantastic piece of whirling machinery but as another form of aerial conveyance. The shroud of mystery which in the past has enveloped the helicopter should be lifted. After all, it only flies, and we have been doing that for forty years.

**Flight-Lieut. H. C. Taylor** (Airborne Forces Experimental Establishment) : I must first say that any views I may express are my personal views and are not necessarily those of my Lords and masters.

The main points on maintenance have been dealt with admirably this morning in the three excellent papers we have heard, and two salient points have emerged which must be borne in mind. First, this rather extraordinary piece of machinery which we call the "helicopter" is efficient only so long as we can give it an efficient backing in the shape of good and speedy servicing; we are anxious to apply all our resources to maintain maximum output and the minimum expenditure of man-hours per flying hour. Secondly, the helicopter has revolutionised air transport by making accessible from the air places which are remote from airstrips, and we must not nullify that flexibility of helicopter operation by increasing the ground equipment and other impedimenta for servicing the aircraft.

A good deal has been said about removing major components for inspection and overhaul, and I agree there is a tendency also to over-inspect components, and that we might give our individual components a specific life, adopting what we know in the Service as the principle of servicing by replacement, which means that the individual components which are changed can be replaced immediately by components which are known to be serviceable, in a minimum time; the components which have been removed can be serviced under ideal conditions away from the first-line work which is being done on the aircraft.

I noted with interest Mr. BRISTOW's remarks on the use of pilots for the first-line servicing of aircraft. That brings us to the point that we must simplify the helicopter to the extent that we need not have a qualified engineer to do the day-to-day servicing. cursory inspection should be all that is necessary before taking the air, provided that, on the last flight, no un-serviceability was reported.

As to design for maintenance, probably all engineers would like to see inspection doors, let-down platforms, and so on, which might lead us to the situation where the aircraft will never fly. But we do appreciate a platform which enables us to inspect the rotor head; we appreciate accessible fuel tanks, starters, generators and other ancillary components which we can see.

When we come to servicing cycles we are touching on very controversial ground. The progressive and block servicing methods have been mentioned, and I think the decision depends very largely on the number of aircraft we are operating. There is a lot to be said for the progressive servicing cycle if only a few aircraft are in use, where one will be out of commission from time to time. But where large numbers of aircraft are in use I feel we should do better by adopting the block servicing system. I would prefer to see a greater number of flying hours between overhauls, and rather longer inspections than at the moment, instead of having shorter inspections carried out more frequently.

I agree heartily with all the remarks made on standardisation and on the accessibility of grease nipples, and so on. I feel that we must get down to greasing on a calendar or time basis, every week or five days, as necessary, and not purely on the basis of flying hours.

Tracking is a very sore point, and the subject is very much shrouded in mystery. Adequate tracking cannot be carried out without employing six men and a boy and two 2-ft. slide rules. Until we have a simple tracking technique which can be carried out by a first-line servicing tradesman with the minimum of equipment and calculation, I feel that we have not evolved the sort of rotor that we require.

Again, I endorse heartily the view of Mr. DAVIS that there is a dire need for courses suitable for the training of engineers in helicopter maintenance. The helicopter is entirely different from the conventional fixed-wing aircraft, and it is not a simple matter for a man who has been trained in and has spent several years in the maintenance of fixed-wing aircraft suddenly to forget much of what he has learned and to learn the new techniques of control adjustments and to realise the importance of many of the components which are not used on fixed-wing aircraft.

I can sum up by saying that we require standardisation, simplicity of

design, and we require as many inspection panels, as many small let-down platforms and in-built items of equipment as possible on the helicopter so that the aircraft are not grounded simply by the lack of external tools and apparatus.

**Mr. G. R. Shaw** (Pest Control Ltd.): I am both a visitor and a beginner, so that I am diffident about entering into the discussion. But I have listened to the papers with very great interest and also with an ever-gathering gloom, because I am interested in helicopters purely for commercial reasons and most of the speakers this morning have said that they are entirely non-commercial. I said *most* speakers. However, having been responsible for the engineering of large fixed-wing aircraft, I should like to endorse practically every word that Mr. BRISTOW has said; I would even subscribe a modest sum from my small resources towards the provision of a penitentiary for designers who put things in awkward places and who re-design, for their own satisfaction, perfectly satisfactory components of one sort and another which we can buy off the shelf. It is a most infernal practice which I am afraid is very prevalent.

You cannot operate any flying machine commercially until you give up the principle which has been mentioned in various forms and which I am afraid I call "progressive fiddling." I have had experience of progressive C. of A. work and also of C. of A. work at the end of a fixed period, and I have never found that the progressive system does save time and money, because the job of clearing up the mess at the end of the year takes almost as long as a full C. of A. at the end of the year.

What we must arrange for commercial purposes is a period during which the wretched machine is left severely alone and will function satisfactorily, and that period must be lengthened as the operators', the manufacturers' and the Air Registration Board's experience grows. After listening to the remarks made this morning I feel that we are still in the stage when we have to take the thing to pieces at very frequent intervals to make certain that it is still sound. That is a very difficult stage for everyone. It is very difficult for the Board because they have to watch the safety of the aircraft the whole time, and it is equally worrying for the engineer, because he is trying to learn for how long he should ask the Board to leave it alone, and whether he can rely on the life which is allowed for each component. Eventually we have to put the components into line, so that the magneto does not come off at 50 hours, something else at 100 hours, and this, that and the other at 120 hours, and we have continually to look up some awful list in order to find out what comes off next. I am interested in a flying machine which will operate for a certain period during which it calls for nothing more than the obvious cursory inspection to show that it is all there. Until we reach that stage I am sure that no flying machine or any other form of transport can possibly be operated commercially.

I commend to everyone the remarks of Mr. BRISTOW, which I again endorse in every possible way.

**Mr. F. L. Hodges** (Fairey Aviation Co. Ltd.—*Member*): I should like to say a word on behalf of the designer. Mr. BRISTOW has made a very good point, which has been endorsed by Mr. SHAW; he says "let us use commercial parts." That is an excellent idea provided the A.R.B. will agree

to them being fitted. Those who have had experience of even trying to put the smallest commercial component into an aircraft will know that the inspector will ask if there is a release note and whether the component is proved. If the answer is "No," then he will say that we cannot use it.

I will not enlarge on the subject ; but if people could get together and approve certain commercial parts and say that we can use them on helicopters, we could make some progress. That may cost a few lbs. on weight, but will help to give us commercial aircraft.

**Mr. R. B. Brigham** (Westland Aircraft Ltd.—*Member*) : I should like to make one or two points in defence of the inspection organisation. Mr. BRISTOW has urged that we should leave well alone ; in other words, he is suggesting that over many years of experience of engines and various components sufficient information has been gathered to enable us to say that a thing is still working all right and will continue to work all right. I do not think the majority of the designers or engineers in this country agree ; otherwise the people who have laid down the complete overhaul period of engines would not still fix the overhaul period at 600 hours. The helicopter is new and, therefore, it is absolutely essential that every effort be made to ensure that it will continue to work. A gear box has to be stripped at 200 hours, and it is vital that it should be so stripped until sufficient experience has been obtained to assure us that the period can be increased to (say) 400 hours.

The point with regard to the use of proprietary articles—magnetos, and so on—is fully appreciated. One would like to see them used, provided that there was sufficient mass production of aircraft to justify some commercial supplier in supplying them, and that we knew they would stand up to the work they have to do in an aircraft. I have had some experience of what happened in France in respect of the regulations there, with the opposite number of the A.R.B., but I cannot say much about it. Mr. BRISTOW, until recently the Technical Manager of Helicop-Air Ltd., made reference to the milking of the user by the Commercial Managers ; he must have got rather at loggerheads with the Commercial Manager of Hillers ; otherwise that remark might not have been made.

We have heard of the bogey of tracking, but I do not see that tracking is a problem. We have heard about this business of having to employ six men and a boy on tracking, but I do not see that that is necessary if you have the equipment. All you need is something with which to fix the aircraft to the ground, and you have only to put a socket at certain distances so that the operators are not just hanging on ; then the tracking can be done with one man in the cockpit and two on the tracking flag. I do not see that there is any necessity for the use of slide rules.

Then crack detecting in light alloys was referred to as being a bogey. I am not sure whether it was said that the method is not proved.

**Mr. Leason** : It is not recommended.

**Mr. Brigham** : It is proved. It is no better than the oil and chalk method, but it is clean and it is much easier to do, and for about £50 you can instal the complete apparatus. The liquid used costs about £1 per gallon, and for the average helicopter you have to use more than 10 gallons.

The problem of greasing of helicopters has been discussed and, of course, we have gained a lot of experience of that. The alternative was

put forward by "Intarva," and I think they have the equipment now installed.

**Mr. R. E. Hardingham** (Air Registration Board) : With reference to the remarks of Mr. HODGESS—I think I should make it clear that the Air Registration Board is always ready to approve material or any piece of apparatus, whether commercial or otherwise, provided it can be proved that it does the job.

**Mr. A. A. Reichel** (The Bristol Aeroplane Co. Ltd.—*Student*) : I come from Finland, and perhaps I may point out a few things which may arise in the future operation of this particular kind of machine in my country and in Scandinavia in general.

If the helicopter is being operated, and in Sweden it has been, the buyer may be prepared to pay a rather higher initial cost than otherwise for the machine if he knows that he can get a definite life out of it, that it is robust and can be operated away from its base for a considerable time at a minimum cost of spares. Also the training of the pilots as mechanics and those who maintain the machines in general will definitely be considered as of very great importance.

Again, the machines should be 100% amphibious, so that they can be brought down on lakes and rivers as well as anywhere on land any time of the year. So that the conventional undercarriage having wheels will have to be very much improved and provision made for the machines to float, to enable them to be used in any circumstances anywhere—and I would remind you that our landscape is entirely different from that in England.

**Mr. J. S. Shapiro** (The Cierva Autogiro Co. Ltd.—*Founder Member*) : First we should understand that in helicopter design and maintenance we are still at a very early stage. Nevertheless let us compare helicopters with motor cars. We have had a lot of publicity about the B.R.M. car, and I would say that we can do better with helicopters, both in respect of cost and results. I defy anybody to prove that the motor car is less complex than the helicopter ; it is more complex, and yet it is accepted everywhere.

Engineering consists of selecting the details which are important, and we have not arrived at the proper selection yet in the case of helicopters. The whole essence of training, it to teach people to attend to the important features. No-one is of much use who does not know how to select the details. But it is a long process ; in helicopters we have not quite finished yet, but we shall, and I do not see any reason why we should not do so in less time than the motor car people have taken.

Tracking provides a good example of what might be done. Complaints about tracking are due to the fact that we have not a standardised system. It is quite easy to devise methods which will obviate the use of the slide rule and by which the work can be done by the pilot and one man. But my experience goes to show that tracking will not be necessary at all in the future ; we shall have blades which will be completely interchangeable, and will be adjusted to the right pitching angle and pitching moment. We have not had enough operation to justify interchangeability so far. That is a reason why tracking is still to some extent a problem ; but it is a transitory one and it should not affect the helicopter of the future.

On the question of standardisation, I agree thoroughly with Mr. HARDINGHAM ; I think the designer has not grounds for asking the air-



worthiness authorities to approve anything until it has proved that it can do its job. To use industrial or commercial components in helicopters would make helicopters impossible, because they would not carry any pay-load; that is a fact which even Mr. BRISTOW'S oratory cannot disprove.

If we have the maintenance engineers saying that they want this, that and the other, then it looks as though we shall have an irresistible force meeting an immovable object! If we need to compromise, the question is to decide how much or how far to compromise. We have to consider how much is each maintenance requirement worth to the operator. I would ask that if those who are particularly concerned with maintenance have any specific ideas they should express those ideas quantitatively. Is Mr. BRISTOW prepared to accept a helicopter the efficiency of which is 90% of that of the most efficient available? That would mean reducing the payload to two-thirds of the present pay-load, and I do not think any operator will accept it. They may be able to accept 98% efficiency, but hardly 90%. Generally, since it is no use asking for 100% of everything, it is a question of arriving at a proper compromise by co-ordination, and co-ordination requires numerical expression of requirements.

**Mr. N. E. Rowe** (British European Airways—*Member*): There is a great deal to be learned in this business, and there is no doubt that the maintenance side of air transport is of the greatest importance. That is quite clear in the case of fixed-wing aircraft, and it is even more important with the rotary wing aircraft because its "rate of production" in terms of ton-miles or passenger-miles is likely to be less than that of the fixed-wing type, for generally speed will be lower; hence it is necessary to get more use out of the aircraft, and that can be done mainly by ensuring that maintenance is more effectively performed. We are in what Mr. SHAPIRO has called a very early stage. We all have these difficulties, and they will continue for some time, because the volume of experience that we have on the engineering and maintenance side in respect of rotary wing aircraft is comparatively small; the total number of hours of experience is minute as compared with that on the fixed-wing aircraft, and our experience is still being built up.

As has been mentioned, we have to aim at establishing the lives of parts and gaining a proper knowledge of them. That knowledge is obtained normally by the process of experience in the field; the aircraft are run for a number of years and towards the end of their life we begin to know something of the lives of some of the components. You may think that in what I am about to say I am being very academic, but I am merely putting up a target. The aim should be to determine the lives of components and of important parts before the aircraft goes into service, if we can. That is a very big problem, but it is one we have to tackle. We are trying to tackle it on the fixed-wing side, and I think we have a better chance altogether of tackling it successfully on the rotary wing side. The rotary wing aircraft is mainly mechanical, and we have to develop methods of testing which will enable us to pre-determine the lives of important parts such as clutches rotors, and so on, which are continually sources of trouble; and we shall apply the same sort of methods, of course, to ancillaries, which also are of vital importance.

The essence of the problem is to simulate effectively in such tests the conditions of flight. That involves something in the nature of research,

because very often we do not know exactly what are the flight effects which are causing early breakdown. In our fixed-wing work we are attempting to simulate flight conditions, to apply the vibrations which are present in flight, the temperature and humidity variations, and so on, as far as we can, for we think these factors are important; and I think a similar sort of approach is possible in the case of rotary wing aircraft. There is no doubt in my mind that, if we are only partially successful in our efforts to predetermine the lives of as many components as possible before the aircraft go into service, then the troubles we have heard about today will largely disappear.

That may sound academic and far-fetched, but I put it to you as a target, and I think it is realistic.

**Mr. L. S. Wigdortchik** (British European Airways—*Founder Member*): To the operator the prospect of receiving from a manufacturer an aircraft which has not yet been cleansed of the fundamental teething troubles, is terrifying. I can quote an instance in America which concerns an operator working purely on a commercial basis. This operator purchased a fleet of a new type of aircraft and had the unfortunate experience of having his fleet grounded for four months of his first year of operation. This operator is now suing the manufacturer for damages.

To a large extent, reliability can be obtained both by laboratory testing and by intensive flying. The best way to do this is to get the helicopter into simulated service as soon as possible in order to build up the maximum number of flying hours at the earliest possible time. The problem is so acute with the complex aircraft of today and is appreciated so well in the United States, that there is actually legislation before Congress which has the object of making it the responsibility of the armed forces to take over new aircraft for intensive flying. In this way, the burden of improving aircraft's reliability will not fall on the operators.

It may seem facetious to talk of securing reliability at this stage when we have perhaps little more than one thousand hours route-flying experience of helicopters in this country. Nevertheless, it is not too early to understand how reliability can be obtained. It should be the principle of manufacturers and operators to subject new aircraft to firstly, extensive laboratory testing, and secondly, intensive flying, which, coupled with a full appreciation of maintenance and servicing requirements will give us the aircraft we need so badly, capable of operation with the minimum time on the ground and the minimum cost in maintenance.

END OF MORNING SESSION

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*The AFTERNOON SESSION and GENERAL DISCUSSION  
on "Helicopter Maintenance" will be published in the December  
issue of "The Journal of the Helicopter Association."*