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MINISTRY OF AVIATION

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

DETERMINATION OF THE RANGE PERFORMANCE OF A GAS TURBINE ENGINED HELICOPTER FROM FLIGHT TEST RESULTS

BY

G. F. LANGDON, B.SC. (ENG.)

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Determination of the Range Performance of a Gas Turbine Engined Helicopter from Flight Test Results

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Summary

After a simplified theoretical introduction this report deals with methods of analysing flight test results and planning a test programme to determine the range of a turbine engined helicopter and how it should be flown to achieve the greatest range.

Results for a particular helicopter show that in standard atmospheric conditions the best range will normally be achieved when flying at the maximum permitted rotor speed and airspeed at an altitude which increases with decreasing weight but is, for normal operating weights, about 6,000 feet. There may be an appreciable loss of range if the wrong altitude is chosen.

It is shown that a twin turbine helicopter may achieve its maximum range by flying on one engine.

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1. Introduction

In this note we consider the operation of a helicopter to enable it to fly most economically, that is to cover the greatest distance on a given quantity of fuel.

This problem has been considered by Sutherby in relation to design studies of new helicopters (1); in the present report we are concerned with the flight testing of existing aircraft and the use of the test results to discover the best operating technique for range flying.

We begin with a simplified theoretical discussion to show the physical relationships involved; this follows the method used by Annand in his investigation of the range of aeroplanes (2). Following the preliminary theory we take flight test results from a typical helicopter and use them to demonstrate how such results should be analysed, firstly when only the airframe characteristics are considered and secondly when a gas turbine engine is fitted. We then show the effect on range of equipping the aircraft with twin engines and finally examine the conditions for maximum endurance as opposed to maximum range.

2. Simplified Theoretical Discussion

The range of a helicopter can be calculated by the method given in Reference 1, or indeed by any standard performance method, but it is convenient before going on to deal with flight test results to use a simplified method to show the physical relationships involved.

The power required by a helicopter rotor can be divided into three parts: the power required to overcome fuselage drag, the power required to rotate the rotor and to drag it through the air and the induced power required to produce lift.

We have then

$$P = DV + P_R - Tv$$ (noting that by convention an upward induced velocity is positive)

To simplify the analysis we now make the following assumptions.

1. That the fuselage drag coefficient is constant, although it may in fact change slightly as the altitude of the aircraft varies with speed.

2. That the thrust is equal to the weight and that the momentum theory is valid. This is reasonable for the speeds of interest in range flying.

3. That the effect of both radial flow and the variation of blade incidence round the disc can be represented by including the factor $(1 + c\mu^2)$ in the expression for rotor power. Glauert (3) showed that radial flow effects could be accounted for by putting $c = 4.6$ at normal values of μ while Armitage (4) presents a curve which shows that the effect of cyclic incidence variation on blade drag can be represented by multiplying P_R by about $(1 + \mu^2)$. Combining these expressions we get $c = 5.6$.

4. That the mean drag coefficient of the rotor blades can be expressed as $\Delta + \Delta_1 \frac{C_T^2}{s_1}$.

With these assumptions we have

$$P = K_D A \rho V^3 + \frac{A s_1 \rho}{8} (\Omega R)^3 \left(\Delta + \Delta_1 \frac{C_T^2}{s_1^2}\right) (1 + 5.6\mu^2) + \frac{C_T^2 \rho A (\Omega R)^4}{2V}$$

/Figure 1 ...

Figure 1 illustrates the way in which the power required for level flight varies with forward speed at constant weight, altitude and rotor speed. It will be seen that there is a speed, usually about half the maximum, at which the power required is least. In the same way Figure 2 shows the variation of rotor profile power with rotor speed for a particular rotor with $s_1 = 0.05$, $\Delta = 0.01$, $\Delta_1 = 1$. The profile power depends on the blade drag coefficient and the cube of the rotor speed and at a given weight the drag coefficient falls as the rotor speed is increased. The power required will then be a minimum at the thrust coefficient corresponding to a particular rotor speed.

The fuel used per mile is then, from the equation for power

$$F = \frac{Ps}{V} = s\left\{ K_D A\rho V^2 + \frac{As_1\rho(\Omega R)^3(\Delta + \Delta_1 C_T{}^2/s_1{}^2)\ (1 + 5.6\mu^2)}{8V} + \frac{C_T{}^2\rho A(\Omega R)^4}{2V^2} \right\}$$

where s is the specific fuel consumption of the engine.

Before proceeding it is convenient to introduce

$$K = V\left(\frac{A\rho}{W}\right)^{\frac{1}{2}} (2K_D)^{\frac{1}{4}}$$

K is the ratio of the equivalent airspeed to the minimum drag speed of an idealized aeroplane with the same lifting area and parasitic drag. The equation for F then becomes

$$F = sW\sqrt{\frac{K_D}{2}}\left\{ K^2 + \frac{1}{K^2} + \frac{s_1{}^{-\frac{1}{2}}}{4.76K_D{}^{\frac{1}{4}}}\left(\frac{\Delta s_1{}^{3/2}}{C_T{}^{3/2}} + \frac{\Delta_1 C_T{}^{\frac{1}{2}}}{s_1{}^{\frac{1}{2}}}\right)\left(\frac{1}{K} + \frac{3.96KC_T}{\sqrt{K_D}}\right)\right\}$$

The fuel used per mile is thus given for any particular helicopter in terms of the specific fuel consumption of the engine, the weight of the helicopter and two non-dimensional quantities*; K, which is proportional to $V_i/\sqrt{W}$ and C_T which is proportional to $W/\sigma\Omega^2$.

For maximum specific range at any weight then the aircraft must be flown at such a speed, altitude and rotor speed that the specific fuel consumption multiplied by the expression inside the curly brackets is a minimum.

2.1 Engine of Constant Specific Fuel Consumption

The minimum possible value of F, which can only be achieved with a dragless rotor, is $sW\sqrt{2K_D}$ at $K = 1$, corresponding to the performance of an idealized aeroplane. For any real rotor the best value of F will be greater than this and will occur at a rather higher airspeed at a thrust coefficient above that which gives minimum rotor profile power. This is illustrated in Figure 3 which shows the variation of F with K for various thrust coefficients for a helicopter with $K_D = 0.01$, $s_1 = 0.05$, $\Delta = 0.01$ and $\Delta_1 = 1$.

We can say then for the simple helicopter with engine of constant efficiency the maximum range will be attained by flying at a certain equivalent airspeed proportional to the square root of the weight and at such a combination of altitude and rotor speed that the thrust coefficient has a particular value.

This means that at any weight there is, at least theoretically, the choice of flying high with a high rotor speed or low with a low rotor speed and that at any altitude the best rotor speed increases with increase in weight. When the aircraft is flown at the optimum conditions the range will be inversely proportional to its weight.

/2.2 ...

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*This system is used in this section instead of the more familiar μ and C_T in order to separate the effects of forward speed and rotor speed.

2.2 Effect of Variation in Engine Specific Fuel Consumption

The specific fuel consumption of a real engine may vary with power, with altitude and with rotor speed, all of which are under the control of the pilot. It will also vary with air temperature.

The specific fuel consumption usually falls with increasing power and the main result of this is that it becomes efficient to fly at a speed higher than that for minimum drag as the increase in power required to do so is offset by the fall in specific consumption.

An idea of the size of this effect can be gained by putting $s = s_o\left(\frac{P}{P_o}\right)^n$ and differentiating the equation for F. This leads to the expression

$$\frac{dF}{dK} = sW\sqrt{\frac{K_D}{2}}\left\{(2 + 3n)\,K - \frac{(2 + n)}{K^3} + \frac{s_1}{4.76K_D^{\frac{1}{4}}}\left(\frac{C_D}{C_T{}^{3/2}}\right)\left(3.96[1 + 2n]\,\frac{C_T}{\sqrt{K_D}} - \frac{1}{K^2}\right)\right\}$$

and from this the best value of K can be found for any value of n and C_T. Figure 4 shows the best values of K associated with different n's and it can be seen that for a gas turbine in which the s.f.c. falls rapidly as power is increased it pays to fly considerably faster than the speed for minimum drag.

It is also apparent that as C_T is increased the value of K for best range decreases. In some practical cases it will be found impossible to maintain the most efficient thrust coefficient at high weight and altitude without exceeding the rotor speed limit and under these conditions the best value of K will decrease as weight is increased, sometimes rapidly enough to lead to a decrease in the best range speed as weight increases.

Any change in specific consumption with rotor speed will result in a change in the thrust coefficient for best range; the change will usually be small.

Turbine engines become increasingly more efficient as their operating height is increased and therefore for the greatest range a turbine engined helicopter must be flown high, using a high rotor speed to maintain the thrust coefficient near its optimum value.

3. The Analysis of Experimental Results

It is impracticable, and indeed unnecessary, to measure the fuel consumption of a helicopter at all possible combinations of weight, altitude, airspeed and rotor speed to determine the most economical way of flying at any weight. In this section we show how flight test results obtained at a limited number of conditions can be used to predict the performance throughout the permissible flight envelope.

Before going further two points must be emphasised: first, that the simplifying assumptions of Section 2 are not used in the present section, and second, that although range performance can be deduced from quite a small number of flights the number can be curtailed only by careful selection of the conditions of the tests.

3.1 Basis for Analysis

If we neglect the effect of changes in Reynolds number the power required to maintain a helicopter in level flight can be expressed by dimensional analysis in either of two forms

$$C_p \;=\; f(\mu)(C_T)(M)$$

/which ...

which for a particular helicopter becomes

$$\frac{P}{\sigma\Omega^3} = f\left(\frac{V}{\Omega}\right)\left(\frac{W}{\sigma\Omega^2}\right)\left(\frac{\Omega}{\sqrt{\theta}}\right) \quad \text{..........} \quad (1)$$

or alternatively the power required can be expressed as

$$\frac{P}{p\sqrt{T}R^2} = f(\mu)\left(\frac{W}{pR^2}\right)\left(\frac{\Omega R}{\sqrt{T}}\right)$$

which for a particular helicopter can be written

$$\frac{P}{\delta\sqrt{\theta}} = f\left(\frac{V}{\Omega}\right)\left(\frac{W}{\delta}\right)\left(\frac{\Omega}{\sqrt{\theta}}\right) \quad \text{..........} \quad (2)$$

If compressibility effects can be neglected the first presentation reduces to

$$\frac{P}{\sigma\Omega^3} = f\left(\frac{V}{\Omega}\right)\left(\frac{W}{\sigma\Omega^2}\right)$$

3.2 Typical Experimental Results - Airframe Characteristics

In this section we take the results of level flight tests on a particular helicopter and use them to illustrate the effect on range of changes in airframe operating conditions neglecting the effect of these changes on the engine. This exercise serves as an introduction to the method of dealing with flight results and as a check on the theoretical predictions of section 2.1.

Figure 5 shows the power required in level flight plotted on the basis of Eqn. 1. The results were obtained at different combinations of weight and altitude but at one rotor speed, and in plotting them in this way we assume that compressibility effects can be neglected. It is convenient here to introduce the symbol ω - the ratio of the actual rotor speed to the datum speed, in this case 220 r.p.m. From this figure the power required at any speed, weight, altitude and rotor speed can be found.

If we use V/P, which is equal to specific range multiplied by specific fuel consumption, as a measure of airframe efficiency then from the data in Figure 5 we can prepare Figure 6 from which the efficiency can be found for any conditions. From this we can plot Figure 7 which shows the best efficiency that can be obtained at various aircraft weights. It can be seen that this bears out the theoretical predictions that the best range is inversely proportional to the weight and is obtained at a value of $\rho\Omega^2$ roughly proportional to weight. The range is independent of altitude if the correct rotor speed and airspeed are used for the altitude concerned but it may in fact be impossible to use the best rotor speed without exceeding the airframe limitations. The effect of these limitations is shown in Figure 8 which demonstrates that at any given weight the maximum specific range will only be attainable within a restricted altitude band. This figure also shows the rotor speed and airspeeds associated with maximum range.

3.3 Typical Experimental Results - Helicopter fitted with Turbine Engine

We now consider the practical problem of calculating the best specific range of turbine engined helicopter from test results. It can be shown that the specific fuel consumption of the engine is a function of $(P/\delta\sqrt{\theta})$ and $\Omega/\sqrt{\theta}$. The fuel consumption of the particular engine fitted to the test aircraft was measured during the level flight tests and was found to be independent of $\Omega/\sqrt{\theta}$ over the limited range covered: the results are therefore presented as the single curve of Figure 9. It is likely (5) that the s.f.c. of most turbine engines fitted to helicopters will not vary much with rotor speed, but the following method of dealing with test results is suitable whether or not this is so.

/Because ...

Because changes of rotor speed affect the airframe and engine performance differently it is first necessary to prepare separate plots of non-dimensional range performance at a number of rotor speeds. Such plots can be derived from Figures 5 and 9 by simple arithmetic if we neglect compressibility effects and are shown for the example aircraft as Figure 10. If compressibility can not be neglected in any particular case the results can still be plotted in the same form as Figure 10 but will have to be obtained at more than one rotor speed. The engine fitted must not exceed a particular compressor speed for continuous operation and the permissible continuous value of $P/\delta\sqrt{\theta}$ is therefore dependent on temperature. Lines showing the effect of this limitation are plotted on Figure 10 and this figure then presents the range performance of the example helicopter in a generalized form applicable to all atmospheric conditions.

From this generalised presentation the performance in particular conditions can be calculated and this has been done for a band of weights and altitudes with the results given in Figure 11.

By comparison of this Figure with Figure 8 it can be seen that the effect of the engine is to modify the airframe efficiency in two main ways; the best speed is increased and there is an optimum altitude which depends on the aircraft weight.

4. Planning the Test Programme

Adequate information for specific range calculations will usually be available from the results of the normal level flight tests on the aircraft. Cases may arise, however, when it is necessary to assess the range performance ab initio and in such cases the flying programme must be arranged to yield the information required in as little flying time as possible.

If, after consideration of the rotor tip speeds and lift coefficients involved it is decided that the effects of compressibility can be neglected it will only be necessary to consider the variation of range with C_T and μ.

The measurements need only be made at tip speed ratios above that for minimum power but the range of thrust coefficient covered should be as large as practicable. It is particularly important to obtain results at high values of C_T, by testing at maximum weight and altitude with minimum rotor speed, because the permissible all up weight of an aircraft type is usually increased as it is developed and so it is extremely useful to be able to predict the specific range performance at higher weights than that allowed for the test aircraft. There should, in fact, be little difficulty in covering the required range of thrust coefficients in three, or possibly four tests and because we are only interested in speeds above that for minimum power it will often be practical to carry out tests at two thrust coefficients in one flight by changing altitude.

If preliminary estimates indicate that Mach number may be important the programme must be planned to cover the range of thrust coefficient at two Mach numbers by running tests at two rotor speeds.

5. Effect on Range of Departure from Best Operating Conditions

We have shown how to use experimental results to determine the speed, altitude and rotor speed at which a particular helicopter flies most economically and for the best range the aircraft must be operated to keep these three quantities at their best values as the aircraft weight changes during a flight. We now consider what penalty must be paid if we chose to fly at conditions other than the optimum.

Figure 12 shows the range of the helicopter used as an example when operated with the same fuel load in various different ways. In each case the take-off weight is 12,000 lb. and the fuel load 2,000 lb., and it can be seen that the best attainable range without exceeding the airframe limits is

/340 nautical ...

340 nautical miles. To attain this would involve changing altitude and speed throughout the flight, which is inconvenient, but it appears from the figure that there is practically no loss of range if the aircraft is flown at the constant airspeed, rotor speed and altitude appropriate to the take-off weight. Using the best altitude but a lower rotor speed results in a decrease in range of about 20 miles (6%). As a final example the range at sea level, flying at the best airspeed and with rotor speed constant at the best value for the mean weight, is reduced by 55 miles (16%) of the theoretical optimum.

From these examples we can see that for a typical helicopter there is little advantage to be gained in altering the flight conditions to take advantage of the weight changing as fuel is used, that it is advisable to select the correct rotor speed for the altitude and weight concerned and that in long flights it is definitely worth while operating at the best altitude.

In preparing Figure 12 no allowance was made for the fuel used in climbing and the actual range must depend to some extent on the climb technique used. A slow climb is obviously unprofitable because of the marked decrease in range at low altitudes and we have only to decide between climbing at the speed for best rate of climb, or for best range, in either case using the 'one hour' rating of the engine. For the helicopter we are considering we obtained the following estimated figures:

	Climb at speed for best range	Climb at speed for best rate of climb
Fuel used on climb	130 lb.	67 lb.
Distance covered on climb	16 n.m.	5 n.m.
Range at 8,000 ft.	313 n.m.	323 n.m.
Total range	329 n.m.	328 n.m.

from which we conclude that the climb technique chosen has little effect on range.

6. Twin Turbine Engined Helicopters

Let us suppose that the helicopter used in the preceding examples is fitted with twin engines and that for safety in the event of engine failure the engines are chosen so that the aircraft can just hover on one engine under I.C.A.O. conditions at a weight of 12,500 lb. This gives an emergency power rating of 1,200 H.P. and a maximum continuous rating of, say, two-thirds of this or 800 H.P.

It will be obvious that at any total power the specific fuel consumption of the installation will depend on the way this power is divided between the two engines. From the point of view of transmission loads and engine maintenance it is probably best and certainly simplest to run each engine at the same power but this will not give the best fuel consumption. For maximum range one engine should be used to deliver all the power up to its maximum continuous rating and the second engine only used at higher powers. Figure 13 shows the variation of overall specific fuel consumption with total power and it will be noticed that at single engine continuous rating there is a saving of 20% in fuel consumption given by flying on one engine instead of two. In the remainder of this section we assume that there is no restriction on the way power is shared between the engines and for simplicity we consider the range at a constant rotor speed of 220 r.p.m.

/Figure 14 ...

Figure 14 shows the variation of specific range with weight and altitude and it appears from this that for this particular aircraft the best range will always be obtained with a single engine provided that the helicopter maintains level flight. The best range speed will be much lower than the corresponding speed with both engines operating. It may be noticed that the best specific range is rather greater than that of the original single engined machine. This is because when flying on one engine the minimum specific fuel consumption of the twin engine installation occurs nearer the minimum drag speed of the airframe than is the case with the single engined machine.

7. Endurance

The greatest endurance is attained by flying at minimum fuel flow which will occur at a speed slightly above or below that for minimum power. Flight test results can be analysed to predict the conditions for best endurance by methods similar to those presented for specific range calculation. As an example Figure 15 shows the results of such analysis for the example helicopter at a particular value of $\Omega/\sqrt{\theta}$. Once again the wisdom of choosing the correct altitude for the operating weight is evident.

8. Conclusions

The range of a helicopter varies with weight, altitude, airspeed and rotor speed; however by using a non-dimensional method of analysis it is possible to decide the best operating conditions for any given weight from the results of a carefully planned flight test programme involving comparatively little flying time.

Test results for a particular helicopter show that for best range it should be flown at maximum rotor speed, at an airspeed at or near the maximum permitted and at an altitude dependent on weight, being about 6,000 feet for a normal operational weight and increasing as weight decreases. For the particular helicopter used as an example restrictions on both altitude and airspeed prevent the best theoretical range being achieved at the lowest weights in temperate conditions.

It has been shown that for a representative fuel load there is little loss in range caused by flying at constant rotor speed, airspeed and altitude instead of varying them to suit the weight change provided that the correct speeds, and in particular the correct altitude is chosen. An appreciable loss in range results from flying too low.

Turning to the case of a twin-turbine installation, for the best range neglecting other considerations, it will probably be advantageous to fly on one engine.

References

No.	Author	Title, etc.
1	P.F. Sutherby	Possible Flight Paths for Helicopters. Journal of the Royal Aeronautical Society. December 1957.
2	W.J.D. Annand	The Range of Reciprocating Engined Aeroplanes. A. & A.E.E./Res/235.
3	H. Glauert	A General Theory of the Autogyro. A.R.C. R&M 1111 November 1926

/4. ...

References (Cont'd)

No.	Author	Title, etc.
4	A. Armitage	A Graphical Method for the Rapid Estimation of Helicopter Performance. Report No. RD(H) F20/1.
5	P. Krebs and W.S. Miller, Jr.	Performance Analysis of Fixed and Free Turbine Helicopter Engines. N.A.C.A. TN3654 June 1956.

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List of Symbols

A	Rotor disc area
b	Number of blades per rotor
c	A constant, defining variation of blade profile power with μ
c_1	Rotor blade mean chord
C_T	Thrust coefficient, $T/\rho A(\Omega R)^2$
D	Fuselage drag
F	Fuel used per unit distance flown
K	Defined in Section 2, proportional to $V\sqrt{\frac{\rho}{W}}$ for a given helicopter
K_D	Fuselage drag coefficient based on disc area = $D/\rho AV^2$
M	Mach number
n	A constant, defining variation of engine s.f.c. with power
P	Power
P_R	Power required to overcome rotor blade profile drag
p	Atmospheric pressure
R	Rotor radius
s	Engine specific fuel consumption
s_1	Rotor solidity $bc_1/\pi R$
s_o	Value of s at a particular power P_o
T	Thrust
V	True airspeed
V_i	Equivalent airspeed
v	Induced velocity
W	Helicopter weight
$\left.\begin{matrix}\Delta \\ \Delta_1\end{matrix}\right\}$	Constants depending on blade profile drag characteristics
δ	Ratio of atmospheric pressure to standard sea level value
θ	Ratio of atmospheric temperature to standard sea level value
μ	Tip-speed ratio, $V/\Omega R$
ρ	Atmospheric density
σ	Ratio of atmospheric density to sea level standard value
Ω	Rotor rotational speed
ω	Ratio of rotor speed to a nominal standard value

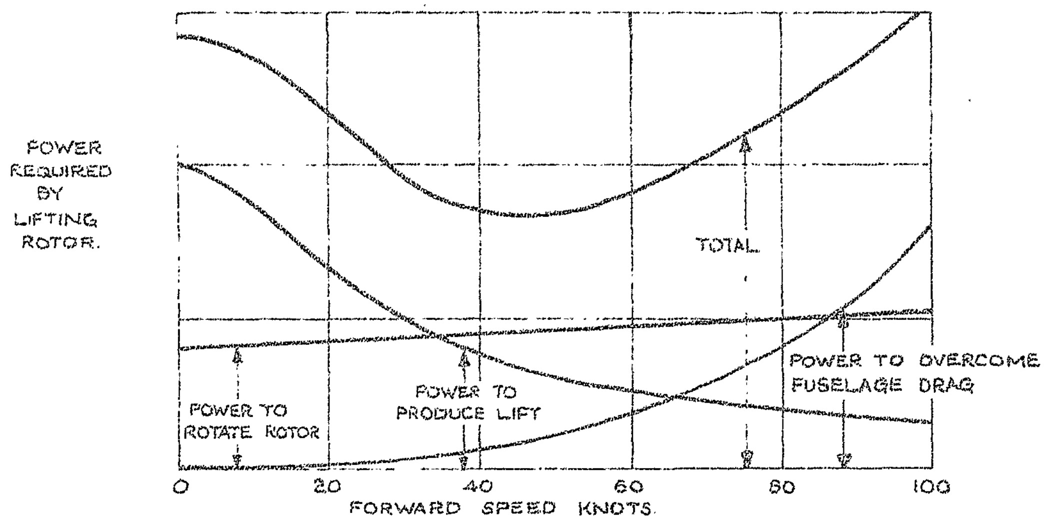


FIG. 1. POWER REQUIRED BY A HELICOPTER ROTOR IN LEVEL FLIGHT.

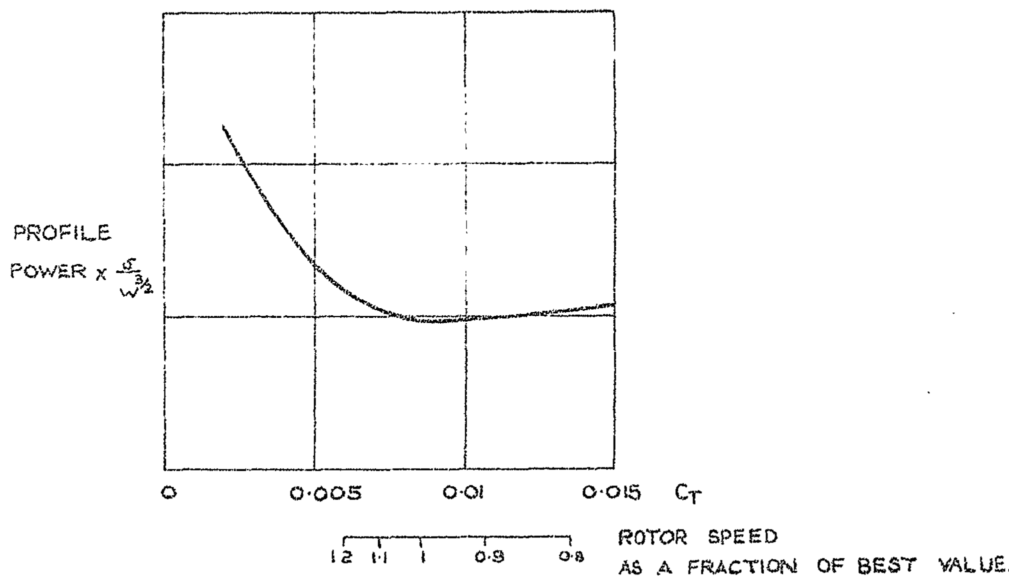
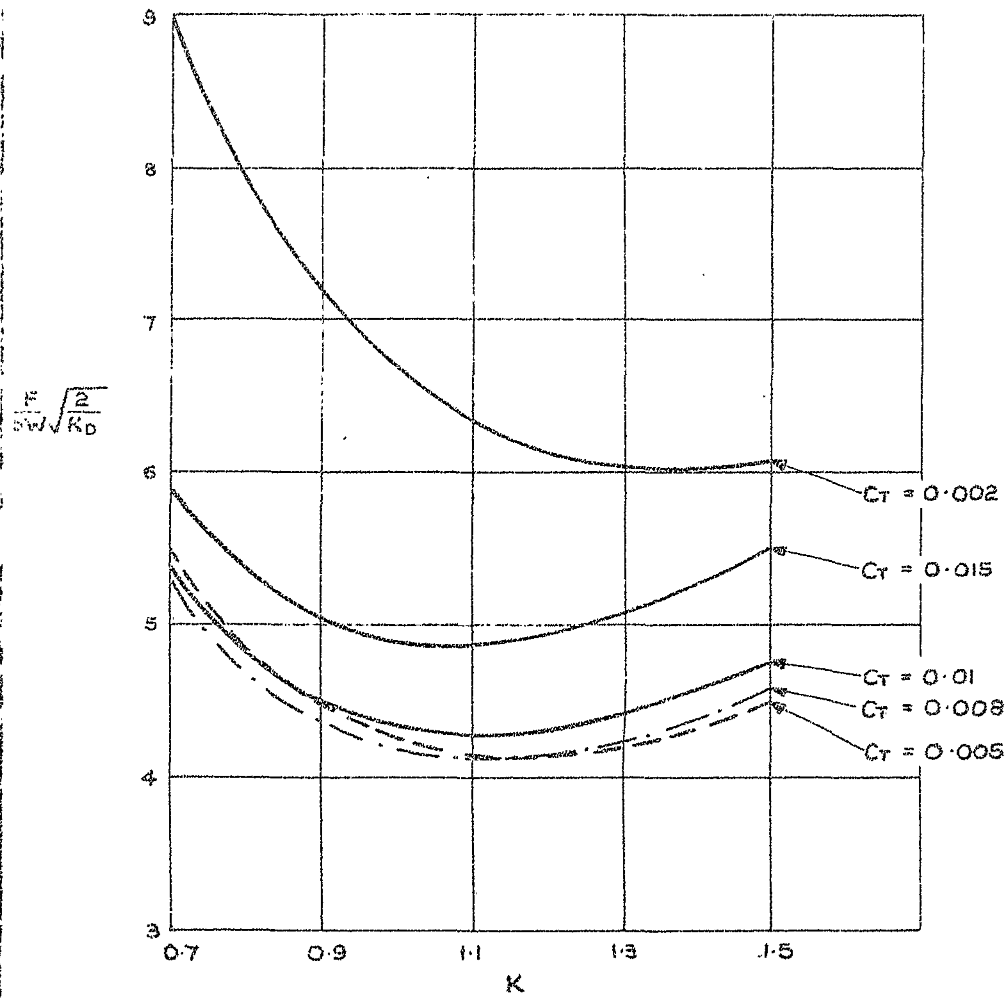


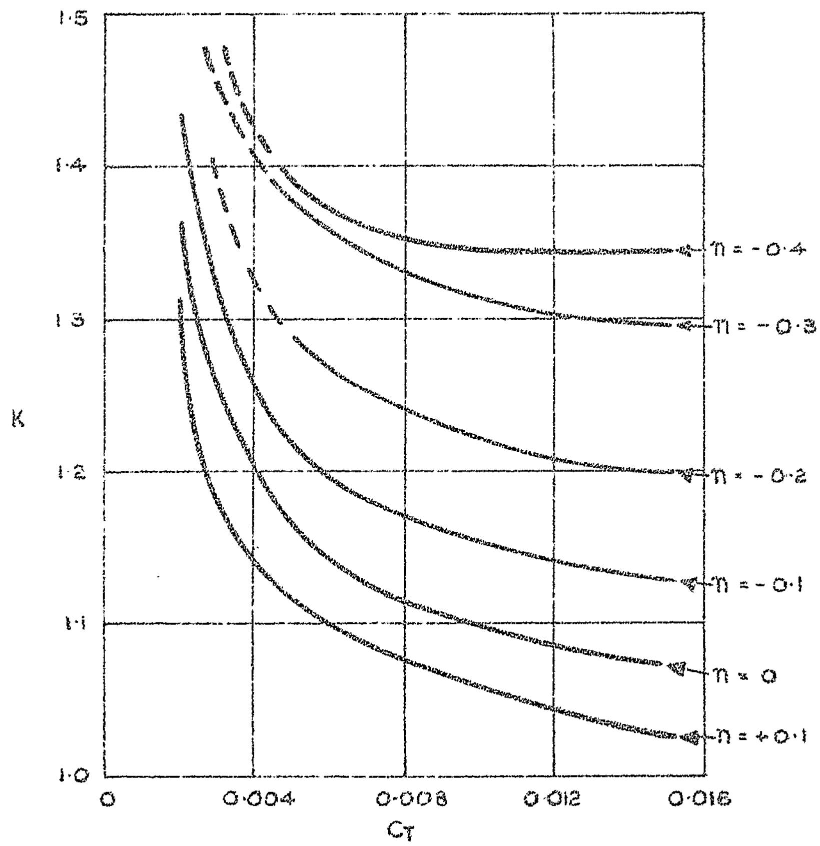
FIG. 2. TYPICAL VARIATION OF ROTOR PROFILE POWER WITH ROTOR SPEED WHILE HOVERING.

FIG. 3.



VARIATION OF FUEL REQUIRED PER MILE WITH K & C_T FOR A PARTICULAR HELICOPTER.

FIG. 4.



BEST VALUE OF K FOR VARIOUS VALUES OF n & C_T FOR A PARTICULAR HELICOPTER.

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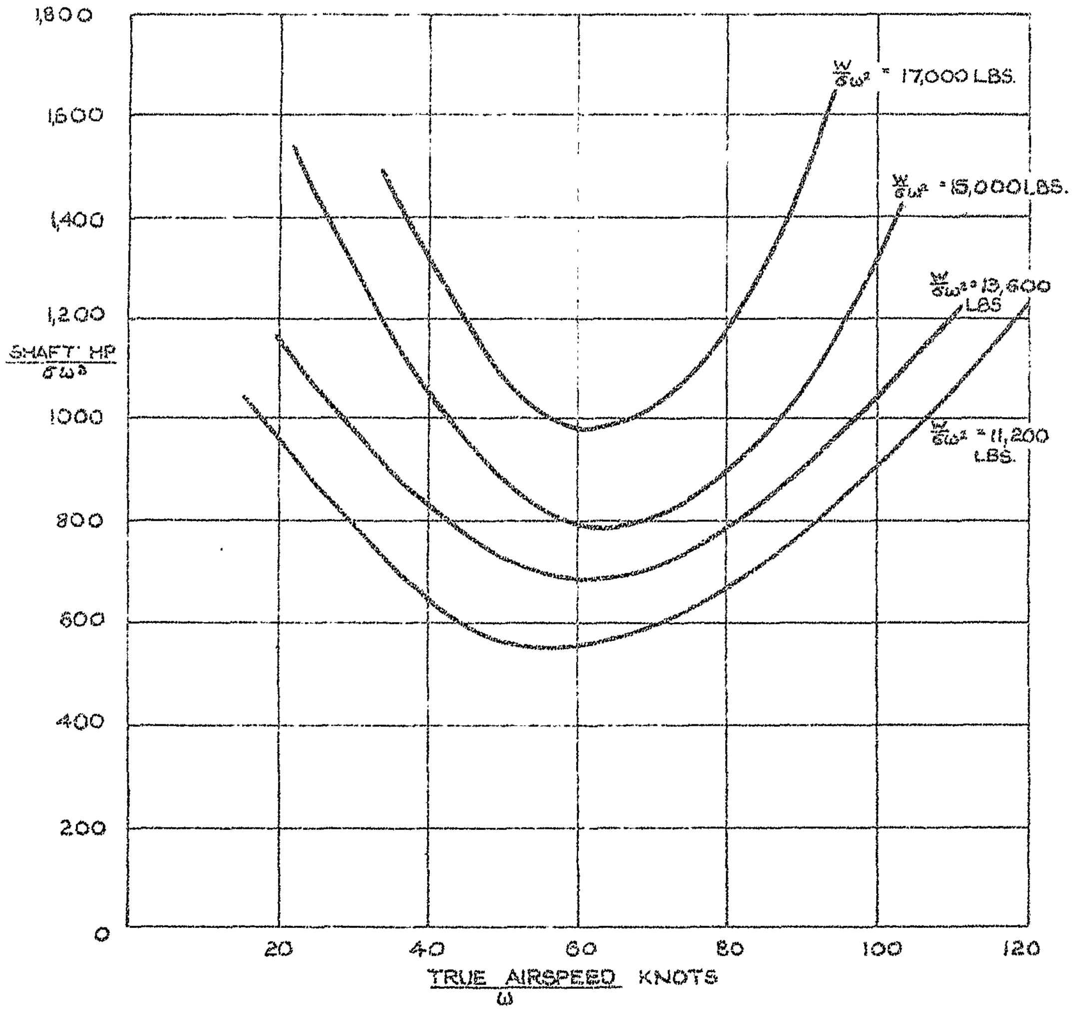
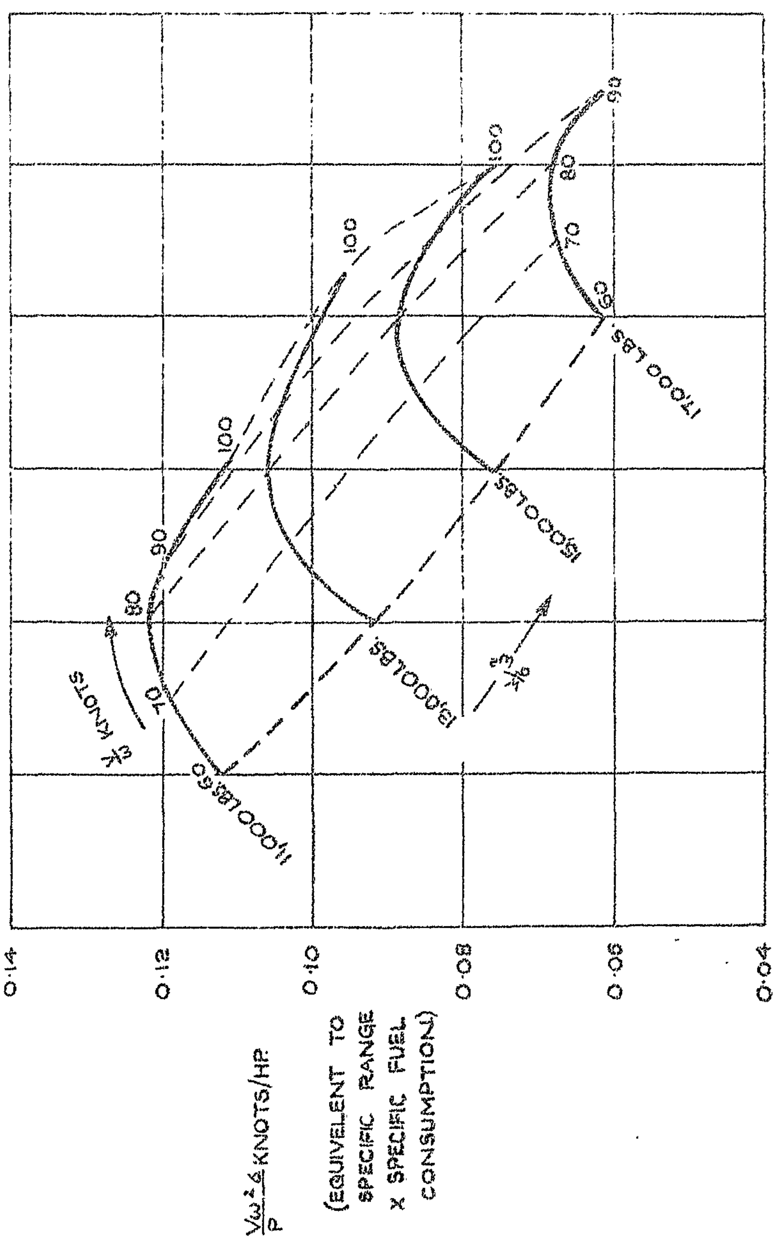
FIG. 5.



POWER REQUIRED FOR LEVEL FLIGHT. EXPERIMENTAL RESULTS AT 220 R.P.M.

FIG. 6.



AIRFRAME EFFICIENCY FROM EXPERIMENTAL RESULTS.

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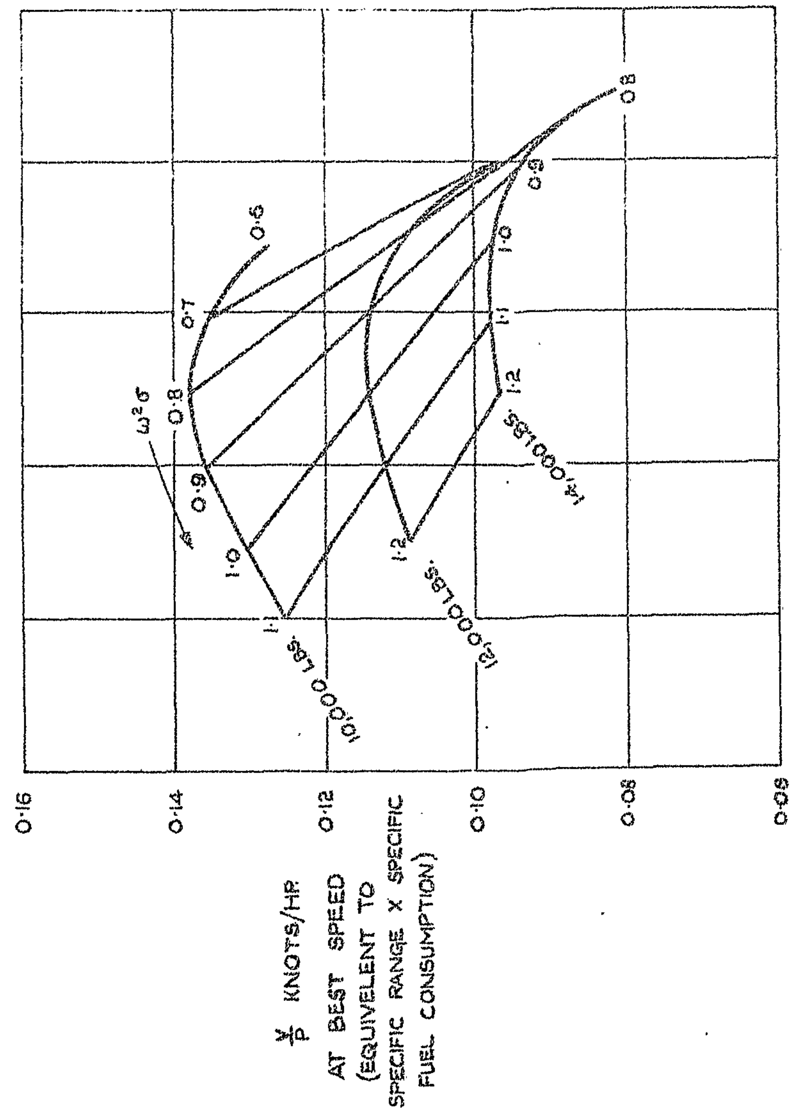
FIG. 7



AIRFRAME EFFICIENCY AT BEST SPEED FROM EXPERIMENTAL RESULTS.

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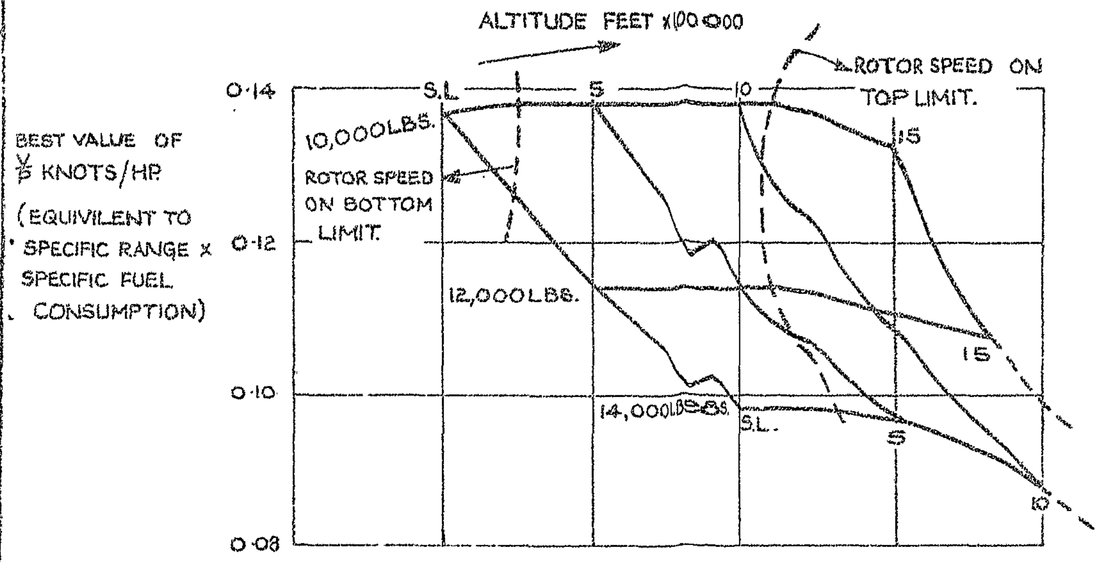
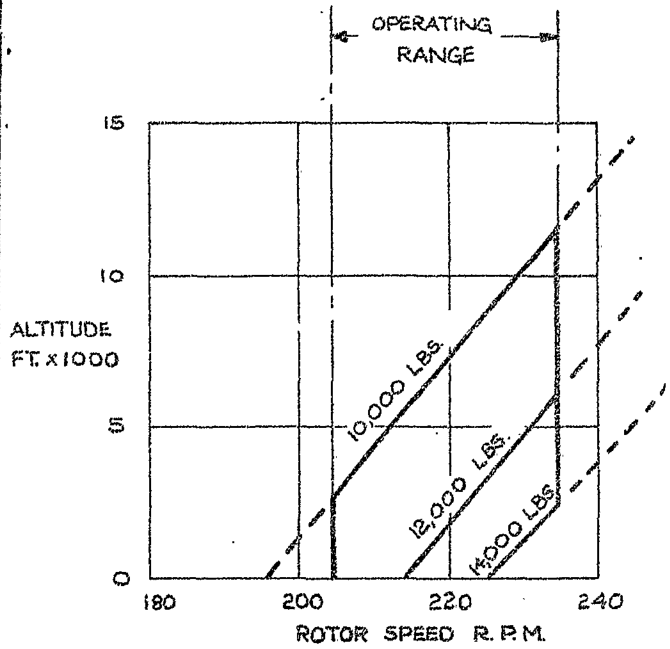
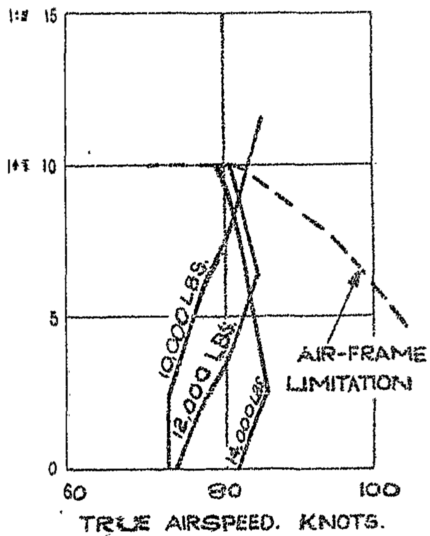
FIG. 6.



BEST AIRFRAME EFFICIENCY. (I.C.A.O. ATMOSPHERE)

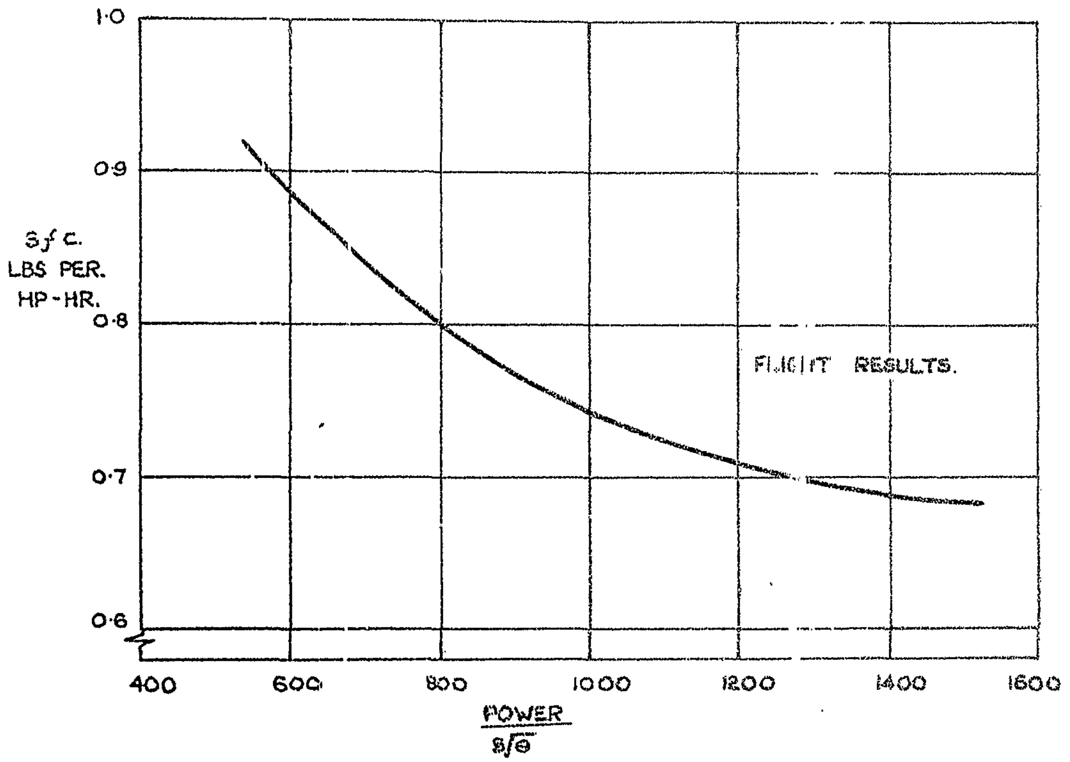


ROTORSPEED FOR BEST AIRFRAME EFFICIENCY.



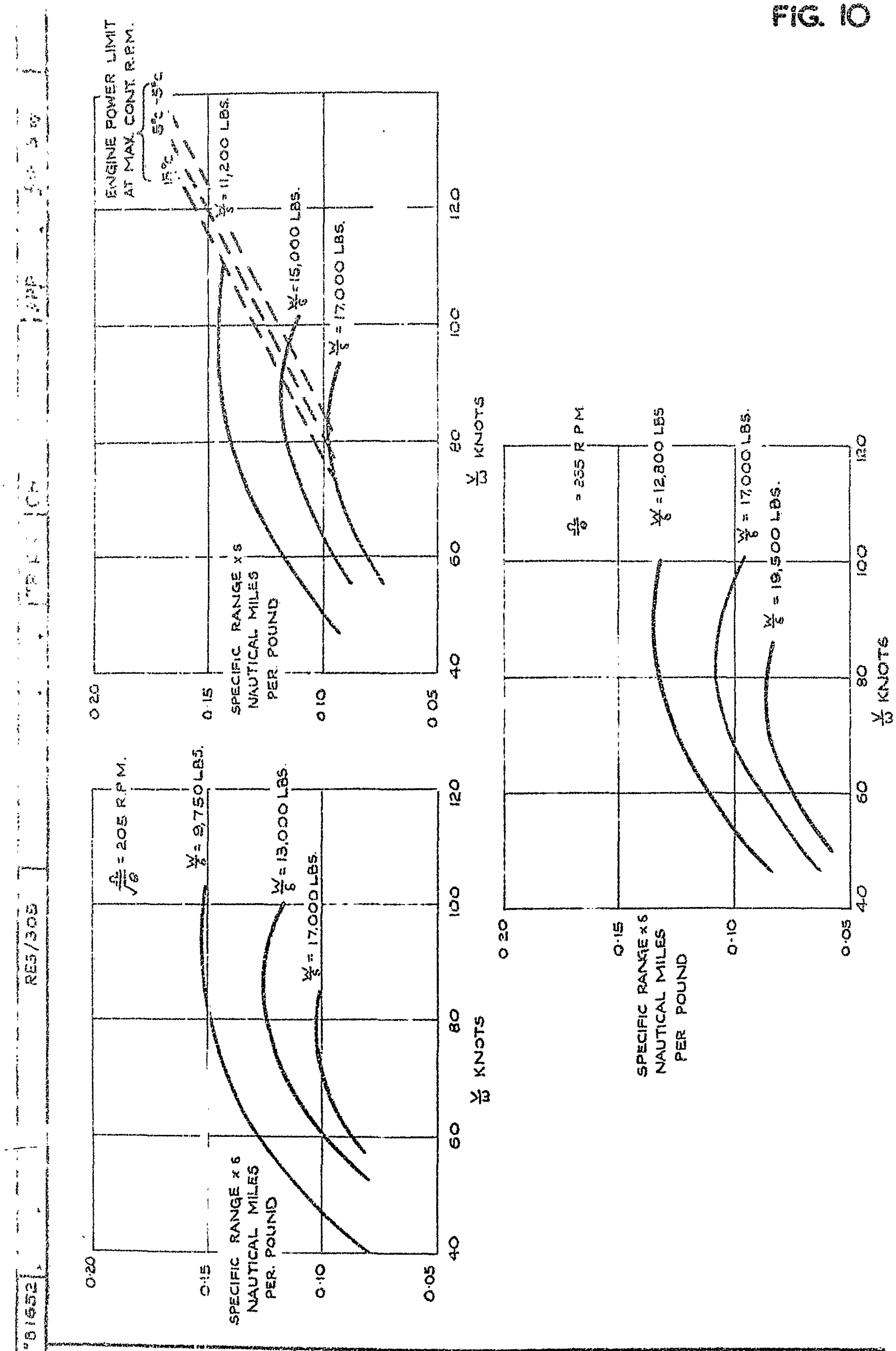
AIR SPEED FOR BEST AIRFRAME EFFICIENCY.

FIG. 9.



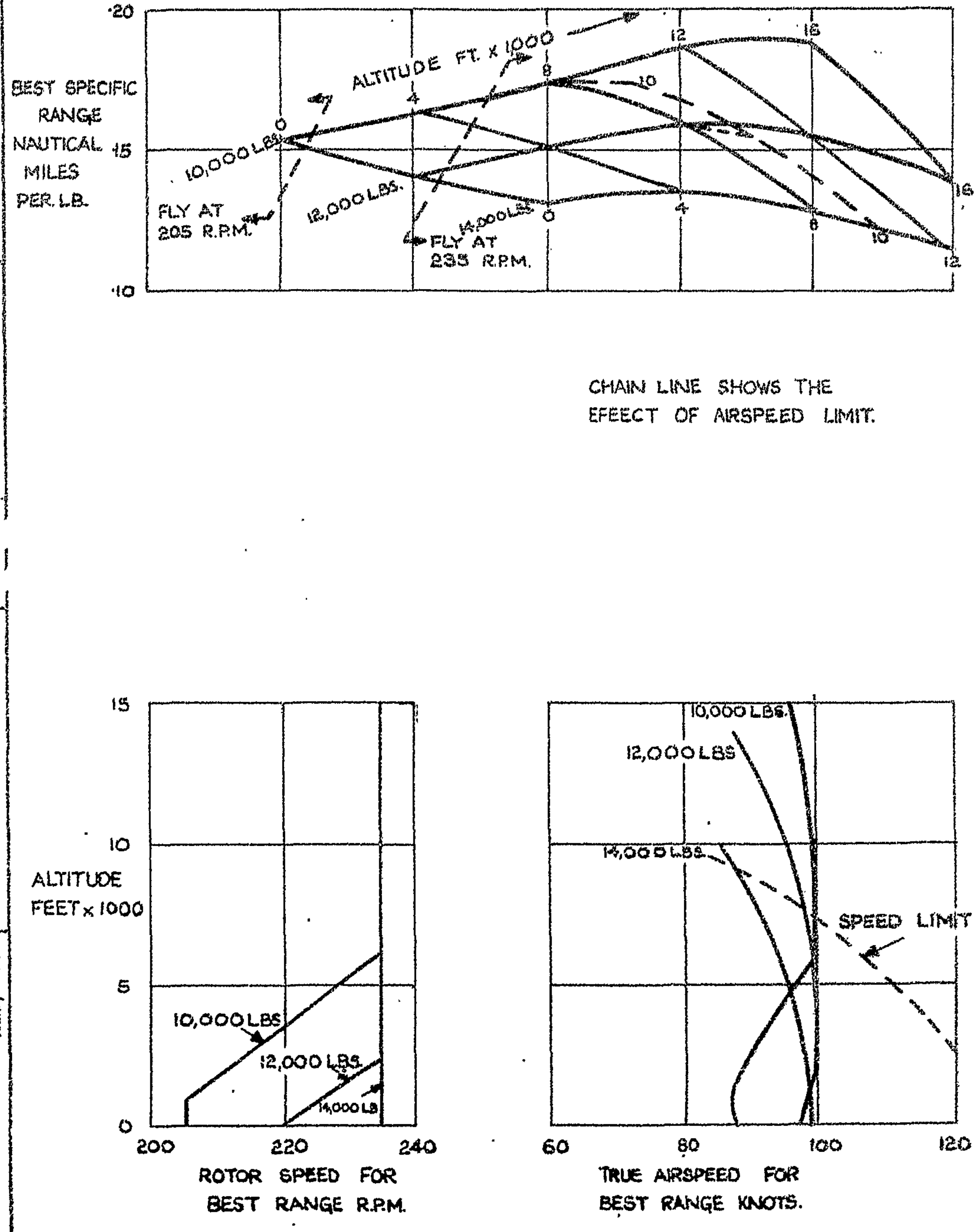
SPECIFIC FUEL CONSUMPTION OF ENGINE.

FIG. 10



GENERALIZED SPECIFIC RANGE OF EXAMPLE HELICOPTER.

FIG. 11.



SPECIFIC RANGE IN I.C.A.O. ATMOSPHERE.

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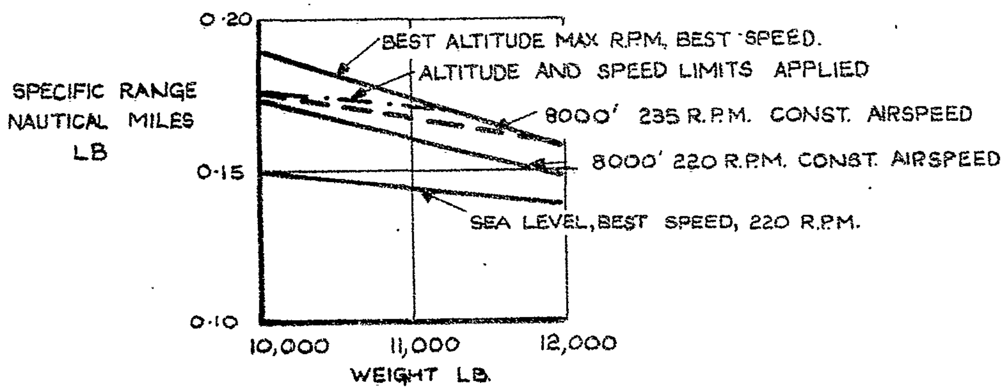


EXAMPLE HELICOPTER.

T.O.W. 12,000 LBS.
FUEL LOAD 2,000 LBS.

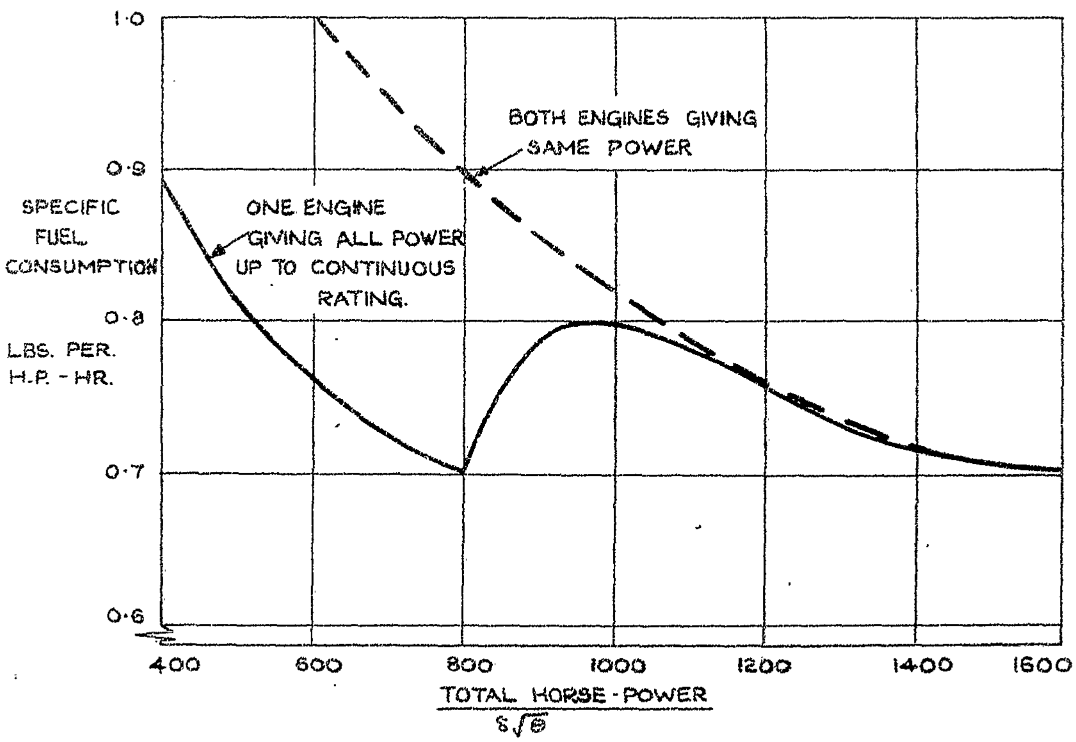
RANGE UNDER BEST THEORETICAL CONDITIONS	350 N.M.
RANGE WITH AIRFRAME LIMITATIONS	340 N.M.
RANGE AT 8000' 235 R.P.M.	335 N.M.
RANGE AT 8000' 220 R.P.M.	320 N.M.
RANGE AT SEALEVEL 220 R.P.M.	285 N.M.

NO ALLOWANCE FOR CLIMB OR RESERVES

FIG. 12.

ABSOLUTE RANGE OF EXAMPLE HELICOPTER.

FIG. 13.



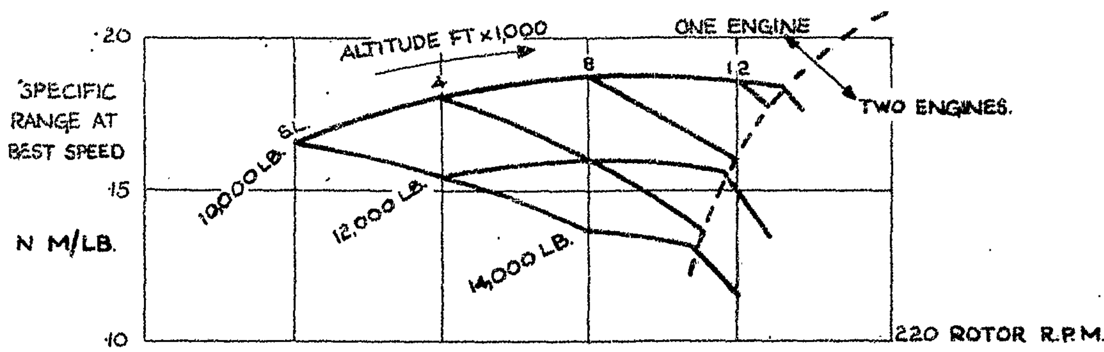
SPECIFIC FUEL CONSUMPTION OF HYPOTHETICAL TWIN-TURBINE INSTALATION.

TR. K.G. | CH. MR LANGDON | APP | 22·11·

RES/305

SK.No B 1418

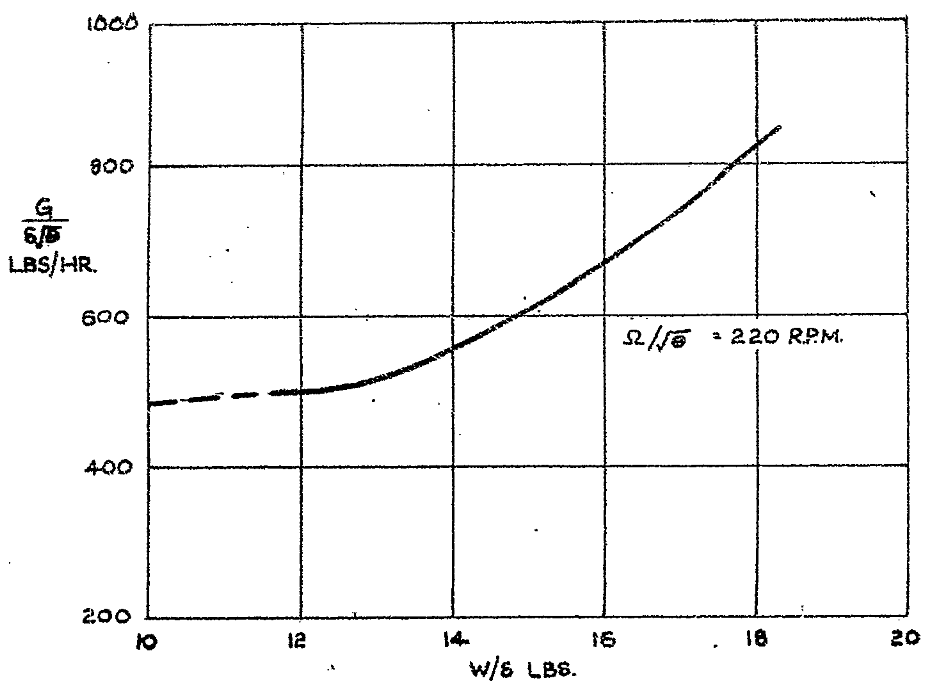
FIG 14.



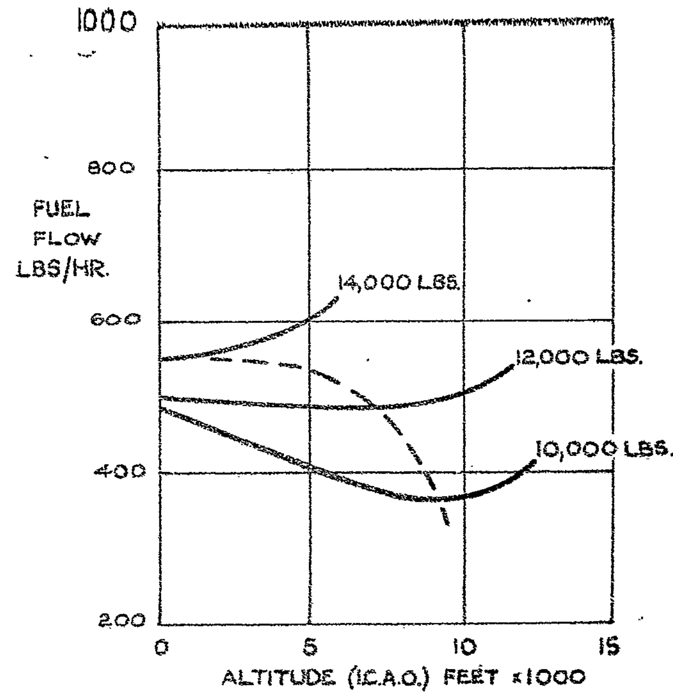
SPECIFIC RANGE OF HYPOTHETCAL TWIN-ENGINED HELICOPTER.

SK. No B1419 | RES/305 | TR. KG. | CH. MR. LANGDON | APP. [illegible] for D of P | 22.11.62

SK.Nº S.1420 | RES/305 | TR K.G. | CH. MR. LANGDON | APR



FUEL FLOW AT THE SPEED FOR BEST ENDURANCE.



VARIATION OF MINIMUM FUEL FLOW WITH WEIGHT AND ALTITUDE.

FIG. 15.

ENDURANCE OF EXAMPLE HELICOPTER.

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