The Automatic Stabilization Equipment has passed all the Civil Aeronautics Authority certification tests, hence it may be installed and used on regular airline service There are no restrictions to its use It may be turned on while on the ground throughout ground and flight operations Modifications of the sonar coupler have been made to provide a tether device, or guide line, which permits a man on the ground to control the aircraft This proved useful during night flights, or over a dusty area when visibility made it difficult or impossible for the pilot to control the helicopter with sufficient precision to hook on to and pick up an external cargo With the same basic coupler, stabilized flight during towing is being maintained The application of this equipment towards a drone helicopter is being tested with the simple addition of a standard radio link used for fixed wing aircraft

When commercial multi-engine turbine helicopters are available in the near future, the necessary automation in the cockpit to assist the pilot will be available as well Government agencies and industries are proceeding with developments of suitable and compatible navigation systems which will accelerate the evolution of an All Weather System Development of improved de-icing equipment is proceeding on current models, paralleled by the incorporation of these de-icers in the original design of the rotor blades in the immediate future When the All Weather System becomes a reality, by virtue of the integration of all the essential elements, there will exist even a greater demand for improved systems with lower cost, greater reliability and less weight The ultimate result must be the satisfaction of these demands to the point where feasibility is no longer a question, merely the degree of perfection as dictated by the law of diminishing returns

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Discussion

The **Chairman** thanked Mr Gerstenberger for his most instructive lecture and for showing his wonderful films

Mr D L Hollis Williams (*Westland Aircraft Limited*) (*Member*), said that it gave him the greatest possible pleasure to open the discussion, for it was not so many days ago that he had been with Mr Gerstenberger and his team at their Stratford plant in Connecticut, when some of these same problems had been discussed

Mr Hollis Williams proposed not to ask questions, but merely to illustrate and underline one or two things which had already been said The work which had been done by the Sikorsky Dynamics team was really a major break-through There had already been helicopters with automatic pilots, but this was the first time that a complete system had been worked out and it had really put the helicopter in business as an anti-submarine weapon It meant that fleets and merchant ships could now

rely upon this protection at any time, in any weather What Mr Gerstenberger had achieved was a helicopter that could work on a pitch-black night or under zero-zero conditions

The most difficult task was to obtain good serviceability from the somewhat complicated equipment The U S Navy had started with the automatic stabilising equipment (A S E) and run into a considerable amount of unserviceability The Navy Chiefs thereupon decided that in future if any item of the equipment was unserviceable the aircraft would not fly The result was that after a period of poor utilisation, maintenance improved and was brought up to a stage where unserviceabilities were infrequent

Then the sonar coupler was introduced and worked up, and now the remainder of the all-weather equipment is being brought in His own Company was required to introduce the full all-weather system right from the start, and this would present quite a big educational maintenance problem

Although many experts present in the audience were probably familiar with the equipment and the way it worked, there might be some others present who, like himself, had some initial difficulty in understanding the system For the benefit of these perhaps he could give his own simplified version of the system which Mr Gerstenberger and his team had developed

The system consists of 5 null seeking loops Thus the equipment is trying to reproduce zero pitch, roll, and yaw In addition it is trying to return a null reading on a pre-set height datum, and also zero drift At the same time the engine is automatically meeting the power demands of the rotor to satisfy these conditions

When the automatic system is put into operation the helicopter will then carry out a transition from cruising conditions to seek and hold the hover He understood, however, that it took a certain amount of training and nerve for pilots to accustom themselves to rely on the automatic control when sinking into a position in close proximity to the water on a dark night, and this is where the " limited authority " principle is so valuable in that the pilot can at any time take over

The **Chairman** said that he had recently been to the Madrid Conference, where there were several discussions concerning V T O aircraft One speaker had said that V T O aircraft should not only have duplication of the automatic stabilisation systems, but should have triplication One lecturer, in fact, had even insisted on quadruplication

From tonight's paper, Mr Gerstenberger seemed to have achieved considerable reliability already, and he had mentioned that the equipment failed only once in 800 flying hours Helicopter manufacturers claimed only 1,000 hours for transmissions—at least, they hoped they could It seemed, therefore, that the reliability of systems was catching up on that of transmissions, but there was no duplication of transmissions Was it possible to have a minimum of duplication in the systems described by the Author as compared with the requirements of V T O aircraft which had been the subject of discussion in Madrid ?

Mr Gerstenberger replied that he had no objection to putting in duplication or triplication, or even quadruplication, but at that stage he would give up being a technical engineer and would get a job as an efficiency expert to cut them out In the true sense of the word, two complete systems were not needed

Looking at typical failures, one realised that it was necessary to duplicate the power supplies or arrange them so that each one was run at partial load Then, in an emergency, one could provide reduced but adequate service This is similar to the reliability provided by several engines In a four-engined transport, the engines were not duplicated The pilot throttled them down and cruised Then, if two of them went out, he could still go on the other two, although they were loaded up This was not true duplication It was breaking down the multi-components so that their capacity could be increased by a certain reasonable percentage in an emergency This was what Sikorsky was doing with the electrical power

On the hydraulic servo control, there was true duplication There were two servo systems, but there was some degree of "cheating " The ASE was introduced on one of the servo systems It was really an actuator to provide the automatic

control, but it could also act as the only hydraulic control in the helicopter if the primary servo should go out Here again, therefore, there was an extra benefit when the duplication was put in

There was duplication in the vertical gyro reference with the remote indicators Providing one for the pilot and one for the co-pilot resulted in duplication No attempt was made to add duplication upon duplication Instead, one gyro was used to drive the pilot's indicator, and another gyro was used to provide a vertical reference for the ASE system and to drive the co-pilot's indicator Thus, in the event of a single gyro failure, the pilot either has a vertical reference on his instrument panel, or his ASE system

An analysis should be made of what could happen and what could be done in the event of failure In the event of, say, a double failure, what would be the third line of defence? If the automatic stabilisation went out, it was not possible to do certain things like approach to a hover over the water under zero-zero conditions, but the pilot could pull up the collective pitch, push the cyclic forward and proceed along at 50 or 60 knots and fly without the stabilisation The mission might be aborted, but this would not endanger the helicopter or its occupants

The time has come where we must anticipate the problems of commercial operation It is difficult to listen to the argument that a helicopter flying instruments on an airline route must "stack up" at 10,000 feet with aeroplanes and work down The helicopter should have its own terminal navigation facilities If something went wrong with these facilities, it could make a Ground Controlled Approach at the nearest available airport, provided emergency conditions could be instituted at this facility

Mr Curties (*B E A*), congratulated the Author on his excellent description of the work he had done on the problem of all-weather systems, which was of great interest

He was a little unhappy about the Author's philosophy of the 801st hour The worrying feature was that, with all respect to the equipment described, it might not be the 801st hour, it might be the 401st or even the 201st with the equipment as now known From a civil operator's point of view, the philosophy of flying the helicopter as a fixed-wing aeroplane during the 801st hour was not really adequate

Everybody would agree that there was a considerable penalty in going to duplicated or multiple systems, but what else could be done? As Mr GERSTENBERGER knew, experiments had been carried out with such devices as flight directors as alternative means of control for the pilot in the event of failure of the automatic system Did he consider such devices to be useful, and had he had any experience of this sort of thing?

The paper gave a solution to a particular military task and it described the development of an elegant system for performing an anti-submarine operation Could the Author say anything about the application of the kind of facilities described in the paper to the landing of a helicopter under instrument conditions on a helicopter site? Had any work been done on the type of equipment that was needed to fly the helicopter down a radio beam and bring it successfully to a hover over the site?

Mr Gerstenberger expressed his appreciation of the interesting questions His first attempt to accomplish the mission which he had described was made through a flight director, which had been developed by the Aircraft Instruments Laboratory of the Navy in Philadelphia Several Flight Directors had also been used In it was a computer which would keep the helicopter away from the "dead man's curve" and include in the director any information that was vital for the safe operation of the aircraft, which it would present, in addition to the other information that ordinarily came on the remote vertical gyro indicator This attempt had been given up a little early because the other solution had presented itself, but work would certainly continue along this approach to the problem

The approach had been to avoid the bottleneck of the pilot, and the first thought had been that the pilot would resent being deprived of certain functions It had been tried out with the pilots of the Navy Air Test Centre at Patuxent River, Maryland The Doppler automatic approach could be easily investigated because, obviously the

system had a switch for engaging and disengaging, and if it was engaged at 40 knots, the machine would naturally come to a hover

The pilots liked it better than the flight director which they did not think could do the job When discussing it later, their reaction was to say "This is just like an elevator When you go into a good hotel, there is an automatic elevator, but you still have the elevator operator there The elevator does a better job remembering which floors have somebody going up and somebody going down Bringing this helicopter down to a hover is just like pushing a button on an elevator You just push the button, and down it goes " Whether it was done with a flight director or with the seek-and-retain hover device was a matter of principle and convenience

It is not too desirable to provide two things exactly the same, because the pilot could use only one of them at a time It is better to provide two separate means of accomplishing the mission, one through the primary controls and the second by means of a display in the shape of a flight director, having it so that if one went out, the other was available In the military vehicle, however, it had been decided that there would be an unnecessary weight penalty Mr GERSTENBERGER was not, however, seeking an argument with Mr CURTIES when talking about commercial application It might be the best thing to do, there would be that little extra safety which might prove very useful in a tight spot

The reply to the question about the problem of landing a helicopter on a helicopter site with a radio beam was that I L S approaches were done through a director as a routine performance There was no question about it When it was done, the same glide path was used as in the case of the fixed-wing aircraft Experiments had been run to show that it was much better to use the steep glide path The machine would get there faster and there was less worry about obstructions Less valuable air space was taken up in doing it, less fuel was used and the flight time was cut down It appeared, therefore, as though the helicopter would have to get its own I L S so that the optimum could be achieved

It might be possible, however, to simplify it a little bit, and an opportunity was awaited to do the same job on a problem of this sort as had been done on the sonar mission The military and non-Military government personnel were working with airline and aircraft companies in a more general solution of bringing the helicopter to an exact spot through better beam guidance and navigation systems

In the New York area, the Air Modernisation Board was working on the Decca navigation system for accurately pinpointing various places

This system, which requires several ground stations of considerably more complexity than the equipment on the helicopter, has the advantage of serving an unlimited number of heliports within the range of the equipment At present, this is an important consideration, since most helicopter airlines have more heliports than helicopters

There will probably result several navigation systems from the current developments, and a choice of several will be necessary to secure the optimum system for each of several types of helicopter operations Although the Civil Aeronautics Authority would prefer to certify a well-defined helicopter for instrument flying, it is hoped that the type of operation as well as the helicopter will be considered in determining the minimum ceiling and visibility necessary for approved operation

Mr A E Bristow (*Bristow Helicopters Limited*) (*Member*), said that the lecture had been very interesting from a technical point of view, although it was limited as far as the all-weather system for helicopters was concerned to one particular military application and one which those in commercial helicopter operations would ultimately "ride home "

Very little reference was made by the lecturer to de-icing in spite of the fact that rotor blade de-icing was in Mr BRISTOW'S opinion vital to the all-weather flight system for helicopters Mr BRISTOW asked how far behind automatic stabilisation development was the development of rotor blade de-icing ?

Mr BRISTOW asked what acceleration could the equipment described by Mr GERSTENBERGER withstand in rough air conditions, and would it be necessary for the pilot to disengage the auto-pilot system and fly the helicopter without the assistance of an auto-system in turbulent air conditions ?

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From a commercial point of view Mr BRISTOW found it difficult to see how such a complex piece of equipment could be acceptable to civil helicopter operators and asked what steps were the manufacturers of such auto-stabilisation equipment taking to simplify this equipment for the civil market, in particular the simplification relating to weight and maintenance costs

Mr Gerstenberger replied that he did not think the de-icing was very far behind There were the various problems of the stabilisation equipment and the navigation equipment, there was the power plant problem, in which there were to be two or three power plants, there was the call to be able to hover with one engine out, and in addition there was de-icing The de-icing might be a little bit behind the general electronic stabilisation of the helicopter but it was ahead of, say, the navigation problem of a certain area It was certainly ahead of having the ideal combination of power plants in a helicopter where an approach was made in zero-zero weather in a congested area, with, perhaps, three engines on which to do it

The Sikorsky helicopters now on the boards were being designed with de-icing equipment on them The S-58 (the HSS, the H34 or the HUS) was going to Mount Washington during the coming winter to have the latest design of blade de-icing tested This would be a final check for the production of the HSS-2, which was the twin turbine S61, it would have de-icing when it first came out It would have been better if the same routine checking stage had been reached in some of the other problems

The next question was what accelerations could be flown in rough air with the equipment which had been described When a helicopter flew, it did not produce much acceleration With the hinged blades, there was attenuation of the severity of a gust and not much acceleration was produced Normally, one might expect 5G in addition to the 1G

When the helicopter was put through its paces at Patuxent River, the requirement was to produce accelerations in flight up to the design load or the limit of the control, or an arbitrary value negotiated between the Customer and the Builder if it was a particularly "hairy" manoeuvre This was done with A S E on and A S E off

When the pilot got into these "hairy" manoeuvres, he might not have any A S E , it might be beyond the range of the small authority limit Therefore, no change was seen In other words, the manoeuvrability of the helicopter had not been changed It could still be manoeuvred as it was without the A S E

The question was understood as asking what effect the A S E had upon the ability of the helicopter to stand accelerations The answer was that the A S E probably did not affect it at all Although the automatic stabilisation equipment included a very fast servo system (the servo would follow 15 cycles per second, which was a lot faster than a pilot could move the stick), the accelerations when the A S E was in control were usually much smaller than when the pilot would move the stick There was insufficient authority in the A S E to develop accelerations equivalent to those which were the result of large gusts

Concerning the question of weight and maintenance, the problem was likely to become a little more complicated before it became simpler, but thought was being given to the poor man's stabilisation and navigation system They were really fairly simple now, using "beer" signs The trouble was that they went off at 1 o'clock in the morning, then, the airline was grounded

The time had come when it was necessary to get more helicopters than heliports The only way to do it was to give regular service, even though it cost a few more dollars, and to have the additional revenue derived from the regular service which more helicopters would provide

At the moment, the weight of the equipment in the HSS-1N over the HSS-1 was about the weight of an additional man If this weight penalty was felt to be a severe handicap, there would be more likelihood of discarding the relief sonar man than the co-pilot, who was needed to help with the navigation Weight savings with turbine power plants would also alleviate the weight problem stimulated by the desire for more navigation equipment

Mr J S Shapiro (*Consulting Engineer*) (*Founder Member*), recalled that about three years ago he had arranged and introduced a set of lectures before the Association on all-weather scheduled civil operations, as a result of which he was branded an optimist He was very glad to hear from Mr GERSTENBERGER, who had done so much work in the same direction, that victory, the achievement of all expectations, was in sight The trend which had taken place during the past three years tended to confirm Mr SHAPIRO's original assumptions It was encouraging also to hear, late one night in September, that Mr Sikorsky himself was thinking exactly along the same lines of what might be called "the funnel approach for civil helicopters" In short, having been declared by some of his friends three years ago to be mad, Mr SHAPIRO considered that he was now becoming sane

The Author had adopted a solid philosophy in suggesting that it was unwise to try to solve all problems, or even all civil problems, with one set of equipment Certainly, whilst they had just been demonstrated a magnificent solution of a definite problem in the military sphere, its similarity with civil requirements was very small

The reception of the helicopter at its destination was a very different matter and it was surprising that there had been no reference to it After all, a solution had been described which relied entirely on what might be called "strictly non-co-operation at the receiving end" Surely, in the civil role, there could be a lot of co-operation at the heliport This meant quite a different technique and a quite different weight penalty

The kind of approach which had been attempted in the earlier lectures would bring a much more efficient solution from the weight point of view to the regular, and particularly to the scheduled, civil operator with pilots who knew their way with prepared sites and aids specifically developed for the purpose

There appeared to be some confusion in the talk about the 801st or the 401st hour It did not mean that the machine was operated for 800 hours and then failed, nor should it be confused with the number of hours which a gearbox was allowed to operate A gearbox had a reliability many times greater than 800 hours A similar figure for a gearbox would be somewhere in the region of half a million hours, although it had to be serviced after 600 hours It was a completely different concept and was in no way comparable

In civil operations, with a reliability of one failure in 800 hours of flying or functioning, and a probability of functioning measured by the number of occasions of zero-zero flying during the year, the true incidence of failure would be only a small fraction of once in 800 hours and was probably more like once in 80,000 hours If once in 80,000 flying hours the helicopter had to be flown to an aerodrome as a civil aeroplane, this was no penalty at all It was, therefore, difficult to understand the objection of B E A to the philosophy of converting into a completely different and completely ground-aided blind descent in this very rare eventuality

Mr Gerstenberger, in welcoming Mr SHAPIRO'S remarks, felt that in what he had said earlier he had perhaps belittled some of the efforts that were being done about the receiving end It had just occurred to him that the HSS-1N had to get back to its aircraft carrier, but this was no problem The problem was to get it to hover

The arrival of the HSS-1N would make for a "round-the-clock" utilization of the helicopter and helicopter pilots on the aircraft carriers They would be on a 24-hour stand-by during any alert, whereas previously they were idle whilst the fixed-wing pilots were operating Even before the HSS-1N joined the fleet, pilots were doing practice night flying and making approaches and landing at night on the carrier, the intention being that this part of the training would have been finished with by the time that the HSS-1N and its equipment reached the carriers

Not very much of that type of training had been done in the past There was little use in flying at night if it was impossible to hover or to make a rescue Now, however, the pilots knew that they could do it They were getting perfection on the easier part of taking off and finding the carrier and landing at night with the co-operation at the receiving end They did not get any co-operation when they had to make for a black spot out in the ocean and remain there for a length of time when doing their mission

The team at Stratford were working hard to improve upon the figure of 800 hours, and suddenly, Mr Shapiro had declared that the true figure was 80,000 hours—and he was right The 801st hour might occur in broad daylight, with visual roles, when the pilot would go down with a smirk and simply say "I knew this thing would stop working sometime, you had better fix it up "

It was, of course, liable to happen on the first hour

Mr GERSTENBERGER said that in any event, he would consider some other way such as a Ground Controlled Approach at an alternate landing place to be necessary, but it was good to know how much dependence there would be upon these facilities, which were already fairly well saturated, to provide an emergency procedure with little risk rather than a hazardous landing without the proper equipment, which might result in breaking the aircraft and killing somebody

Mr O L L Fitzwilliams (*Westland Aircraft*) (*Founder Member*), said that since the significance of this development had been dealt with by Mr HOLLIS WILLIAMS in opening the Discussion, and since the other speakers were dealing with the technical aspects, he thought that his most useful contribution might be a short comment on the relationship between Mr GERSTENBERGER and the developments which he had been describing

In his talk this evening Mr Gerstenberger had not merely been describing the work of his Company and his colleagues in the usual way, he was in fact describing the achievement of a personal ambition on which he had commenced work ten or more years ago, with the aim of providing auto-pilot facilities substantially similar to those which had been described this evening At that time, Mr Gerstenberger had to start from scratch, and his first job had been to solve the problem of helicopter control forces It was in fact he who some ten years ago had initiated the Sikorsky development of powered flight controls for helicopters, on which such a large amount of experience had since been accumulated This was the essential basis for provision of auto-pilot facilities

During a recent visit to Sikorsky Mr FITZWILLIAMS had seen on the desk of one of Mr Gerstenberger's staff a notice which read "My mind is made up Do not confuse me with the facts " He could not imagine anything less accurate as a description of the way in which Mr Gerstenberger and his staff had operated through all these years of remarkable achievement Throughout this development Sikorsky was the prime contractor exercising full responsibility, even though some of the specialist work had been sub-contracted Mr Gerstenberger had been in charge of the Sikorsky team from the beginning and the developments described this evening were his personal achievement, to a degree which might not have been entirely clear from his modest presentation

Mr J B Bower (*Marconi's*), said that the servos appeared to perform two main functions The first was actual control of the aircraft, albeit limited in extent, the second took the form of guidance to the pilot With regard to the first type the Author had mentioned a pass band of 15 cycles per second Some of the sensing elements were notoriously noisy, consequently one wondered how far their data had been smoothed before being fed to the mechanisms which had these relatively fast time constants

One item about which he was not quite clear was the Doppler censor Was this in the executive or legislative section? Did it take control, or did it merely give advice?

Mr Gerstenberger replied that the 15 cycles per second was correct He was thinking mainly that the muscles of the hydraulic servos were good for 15 cycles per second This was an average performance for a hydraulic servo valve unless there was chatter in the air (self-excited instabilities) and it was necessary purposely to cut down the speed of the servo in order to have one that was chatter-free

On the electrical side, the frequency could still be kept high because the hydraulic valve weighed only 3 or 4 oz with about 2 or 3 oz of friction on it, hence there was no requirement for a large servo mechanism It was therefore possible to be extravagant, use a very small control motor weighing less than 1 lb and put on an appropriate

follow-up With this light load upon it, it could perform at 15 cycles per second operating at amplitudes of ± 006″

A much higher frequency could be achieved by resorting to the two-stage electro-hydraulic valve There were, however, limitations to the rate of response When differentiating the gyro signals noise would start to come in, and when it was differentiated it would give amplified noise This would deteriorate the signal to the noise ratio Therefore, somewhere in the circuits, filters would occasionally be put on to attenuate the high frequencies or by taking care to keep the noise level to a minimum In these high performance systems, it was necessary to consider the signal to noise ratio, especially after differentiating it

The Doppler was both an executor and a legislator In other words, it presented its information on the hovering indicator with its longitudinal and lateral crossbars in front of the pilot on his instrument panel

The pilot therefore got the information and could hover from it without engaging the automatic hover, an operation which he might do a little faster manually The seek-and-retain hover took its time, it was geared for the average pilot In other words, both facilities were present, both the presentation to the pilot and the input of the Doppler signal through the control system

Mr C J Carter (*D A Nav , Mimstry of Supply*), said that the only question he had intended to ask was concerned with the problems of navigation since Mr GERSTENBERGER had dealt primarily with equipment for flying the helicopter and had not touched upon navigation, but this question had already been asked and replied to However, two or three words used by Mr Gerstenberger in dealing with the last question but one prompted him to add a little to the confusion on the question of the meaning of the 800 hours' reliability and perhaps to disagree a little with Mr SHAPIRO The few words in question used by the Author were that he "wanted to increase the 800-hour reliability to reduce the risk of somebody breaking the aeroplane and killing somebody "

Mr CARTER imagined that the saving grace of the system which had been described tonight, and the reason why 800 hours was acceptable, was that if a failure occurred, probably no one was killed, it was to a large extent a "fail-safe" system because the pilot could, if necessary, take over and do most of the work that the automatic mechanism was doing It was not like the case referred to by the Chairman when talking about triplicated and quadruplicated equipment, which probably applied to aircraft which had to be landed "hands off," in which case the reliability required was much greater indeed than one failure in 800 hours of flying

It was wrong to say that one failure in 800 hours meant one failure in 80,000 hours because it would not be zero visibility when the machine was landing It was true that the failure might not occur when there was zero visibility, but one failure in 800 hours meant one failure in 800 hours, and irrespective of when the failure occurred, if the failure was likely to cause a fatality this figure would be several orders of magnitude too small One failure in 800 hours was therefore only a reasonable figure so long as the probability of a failure causing somebody to get killed was very small

Mr Gerstenberger, replying to the comments concerning the use of the words "killing somebody," said that he had been talking about a pilot who wanted to use the G C A facilities in lieu of running the risk of killing somebody In other words, after experiencing a complete A S E failure, he could then fly in the same way as an aeroplane and request help from a G C A facility If he was not brought in on G C A , somebody might get hurt It was not the fact that if the A S E or the pilot's navigation "went out," somebody was sure to get hurt He still had G C A to help him if he was near an airport, as helicopter operations usually were

In other words, there was definitely no fatality in the 800 hours In fact, when the A S E certification came from the C A A , Sikorsky Aircraft did not have a specific problem to work upon but said that they wanted to be able to sell their helicopter with the A S E on it so that a commercial operator could use it for whatever purpose he wished, perhaps, even approach the C A A with it and get special consideration in his weather problems

They said to the C A A , "We will present this on the theory that it can do no harm We want permission to put it on our helicopters " The C A A then conducted some fairly rugged flight tests, including four-channel hardover signals unbeknown to the pilot The results were no worse than a good gust The pilot did not have to disconnect anything He did not have to say, "That is an A S E malfunction and I will have to do something about it " He was ready for it, his hands would be on the controls and he would react as he would normally do if a good gust hit the helicopter

There were pilots who did the right thing and there were those who did the wrong thing If the pilot did the right thing, there was no strain and no pain If he did the wrong thing, he would go over a little further and then do the right thing Therefore, the condition was rather like that of the gust hitting the helicopter

Mr GERSTENBERGER could prove to his own satisfaction, as well as to the satisfaction of others, that an A S E malfunction, even in four channels, would not produce disastrous results In fact, it would not even produce results that would scare anybody It was merely a routine affair The circuitry was designed so that the chance of four channels giving a hardover signal was very slight Each circuit was isolated so that the pilot did not get a four-channel hardover The situation with the helicopter is better than with the fixed wing automatic pilot because a multichannel hardover on a fixed-wing automatic pilot was a little more serious because it had more authority

Captain E C Beard (*Ministry of Supply*), suggested that the question of failure had been approached in entirely the wrong context The failure of the equipment did not normally mean that the aircraft itself would be damaged or even suffer any damage It did, however, mean that the role which the aircraft set out to fulfil would fail

The equipment had been described as being designed primarily for helicopters in the anti-submarine role In any war, there would be increasing reliance upon helicopters to find the submarines If, in fact, there was a failure rate of one in 800, or whatever the figure might be, with the result that the helicopter could not perform its mission, the ultimate loss of life might be much greater by reason of the enemy submarine not being detected

The **Chairman,** in closing the meeting, remarked that the Lecturer had been subjected to a gruelling session On behalf of the Association, he thanked Mr GERSTENBERGER for the important contribution he had made and for the very attractive way in which he had dealt with a complex subject

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