Discussion

The Chairman said that as one who had mostly been associated with the operating and design side he had found the lecture of entrancing interest They were much indebted to Mr Boulger for his extremely instructive and lucid attack on the problems which Westlands had to face when embarking on the production of Sikorsky helicopters in this country He would now call on Mr GORDON, of Saunders-Roe, Ltd , to open the discussion

Mr Hugh Gordon (*Member—Saunders-Roe Ltd*) said that Mr BOULGER, whom he congratulated on an excellent lecture, had the distinction of representing a firm which had produced about 200 helicopters Most helicopter firms in the country had been producing in one's or two's and, in consequence, had had to use the knife and fork methods of production This was a sad state of affairs which, he hoped, would not last too long There was nothing worse for a planning engineer than to be told " We are producing only one or two " of this or that

He had been particularly interested by the description of the budgetary control over tooling exercised by Mr Boulger's Company, and he agreed that a planning office should do a certain amount of planning within its own department So often planning engineers were good at planning the works but seldom did any planning for themselves The form of budgetary control mentioned had appealed to him As the Author had said, the basic principles were obvious but the fundamentals were all too often overlooked

He was not so sure that he agreed with Mr Boulger's comments on the use of the copying lathe and copying miller for rough machining The Author had advanced some convincing arguments, almost convincing Mr Gordon, but it seemed to be a misuse of this type of machine and rather expensive, even though it did the job satisfactorily

The use of radioactive isotopes for measuring the spar thickness during the milling operation would appeal to many of them He did not know much about radioactive isotopes Were special precautions necessary to protect the operator ?

Had the radioactive isotope method of measuring spar thickness been developed by Sikorsky or had it been developed over here ? To what extent had Westland's followed the production techniques employed by Sikorsky in the manufacture of the S 51 and S 55 ? Were Westlands handed all the process sheets ? He was sure it was not quite as straightforward as that Were there any instances where they had been able to improve on the production techniques and methods used by the Americans ?

The Author had also spoken of the very close limits and the high finish necessary on rotor heads and transmission parts He had said that it took a long time for the staff of the various departments to acquire the necessary 'know-how' Did this mean that there was a case for separating the manufacture of these parts from the manufacture of fixed wing parts ? Or could they be combined ? What were Mr Boulger's views on this ?

The Author had mentioned some of the test rigs used at Westlands for the testing of gearboxes and dampers, and for transmission systems Mr Gordon agreed with this policy In the past it had been the practice to use a ground-running aeroplane for this purpose, probably because there was no alternative, but he thought this phase had now been outgrown Such rigs should be used more than at present, not only for functional testing but also for fatigue running

A year or two earlier, Dr HISLOP had undertaken some interesting experimental work on what was known as " sealed servicing " The name was an unfortunate choice and rather misleading, but possibly something along those lines was necessary on helicopters He thought that as Dr H slop was present this evening, he might like to add a few words on the subject

The Chairman replied that the name " Sealed Servicing " had been proposed by Mr N E ROWE when they were both n B E A The aim was to try to diminish or prevent the arising of random defects on fixed wing aircraft These frequently arose at the most embarrassing moments, *e g* , when they were just ready to take off

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In those cases, passengers often had to be off-loaded because of some minor defect and it was with the object of preventing this and improving reliability generally that this research project was begun in B E A with financial support from M O S Certain representative parts of the aircraft (the " Ambassador ") were installed in test rigs which were developed as far as possible to reproduce the environment in the aircraft They were subjected to protracted periods of running under environmental conditions reproducing the representative operating conditions of the aircraft The main parameters fed in were temperature, dust, humidity and, above all, vibration The work was getting into swing at the time he left B E A and he understood that it had been reasonably successful in achieving one at least of its objects, *viz* , that of subjecting the test components to continuous representative flight conditions at a very early stage of the aircraft's career Rigs had been run, he understood, for long periods on a shift basis, at about 16 hours per day

Mr Boulger said he was an enthusiast for copying lathes, but some of his colleagues were not fully convinced His company had, in the recent past, bought three copying lathes, but the machines had not been in use long enough to say whether they were as good as he personally thought they were His views on the subject were based more on theory than knowledge, theory reinforced by information obtained from companies he had visited to see machines operating under production conditions At one firm the chief production engineer had told him that his only complaint was that they turned out work so quickly that he was put to a great deal of trouble to keep them fed with suitable jobs

Mr Boulger thought they were a most efficient method of production, and for roughing were far superior to capstans The one defect was that if screw threading or boring was being done, the work had to be transferred to another machine for finishing, but he had never believed that economy in production should be sacrificed to avoid difficulties in progressing

The metallurgical engineer, who was present, knew more about radio active isotopes than he did—he had left the chief planning engineer's job when the use of isotopes started—at the moment the system was not used in regular production, but was in course of development He knew precisely as much about it as he had indicated in the lecture

The whole of the manufacturing information from Sikorsky had been made available, and, in the main, Westland had copied their assembly fixtures They had not used the Sikorsky detail methods exclusively however, because, as was common, they were frequently based on equipment different from that which was available at Westland

The spar machining method which he had described was developed quite independently, although he believed that Sikorsky were now using a somewhat similar process

His own view was that American methods of manufacture, as applied to aircraft in moderately small quantities, were very similar to British methods, both in the methods themselves, and in the type of production

Dealing with the question about segregation from the fixed-wing work, he said they had not segregated their machine shop work at all It was probably true to say that their fixed-wing machining had improved as a result of their helicopter experience

On helicopter work itself, draughtsmen were now better acquainted with the standard of finish required, and the limits necessary to ensure the correct functioning, and the workshops and inspection department were more alive to the fact that these limits must be strictly adhered to

The assembly of the transmission items had been segregated, but that was almost entirely on the score of cleanliness and convenience

Mr P W Hyde (*Westland Aircraft Ltd*), replied about the use of radioactive isotopes He said that when they were starting on the work in 1949-50, the only instrument capable of measuring wall thicknesses from one side was American Kelvin-Hughes could not help at the gauges below 0 2 in in which they were interested

The American system was adopted and good results were obtained , it could not be applied straight away to measuring wall thicknesses because first they had to determine what kind of harmonics to use, but ultimately an accuracy of about two-thousandths in a dimension of 50—60 thousandths was achieved On a dimension of 18 in they could achieve about plus or minus three thousandths They adopted a system based largely on the Sikorsky experience and on the obvious merits of the situation

Next, they decided to buy another instrument, but dollars were scarce so they considered the use of isotopes Interest was being taken in this system at the time but nobody in this country had an instrument to offer and eventually it was decided to talk with Harwell to see whether an instrument could be developed After 18 months work one was developed

The health hazard for the operators was zero Photo film badges were supplied to them and were subsequently sent to the N P L for development, but in over six months of use not one had shown darkening, apart from that of normal radiation There was possibly a greater hazard for the development personnel, but so far they had produced no peculiar monsters ! There had been no ill-effects

In his view, everybody was scared stiff of the system and Harwell were still naturally inclined to emphasize the dangers inherent in the use of such equipment Any person with scientific training and discipline could use it and could " can " it so that a semi-skilled or unskilled worker could use it happily at the activities involved It was merely a question of packaging so that people could not put their fingers inside or put it in their pockets Neatness, cleanliness of operation and following a few simple rules was all that was necessary

The use of such methods during manufacture, so as to give a continuous reading of the thickness while the machining was proceeding, was limited to a certain extent by the vibration which was taking place in the spindling machine , it was rotating at 3,000 r p m and bucking and shaking was going on The geiger counter, which lasted about 10 hours in these conditions, cost about £7 10s That was acceptable in special cases or where considerable variations in thickness of the spar were expected owing to twisting, but the position was not satisfactory and it had been decided to work with Harwell on methods other than that of the geiger counter to measure the radiation coming through the spar The principle remained quite valid, however, although the snags must be overcome by the new method

Mr L R Benton (*Bristol Aeroplane Company, Limited*), referring to the requirements of surface finish on transmission component parts, requested how the information was imparted to the operator and how the finish was controlled from the inspection point of view

Secondly, considering the extensive use of wood working type machines on light alloy components, as for example the main rotor blade spars, did Mr Boulger consider that from experience, wood working machinists were preferable to metal machinists

Mr Boulger, in reply, said that the surface finish required was indicated on the drawing in the usual manner by showing the micro-inch number with a tick adjacent to it The inspection department had a machine for checking the surface finish, but this could not be used on every single part The detail inspectors used a plaque made from material similar to a gramophone record with a number of squares, each square having machine marks giving a roughness of finish equivalent to a given micro-inch number The procedure was to run the finger nail down the relevant square on the plaque, and then down the surface of the work, comparing the two At first he had thought this a crude and in-effective method, as the finger nail did not seem a very sensitive measuring device, but it was very easy in use to distinguish between different standards of finish

The real answer was that the planning engineer must call for the method of manufacture which would give the required finish For example, if he wanted a very high finish, he must call for the material to be ground, because it could not be guaranteed by any other method

The spar machining method he had described was operated by spindle hands, who had originally been in the Company's wood mill, and quite a number of the operators in the rotor and spindling departments had previously been wood working

machinists He had found that operators accustomed to ordinary machine tools were rather nervous of the high cutter speeds, which were common in this class of work

Mr R E Clark (*Ministry of Supply*), congratulated the Author on an interesting lecture Although not belonging to the Company, he had been privileged to see the methods which Westlands had employed from the start in the manufacture of the helicopter and he thought that in the manufacture of so difficult a component as the all-metal blade they had done some useful research They had used novel, and in his opinion, very efficient methods

He agreed entirely with Mr Boulger about copying lathes and he asked Mr GORDON what alternative methods could be proposed to give the same or better results In dealing with batches of five to fifteen the copying lathe was ideal, although it could be used for large quantities The only alternatives seemed to be the centre lathe, which involved highly-skilled labour and was not economical in time, or the turret lathe, which might not be as expensive as the copying lathe but was still quite expensive and involved considerably more time in setting up

Mr Gordon agreed that the copying lathe did its work well, but it was an expensive machine which he considered ought to be fully utilized, but not on rough machining This might well be done on an ordinary machine where the same limits were not required He certainly did not question the ability of the copying lathe to do the job

Mr Boulger welcomed Mr CLARKE'S support, and added that in buying the copying lathe or miller they had to decide not to buy two ordinary millers or ordinary lathes, because the former were about twice as dear as the latter But the rate of output of the copying machine was undoubtedly higher—there was a substantial reduction in time with nine jobs out of ten—and it was possible, owing to the simplicity of the work, to use low grade labour, which in turn made it possible to get fuller utilisation

Mr J Shapiro (*Founder Member—Consultant*), said that many who, like himself, graduated through mechanical engineering, had at last observed a faint smell of cutting oil in this hall

Turning to the discussion between the opponents and the proponents of copying lathes, he said that Mr GORDON had described the machine as misapplied Every machine was misapplied in helicopter production From this followed a far-reaching question for a long time, in helicopters, they would be working in quantities of production between 50 and 500, and the industry which made production machinery was not tuned to this quantity Since he thought Mr BOULGER, too, was a bit of a philosopher, he would go further and say that the future development of engineering, and not only of helicopters, would call for more and more types of machining which demanded just that quantity

He had heard an experienced production man in aero-engines—a field perhaps nearest of all to helicopters—say that one could not produce 50 aero-engines any cheaper than one could produce five That might be disputed, but it was a serious view of an experienced man and it was possible to give good reasons for it

He believed that production engineering had to develop along the lines of greater efficiency in intermediate quantities He had seen several advances in that direction in recent years and he did not altogether agree with the Author when he said there was no scope for large margins in the improvement of production efficiency, except in larger numbers He thought there was scope

He put two questions to Mr Boulger—questions over a longer period perhaps, than had occurred to the Author first, what did he want the industry which made production equipment to offer in order to help helicopters to bridge the difficult gap between 50 and 500 , and secondly, were there any particular points to which he wished designers to attend ? As an example, as he was discovering from comparing

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some American methods, not necessarily in helicopters but in similar types of production, the use of welding was less well developed in this country than it should be There lay one of the biggest and most important sources of advance in the production of helicopters

Mr Boulger said he agreed with a great deal of what Mr SHAPIRO had said He had not intended to suggest, however, that an improvement in efficiency would have little effect, but that it could have only a marginal effect on the price—on the understanding that the planning engineers and production departments in the Company were already fully aware of the necessity for economical production If the organisation were already fully aware of this necessity, then although improvements might be introduced which were striking in themselves, they were likely to have only a marginal effect on the price of the aircraft, which was affected by so many other things which had nothing to do with production at all For example, there was the need for the provision of banks of service spares, and the cost of design, which was a fantastically large part of the cost of the aeroplane in the small batches which they were discussing

He was convinced that copying machines were suitable for small or large production, but he was not suggesting that people should fill their machine shops with copying machines For the quantities they were at present considering—50 to 500 —the planning engineer's job should be, in the main, to build with the equipment already available in his Company Most aircraft firms of any size had equipment which was quite suitable, and additions to their plant were likely to be comparatively small If they were to leave the figure of 500, and start thinking of 5,000, then the time for special plant might arise

He agreed entirely with Mr Shapiro's remarks on welding Welding was limited in this country, he thought not so much because of lack of knowledge, as because of stringent regulations arising partly from the availability of suitable specification steels, and partly from conservatism The Americans seemed to have a number of high grade materials suitable for welding, which were not available in this country He said he spoke with little authority on welding, but those were his views

The last question was what he would ask from a designer The design of a helicopter would require another lecture ! He thought he would ask of the designer that he should design a helicopter for which there would be a large sale ! The planning engineer could then get down to some real production As to how this design could be achieved, he did not feel the production department could offer any real assistance

Mr F H Pollicutt (*Hunting Percival Aircraft Ltd*), in reply to a question from the Chairman, thought that blades constructed in spot welded stainless steel held great technical promise, but added that at this stage he did not want to say much about production engineering aspects He asked whether the author had established relative costs for a production run of, say, 100 off or more for moving parts, similar to those of aero engines and fixed structure, similar to that of fixed wing aircraft How did the cost of a helicopter compare with the cost per lb of aero engines ? He thought the comparison might be very difficult as aero engines were usually produced in much greater numbers than had so far been the case for helicopters

He had been interested in Mr Boulger's statement that, on the helicopter, out of 100 per cent material he averaged 40 per cent finished parts Would he enlarge on that point, because it seemed a high figure

Mr Boulger, in reply, said he had some figures to compare the cost of the fabricated structure with that of the transmission items When he spoke of ' cost," he meant the price for which the Company sold the article When people talked about costs, it often transpired that they were talking about some arbitrary figure which they had decided to call the cost There was only one cost as far as he was concerned, and that was the cost of sale In reply to an interjection concerning profit, he said naturally it included profit, for profit was a cost, as it was essential to the existence of any company

The cost of fabricated structures was slightly higher than that of the transmission and machined items There was a reason for this, which probably meant that it was not a sound comparison The fabricated items were " one off " on the helicopter, and the transmission items were, to a large extent, " three off," and therefore the tooling and other expenditure was amortised over a larger quantity If one arrived at an average cost per lb by dividing the price by the all up weight empty, the fluctuation above and below that figure of fabricated, compared with transmission, items was very small Transmission items were about ten per cent less than the average cost per lb , and fabricated items were about ten per cent more The reason was probably that transmission items were much heavier—in other words—the price per lb was not a good standard of comparison, but similar objections applied to other standards

It was difficult to be precise on the question of forty per cent , but of the quantity of material ordered to manufacture a given helicopter—he was using the example of the Dragonfly, but other helicopters would give a similar answer—about sixty per cent had to be machined off, or otherwise removed The Company used stampings considerably , the forging which he had shown on the slide was a stamping, and the weight was less than one-third of the weight of the stamping It was not possible to get forgings to the required thickness , the forgers could not make them

Mr POLLICUT asked for comparable figures when Westland's produced a fixed-wing job, and the Author said he would try to arrive at the figures

Mr A Johnson (*Hunting Percival Aircraft Ltd*), said he had been interested in the remarks on surface finish He was pleased to note that his methods were similar to those described From a production engineer's point of view, he thought the welded blade was a good thing The initial equipment was expensive, but blades could be produced very quickly and cheaply He had not produced many blades by this method to date but already the saving was apparent, the last blade made having been welded in approximately six hours

Mr P R Payne (*Member—Auster Aircraft Ltd*), said the Author had not specified the metal-to-metal cement used on the blades If it was redux, how was it cured and, after curing, how was it inspected ? Had the Author had any trouble with redux on blades during service ?

Mr Boulger said redux was used on only one part of the blade, and would prefer Mr HYDE to speak on this subject

With every rotor blade a test pocket was manufactured, the pockets being the sections forming the trailing edge portion of the blade, and these were tested to ensure a satisfactory bond

Mr R B Brigham (*Member—Westland Aircraft Ltd*), said the tests on the adhesives used in the manufacture of blades were carried out by testing arrangements under Mr HYDE and not by the inspection department Mr Hyde had done a lot of research into sticking these things together and could give the information, if he were so minded In certain cases the information would not be forthcoming, but no doubt Mr Hyde would give some information on his method of testing and curing with redux

Mr Hyde said he was not 100 per cent keen on Redux Over 50,000 hours with the metal blades they had not had a rubber metal-to-metal failure but there had been plenty of Redux failures The blades had been used in tropical and arctic conditions, as well as in weather corrosion conditions One of the most serious problems was that of the storage condition, when the Navy put a blade in the open and left it there for two years The metal did not like that and could erode away from the adhesive There had thus been mechanical damage but there had never been rubber metal-to-metal cement failure in service

Redux was cured in the normal manner, with normal pressures, temperatures and times The assessment of whether the bond was good or not was always conservative Test pieces were processed with the component during the initial blanking

and forming , the test piece went through the anodic shop and back to the bonding shop and was processed with the component If there were any suspicious about the results, the component was taken in and done again This was an unpopular move with the shops, for it was usually found on stripping that the bond was, in fact, satisfactory

When blades were taken to the tropics or Malaya there was sometimes Redux trouble Whether this was due to the arduous conditions in Malaya, for instance, with lifts from very small jungle clearings, or whether it was due to high temperature and moisture affecting the fatigue life of the redux, he was not sure

He would prefer to leave the use of redux and use some other adhesive—a softer and tougher adhesive They did not need strong adhesives but soft, reliable and tough adhesives

Mr H J Brooks (*Hunting Percival Aircraft Ltd*), asked for further information on the Author's comments on blade cracking machines Were there special machines or was an aeroplane used ?

Did Mr BOULGER think it would ever be feasible to say that certain definite standards of finish could be tied to some degree of economy ? Could the planning department tell the design department, " This will cost you so much, for that type of finish, as against another type of finish " ?

He had been interested in the test on the gear box It always seemed to him that when fatigue failure occurred, the radius was never big enough !

Mr Boulger said he agreed , it never was big enough But, as a planning engineer, it was not part of his job to say whether it was big enough, nor after failure to decide whether it had been big enough All he was asked to do was to get a new part made to new drawings at the greatest possible speed

The answer to the question of whether the planning department or the production department could give the cost of a finish was " No " The cost of producing a given finish varied with the circumstances

In his Company it was common practice to manufacture special bolts with a moderately close tolerance on diameter by rough turning, finishing on a centreless grinder This was done in the interests of cheap production, but it automatically gave a high standard of finish In other cases such as where screw threads had to be ground, there might be a considerable increase in cost

The design office should call for what they required on the drawing, and let the production department make suggestions if they found it difficult to achieve

On blade tracking Westland were using a standard helicopter, and not a special machine They had originally built a special tracking tower, but owing to the unsuitability of the prime mover, and defects in the design of the gearing and transmission it had not been a success, and the project had been abandoned, and a Dragonfly aircraft converted instead Actually the provision of the equipment for whirling the blades was very much the simpler part of the job, as the main difficulty in designing the rotor test rig lay in the transmission and recording of the electrical impulses which indicated the characteristics of the blade

The Chairman, in concluding the discussion, said they had had a stimulating talk from Mr BOULGER, followed by a very good discussion The length of the discussion and its extent was always a criterion of the success of a lecture, and in this case the Author could leave feeling that he had done very well He had found the evening very interesting, especially in listening to arguments on the pros and cons of lathes whose existence had been almost unknown to him ! A number of points which had been raised had been met with very useful answers, particularly that concerning the application of Redux bonding to rotor blades He moved a hearty vote of thanks to the Author for a first-class talk

The vote of thanks to Mr BOULGER was carried unanimously with acclamation, and the proceedings then terminated

Helicopter Film Evening

By arrangement with the Royal Aero Club, Members of the Association attended a film evening at Londonderry House on November 23rd

A most interesting resume was given by one of our Members, Mr L Thornhill, of Sabena Belgian Airlines, on the control of insect-borne diseases by helicopter spraying in the Belgian Congo This was followed by a film to which Mr Thornhill gave a commentary

The film, which followed the lecture, included a number of sequences showing a helicopter spraying over the swamp areas in the vicinity of Leopoldville, and also spraying at roof height of the buildings in the town itself Mr Thornhill stated that far from there being any complaints as to the disturbance of low flying aircraft, the local inhabitants regarded the helicopter as a normal part of their daily life and were quite accustomed to seeing them flying almost in their back gardens He went on to say that what had previously been one of the worst malarial areas in the world was now almost free from the disease

The meeting culminated with a vote of thanks to the lecturer which was proposed by Colonel R L Preston, O B E , Secretary-General of the Royal Aero Club, and seconded by Dr G S Hislop, Chairman of the Helicopter Association

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Book Review

Flight Handbook, 5th Edition Compiled by the Staff of "Flight"

This book sets out to give information on matters of interest to aviation enthusiasts It covers an extremely wide range of subjects, gives some historical background, basic explanations in simple terms of important basic principles and information on modern developments In a work of this sort it is difficult to strike a balance between technical and general matter "Flight" are to be congratulated on producing a well balanced book that is very readable and right up to date

The chapter on rotorcraft correspondingly gives a picture of historical developments leading on to a description of the more advanced present day types including those with jet drive rotors A section is devoted to control systems and mechanical details of the rotor head To a helicopter enthusiast the treatment is brief but in so general book this is inevitable , only the due proportion of space can be allotted

In general the book can be recommended as a useful semi technical work of reference

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