Discussion

The Chairman, who invited Mr Shapiro to open the discussion, announced that Mr Shapiro would also act as interpreter for M Legrand's replies to questions

Mr Shapiro (*Servo-tec Ltd*) (*Founder Member*), said that it was indeed a pleasure to open the discussion, for he had enjoyed the lecture not only for its content, but also for the manner in which it was written and clearly set out He thoroughly approved of the Author's principle, which was once expressed by a Frenchman who became a very well-known English writer, Hillaire Belloc, who said that the way to deliver a good lecture was for the lecturer to tell his audience what he was going to tell them, and then to tell them what he had told them This was a very good principle

In a brief hour, the meeting had been given a short and, certainly, a very competent picture of the French helicopter situation To those who were primarily interested in the technical questions and the design of helicopters, the paper had posed a large number of detailed questions

When Mr Shapiro had published a popular book on helicopters, he was accused that he did not take sides and did not say which configuration was the most promising This was probably a good principle for somebody writing a book, and probably also a very good principle for someone who had the task in a Government establishment to look after the whole industry M Legrand had been extremely fair However, without wishing to depart from this fairness, there were two questions to be asked concerning the discussion of the advantages and disadvantages of the Djinn

On the one hand, did the Author not think that the comparison of a weight breakdown between two machines of very different size was a little unfair, particularly in the case of a very small machine? This was a possible criticism of the direct comparison between the weight breakdowns of the Djinn and the Alouette

On the other hand, the following argument could be advanced in the opposite direction He had often pondered over the question "What is simplicity?" and come to the conclusion that from the technical point of view there was only one true answer "Simple is that which I can understand" What simplicity meant in the practice of maintenance and the practice of economics or any other significant consideration of operators, must be brought down to the very simple criterion of either cost or weight

It was difficult to understand how a heavier structure could be simpler than a lighter one if both were properly designed In other words, if the Djinn had more structure for its all-up weight, it must be more complicated Any other appraisal must be purely subjective What probably happened was that the helicopter maintenance was simpler because one-half of the helicopter was sent away to the turbine maker That was what it appeared to amount to

Concerning hazards to personnel on the ground, it was doubtful whether any difference existed between the hazard from a tail rotor and that from the main rotor of a very small machine which could cut off one's head anyway Was this really an important point in a machine of the size of the Djinn? Undoubtedly it was a point of importance in a machine of the larger size which could not cut off one's head

In view of earlier history, there was one point in the lecture which was of particular interest to him In earlier days, when the throttle control was considered a great trouble—and probably it was still so considered today—the development of the governor came in and was discussed and tried, particularly in America For a piston engine the problem was never solved, probably because it did not have to be solved, and there was extensive discussion on the advantages of collective pitch versus throttle governing It seemed that when one used what was sometimes called a solid shaft turbine, one had chosen, as one had to do, a governor which acted on the throttle and not on the collective pitch

That also had been tried with piston engines, but there had been shown to be certain disadvantages One in particular which he recalled was that the speed of the rotor could not be changed quickly when one wanted to change it

That led to another question and one that was of interest in broad principle Among the advantages of the Djinn was mentioned its ability to store up a great deal of kinetic energy This was undoubtedly a statement of fact as regards the comparison of the Djinn with existing shaft-driven helicopters If, however, this feature became of major importance, and if it became understood that it was possible to get past the C A A certification with a higher all-up weight by that means, would it not be worth while running shaft-driven helicopters at a higher rate of speed or put some weights at the end of the blade, and thereby achieve the necessary storage of kinetic energy? If the Author had had a chance to examine this problem, it would be of interest to hear his views

There was one interesting feature of the Alouette III which the Author had not mentioned but which was apparent from its picture Mr Shapiro had always found, at first to his amazement, that the Alouette II had the skid landing gear Nowhere else in the world had anybody designed a helicopter with drag hinges and a skid landing gear It was achieved, one was surprised to find, by tuning in frequencies without any damping in the undercarriage This was important, because it had always been thought that without proper damping in the undercarriage, it was impossible to achieve it

Would the lecturer give an authoritative view on how this was achieved and why the skid undercarriage had been abandoned in favour of the tricycle? Mr Shapiro thought that the skid was considered to be an advantage but that it could not always be easily installed in a helicopter with drag hinges

In the case of the new machine, was the three-engine formula one of those compromises which became necessary because the number of types of available engines was very limited, or was there real intrinsic merit in the three-engine formula for a helicopter?

Translation

M Legrand agreed that there was doubt concerning the validity of the weight breakdown comparison between machines of different weight Comparison had, however, been made between helicopters of the Djinn principle and of the Alouette principle for the same weight This comparison had confirmed the weight breakdown as shown in the paper

The fact that the engine occupied a more important place in a jet-driven helicopter did not mean that the maintenance of the engine compensated for the lower maintenance of the remainder Sometimes a larger motor which might be necessary for jet drive was not more difficult to maintain than a small motor In the case of the Djinn, its gas generator engine was simpler than a turbine which drove a shaft through a mechanical system The engine was heavier because it gave more power It was necessary to put in an engine which was twice as powerful as one which would suffice for the mechanically-driven helicopter of the same weight

Admittedly, the danger from the main rotor in a smaller machine was, in principle, as great as that from the tail rotor This aspect had, in fact, been considered, and to eliminate partially the danger in the production model of the Djinn it had been necessary to raise the rotor beyond the height that was best from the performance and structural viewpoint In practice, however, there had been no serious accidents with the Djinn, whereas there had been several fatal accidents from the tail rotor of the Alouette

The application of the jump take off technique to mechanically driven helicopters has been considered for the case of free wheel turbines which enable important variation of the rotor rotational speed Interesting experiments have been made to this effect on an Alouette equipped with a free wheel turbine, as I said in my lecture No doubt that the performances of mechanically driven helicopters can be improved in this way

The increase of performance to be expected is more limited, however, than in the case of the Djinn, and this for two main reasons

Mechanically driven helicopters have rotors with relatively lower moment of inertia

Difficulties are experienced when using such a wide range of rotor speeds one is limited, at high r p m , by the permissible overspeed of the free turbine, at low r p m , by both the high torque developed in the transmission and the effectiveness of the tail rotor

The question concerning the ground resonance of the Alouette II would merit its own full discussion Admittedly, the Alouette II was the only helicopter with a skid landing gear and drag-hinged blades But the Alouette was alone, too, among present helicopters in having inter-blade cables as used in the autogyro

Those inter-blade cables were not pretty to look at, but they had been extremely effective in delaying ground resonance and particularly in making the effects of ground resonance less severe The problem of overcoming ground resonance in the Alouette II had been one of the main development tasks, and those who remembered the silhouette of the machine would perhaps know that there were hydraulic dampers which provided the damping capacity to the undercarriage which it did not have as a

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result of its inherent design In addition, one other main modification which had been carried out in the course of development was the replacement of friction blade dampers by hydraulic blade dampers which had proved to be more effective and smooth

At the moment, the Alouette II was free of ground resonance To keep it like that, however, required a precise adjustment of all the factors mentioned namely, the cables, the blade and the undercarriage dampers This adjustment was not quite so critical in the case of a tricycle undercarriage

But, the question of ground resonance was a subsidiary reason for changing over to the tricycle undercarriage, the main reason being that the Alouette III had reached an all-up weight which made ground handling of a skid gear machine rather difficult, and it was, therefore, natural to change over to the tricycle

It should be added that one application in which the wheel undercarriage was essential, was carrier or any other shipborne operation, and even the Navy type of the Alouette II had a wheel undercarriage, the reason being that it was possible to absorb higher vertical landing rates and also to manipulate more effectively on deck

The main defence of the three-engine formula rested upon performance in the event of one engine becoming inoperative To maintain level flight it was necessary to have more than half of the power available at take-off

For example, in the case of the SE 3200 in anti-submarine role, it was possible to continue the operation with two engines although the jettisoning of one tank could be necessary

Dr G S Hislop (*Fairey Aviation Ltd*) (*Member*) added his appreciation of M Legrand's excellent paper, which had been most interesting, easy and straightforward to follow and had brought out some very interesting points Dr Hislop added that he proposed to confine his remarks mainly to asking direct questions

1 In the case of the Djinn, how much overspeeding of the rotor was normally used for the jump take-off? How much was it above the normal r p m as used on straight and level cruise flight?

2 Was it correct to assume that the Djinn III development would still be based on the 4 1 compressor ratio?

3 The SE 3200, with the three engines, was quoted in the paper as having a hovering ceiling in standard atmosphere of 1,640 ft out of ground effects Did the Author feel quite happy that the performance obtained with three engines would meet the civil airworthiness requirement with one engine failed? Would it be possible to meet the requirements on, say, a warm day, with a temperature of 30°C, especially in view of the very high disc loading that was employed? Why did the Author not consider employing the overload characteristics possessed by turbines, which in emergency would allow one to draw a great deal more power? This might permit the use of two engines instead of three, the latter appeared to be a luxury

Translation

M Legrand replied that in the case of the Djinn, the range of rotational speed was 400 r p m at high speed down to 300 r p m , which was below normal r p m but which still permitted safe flight

The pressure ratio of the new Djinn would be about the same as that of the existing Djinn, which, to be more precise, was not quite 4, but 3 7

Dr Hislop, asked by M Legrand to repeat his question concerning the use of three engines, said that the philosophy of the three engines was presumably to obtain adequate performance in the event of one engine failing From the figures quoted for a standard day, it seemed that in hovering performance the machine was likely to be inadequate What was the Author's view of this?

Secondly, instead of using three engines, why did he not consider the possible use of only two engines and developing the inherent capability of turbines to accept a very high load for a very short period in the event of emergency?

M Legrand, in reply, said it was perhaps not sufficiently emphasised in the paper that the production version of the 3200 would have three engines of 1100 h p each These engines would give the necessary performance in case one engine became inoperative

Mr O L L Fitzwilliams (*Westland Aircraft Ltd*) (*Founder Member*) thought that the Author's further comments would be interesting on the statement in the written Paper—

"You are aware that this helicopter is equipped with a fixed shaft turbine In 1954, when the design specifications of the "Alouette" were drawn up, such a choice involved a certain amount of risk "

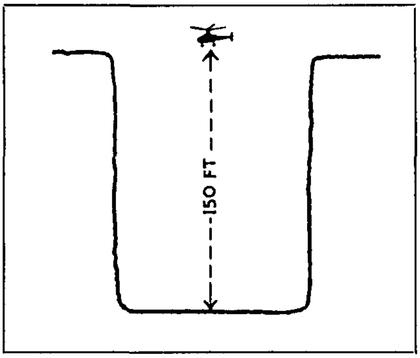
This statement was followed by some popular remarks about experts

Actually, in August 1954, a world speed record of 156 m p h had already been established by a Sikorsky S 59 powered by the same Artouste engine In October of that year this machine also established a 24,500 ft altitude record The control characteristics of this Sikorsky machine were excellent, and one wondered to which experts the author was referring?

Mr Fitzwilliams said that he had never seen a really satisfactory fuel level indicator He was intrigued by the one illustrated in Fig 4 and wondered whether it worked satisfactorily?

Concerning the big machine, the Paper was most interesting and timely, because one suspected that some of one's colleagues were busy designing the same machine! The saving of a helicopter from entering the water in the event of power failure in the anti-submarine role was important, but the objects of saving the occupants and the equipment, and particularly in avoiding loss of valuable evidence as to what had gone wrong, could also be achieved with suitable flotation gear in a single engined helicopter This was likely to be about three-quarters of the gross weight and very much simpler It would be interesting to hear the lecturer's views as to which solution was likely to be the more economical in the long run?

The jump take-off of the Djinn was said to be 150 feet What would be its state



of security in the event of engine failure at the top of a chasm between two cliffs of that height? It might be quite satisfactory but it would be interesting to have the Author's comments

Translation

M Legrand replied that charity forbade him to mention the names of the experts whom he had quoted It should, however, be pointed out that at the time in question there was one machine which flew a turbine of this description but there was also another which, in exactly the same configuration, had no end of trouble It was, therefore, the opinion of those nameless experts that although a helicopter might be made to fly with a solid-shaft turbine, it was likely to have a lot of trouble in general, and could not be evolved into a practical machine

The figure of 150 ft which was given as the possible jump take-off height was an illustration of the physical possibilities of the manoeuvre It did not mean, however, that the Author would advise somebody who found himself at the bottom of a canyon to get out of it by jumping vertically

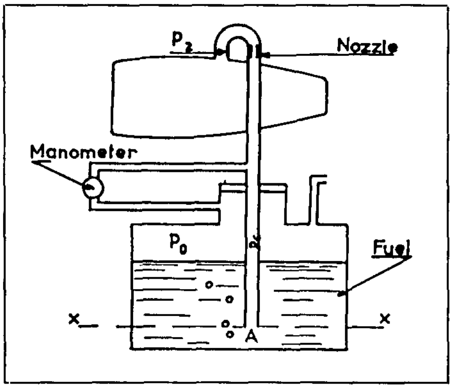
Mr Fitzwilliams asked what the Author meant by the extraordinary statement that it was safer to do a jump take-off than to do a normal take-off at a lighter weight?

M Legrand replied that a jump take-off was not vertical, but consisted of a well-known procedure of jumping forward

Mr Fitzwilliams suggested that the correct word in English was "towering" take-off, not "jump" take-off The fault was that of the translator

M Legrand said that with regard to the operation of the Djinn fuel gauge, he agreed that the sketch diagram of Fig 4 was not sufficiently clear

The operation of the fuel gauge is based on a principle similar to that of Solex micrometers, and it will be better understood with the help of the following detailed drawing



From this drawing, it is clear that the gauge differential pressure p_c—p_o is that of the fuel pressure in point A Therefore, the gauge pressure corresponds to the weight of the fuel column above XX plane The nozzle is calibrated to maintain the air flow at a very low level Fuel gauges based on this principle have existed for a very long time now, but they were not very practical in the absence of a continuous compressed air feed

The comparison of a three-engined helicopter which could not float with a one-turbine helicopter which could float was another vast subject for discussion The performance capacity of the SE 3200 was given as an example There were, however, other points that might be of importance For example, the height of the helicopter might make it difficult to alight on water Furthermore, if the fault developed over land, the floating gear might not be very effective

M Legrand added that he would discuss privately with Mr Fitzwilliams afterwards the complicated question about the folded wings

Sq Ldr Gellatly (*Fairey Aircraft Ltd*) (*Member*) said that he wished to follow a little further the philosophy of the "three-engined" approach to the larger helicopters, in trying to obtain engine-fail safety This seemed to be somewhat odd, it became a rather specialised vehicle in that the requirement that people were trying to meet must surely only be that of the prolonged hover with one engine out, or the climb-away from that condition Therefore, it appeared to be solely for the one role of prolonged hover, in anti-submarine work

There were many other roles that the larger machine could fulfil, particularly if it could carry passengers If the engines were to achieve their power, it would appear that the machine would carry a large penalty with it the whole time, in the attempt to meet the very limited engine-fail case

These were merely some of the arguments that were currently heard, because many of the civilian operators who would like to have a machine of this description—and others were coming along—wondered how valuable three engines, as opposed to two, really were

In stating that naval aircraft must always have a wheel undercarriage, the Author was probably referring solely to carrier-borne aircraft In the case of the smaller ships and the smaller aircraft, the wheels actually became a disadvantage, in that it was necessary to have the larger bearing surfaces given by skids to cope with the heavy rolling deck, and the aircraft itself must be strong enough to take the fairly high velocity landings that would ensue

M Legrand was, in principle, in agreement with Sq -Ldr Gellatly, he wanted only to make two comments

With regard to passenger transport in the centre of inhabited areas, the emergency landing areas to be provided for to ensure safety, in case of engine failure, are all the less extensive as the power left is high at first sight, the more engines the helicopter has, the easier it is to comply with the safety standards established by the civil authorities

The French naval authorities also shared the view expressed by Sq -Ldr Gellatly that for landings on aircraft carriers it was necessary to have a wheel undercarriage in order to release the deck quickly, but in the case of small helicopters on small ships, either skid or float undercarriages were convenient

Mr T L Ciastula (*Saunders-Roe Ltd*) (*Member*) said that the question of relative merits of the fixed shaft and free power turbines has been discussed many times and he did not propose to go into any details on this problem He did not, however, agree that it was an advantage that the extra power could be available from the fixed shaft turbine even if the turbine was damaged What this implied, in fact, was that if a helicopter was taking off in overload conditions, particularly in normal climatic conditions, this extra power would also, of course, go through the transmission system Therefore, it would mean that the damage could occur not only to the turbine itself but also to the transmission and presumably the transmission would have to be covered for this contingency It seemed to him that it would be much better to use a free power turbine, particularly if the de-rating principle is employed He then asked what was the specific fuel consumption of the Artouste IIIB when derated to 450 h p

Concerning the performance of the Alouette III, it seemed to him that considerably larger engine turbine power will be required if this helicopter were to meet British Services requirements at its normal gross weight in extremes of altitude and temperature conditions such as are encountered in the tropics

The Author had obviously had experience of operation of the Alouette III in Africa in sand and dust conditions What effect would these conditions have on the turbine itself? This is an important problem and the French are perhaps the only people who have actual operational experience in these conditions

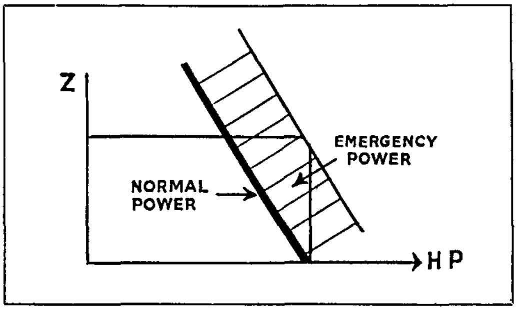
Finally, he said that this is a proper time and place to remark that the French helicopter industry had made a great contribution to modern helicopter development Firstly, they were very early in grasping the significance of the small and medium power turbine They designed and developed these turbines They had the courage quickly to build a helicopter powered by this turbine and, what is most important, they had the courage to put it into production, as a result of which they have now accumulated operational experience which, in fact, no-one else in the world has at the moment

There are many lessons to be learned from this approach

Translation

M Legrand replied that the increase of excess power of the turbine was still quite moderate and could usually be taken by the transmission for a short time Moreover, in most cases, it was a question of saving the occupants or the machine and, therefore, it might even be acceptable that the transmission deteriorated

In practice, however, most cases when excess emergency power was required



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from the turbine, arose at altitude when the helicopter was operated in mountainous areas under difficult atmospheric conditions and when, therefore, emergency power was not very great and did not exceed the normal capacity of the transmission (See Figure Page 181)

The exact fuel consumption figure was not available

(*Written contribution* in the case of Alouette III, the use of a derated turbine causes a fuel consumption penalty of about 14% at sea level)

Translation

M Legrand replied that he wished to emphasise something which had, perhaps, been said insufficiently clearly in the paper He was anxious to defend the fixed shaft turbine against amendments which, perhaps, were not always justified This did not mean, however, that it was the best solution in all cases In fact, he did not wish to set himself against current opinion that in large helicopters with several turbines, free turbines were better Nevertheless, as people in Britain knew, very good multi-engined helicopters could be built with fixed shaft turbines

It was well known that experience of operating in conditions of sandy atmospheres showed that whatever the type of helicopter, and whatever the type of engine, there were two aspects which suffered most On the one hand, the blades underwent rapid erosion, and on the other hand, the engine suffered absorption effects as a result of the sandy atmosphere

Disregarding the problem of the blades, the main solution for providing protection against sand for the engines was to filter the air In this respect, piston engines were much easier to protect because they consumed less air than turbines

It must not be forgotten, however, that in the case of piston engines, not only the air that was induced in the engine must be filtered, but also the air going through the cooling fan In one type there had been troubles with this air also, which represented a much larger flow than the engine air As a result of the work which had been carried out, it was believed that the filtering of turbine air had been solved It must, however, be admitted that this led to a certain loss of performance This method could certainly be adopted where excess power was available, but no machines were yet equipped with this type of filtering At present, it was in the testbed stage

French opinion was that the operat on of helicopters in sandy atmospheres was possible but that a loss of performance and a loss in the service life of components was unavoidable

Mr R G Austin (*Bristol Aircraft Ltd*) (*Member*) recalled that three years ago precisely, he had expressed concern that Britain was not utilising the obvious advantages of the gas turbine in mechanical drive helicopters He congratulated the French industry upon having the courage to precede Britain in this direction by at least three years and also on giving a concrete example for a comparison between tip jet, and mechanically driven helicopters

It was, as the Author had said, fair to make a comparison between the Djinn and the Alouette It was, in fact, more than fair, for the Djinn, because as the size of the helicopter came down, it would be agreed that the shaft drive benefited in that the transmission weight was reduced Therefore, forgetting the advantage in size coming down on the shaft drive machine, comparison could usefully be made of the Alouette and the Djinn

By the figures given in the paper, the Author stated that the fuel consumption of the Djinn was twice that of the Alouette type machine This was true on an all-up weight basis, but on a given duty basis—in other words, the type of machine required to do a given job—it was more than three to one In fact, when considering a flight duration of an hour, a rough calculation showed that the fuel consumption of the Djinn must be something like 300 lb of fuel per hour The disposable load was roughly 730 lb at normal all-up weight and the payload, therefore, was about 450 lb An equivalent shaft drive turbine-powered helicopter to do the same job, assuming that a suitable turbine was available, would have an all-up weight of only 1,100 lb and, therefore, a fuel consumption of the order of 100 lb an hour

That was reflected in the costs of the machine, especially in view of the fact that the engine weigh*, on the size of engine in the Djinn, was a much larger proportion of the all-up weight, and everybody knew that engines were the most expensive components given on a helicopter

The figures could only be compared relatively because production costs varied from place to place and from time to time, but one calculated that on a production basis the Djinn might cost about £14,000, whereas a small shaft driven turbine-powered helicopter to do the same job would cost only £9,000 For one thing, it would be that much smaller As insurance, depreciation, overhaul and such items were also a function of first cost, the effect of simplification concerning maintenance of the Djinn concept would have to be very great if it was to approach the operating costs of the direct drive turbine-powered machine

This was probably a leading question, but if the French authorities were considering a specification for a machine to do the same job as the Djinn today, would they choose in favour of a pressure jet machine or the small turbine driven shaft machine?

Mr Austin agreed with the Author concerning the fixed shaft turbine for the small helicopter The small helicopter could benefit from a single shaft in that the control system was probably more simple than with the free turbine It seemed to be the trend today to provide a constant speed rotor to alleviate the usual trials and tribulations of a helicopter pilot It was more easy to achieve a constant speed rotor on a fixed shaft turbine Provided the rotor of the small helicopter was designed to accept the characteristics of the single shaft turbine, a great deal could be done in alleviating the torque troubles

Not only was it the better method for the small helicopter, but it was a more simple engine and the weight of the extra free turbine went most of the way in cancelling out the extra weight of the clutch on the fixed shaft installation

Some time ago, the statement had been published that on the Alouette a warning light was provided to indicate when maximum fuel flow was achieved Was this device still used? It was a sensible scheme in that it warned the pilot that he was getting into the region where he could get into difficulty when demanding more power Should this, coupled with a limit in pitch range, be the entire answer to the problem?

It had been stated by the Author that if the specific weight of the turbine engine was reduced, this to some extent helped the pressure jet type of machine although, even so, the difference was small This was doubtful If the specific weight of the turbine was reduced on a mechanical drive machine, there would be a tendency to increase the disc loading somewhat because one could afford to expend a little more power to make a saving in gearbox and rotor weight If anything, the shaft turbine would gain more than the pressure jet as the specific weight of engines improved This, however, was another point of controversy

The Chairman suggested that the Author's reply to Mr Austin's questions could be left to be communicated in writing, and that time did not permit of further questions

He thanked Mr McClements for accepting the Author's invitation to read the paper and Mr Shapiro for acting so ably as interpreter There were also present at the meeting representatives of the French aircraft industry and it was a pleasure to welcome them to the Association

The Author was to be congratulated not only for his excellent paper, but also for having conducted so successfully the National development of helicopters in France

The vote of thanks proposed by the Chairman was carried unanimously by acclamation and the meeting then ended

M Legrand's written reply to Mr Austin

The questions raised by Mr Austin cover a very wide field and bear practically on the whole design philosophy of helicopters The Author will therefore confine himself to the more significant points

Comparison of the Djinn and Alouette fuel consumptions

The Author does not agree with Mr Austin as to the values he gave

For a one-hour flight at cruise speed, which corresponds to a covered distance of 62 miles, the weight breakdown for the Djinn appears as follows —

Weight empty	840 lbs
Fuel	220 lbs
Pay load	700 lbs
Total weight at take-off (military)	1760 lbs

A helicopter of the Alouette type, capable of carrying the same load over the same distance, would have the following characteristics

Weight empty	1090 lbs
Fuel	110 lbs
Pay load	700 lbs
Total weight at take-off	1900 lbs

It so happens that the mission proposed by Mr Austin entails a fuel consumption for the Djinn exactly twice that for the Alouette, which confirms the views expressed in the lecture Of course, this is an entirely coincidental occurrence since the ratio of the fuel consumptions for the two types would have been quite different, should the selected flight duration be different

Choice between the pressure jet-driven machine and the turbine driven shaft machine

The Author does not wish to give a straightforward answer for several reasons

(1) He does not, by himself, represent all the French Authorities involved in the choice of a new type of helicopter

(2) The choice depends on numerous factors, which are not only technical, but requires a long study in each particular case

However, an indirect answer to the question can be found in the part of the paper dealing with the design studies about the Djinn III

Use of a warning-lamp for maximum fuel flow on the Alouette II

It is true that the Alouette II is equipped with such a warning lamp which is always used as an additional device to the pitch limiting system If it has not been mentioned in the lecture, it is purely for the sake of clarity since this warning lamp does not come into play in the operational critical conditions, as far as overheating and surge are concerned As a matter of fact, it is only at low altitude and at temperatures definitely lower than standard temperature that the maximum available fuel flow becomes a limiting factor of turbine operation Such a device is particularly useful as a warning means in case of unsatisfactory operation either of the governor or, more especially, of the fuel feed system (filter or line clogging)

Influence of the turbine engine specific weight on the design of helicopters

This is a very interesting topic which, by itself, would provide matter for a whole lecture The Author wishes, therefore, not to deal completely with this subject here He agrees with Mr Austin that any reduction of the engine specific weight will lead to an increase of the disc loading of mechanically-driven helicopters A good example of this is precisely that of the Alouette II, the disc loading of which is much higher than that of piston engined helicopters of the same tonnage It is felt, however, that reduction of the engine specific weight favours the pressure jet driven helicopter types, this is well demonstrated by the fact that we owe the achievement of a usable pressure jet helicopter to the advent of turbine engines