F/O TWELLS

Form 619

ROYAL AIR FORCE.

Notebook for use in Schools.

91/5769. Wt. 6631. 500M Bks. 11/43. C.W.S. Ltd.

1492
9
1501

AERODYNAMIC ENGINES 69
65

CALCULATION OF I.H.P

P 80
RPM 1,600
DIA 6"
L 8
NOC 9

$\frac{6 \times 22}{7} = \frac{132}{7} = 18.8$

19 × 19 = 171, 19, 361

$\frac{80 \times 8 \;\; 28.26 \times 800}{33,000 \times 12} = \frac{8 \times 8 \times 28.26 \times 2}{33 \times 3} = \frac{28.26 \times 128}{99}$

$= \frac{2826 \times 128}{9900} = \frac{1413 \times 64}{2475}$

9900
4950
2475

1413 × 64

3.1501
2.1072
7.2543   .1808000

$\frac{3.14 \times 6^2}{4} = \frac{3.14 \times 36}{4}$

3.14 x 6 / 18 314 / 4 / 28.26 12 x 3.14 / 12 / 6 28 / 31 4 / 37.68

AREA of PISTON $= \frac{\pi d^2}{4} = \frac{3.14 \times 6^2}{4} = 28.26$ sq"

TOTAL MEAN FORCE = PRES x AREA $= 80 \times 28.26$
$= 2261$ lbs

WORK PER CYCLE FORCE x DISTANCE $= 2261 \times \frac{8}{12}$
$= 1508$ FT lbs

WORK PER MIN $= 1508 \times \frac{1600}{2} = 1206400$ FT lbs

WORK PER MIN FOR 9 CLY $= 1206400 \times 9 = 10857600$

I H P $\frac{10,857,600}{33,000} = 329$

B.H.P = $\frac{\text{R M.E.P x AREA OF PISTON x STROKE x CYCLES x CYLDS}}{33,000}$

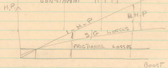
B.M.E.P = $\frac{\text{B H P x 33,000}}{\text{AREA x STROKE x CYCLES x CYLDS}}$

For constant boost and Varying R.P.M.
I.H.P proportional to R.P.M for a constant boost.
R.P.M will determine weight of air consumed
and I.H.P is ∝ to the weight of air consumed.
The losses of power between I.H.P and B.H.P
will be
a Frictional losses which are ∝ to R.P.M
B S/C which are ∝ R.P.M at constant Boost

EXAMPLE Since I.H.P ∝ R.P.M let I.H.P = $\frac{1}{4}$ R.P.M
∝ as P.F + F.S are both ∝ R.P.M^2 we can say that
$PF + Ps = \frac{RPM^2}{10,000}$

R P M	1000	1500	2000	2500
R P M^2	1000000	2250000	4000000	6250000
PF + PS	100	225	400	625
I. H. P	250	375	500	625
B. H. P	150	150	100	NIL

CONSTANNT R P M



P.F = 25 HP
P.S = 5% OF IHP
IHP = 80
TOTAL LOSSES 25+4 = 29 HP
BHP = 80-29 = 51
$\frac{BHP}{IHP} = \frac{51}{80} = 64\%$

P.F = 25 HP
P.S = 5% OF IHP = 9
TOTAL LOSSES = 25+9 = 34 HP
BHP 180-34 = 146
$\frac{146}{180} = 81\%$

SUPER CHARGING

Rate of air consumption by weight govern the I.H.P

Supercharging is a means of obtaining higher power at S.L or of maintaining cruising power to a higher altitude

$\propto R \times N^2 \times \rho V$

Pressure ratio = $\frac{\text{Outlet pressure}}{\text{Inlet pressure}}$ $\left(\frac{1.5}{2.5}\right)$

Air Temp	Inlet Press	Air density	Press Rise	Man Press	Press Ratio
0°	10 lbs□	1.0	10 lbs□	20	2.0
0°	9 lbs□	.9	9 lbs□	18	2.0
- 30	9 lbs	1.0	10 lbs□	19	2.1

Power absorbed
1 Friction $\propto (RPM)^2$
2 Pressure built up $\propto (RPM^2)$
3 Weight of air consumed $\propto$ I.H.P

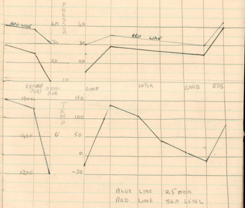
Power absorbed prop to square of RPM and weight of air consumed.

Input = Compression + Friction + Output

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input} - \text{Compression} - \text{Friction}}{\text{Input}}$$

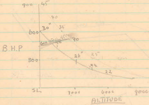
$$= 1 - \frac{\text{Compression}}{\text{Input}} - \frac{\text{Friction}}{\text{Input}}$$

TEMP AND PRESS IN ENGINES FITTED WITH TURBO S/C



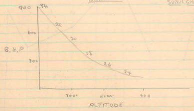
Performance of Supercharged Engines

1. Normally aspirated engine



CONST RPM 2,000
FULL THROTTLE

SUPER CHARGER



1 KNOT 100 FT/MIN

POWER = $\frac{F \times D}{TIME} = \frac{T}{D \times SPEED}$

T.H.P = $\frac{\text{DRAG lbs} \times \text{TAS ft/min}}{33,000}$

or $\frac{\text{DRAG} \times \text{T.AS ft/sec}}{550}$

DRAG = $\frac{\text{T.H.P} \times 33,000}{\text{T.A.S}}$

10,000 | V_1 = 150 KNOTS =

TAS 150 x 1·16 x 100 = TAS ft/min

DRAG 4224

T.H.P = $\frac{4224 \times 150 \times 1{\cdot}16 \times 100}{33,000}$ = 2224

V_1 150 KNOTS = 150 x 100

SL | TAS = 150" x 100 =

$\frac{4224 \times 150 \times 100}{33000}$ = 1920

POWER REQUIRED FOR CLIMBING

T.H.P FOR LEVEL FLIGHT + THP TO CLIMB
TO OVERCOME DRAG — TO OVERCOME WEIGHT

$$\text{POWER FOR CLIMB} = \frac{W \times \text{RATE OF CLIMB}}{33,000}$$

$$\text{RATE OF CLIMB} = \frac{\text{THP} \times 33000}{W}$$

or T.H.P OVER THAT REQUIRED FOR LEVEL FLIGHT

POWER FOR DECENT

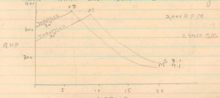
THP PRODUCED BY GRAVITY = ~~5500~~ $\frac{W \times R}{33,000}$

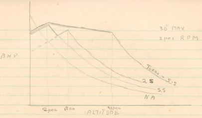
For any given revs and boost there is a full throttle height - it is the height up to which the given boost can be maintained with the given revs

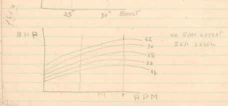
Full throttle height affected by
1 Given boost higher the boost lower F.T.H
2 Given R.P.M higher RPM higher F.T.H
3 Ram effect
4 Intake efficiency

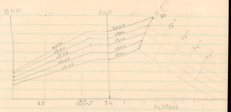
Rated conditions are those that may be used for more than 5 mins and less than 1 hour (1) generally the max climbing conditions in rich mixture

Rated Power is the power developed with rated R.P.M and Boost at rated height

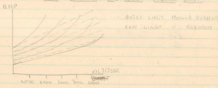








POWER DEVELOPED AND POWER REQUIRED GRAPH



To find power required at any altitude multiply BHP by Altitude Factor for height wanted

FUELS

1. DETONATION

2. FREEDOM FROM VAPOUR LOCK

3. ES DISTRIBUTION VARIOUS CYLDS

4. ABSENT OF TENDY TO FORM DEPOSITS

EFFECT O DETONATION

(a) Increase of heat losses to cylinder walls and pistons

(b) Maximum pressure exceeds normal max value

Factors governing detonation.

1. Nature of Fuel
2. Compression Ratio
3. Boost Pressure
4. R P M
5. Air intake temp
6. Ignition advance
7. Cylinder cooling

Anti Knock Fuel the Property of the fuel to resist detonation

Iso octane and Heptane to get the octane N°.

Volatility Tendency of a fuel to vapourize

Absent of vapour lock

SPECIFIC FUEL CONSUMPTION

$$S F C = \frac{\text{Fuel used}}{\text{work done}} \qquad \frac{\text{pints per B H P hour}}{\text{lbs " B.H.P "}}$$

$$\text{Brake therm eff} = \frac{\text{Output}}{\text{Input}}$$

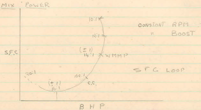
$$= \frac{\text{work done}}{\text{Energy of fuel supplied.}}$$

$$= \frac{\text{work done / hour}}{\text{cal value} \times \text{amount of fuel / hour,}}$$

$$= \frac{B.H.P}{\text{Cal value} \times \text{rate of fuel consumption}}$$

$$= \frac{1}{\text{Cal value} \times S.F.C}$$

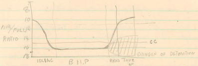
$$B.T.E \propto \frac{1}{SFC}$$

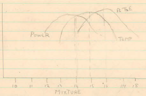


20:1 rough running combustion will not take place below this ratio
16:1 most ecconical used for cruising not power
15.2:1 C. C
14:1 Weak mixture max power.
12:1 Rated mixture streath
10:1 Take off

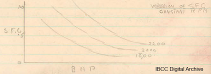
Required

Idling rich
Cruising 16:1
High power. 14:1
Take off 10:1

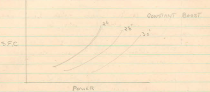




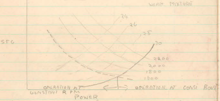
B Th E = I Th E x MEC EFF



VARIATION OF S.F.C ON BOOST



S.F.C GRID



The S.F.C Grid shows a variety of ways ~~which~~ which any given power out put can be obtained But there is only one seting for any given power which given ~~envelope~~ minimum S.F.C this seting is that given in the SFC

EFFECT OF HEIGHT ON SFC GRID

1 Up to full throttle height better S.F.C same power can be obtained with less revs ie better mec effy

3 Above full throttle height S.F.C increases as to maintain same power revs must be increased.

2 If operating at min RPM to maintain constant power. throttle must be closed gradualy to full throttle height and opened above full throttle. height

Summary of Factors affecting S.F.C

1 air fuel ratio (SFC Loop)
2 Power developed.
3 R.P.M (friction losses)
4 Butterfly opening (boost)
(power wasted in S/G)

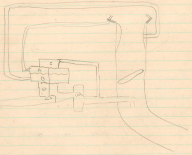
TEMP HIGHER RICHER MIXTURE

Carburation

Venturi injection type Stromberg and Geco.
Venturi with float chamber. S U C. T.
Non Venturi injection no float chamber R A E Hobson

G.E.C.O AND STROMBERG

Basic Principles of operation
A – B chamber pressure α airflow
D – C " " α Fuel flow



SUMMARY OF ENGINE PERFORMANCE

Engine caracteristics of interest

1/ Power – speed rate of climb
2/ Fuel flow – endurance
3/ Specific consumption – range

Factors affecting performance charact

1/ Boost
2/ R.P.M
3/ Barometric pressure altitude
4/ Temperature
5/ Mixture strength

[illegible] BOOST

INCREASE →	BOOST ↗	R.P.M ↗	BAR PRESS ↗	AIR TEMP. ↗	MIXTURE STRENGTH ↗
G.P.H	↗	↗	↘	↘	↗
B H P	↗	↗	↘	↘	↗
S.F.C	↘	↗	↗	↗	↗

SPECIFIC FUEL CONSUMPTION TENDENCIES

1 Variation of power - const height temp mixture

(a) Increasing boost R.P.M const S.F.C decreases

(b) " R.P.M boost const S.F.C increases

(c) " Power at full throttle S.F.C remains rough constant may decrease at low R.P.M definite increase at high R.P.M

2 Increase in height.

(a) constant boost and R.P.M S.F.C decreases up to full throttle height

(b) Constant I.A.S increasing power

(i) at const R.P.M S.F.C. decreases because increase boost decrease in back pressure " " temp

(ii) At const boost S.F.C may decrease at low R.P.M otherwise increase.

(iii) Full throttle - much the same as (ii) poss more favourable see (i c)

(3) Increase in temp.

(a) Const boost and R.P.M - S.F.C increase. more so uncompensated carb

(b) Const I.A.S increase of power
(i) const boost S.F.C increase more so with uncompensated carb

(ii) Const R.P.M. S.F.C may decrease slightly with a comp carb increase with uncomp carb

(iii) Full throttle. S.F.C increase more so at high R.P.M and even more so with uncomp carb (P.R of supercharger labs for higher temp : not such a great increase of boost)

General Range Flying Principles

Range is distance with a given amount of fuel

Specific Range dist with a unit amount of fuel

Specific Air Range (S A R) is A.M.P.G

$$S.A.R = A.M.P.G$$

$$= \frac{MILES / HR}{GALS / HR} \qquad GPH = B.H.P \times S$$

$$= \frac{V}{S \times B.H.P} \qquad B.H.P = \frac{T.H.P}{E}$$

$$= \frac{V \times E}{S \times T.H.P} \qquad T.H.P = D \times V_{T.A.S}$$

$$= \frac{V \times E}{S \times D \times V}$$

E - PROP EFF.
S S.F.C consumption
D - DRAG

$$= \frac{E}{S \times D}$$

If E is a % S - pints/BHP hr D in lbs
and working in knots

$$S.A.R = 26.05 \times \frac{E}{SD}$$

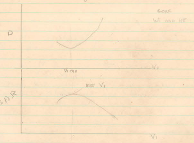
S.A.R is a measure of overall eff of A/C since E = prop eff S gives measure of B.T.E and air frame efficiency

Speed and power can only affect S A R through there affect on E. S or D

Assumption of const S and E.

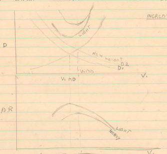
$$S.A.R \propto \frac{1}{D}$$

∴ For maximum range D minimum.



Since V_i and D remain constant for change of height and temp best V_i for range will remain constant and also S.A.R

INCREASE IN WEIGHT

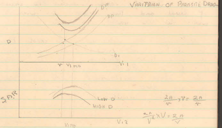


$V_{I\,MD} \propto \sqrt{W}$

$D_M \propto W$

Best speed for range prop square root of weight
Range inversely prop to weight

VARIATION OF PARASITE DRAG



$\frac{2A}{v} \times v = \frac{2A}{v}$

$\frac{2A}{v^2} \times V = \frac{2A}{V}$

Increase in parasite drag reduces the best speed for drag and reduces the range for also the power required at the new speed is greater than the old speed.

For summary for const

Best V_i for range is the same as $V_{I\,MD}$ independent of ht and air temp and prop to the square root and weight
Percentage rise of best $V_i = \frac{1}{2}$ of % rise in weight
Increase in parasite drag increases total drag decreases best V_i also increases power required

S.A.R at the best Vi is allso independent of height and temp and is inversely prop to the weight.

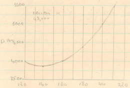
Although the assumption of const E and S. it is not generaly true in practice it some times occours that the value of $\frac{E}{S}$ is allmost negible neglidble and the above conclusions hold. And in any case can be graphed on to the above results.

EFFECT OF VARIATION OF S.F.C

$$S.A.R \propto \frac{E}{D \times S}$$

Assume E const

Then $S.A.R \propto \frac{1}{DS}$



BHP 426

$$\underset{120}{THP} = \frac{4000 \times 120 \quad 5280}{60 \times 33000} \quad H.P.\ 1280$$

$$B.H.P \quad 1280 \times \frac{100}{75} = 1706$$

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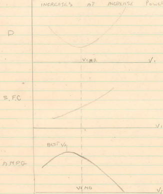
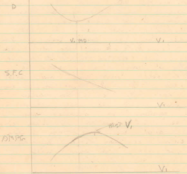
OPERATION AT CONST BOOST WHERE SFC INCREASES AT INCREASE POWER



At V1MD drag is aprox const a small decrease in speed required
but this small decrease in speed gives a decrease in S so D x S is decreased S.A.R increased. If speed is still reduced we shall reach a point where decrease in S and increase in D. are balanced. and we get lest S further reduction in speed shows ~~decreasing~~ D increasing much more rapidl than S decreasing So D x S has a net increase S.A.R therefor fall off
Increase in speed above V1.MD shows both D and S increasein therefor D x S increases and therefor S.A.R decreases see graphs

OPERATION AT CONSTANT R P M.
S.F.C decreases with increased power

SAR ∝ $\frac{1}{DS}$

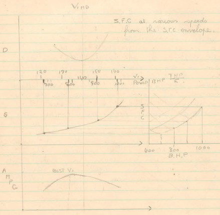


An aircraft is said to be underpowered for range flying when the power used at the best speed for range is greater ~~than~~ than the power giving min S.F.C.

It can be seen that an aircraft can commence a sorti under powered and finis overpowered.

VARIATIONS OF PROP EFF

Prop eff can generally be taken to be between 75% and 85% but in any particular case the variation in eff will be small and of the order of 2% to 4%. Above rated altitude however eff drops off due to the high angle of attack ~~to~~ required to absorb the power. High angle may also give reduced eff when operating at high boost low RPM ~~In~~ a few isolated cases where prop eff does not remain approx constant the variation may override the variation in drag and S F C and the need for operating at certain conditions may override the low RPM high boost rule



EFFECT of VARIATION of WEIGHT

48,000 lbs

T.A.S(SL)	220	190.8	170.5	155.8	144.2	135	120.5
D	5800	4800	4258	3978	3895	3885	4082
THP SL	3455	2442	1936	1650	1538	1399	1310
BHP/ENG.	1080	763	604	514	468	437	408

58,000 lbs

TAS SL	242.4	209.9	187.7	171.4	158.4	148.5	132.4
D	7114	5800	5139	4806	4719	4400	4930
THP SL	4580	3248	2571	2190	1998	1861	1742
BHP/ENG	1430	1015	802	685	624	582	545

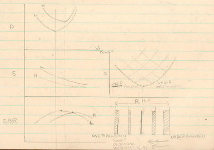
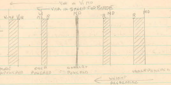


Fig. A



The tables show that the rate of power around V_i MD is generally lower for lower weights in other words as weight is decreased the aircraft becomes less underpowered or overpowered.

We saw that for an underpowered a/c speed for range is less than V_i MD in an overpowered aircraft speed for range is greater than V_i MD.

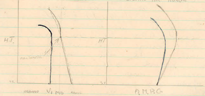
This difference depends on slope of S.F.C envelope. As the aircraft becomes less underpowered (i.e) as power is reduced the slope of the envelope is reduced and speed for range becomes nearer V_i MD. As the aircraft becomes more overpowered i.e power required still less the slope increases and speed for range becomes more and more above V_i MD.

Fig. A shows that the variation of speed for range is less for V_i MD and in practice we say the % of speed for range is

% VAR of speed for range − ¼ to ½ % VAR. V_i MD

EFFECT OF VARIATION OF HEIGHT

For a constant S.F.C and prop eff. we saw that variation of height had no effect on range for or best speed for range and so in practice variation in height will only effect range and speed for range where it effects S.F.C and prop eff



AIRCRAFT OVER POWERED.
AIRCRAFT UNDER POWERED.

Aircraft overpowered at Sea Level

There fore operated at const R.P.M increased ~~with~~ power with height by increasing boost. S.F.C improves therefor range improves therefor S.A.R improves up to full throttle height. At full throttle height aircraft correctly powered S.F.C minimum. If above full throttle height extra powered required obtained at higher RPM this gives greater S.F.C therefor smaller air range At Sea level over powered the best speed for range is higher than V_{i} MD at full throttle height it is correctly powered speed for range V_{i} MD. Above full throttle height high RPM required therefor reduce speed to avoid uneconomical engine setings

Aircraft underpowered at sea level (at height)

Operating at max boost - increase power increase R.P.M S.F.C may improve at first giving slight increase of range with height, but when high RPM are required. S.F.C increases more rapidly giving reduction in range. Speed for range aircraft underpowered V_i less than V_i MD remains approx constant up to full throttle height

~

up to when heigh RPM make a reduction neccesary to avoid uneccon engine setings

EFFECT OF VARIATION OF TEMP (INCREASE)

Constant IAS RPM compensated carb SFS decreases slightly therefor range increase Uncompensated carb SFC increases slightly therefor range decreases.

At constant boost and IAS full throttle range will allways decrease more so with uncompensated carb ½ 5%

With increase of temp aircraft become less overpowered ~~of~~ or more underpowered. (due to increase TAS) the effect in both cases on the best speed for range is the same and is a reduction

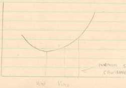
PERFORMANCE AT LOW SPEEDS

$D \times V \times \alpha$

$= (aV^2 + \frac{b}{V^2}) V \alpha$

$= \alpha (aV^3 + \frac{b}{V})$

D_P D_i



Minimum air speed for cruising is the speed at wich a small charge of speed the power-required is sufficiently large. to make the aircraft return rapidly to its mean speed. In rough air bigger changes in speed bigger margin required. fly a little faster. tendency to instability bigger movements of control are required bigger changes of speed fly a little fast.

Recomended speed is chosen suffic. above the minimum speed for cont cruising to allow for all normal variations and C of G and stability and average rough air conditions

SUMMARY OF FACTORS AFFECTING S.A.R

1. Speed - drag. handling.
2. Weight - drag (C of G)
3. Engine settings to S.F.C. Prop eff^cy
4. Height - S.F.C. (prop at height)
5. Air Temp. - S.F.C.
6. Burpines - average drag
7. Pilot eff^cy - use of auto pilot

	SPEED FOR RANGE	SPECIFIC RANGE
WEIGHT ↗	↗ 1/4 - 1/2 %	↘ 2/3 %
DP ↗	↘	↘
HT ↗	↘ VIMD	↗ MAX
HT FT ↗	VIMD ↘	MAX ↘
TEMP ↗	↘	↘

Range summary
1. Use max boost and low RPM to obtain optimum I.A.S
2. Use M.S gear at an altitude such that the optimum I.A.S is obtained at full throttle but do not fly so high that RPM near the max must be used

3 Roughly % change best speed = $\frac{1}{2}$ to $\frac{1}{4}$ % change in weight $\frac{1}{4}$ ($\frac{2}{3}$

% change in range = 1 to $\frac{1}{2}$ change in weight

EFFECT OF WIND

$$T.M.P.G = \frac{T.M.}{GALLS} = \frac{G.S}{G.P.H}$$

$$AMPG = \frac{TAS}{GPH}$$

$$TMPG = AMPG \times \frac{GS}{T.A.S}$$

40

TAS 150	AMPG 1·05	=		·700
160	1·05	=	TMPG	·722
170	1·03			727
180	1·005			720
190	0·94			715
200	0·93			·698

Graph shows that best speed for range with a head wind is increased from 155 to 173 TAS aprox 12% graph with tail would show a decrease in speed

$$\frac{AMPG}{TAS} - \frac{AMPG}{GS}$$

It will be seen that the head wind reduces T.M.P.G by aprox 30%. Where as changing our speed for range we regain aprox 3% A similar effect and it is seen that the loss due to the wind is far in excess that than that gained by increase of speed. Thus it will be seen more profitable to change height for more favourable winds. were the gain will be a greater % than any obtained by changing speed or operating at full throttle

$$BEST\ I.A.S\ FOR\ WIND = BEST\ I.A.S\ still\ air + \frac{TAS - GS}{X}$$

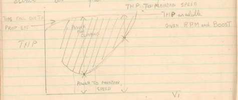
An empirical rule is usely found for each aircraft where by speed for range is changed 1 mile/hour for a given change in ground speed i.e alter speed 1 MPH for every 10 MPH ground speed.

CLIMB AND DESCENT

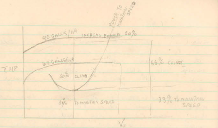
Climbing T.HP = T.HP to overcome drag + THP for climb

Vertical Climb A climb ~~is~~ a where range is of is no importance and height gained per gall is important factor

Setting max climbing revs and boost gall/hr are fixed so to climb max number of feet per gal we must climb as fast as poss



Max climb obtained where max power is obtained for climb in threshold region but flight is not now uncomfortable since a good margin of power is available above that now required to maintain speed



POWER FOR CLIMB DOUBLED
RATE OF CLIMB " SAY FROM 500 FT/MIN TO 1000 FT/MIN
TOTAL POWER INCREASE 50% AND SO FUEL CONSUMPTION INCREASES 50% SAY FROM 60 GALLS/HR TO 90 GALLS/HR
CLIMB PER GALL AT LOWER POWER

$$= \frac{500 \times 60}{60} = 500 \text{ FT/GALL}$$

CLIMB PER GALL AT HIGHER POWER

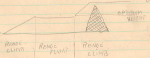
$$= \frac{1000 \times 60}{90} = 666 \text{ FT/GALL}$$

And so increase of power in addition to giving greater rate of climb gives more climb per gall and so is more eff in a vertical climb

RANGE CLIMB

A climb where the horizontal distant is important and there is ample time to available to get height.
At first approximation would be to climb at best speed for range but a little extra power is required for the climb and so the aircraft is less overpowered or more underpowered than it would be when flying level this means a slight reduction in speed is required to obtain the best speed for range. Therefore to obtain rate of climb of 200/300 ft/m by a reduction of speed of from 5/10 M.P.H and an increase of power.

Delayed Climb
Would be employed were unodeet climb is not ~~nessen~~ necessary



RANGE DESCENT

Descent. Power to overcome drag = Power from engines + power from gravity

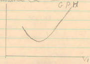
Vertical descent distant covered unimportant

Range descent
Will require ~~st~~ most miles per galls. Less power required from engine therefore aircraft more overpowered or less under powered therefore best speed is slightly over best speed for range (in level flight) e.g. reduce power slightly and increase speed aprox 5 miles / hr. to get rate of descent.

ENDURANCE Max number of hours flying with min fuel.

Total fuel = G.P.H x N° of hours.

Endurance $\propto \frac{1}{G.P.H}$ G.P.H $\propto$ T.H.P



Therogical best speed would be the best speed for MP but this is not pratical and so we fly as slowly as poss for comfort ie the minimum speed for continuous cruising and as low as poss

Height for endurance. Power required $T \propto S \times D$
$= V_1 \times D \times \alpha$

Since endurance flying is at low power 500 ft should be taken as safty height

Endurance decreases 1% per 1000 ft of altitude

Speed

Speed is any speed in excess of speed for range flying $D = aV^2 + \frac{b}{V^2}$

$$P = aV^3 + \frac{b}{V}$$

P is not a minimum when this

$aV^3 + \frac{b}{V}$
↑ POWER TO OVERCOME D_P
↑ POWER TO OVERCOME D_I

a depends on parasite drag
b " " weight

Since V is large the important term is aV^3 and the term $\frac{b}{V}$ has propotaly has much less affect on the power required. Thus changes in weight will have less affect on the power required to fly at speed than changes

(CON AFTER 3 PAGES)

WEIGHT AND CENTRE OF GRAVITY DETERMINATION

Requirement

(a) A standard simple method of calculating Weight and c of G with out use of appliances

b Complete doc prof of safe loading

c) A standard prep of aircraft plan (i.e) lists showing modifications to be carried of out by M Us and units combined with card index checking system

Datum is arbitrary point laid down by the manuf. usely near the root of the leading edge of the main plane but varying with different aircraft

Weight Weight are to the nearest lb

Arm is the horizontal feet measured fore and aft parrel to the datum line of any item from the ref line to the nearest .05 FT

Moments is the weight of an item lbs × the arm in ft = lbs FT

Refference line an ima line perpendicular to the aircraft fore and aft datum at some convenience distance forward of the datum point

__Tare weight__: The weight of the aircraft less all removeable items of equip (bol 9) but modified to a certain standard. Can be found in Vol 4 Sec 4.

	weight	arm	moment
1 Aircraft Tare condition and weight and moment only of any mods fitted but not included list of tare mods, plus weight and moments of any command mods to give.			
2 Aircraft modified tare condition. Add weight and moments of all items of moveable equip. required when aircraft is operating to given role to give.			
3 This gives a/c basic condition. The weight and moment of the crew and baggage oil and any other item of equip to give			
4 aircraft weight and cond less fuel and pay load. Add all items of pay load this gives			
5 aircraft light condition			

The weight and moment of all fuel is add this gives
6 Aircraft condition

__Compartment loading procedure.__
Object to simplify loading of large number of small items of eqp of known weight
1 Aircraft is devided in to 10 phisical compartment lettled A to K no letter I
2 Aprox mean arm in round feet is painted inside of each compartment this is know as the centroid.
When loading all items are grouped round the centroid in each compartment the arm of the centroid is then taken as the arm of all the items.
3 To find aircraft light condition add weight and moment of all compartments to aircraft less fuel and pay load

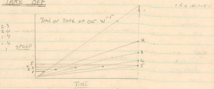
Weight and moments charts
To simplify calculations. The chart consists of weight ploted against moments so that you can read of the arm the C of G limits are also shown on the chart

CONTINUED 2 PAGES

in factors producing parasite drag
Fly at full throttle height for the power require because up to full throttle height power increases and S.F.C decreases
For a given required T.A.S (to make good a required ground speed) the I.A.S will be less if we increase the altitude This means with in increased altitude V_I will be nearer $V_{I\,MD}$
That is we are approaching nearer to the most eff flying condition for A.M.P.G

ASSYMETRIC FLIGHT Flight with (engine failed one or more) a windmilling of or feathered prop and the fact that the a/c is "crabbing" (due to unsymetrical thrust) all tend to increase parasite drag therefore best speed for range is reduced In addition power required from the remaining engine(s) will be greater thus making the aircraft more underpowered or less under overpowered again reducing best speed for range (except in the case of A/C very much overpowered) were range and speed for range will be increased) Generally then in assymetric flight best speed for range is reduced and range is reduced

TAKE OFF



(i.e) 5% increase weight $4\frac{1}{2}$% increase in take of time
10% " " 15% " " " " "
Take of run is ∝ to W^2
i.e. 5% increase in weight 10% increase T.O run
8% " " " 16 " " "

Compartment loading Tables published with to give a guide of distrubution of pay load between compartments & when any given pay load is to be carried. The section of the table are laid out in the same manner as the app. section of the weight and balance clearance form to facilitate computing

Remember prove of sat loading in the weight and balance clearance form

Weig

This is intended to provide written prof of saf loading of transport a/c. With slide rules no such proff excersted.

It will entail additional work for captain and load control officer. but is felt justified with a view to safty. Loading data in course of prep will greatly simplify its completion, Pending issue of loading data the form must be used in combination with ex-data. Refference to data used will go under remarks collum of weight and clearance

Compleation and distrabution W and B will be comp in Trip, partly by captain and by load control officer. On compleation it will be certified by person i/c loading party. captain and load control officer

Distrubution

Original handed to load control officer next stop

Duplicate retained by captain and attached to MC [illegible]

Triplicate " by local control officer at place of departure

Completion

1 Enter details of flight plan (part 1)

2 3 Crew baggage part 2 3 4.

3 Enter details palload computation (T. M. V sec)

4 " payload offered to trafic (lesser fig col U)

5 " quantity weight and moment of fuel load T O landing sec V to Z

6 " C.G limits at bottom of part 2 and " prepared by pilot

Action by load control officer

1 He will decide load destrubtion from loading tables and will enter ~~data~~ on loading plan (fig 9) giving seperate details for pass mail freight

2. He hands loading plan to a/c loading party to carry out.

3. On receipt of loading plan on comp of loading he checks the captain's entries

4. Enters details in sec D to K. on W.B from loading plan.

5. Enters details in col V V1 V2.

Certification of W an B form. by the loader that load has been dist as shown on the loading plan 3

By load control officer that he has checked loading and is satisfied with the dist

3 By the captain that a/c is safely loaded load is securely lashed and C of G is within limits.

Captain is finally responsible for loading

LOADING DATA

1. DETAILS OF MODS INCORPORATED
2. " " BASIC WEIGHT EX
3. COMPARTMENT LOADING PLAN
4. WEIGHT. MOMENT. CHART
5. COMPARTMENT LOADING TABLES
6. LOADING PLAN. (FIG 9)
7. WEIGHT AND BALLANCE CLEARANCE FORM
8. AIRCRAFT LOADSHEET

AIRCRAFT PERFORMANCE TESTING

Much carefull prep on the ground by pilot and crew

2 Necessary to prepare and complete a flight plan for each member of crew if aircraft is being tested for eco the pt pilot may requires from 10 to 15 min to settle his speed when I.A.S has settled pilot should warn the crew that they may take reading he should note his height at com of the run and endevour to maintain that height during the run

Equip required

A Standard equip

B Flow meters

C Air mileage unit for accurate of T.A.S

D Stop watches

E Kollsmans sensitive altitude meters set to 1013 M.B

F Instruments should be calibrated

G Free air cannot be trusted see met

Take off weight must be assessed as accurate as poss this may be done by carefull check of equip against loading chart and the fuel in the tanks should be checked as accurately as poss

TIME WHEN CAPT IS READY TO START RUN

TO WEIGHT LESS FUEL CONSUMED

CLOCK TIME
R P M
BOOST
METER READINGS
TIME PER GALL
G.P.H
METER READINGS
TIME PER GALL
G.P.H
TOTAL GALLS GONE
WEIGHT
TOTAL G P H
HEIGHT
AIR TEMP
COMPUTED T.A.S
AMU T.A.S
A M P G
REMARKS

TO CHECK WITH ENGINEER	CLOCK TIME
READING OVER 10 MILES TIMES BY STOP WATCH	AMU READING
	HIGHT TO NEAREST 300"
STOP WATCH TIMES	TIME TO COVER DISTANT 10 MILES
CALCULATED ON GROUND	TAS
START OF RECORDING EVERY MILE	START OF RUN
	A.S.I SENSITIVE
	ALTITUDE READING
DOUBLE LINE 4 MILES	
	REMARKS

Find out if the engine drops H R L Revs
Unless aircraft is to be tested
it will be necessary to examine
the power altitude curves at height
is chosen at which the throttle is
likely to be open at series of
revs and boost.

which range of power and with
what combination the best A M P G
results are obtained
In order to find out the mean weight
for the test a series of combination are
tested and then repeated in the reverse
order giving an average result at
a weight aprox for T O and half
fuel consumed

Lancaster A.U.W 55,000 lbs   2880
in level flight HT 12,000 FT
Altitude factor 1.2   2880 / 8   2880 / 8
BHP. 420   2304   2284
PROP EFF 80%   Find the drag

IAS 150 × 1.2   180 T.A.S.   42 × 16 = 432 / 42 / 52

B ~~THP = BH 420 × 4 × 80 / 100~~

THR   BHP   420 × 4 = 288.0 × 10/8

THP 2304.
TAS 180

TAS 180 ~~× 150~~
180 × 100   1152 × 11 = 1152 + 1152 = 12642

DRAG = 2304 × 33,~~000~~ / 180 × 1~~00~~

DRAG   2304 × 33 / 180.3 (1152, 11 / 18)   1152 × 11 / 3

3) 12643
4224

Lancaster A.U.W 55,000 lbs
in level flight HT 12,000 FT
Altitude factor 1.2
BHP. 420
PROP EFF 80%   Find the drag

2880 / 8 = 2304   2880 / 8 = 2284

IAS 150 x 1.2   180 T.A.S.

B ~~THP = BH 420 x 4 x 80 / 10 / 5~~

42 x 16 = 432, 42, 52

THR BHP 420 x 4 = 288.0 x 10/8

THP 2304.
TAS 180

TAS 180 ~~x 150~~

DRAG = $\frac{2304 \times 33,\cancel{000}}{180 \times 1\cancel{00}}$ 180 x 100

1152 x 11 = 1152 + 1152 = 12642

DRAG $\frac{2304 \times 33}{18}$ = $\frac{1152 \times 11}{3}$ (1152, 11 cancelled; 18 → 03)

3) 12643
    4224