" Some Engineering Aspects of Helicopter Assessment Trials "

by

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Professor J A J BENNETT (*Chairman, Lecture Committee*), *occupying the Chair*

The CHAIRMAN, in opening the meeting, said he had much pleasure in introducing tonight's lecturer Mr Webb had been in the aviation field for 29 years In 1930, he joined the Air Ministry and in the pre-war years he worked at the Royal Aircraft Establishment in the Departments of Airworthiness and Aerodynamics At the beginning of the war, he was appointed Resident Technical Officer, firstly at Armstrong Whitworths and later at the Bristol Aeroplane Company It was during this period that he became associated with the helicopter work when the Bristol Company started to develop helicopters in 1944 He remained there until 1950 and during that time he was responsible to the Ministry of Supply for the early development of the Sycamore and the Bristol tandem rotor types

In 1950 he was appointed to Boscombe Down and worked for five years on the engineering assessment of fixed wing aircraft, and from 1955 he had specialised on helicopter work He therefore had a very wide knowledge of the subject to be discussed this evening and the Association was much indebted to him for undertaking to give members the benefit of his experience

MR H J WEBB

INTRODUCTION

"*Never a dull moment*" This old saying may very well apply to the aircraft engineer's work in his efforts to keep an aircraft in the air

The following notes are devoted mainly to the engineering work necessary for the development of a military helicopter to the stage where it can be considered satisfactory for Service use Basically, the work described is equally applicable to a helicopter which is developed for commercial use The main difference between these two aspects is that the former will usually be required to carry out some acceptance tests at the Official Testing Establishment before commencing its service life and the latter becomes the subject of Route Proving Trials in a Corporation before starting to earn its daily bread on regular service

It is the function of the engineering testing at the Official Testing Establishment which the author will discuss on quite broad lines in the

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following pages Before doing this it is necessary to say something about the early history of the aircraft as it will be evident that the tester must have full access to this before the trials begin at the Establishment

Design

The engineering assessment of an aircraft begins on the first day that pencil is put to paper and continues until the day that it is declared obsolete This statement applies even more particularly to a helicopter with its relatively more complicated mechanisms Whether the aircraft is destined for military or commercial use it is essential that the maximum utility shall be derived from this expensive vehicle, it costs money to keep this machine immobile on the ground It must be reliable and it must be easy to maintain and service For this reason careful thought must be devoted to these aspects in the design stage and also during the early flight stages of the prototype

The first question that arises is the amount of design effort which should be afforded to a new project This is probably settled by the number of draughtsmen actually available at the time but in any case the use of too few men must be avoided It is easy to say to oneself that things can be put right at a later stage Although this may economise in design effort it could be very dangerous, as for example, the failure of even a simple pipe clip could very well bring disaster in its wake It could at the best, mean a grounded aircraft while the necessary modification or replacement is being made, with the resultant loss in use of the aircraft and interruption to the service schedule

Compared with the organisation which employs a design team which is too small, there are on the other hand, teams composed of the maximum possible number of draughtsmen when every effort is made to obtain the best possible design before the aircraft flies It can be expected that such an aircraft will give better service as minor defects may be expected to be fewer In this instance the aircraft may be slower in coming into service and the initial design cost will be higher

Somewhere between these two aspects is the compromise design which will give the best possible service with the minimum number of defects and at the same time a reasonable final cost

One purpose of this paper is to suggest methods whereby the information on defects and other shortcomings of installations can be fed back to the design organisation as early as possible to enable the final design of the aircraft to be achieved quickly and preferably before it gets into service

Rig and Prototype Testing

As the prototype begins to take shape complementary testing of ground rigs will be taking place The most important of these in the development of the helicopter is the transmission rig which will consist of a slave engine driving through clutch, free wheel, transmission shafts, gear box to the rotor head and power absorbing fan as many auxiliaries as possible are added, *e g*, hydraulic pumps, starter and generator Problems which would be studied on this rig include a preliminary vibration analysis, wear of gears and bearings, lubrication problems, etc

It is assumed for the purpose of this paper, that the engine as a unit will have been developed or will still be in the development stage by the

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engine manufacturer and would eventually arrive at the production stage of the aircraft in its finalised form

The above rig would also bring out installational problems such as starter malfunctioning, exhaust pipe defects, etc Information will also be obtained from these trials to enable a preliminary estimate to be made of component lives in the transmission system

In addition to the above there will also be rig tests to be made on a representative fuel system and hydraulic system, the latter including power controls if such are to be provided on the aircraft

It is also advantageous at this stage to investigate generator cooling on a rig which should include a mock up of the basic electrical system

The prototype will now be reaching completion and the most important work before flight is the thorough testing on the ground of the transmission and rotor system to an agreed programme This completed, together with structural strength tests, functioning tests of the fuel system, hydraulic system, impedance and stiffness tests of the controls, the aircraft is ready for ground handling prior to flight tests

This paper is concerned mainly with the engineering assessment of a helicopter, but it is pointed out that the initial flight schedule is to ensure that the handling characteristics are satisfactory for all conditions of flight Engineering tests to this stage are directed towards the safety of the aircraft

Having completed the first phase flight testing from the engineering aspect will now turn to general clearance of the systems and in some cases a certain amount of fixed instrumentation will be necessary

The more important tests are as follows

(1) *Temperature (and Pressure) measurements*
Generator, Radio and radar compartments, Instrument panels, Engine bay, Gearboxes, Hydraulic system, Fuel system

(2) *Noise and Vibration levels* The vibration instrumentation including strain gauging may be quite extensive to correlate results from earlier rig testing

(3) *Air conditioning of cockpit and cabin* These tests will include measurement of temperatures and humidity and detection of carbon monoxide or other noxious gases
This part of the investigation will include internal and external misting of the windscreen

The above clearance tests will have been made under temperate conditions, *i e*, between the ambient temperature limits of —10°C and +30°C at ground level Since the specifications for most modern aircraft call for world wide operation, arrangements will have to be made for check tests on all the systems at Tropical and Sub-arctic testing establishments respectively to ensure that the aircraft will operate over the whole specified range of temperature These trials will be required as early as possible to avoid severe limitations in the use of the aircraft

The trials described so far will probably have produced many modifications, some of which may be essential in order for the trials to continue They will, however, enable a standard to be set to which production aircraft can be built thus enabling an aircraft to be produced which will be acceptable for service use It should be remembered that concurrently with these engineering trials, handling of the aircraft is being assessed and also a certain

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amount of performance testing, it is from the results of all these trials that an acceptable production standard is made

Prototype to Production

The foregoing trials have been carried out on one or more prototype aircraft which have probably been made by hand or at the best with a minimum amount of tooling The prototype may be made from special materials which would not have the same rate of wear and tear or fatigue properties as those used in the production aircraft Production limits on the manufacture of moving parts may affect the functioning of systems Experience has shown that the slight changes described above may affect in some degree the overall performance of the production aircraft as compared with the prototype

Little information is available at this time to assess the reliability of the aircraft under operating conditions particularly in regard to maintenance and servicing, and the consumption of spare parts In order to obtain this kind of information an early production aircraft may be subjected to an Operational Reliability (O R) or Intensive Trial

Operational Reliability Trials

The main object of an operational reliability trial is to amass as much flight experience under as near operational conditions as possible on a representative aircraft before it goes into service

The trials should be conducted at the Official Testing Establishment at which the background of service flying experience is available, together with the necessary technical effort to supervise the trials

The scope of the trials should be designed to cover flight within the recommended flight envelope under all possible weather conditions and the aircraft used in all its specified or simulated roles The aircraft should be maintained to the prescribed servicing and maintenance schedules and an assessment made of any difficulties

Any defect arising during the trials should be made the subject of a special investigation, but in order to maintain the intensity of flying, the defective item or component should immediately be replaced while the investigation is being made, subject of course to safety considerations It is essential that the trials should be supported by an adequate spares backing in order to maintain the maximum rate of flying

To enable the trials officer to have a thorough background of the early trials and development of the aircraft, a complete list of reports of rig and flight tests carried out by the contractor should be available Interim reports are written every two weeks by the trials officer while the trials are in progress for the information of all interested parties

The various aspects of the operational reliability trials are now considered in more detail

Servicing and Maintenance

An important feature of an operational reliability trial is an assessment of the servicing and maintenance qualities of the aircraft

The provisional maintenance schedule is used as a basis for the assessment and although the trials are conducted intensively the minimum amount of servicing labour possible is employed in the most efficient manner Suggestions may be made whereby the maintenance schedule can be improved as, for example, by revising the sequence of events or by the introduction of an additional removable panel to improve accessibility to a component

A record is kept of the man-hours spent during the trials, which can be divided under the following headings

(*a*) *Scheduled maintenance*

This is a record of maintenance man hours required to comply with the provisional schedule This should give a reasonable constant figure of man hours per flying hour of the aircraft

(*b*) *Corrective maintenance*

This is a record of man hours required to correct minor defects and to apply on-the-spot repair schemes to keep the aircraft serviceable Where such schemes require to be introduced or those already existing need extending, details of the same are collected for inclusion in the official list of repairs If a defect frequently repeats and it becomes obvious that a particular repair scheme is inadequate, consideration will have to be given to a permanent modification to the part affected

(*c*) *Introduction of modifications*

It is necessary to keep the aircraft during the trials to the latest modification standard The classification of each modification determines when it should be incorporated but in order to maintain a high rate of flying it is desirable to incorporate these in batches, so that during any one grounding several modifications can be installed simultaneously This is arranged whenever possible

Earlier in the paper the question of the amount of design effort to be employed was discussed and an analysis of the man hours used in this section may give a guide as to whether a well balanced design team has been used A continuous flow of modifications at this stage would probably indicate that insufficient attention had been paid to the detailed design during the early stages of the development of the aircraft

Most modifications can be classified under the headings of

(*a*) structural, (*b*) functional, (*c*) operational

The latter cannot as a rule be foreseen, but careful attention in the design stage could help to keep the structural and functional modifications to a minimum

It is important during the trials to keep a record of all spares consumed, to check that the scale of spares, which will at this stage already have been ordered for production aircraft is adequate

Defects

Perhaps the most important feature of a trial of this nature is the recording and investigation of defects The trials officer will keep a diary in which is entered a record and description of every defect however trivial In addition to this the trials officer will also record other flight details such as duration and description of flight and amount of fuel and oil used He will brief and de-brief the pilot and crew noting any cockpit or handling difficulties

The defects are then classified as follows

(*a*) isolated cases in which the sole action is to replace the item by a spare

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(b) cases which can be cured by adjustment or by a repair scheme

(c) cases serious enough to recommend for design action for subsequent modification or extension of repair scheme

Details arising from section (c) should be given to the design department immediately so that the necessary modification action can be initiated as soon as possible

A statistical analysis is made of the defects and invaluable information will be given on the scale of spares required to enable the trials to continue without interruption If a particular component, for example a starter, is constantly being replaced, an investigation would probably show up a defect in the item which by a simple modification would reduce its replacement to a negligible quantity

As the flying hours accumulate information will amass to supplement that gained from the rig tests which was used to estimate the lives of such components as the transmission, rotors and controls The trials can provide

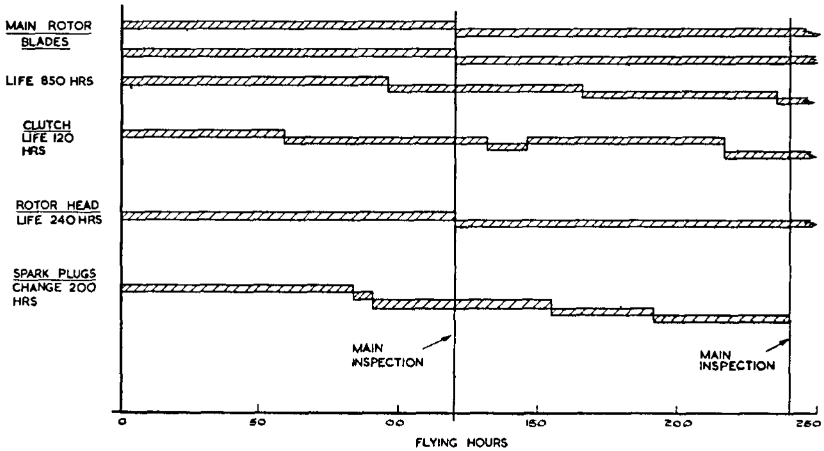

Fig 1 Component failures

a check on the lives which have already been recommended and it is usually minor defects which come to light Fig 1 shows examples obtained from a recent trial where it was necessary to replace components before the recommended life was reached In the case of the rotor blades, cracking of the trailing edge skin rendered the items unserviceable at the widely varying hours of 2 to 235 respectively Although the failures were trivial it meant that the complete rotor blade was replaced and a far greater quantity of spares, in this case expensive items, were required The information gained from these trials was passed back to the designer in order that modification action could be taken to enable the blade to give satisfactory service over its projected life

Several other components have been treated in a similar manner

Service failures which can seriously affect the life of a component have been associated with imperfect manufacturing finish, *e g*, badly cut fillets, badly finished threads, tool marks, etc A sufficiently high standard of manufacturing finish is therefore essential If any failures occur during the trials which could be traced to any of the above defects steps can be taken to improve the standard of workmanship on the production line

Information can also be gained during these trials on the effect of wear, fretting corrosion, etc , on the more important components such as engine, transmission and rotor systems Before the tests begin the components are inspected in detail and a record made of their condition and leading dimensions and clearances measured After a given period of flight, say 200 hours, the components are again inspected for condition, *e g* , fretting corrosion and dimensions are checked and assessment made of deterioration and wear If necessary, the component is reconditioned, *e g* , provision of new seals, worn shafts replaced, and it is returned for a further phase of flight testing, after which the procedure is repeated The subsequent inspection will give a fair indication as to the possibility of the component standing up to its assigned life from the point of view of wear and tear

Engineering Tests

Earlier in the paper it was pointed out that differences between the prototype and production aircraft may also produce differences in system functioning and it is during an operational reliability trial that an opportunity is provided to check that the systems of the production version meet the requirements Some of the measurements may be repeated at intervals to ensure that there is no deterioration with time

Typical examples of tests made during the trials are as follows

(*a*) *Engine installation*

With reciprocating engines checks are kept on the maximum cylinder temperatures and, if possible, an exhaust gas analyser is installed to check the mixture strength

(*b*) *Fuel system*

Tests are aimed at proving that the engine is always supplied with fuel in the necessary quantity at the correct temperature and pressure Transfer checks will be made and a careful watch kept for occurrences of filter or vent icing Possible failures or misuse of the system are simulated, *e g* , booster pumps are switched off or tanks are deliberately overfilled to induce syphoning It is also important to know the amount of unusuable fuel The total consumption during the trials is recorded and any unusual change at any part of the trial may call for an investigation A clue to any alteration in fuel consumption could possibly be obtained from the mixture strength measurements noted in the previous paragraph

(*c*) *Oil system*

Temperatures and pressures in the oil system are noted under all conditions of flight and tests are made for any possible malfunctioning of the oil cooler shutters Oil dilution tests are made and check tests on oil frothing The total consumption of oil during the trials is recorded and any change as in the case of the fuel system should be investigated

(*d*) *Electrical system*

Some flights are made with the maximum possible electrical load under the most adverse conditions of flight to ensure that no malfunctioning of the system occurs

(*e*) *Hydraulic and pneumatic systems*

The primary check on these systems is to determine that the accumulators give a sufficient reserve in case of pump failure or during the simultaneous use of a number of services at once

Hydraulics are sometimes used for power controls and are tested as part of the control system Filters are examined at frequent intervals and samples of the fluid are taken for subsequent analysis The recent recommendation for hydraulic systems to be filtered to eliminate all foreign matter exceeding 5 microns in size will ensure the cleanest possible system and consequently the minimum amount of wear

(*f*) *External misting and rain*

Flights through rain are made to check the functioning of windscreen wipers, water tightness of the aircraft and any effects of erosion on the airframe

Any cases of external misting on the windscreens are investigated

(*g*) *Icing of Rotors, etc*

Cases of icing up of rotor blades have been experienced but to date no successful anti-icing or de-icing system has been devised for production aircraft During the trials any incidents of icing are carefully noted and investigated to enable the problem to be understood Eventually the all-weather helicopter will need full protection against icing

(*h*) *Cabin conditioning*

The various characteristics which constitute cabin conditioning are tested as follows

(i) *Air contamination* The aircraft is checked at an early stage for carbon monoxide contamination and again at an interval of say 100 hours to ensure that there has been no increase due to deterioration in the structure

With the advent of turbine engines as the power unit for helicopters it is expected that trouble from carbon monoxide contamination will be minimised but it should be remembered that carbon monoxide is still present for some power conditions and with the much increased amount of exhaust products issuing from the turbine compared with those from the reciprocating engines there may still be sufficient carbon monoxide present to be dangerous For the present samples will be taken for analysis

Another product of combustion which will require consideration is carbon dioxide Long periods in an atmosphere heavily charged with carbon dioxide will produce excessive drowsiness which may in turn affect the efficiency of operation of the crew due to fatigue No measurements have yet been made of this contamination but some thought on instrumentation for this will soon be required as turbine driven helicopters arrive

The possibility of other kinds of contamination is also examined

There may be a requirement for special ventilation equipment as it may not be acceptable to rely on the opening of windows, which during tropical operation may allow sand to enter the cockpit or during a heavy rainstorm permit the penetration of rain Severe and unacceptable draughts can also arise from an open window

(ii) *Cabin Temperatures* The temperatures of the air near the head, hands and feet of each member of the crew are measured during the most adverse conditions obtainable during the trials

There is a tendency amongst helicopter designers to overlook the provision of suitable heating apparatus but with the increase in duration and use of the aircraft in wider extremes of climate a heat supply is now becoming a necessity With the advent of the turbine the supply of heat should be simplified by taking a tapping from the compressor

(iii) *Humidity and Internal misting* Cases of severe internal windscreen misting have been met particularly on the smaller types of helicopter If it is not possible to devise a technique to overcome this trouble it may be necessary to introduce windscreen heating

(iv) *Noise levels* Noise levels are measured in cockpit and cabin for all conditions of flight In most helicopters the noise levels generally exceed the desired overall level and sometimes conversation in the passenger compartment is impossible without shouting directly into the ear of the person with whom communication is desired The noise levels may also affect radio communication Crews who participate in frequent and long flights may

QUALITATIVE ASSESSMENT OF CABIN CONDITIONS

AIRCRAFT TYPE	DATE
SERIAL No	TO TIME
ENGINE	FLIGHT DURATION
REPORT No	BASE AIRFIELD

NAME	DUTIES	POSITION IN AIRCRAFT

FLIGHT CONDITIONS

HEIGHT	CLOUD
AIRSPEED	SUN
RPM	SETTING OF HEATING
BOOST	AND/OR VENT CONTROL

CLOTHING WORN

TEMPERATURE	HEAD	HANDS	FEET	BODY
COLD				
WARM				
HOT				

CONDITION OF AIR	FRESH	DRY	DRAUGHTY
	STUFFY	HUMID	NOT DRAUGHTY

NOISE LEVEL	VIBRATION LEVEL
SATISFACTORY	SATISFACTORY
UNPLEASANT	UNPLEASANT
EX UNPLEASANT	EX UNPLEASANT
UNBEARABLE	UNBEARABLE

Fig 2

NOTE BACK OF CARD LEFT FOR GENERAL COMMENTS experience temporary hearing losses and in extreme cases irreparable hearing loss may result

(v) *Vibration levels* Vibration levels are measured as near as possible to the crew seats For this purpose the measurements are usually made during a steady flight state, for example, maximum cruise, economical cruise, continuous climb and hover Checks may also be made during transition stages but these cases being of relatively short duration will not be so important to the study of crew fatigue as the steady flight state

It is emphasised that a complete assessment of vibration will already have been made by the contractor as part of the fatigue substantiation investigation It is not intended to extend these tests during the trials unless required for a special investigation of a particular failure during the trials

The vibration levels will be measured from time to time as a rough check on any deterioration of structure or transmission due to wear and tear

(vi) *Qualitative assessment of cabin conditioning* Although measurements of the various characteristics known collectively as cabin conditioning, *i e*, temperatures, humidity, noise and vibration are taken, an attempt is also made to assess the conditions qualitatively A questionnaire (Fig 2) has been devised which pilots and crew are encouraged to complete on each flight In addition to temperatures opinions on noise and vibration levels are also sought as these characteristics affect the comfort and hence the fatigue level of the crew

It is appreciated that there will be a wide scatter in the results in view of the many variables presented and each individual carrying out the assessment will have different ideas as to the required standard of comfort This assessment does, however, give the user the chance to indicate which characteristics he considers to be important in fixing a reasonable standard of comfort, and by cross reference to the quantitative measurements already made of the various characteristics, the individual limitations laid down in the Design Manual can be confirmed or amended to suit

It will be most important to ensure that environmental conditions are acceptable when all-weather flying becomes general in helicopter flight

Instrumentation

Instrumentation is required to make the measurements of the systems described in the previous section In order that the measurements can be made without interruption to the smooth running of the trials, the instrumentation should be portable or semi-portable as far as possible A few fixed instruments such as fuel flow meter or vibration pick-ups may be necessary but it is desirable that these should be kept to a minimum

A brief description of the various instruments which have been assembled now follows

(*a*) *Carbon monoxide indicator* (Fig 3) Samples of air are collected in the rubber containers and transferred to the laboratory for analysis

(*b*) *Temperatures* The following instruments are available for the measurement of temperatures

(1) Portable Thermometer A portable thermometer (Fig 4) has been

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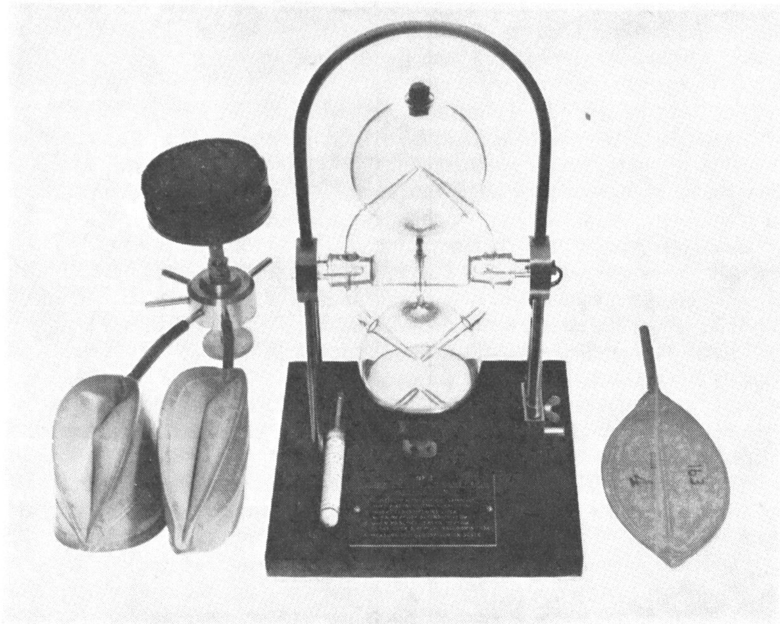

Fig 3 Carbon monoxide indicator

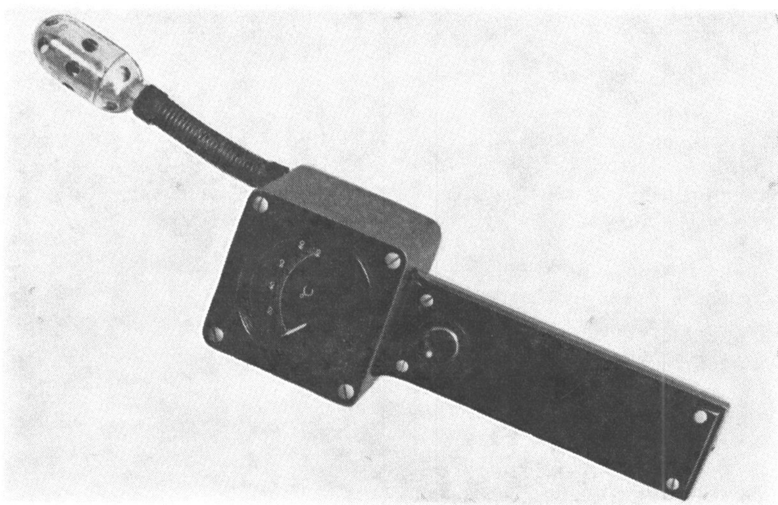

Fig 4 Portable thermometer

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developed which can be carried in the hand and the probe can be used to examine the temperature in a relatively confined space The accuracy is approximately $\pm 2°C$ and the stabilising time in circulating air is about 1 minute

(ii) Rototherm This thermometer, which is the standard commercial instrument, has had the rear casing drilled to enable the ambient air to engage the bi-metallic strips more quickly The accuracy is approximately $\pm 2°C$ and it stabilises in about 5 minutes This instrument can be clipped quickly to any convenient part of the structure for long term tests

(iii) Ratiometer type thermometer If it is found necessary to check temperatures in an inaccessible position the ratiometer type instrument is used, with the gauge placed at any convenient spot in the aircraft for recording If an approximate answer only is required the bulb may be replaced by a " stick-on " nickel element, this being particularly useful for measuring surface temperatures of skins or pipes

(iv) Temperature sensitive paint For rough and ready estimates of temperatures of zones, for example, engine bay temperatures, temperature sensitive paint may be used

(*c*) *Pressures* If pressures are to be measured, for example, in fuel or hydraulic systems the standard Bourdon or capsule type instrumentation is used

(*d*) *Noise levels* Alternative methods of noise measurement are available

(i) The Herman Scott sound level meter is a portable instrument complete with microphone, amplifier and gauge, reading directly in decibels The range is from 34 to 140 db and an accuracy of ± 1 db is claimed An Analyser may be used in conjunction with the meter which consists of

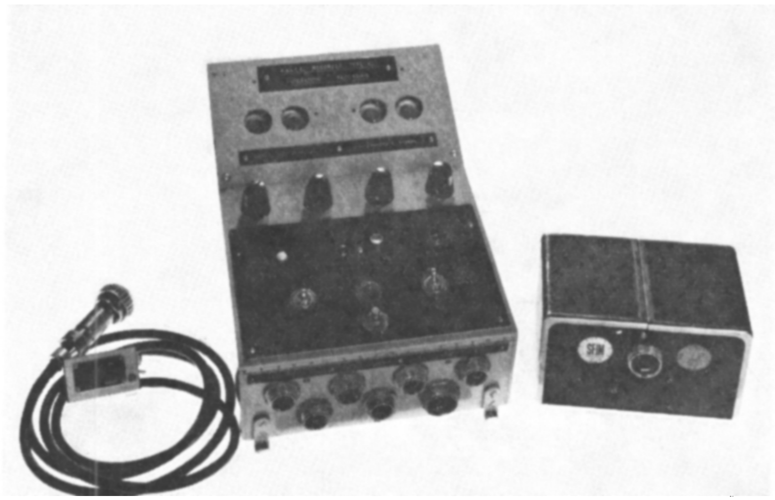

Fig 5 de Havilland pick-up

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a series of filters covering the half octave bands in the above range The results for one flight condition can be measured in about 5 minutes

(ii) E M I Tape Recorder This is the standard commercial instrument which has been modified to incorporate a stepped attenuator on the input side to replace the normal volume control The sound sample can be taken for any specified condition of flight and brought back to the laboratory for analysis into octave bands or close band if required

(e) *Vibration levels* Two simple methods for measurement of vibration levels are available

(i) Askania Vibration Recorder This is the commercial hand held instrument for recording vibration on a spool of waxed paper The stylus is displaced by a probe held against the vibrating object Some skill is required to operate this instrument satisfactorily but a reasonably accurate record of amplitude against frequency may be obtained

(ii) de Havilland Pick-up (Fig 5) This pick-up is a velocity measuring device which may be integrated, amplified and recorded on a Hussenot recorder (A 22) The instrument will give reasonably accurate results down to about 5 cycles per second The pick-ups are fixed at the spot where the vibration measurement is required and the recorder can be placed in any convenient position

Role Trials

An important feature of operational reliability trials is the use of the aircraft to demonstrate that the various designated roles can be successfully undertaken Since the trials aircraft is usually the first completely equipped vehicle to be tested, any difficulties in a particular role due to interference from other roles, for example fixed fittings in awkward places, can be readily assessed During prototype trials when probably one specific role in an empty fuselage is being assessed many installational details may be overlooked One advantage of checking these features during an operational reliability trial is that while the main function of the trial is to build up flight time, this usually gives adequate time for several repeats of a specific role This enables the test conditions to be varied and optimum operational techniques to be worked out Man-hours required to change from one role to another and any difficulties involved, are recorded

Some of the more common roles undertaken by the helicopter are now discussed

(i) *Communication* For this role the passenger seats are installed and the heating and ventilating equipment must be working Typical cross country flights are made under various climatic conditions during day or night Temperatures may be checked and each passenger will complete a qualitative comfort questionnaire

For the trooping role the passengers would wear and carry full operational equipment Suitable stowages must be found for loose equipment carried by the troops

(ii) *Casualty Evacuation* This role is similar to the communication role except that the seats are replaced by stretchers and simulated "patients" are carried together with a medical orderly and medical equipment Environmental conditions affecting the patients are studied and such questions as adequate lighting for emergency operations are assessed Difficulties of loading may arise especially during night flights

(iii) *Air Sea Rescue* This role involves the use of the winch which will have already been cleared technically but which can now be used intensively, particularly for an assessment of the life of the winch cable Trials are made with live passengers firstly dry and later wet and any difficulties associated with the operation are recorded

(iv) *Paratrooping* The fixed fittings for the role are installed and optimum flight conditions, *e g*, speed and height of dropping are determined, firstly with dummies and later with live personnel

(*v*) *Carriage of Freight* Internal and external carriage of freight is considered

(*a*) Internal freight A selection of typical loads is made and techniques for loading are worked out Lashing points are checked and cross country flights are made

(*b*) External freight The equipment comprising cargo hook, controls and cables are fitted to the aircraft, noting the time required and any difficulties of fitting A selection of typical loads is made and in this case size, shape and density of load are important in that these characteristics may affect the stability of the load and aircraft in flight Again techniques of loading are worked out and for this type of operation an important member of the team is the marshaller who controls the operation as the loaders are working under the helicopter while hovering A good marshaller can save considerable time during loading by intelligent anticipation of the events For operations in remote places a marshaller may not be available and in this case the task could be hazardous and calls for great skill in handling the aircraft An important feature of this trial is that the load can be jettisoned safely especially during autorotation

(vi) *Military roles* Special military roles are checked when specified

Duration of Operational Reliability Trial

Without a background of experience it is not easy to decide on the duration of an operational reliability trial for a helicopter On fixed wing aircraft a duration of 150/200 hours has been accepted, during which time it is anticipated that most of the defects and difficulties of operation will have shown up

In the helicopter with its higher proportion of moving parts and inherent higher level of vibration due to its peculiar aerodynamic characteristics, compared with a fixed wing type, it is possible that a total much greater than 200 hours flight time is necessary before one is sure that all the more important snags have been found The higher vibration level will tend to produce fatigue failures of such items as brackets and panels, and to increase the rate of wear and backlash in moving parts this in turn may further increase the vibration level It is probable therefore that a much higher target is required for the trials on a helicopter than for a fixed wing aircraft

Operational reliability trials or functional development trials are now being made in the U S A on new type helicopters with durations up to 600 hours per aircraft In one case a total of 1,000 hours was achieved on one aircraft in the remarkably low time of six months

Fig 6 illustrates the results of an operational reliability trial which is in progress at the Official Testing Establishment The first phase was of 240 hours duration which was achieved in 70 days The task was to build up hours as quickly as possible and the general pattern consisted of two 3 hour sorties/day over 5 days per week with servicing carried out in the evenings and weekends

After strip inspection and rectification the second phase of the trials was commenced but during this time, no overtime was used Sorties of much shorter duration were included in the programme and several investigations were made which included some periods where it was not possible to fly Under these conditions it is apparent that the intensity of flying dropped to about 25% of that achieved during phase 1 of the trials

If, therefore, a very high rate of flying is required, special control of the programme is necessary and servicing must be done during the hours of

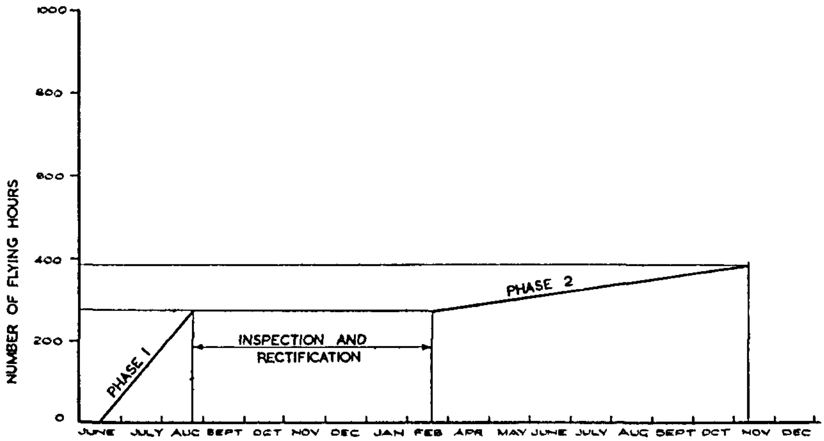

Fig 6 Operational reliability or intensive flying

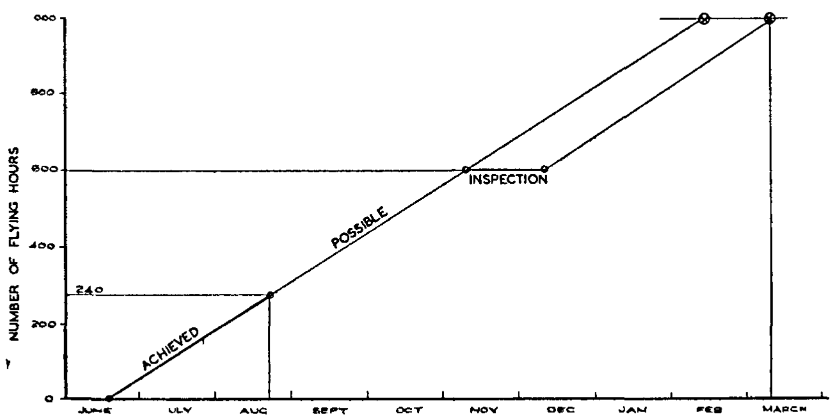

Fig 7 Operational reliability or intensive flying

darkness The flying rate achieved in phase 1 has been extrapolated to a total of 1,000 hours (Fig 7) and an allowance made of one month for a major inspection Under these conditions it will be seen that a total of 1,000 hours is possible in about 9 months This time could, of course, be improved if the task were undertaken by a flight whose sole duty was the conduct of intensive flying

The trials so far have been discussed on the basis of temperate flying only, but it is desirable that some of the time should be spent under extreme climatic conditions and it is considered that by careful timing it should be possible to conduct part of the trial, say 150 hours, at the Tropical testing unit and a further 150 hours at the Sub-arctic unit without much delay in the general programme

Since a lot of the information required from trials of this nature is statistical it would be an advantage if more than one aircraft could be tested and consideration could be given to one or two production aircraft subsequent to the trials aircraft being subjected to a modified form of intensive trials under full service conditions

Conclusions

It is concluded that an operational reliability trial on a new type helicopter will do much to eliminate the snags which arise during the early service life of the aircraft While the flying hours are building up and showing up early defects and difficulties, tests can simultaneously be made with portable instrumentation to check that production type systems function similarly to those tested on the prototype Roles may be checked during the trials It is recommended that the duration of the trial should be 1,000 hours and should be conducted in the quickest possible manner

Experience gained from the trials will be of value to the designer in the development of subsequent types of helicopter

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The opinions expressed in this paper are those of the Author and do not necessarily reflect the official views of the Ministry of Supply

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Discussion

Mr T G G Newbery (*Ministry of Supply*) (*Member*), in opening the discussion, said they had heard a very interesting talk, and there was a great deal in the paper which could lead to argument and discussion At times, opinions were expressed concerning the usefulness of the testing establishment at Boscombe Down Tonight, the Author had given a slight insight into some of the work done at the establishment and he had made a case that at least some of it was useful Mr Newbery added that before making his comments, he should explain that any opinions he expressed were simply his own personal opinions and not necessarily those of the Ministry

In the paper, the Author said it was assumed that the engine development would be carried out in parallel with the helicopter development, so that the engine arrived at the production stage at the same time as the helicopter One of the problems which had faced engine designers and manufacturers in connection with helicopter