PREFACE

PILOT'S NOTES GENERAL consists of a collection of Notes for pilots of operational aircraft, supplementing the information contained in the Pilot's Notes for each type. Pilot's Notes General have been issued from time to time since June 1941, and have now been revised and rearranged in convenient order and grouping in this Second Edition, together with some additional Notes.

Some of the Notes are applicable to all operational aircraft, entirely or with some modification on account of the special features of a type. These Notes should be read by all pilots. The information may have been absorbed in previous training, but new points may well be learnt. Moreover, views on the best practice are continually being revised and these Notes should be used to get the latest and most authoritative statement at the time of issue.

Other Notes deal with special features, such as the tricycle undercarriage, and with special equipment, e.g. automatic pilots, which will be met on a number of types. The pilot who is to fly for the first time with a Sperry Gyropilot will find all he needs to know about it in one of these Notes and not in the Notes for the type of aircraft he is flying.

The issue of Pilot's Notes General as a companion to Pilot's Notes for the various types of aircraft, has made it possible to shorten the latter considerably and so avoid burdening the reader with a mass of matter with which he may be quite familiar, while keeping this material equally available when needed.

AIR MINISTRY *April* 1943

CONTENTS

Page

Preface 1

PART I—GENERAL FLYING NOTES:—

A. Flying Limitations 3
B. Stability and Trim 8
C. Flying for Range and Endurance 12
D. Aircraft Icing 18
E. Tricycle Undercarriages 20

PART II—ENGINES AND PROPELLERS:—

A. Engine Limitations 24
B. Starting, Running-up and Testing 28
C. Handling the Power Unit 33
D. The Various Types of Propeller 42
E. Effects of Low and Negative "g" on Engine 49
F. Engine Icing 51
G. Oil Dilution for Cold Weather Starting .. 55
H. Special Features of American Engines .. 58

PART III—ACCESSORIES

A. Gyro Flying Instruments 64
B. Automatic Pilot Mk. IV 66
C. Sperry Gyropilot 71
D. Norden Stabilised Bombing Approach Equipment 76
E. Minneapolis-Honeywell Automatic Pilot (C1) 80
F. Oxygen Apparatus 84

PART IV—EMERGENCIES:—

A. Engine Failure of T.E. Aircraft during Take-off 89
B. Engine Failure of T.E. Aircraft during a Flight 91
C. Approach and Landing on One Engine in T.E. Aircraft 95
D. Engine Failure in 4-Engine Aircraft 97
E. Propeller Failures 98
F. Abandoning Aircraft by Parachute 100
G. Forced Descent of Landplanes at Sea .. 104
H. Sea Rescue Equipment and Procedure .. 109
J. Fire at the Engine in Flight 116

Appendix Approximate true speed at given I.A.S. .. 118
Index 119
Correlation with 1st Edition 132

PART I

GENERAL FLYING NOTES

PART I. NOTE A

FLYING LIMITATIONS

1. Introductory.

(i) The Pilot's Notes for each type of aircraft lay down certain *flying limitations* which the pilot should observe in the flying of the aircraft. They state, broadly speaking, the demands which it is safe to make of the airframe. Non-observance of the flying limitations may lead to increased maintenance work, or in extreme cases to structural failure in flight.

(ii) In the fixing of these limitations there is of course a margin or *factor of safety* allowed. This factor for airframes varies according to the degree of confidence with which their strength and likely stresses can be predicted, but it is commonly around 2. This means, for instance, that a wing which is intended to withstand 4*g* should not break until 8*g* is imposed, but there is increasing risk of strain and failure as *g* rises above 4.

(iii) The flying limitations also involve questions of safe handling from the aspect of controllability.

(iv) In combat and in emergencies pilots must take risks with their aircraft, balancing one risk against another; limitations must be strictly observed only in so far as there is no sufficient reason to exceed them.

2. Limiting Speeds.

(i) The diving speed limit may be determined by one of several considerations. Generally this speed is fixed by the strength of the tail and fuselage to withstand the downward pressure on the tail required to balance the rearward position of the centre of lift in a highspeed dive. (There is an increasing uncertainty in this calculation as the limiting speed becomes very high and the factor of safety with a very high diving speed may in fact be less than supposed, but the pilot need not expect a tail failure if he exceeds the limit by a fair amount.)

(ii) Other possible reasons for fixing this limit are :—

(*a*) The possibility of the development of *flutter* of tail or rudder or wings, which would lead very quickly to a complete break-up;

(*b*) *Aileron reversal*, that is the loss of aileron control due to the ailerons twisting the wings to such an extent as to annul their effect in banking the aircraft;

(*c*) Difficulties found by test pilots in controlling the aircraft at higher speeds for one reason or another.

NOTE.—The pilot may also have to limit the speed in a dive to avoid exceeding the diving r.p.m. limitation if the propeller is one of the earlier types with insufficient range of pitch to control in the dive.

(iii) The speed limits on the lowering of flaps and undercarriage arise from calculations either of the strength of the parts to withstand the air forces or of the power of the operating mechanism. It should be noted that the figures quoted are limits based on such considerations, and not handling speeds recommended as the best speeds at which to perform these operations. The speeds quoted for other parts such as bomb doors and landing lamps are of the same nature.

3. Limiting Weights.

Pilot's Notes sometimes, but not always, quote two or three different weights, as :—

" Weight for take off and straight flying only . . .
Weight for landing and all forms of flying . . ."

This practice has arisen with the military demand to carry more weight than aircraft were originally intended to carry. The meaning to the pilot is that the aircraft must be handled gently, banked moderately, and subjected only to small increase in *g* until the weight falls to the lower limit; and that, should it be necessary to make an early landing, load should first (if possible) be jettisoned to bring the weight within the landing limit.

4. Manœuvres not Permitted.[1]

(i) *Intentional spinning of operational aircraft* is permitted only in the case of certain approved single-engine fighters within the limitations stated in the Pilot's Notes. (Normal methods will usually effect recovery—A.P.129 Ch. III).

(ii) *Aerobatics* are permitted normally on single engine aircraft and exceptionally on twin engine aircraft. They are prohibited on all aircraft at altitudes below 3,000 feet, unless specially authorised.

(iii) The following manœuvres are prohibited on all aircraft:—
(*a*) All *flick manœuvres* (flick roll and half roll);
(*b*) All manœuvres involving *heavy inverted loading* (bunt, outside loop).
(*c*) *Inverted flying* (other than the brief inversions occurring in rolls and loops) except on aircraft designed or adapted for the purpose (Part II, Note E refers).

(iv) The reasons underlying these probihitions are partly considerations of strength and partly of control. Aircraft are designed to fulfil their operational rôle and not to perform manœuvres of no operational value. The Pilot's Notes state whether spinning and/or aerobatics are permitted.

NOTE.—*Aerobatics* are manœuvres which are not essential to normal flying. Permissible aerobatics (on approved types) include:—

Loop
Stall Turn
Inverted Glide (on approved training aircraft)
Slow Roll
Barrel Roll
Roll off top of Loop
Half Roll

(v) In the normal operational manœuvres—turning, diving, corkscrewing—the controls must be used with due care according to the type flown. Harsh use of the rudder, and violent reversal especially, should be avoided at high speed—except in so far as coarse use is needed in the event of an engine failure.

[1] K.R. & A.C.I. 717 refers

5. Normal Acceleration or *g*

(i) The wings are subjected to an increased *loading* when they are set at an angle of attack greater than that appropriate to the I.A.S. in straight flight, the aircraft then moving in a curved path. The *normal acceleration* in the curved path is felt by the pilot as an increase in his weight (or increase of *g*), which is felt equally by the structure.

(ii) The maximum *g* is got by raising the angle of attack to the stalling angle, and the *g* which can be imposed is limited by the I.A.S. at the time. The greatest possible *g* at twice stalling I.A.S. is 4; at 3 times the stalling speed it is 9; at 4 times 16, and so on. If the stalling speed in straight flight (i.e. at 1*g*) is 100 m.p.h., then 16*g* can be imposed at 400 m.p.h. and so a fighter designed for 6*g* with a factor of 2 (i.e. to break at 12*g*) can easily be broken by coarse use of elevator.

(iii) The pilot, however, has a limited capacity for withstanding *g*; he is liable to "black out" within about 10 seconds at about 4½*g*, and more quickly under higher *g*. It is clearly of no value to design aircraft to withstand *g* much beyond the capacity of the pilot, so sacrificing fighting quality in useless weight.

(iv) In the larger aircraft power of manœuvre is deliberately sacrificed to carrying capacity in bombs, etc., and fuel for range. Whereas the small fighter is designed to be tougher than its pilot, the big bomber is designed to be less tough. In general, the *g* for which types are designed are :—

Single-engine fighter	5 to 6
Twin-engine long range and night fighter	3 to 4
Reconnaissance	3 to 4
Heavy bomber	2 to 2½

(v) The *g* imposed in a level correctly banked turn is moderate until a fairly large angle of bank is applied; it reaches 2 at 60 deg. of bank, and 3 at 70 deg.

6. Flying in Bumpy Air.

(i) "Bumpy" air imposes *g* on the airframe and the effect of either horizontal or vertical variations of the wind on the aircraft is proportional to the speed at which it is flying.

(ii) Speed should be restricted when flying in or near heavy cloud formations (especially cumulo-nimbus). For the larger aircraft speed should be limited to an economical cruising speed and the pilot should cruise away from the region if gustiness is severe.

(iii) As the effect of bumps may be added to *g* imposed by manœuvres, *g* due to manœuvres should be kept to lower limits in rough weather.

7. C.G. Limits.

(i) Flying Limitations properly include the most forward and the most aft permissible positions of the *centre of gravity* or *C.G.* of the aircraft. These positions will be found in the aircraft handbook Vol. I, Sect. 4, Chap. 1. They are not quoted in the Pilot's Notes because it is not normally necessary for the pilot to know them; the aircraft is flown at standard loadings at which the C.G. is within the safe limits.

(ii) It is, however, sometimes necessary to include in the Pilot's Notes some instructions on the use of fuel, the release of load, the disposition of crew, or the carriage of ballast in order to keep the C.G. within the limits, or to give the aircraft the best handling characteristics at the most important part of a flight.

(iii) Pilots may sometimes have occasion to carry non-standard loads and they must ensure that the disposition of load will keep the C.G. within the limits. The balance of loading will be maintained by the omission of a load equal to the additional load to be carried at the same distance from the C.G., or of a greater or less load at a correspondingly less or greater distance, or by carrying ballast on the same principle on the other side of the C.G. If the position of the C.G. is not known, it may be assumed for this purpose to be at one third of the root chord of the wing from the leading edge.

(iv) If these C.G. limits are not observed the aircraft may, in some condition of the flight, become uncontrollably nose or tail heavy. If the C.G. is too far aft it may become longitudinally unstable to an uncomfortable or even dangerous degree.

PART I—NOTE B

STABILITY AND TRIM

1. Stability and the C.G.

(i) If the Centre of Gravity (C.G.) of an aircraft is in the right position fore and aft, the aircraft will be nicely stable in pitch; it will fly itself without attention by the pilot to the elevator controls; it will be pleasant to handle on the elevators. If the C.G. is too far forward, the aircraft will be too stable; it will fly itself, but it will be heavy on the elevators. If the C.G. is too far aft, the aircraft will be unstable; it will not fly itself but require constant attention on the elevator control.

(ii) The position of the C.G. changes somewhat as fuel or ammunition are used up, or bombs are released; it varies with the different loads carried for different duties. It is the aim of the designer to keep the C.G. within suitable limits, however the aircraft may be loaded; but it is not practicable to avoid a considerable variation of C.G. Sometimes the co-operation of the pilot is required in using fuel tanks or releasing bombs in a particular order.

(iii) There is a tendency to add to the service loads of aircraft after the design has been settled, and the addition must generally be carried aft of the original C.G. So the C.G. tends to creep aft and to make the aircraft less stable.

(iv) The ideal position of the C.G. is not quite the same in all conditions of flight, and so an aircraft may become unstable in certain flight conditions only.

2. Stability and the Feel of the Control.

(i) The pilot has a right to expect that, if he trims an aircraft by means of the elevator tabs (so that he is neither pushing nor pulling on the control) and then pushes the nose down, he will need to push to hold the nose down; and, if the aircraft is stable, this will be so.

(ii) If, however, the aircraft is unstable, he will find that, having pushed the nose down, he must then pull to prevent it from going down further. The feel of the control is reversed.

(iii) In the same way, the necessary movement of the elevator trimming tab is reversed, if the aircraft becomes unstable.

3. Stability and Trim in a Dive.

(i) If an aircraft is stable at all high speeds and trimmed in level flight, it will require an increasing push as it gathers speed to hold it in a dive. But the unstable aircraft will need an increasing pull to prevent it from going over onto its back.

(ii) If the push or pull becomes excessive, it may be lightened or annulled by trimming the aircraft nose or tail heavy. There is no objection to the use of trim tabs during manœuvres so long as the pilot realises that he is using a very powerful control and operates it slowly and with care.

(iii) If the stable aircraft is trimmed into the dive, it may need a heavy pull to get it out and it may be carefully re-trimmed (tail down) during the recovery. On the other hand, if it has not been trimmed into the dive, it will tend to come out too quickly and care is necessary to check this tendency.

(iv) The unstable aircraft, trimmed back to relieve the stick load in a dive, will tend to recover too quickly, needing a push to restrain it. If not trimmed into the dive, the pull will slacken during recovery.

(v) An aircraft may be stable, trimmed in the dive, although it was unstable in level flight. This aircraft will have to be pulled out of the trimmed dive; but when recovery has been started, a push will quickly become necessary to check the rate of recovery, because it has passed from a stable to an unstable condition of flight as its angle of incidence was raised. (Stability depends upon incidence and may change when *g* is applied by pulling back the control column, without the I.A.S. having changed.)

4. Stability in Turns.

(i) Too much longitudinal stability makes an aircraft heavy on the elevator in turns. Instability leads to a tendency for turns to tighten, against which the pilot must be on his guard to avoid stalling, blacking out, or overstressing the aircraft.

(ii) The aircraft may be stable in straight flight and become unstable in the turn for the reason explained in the previous paragraph 3 (v).

5. Two Forms of Instability.

(i) When an aircraft is longitudinally unstable it will commonly either dive or stall if left to itself. In the last two paragraphs the instability has been assumed to be of this kind.

(ii) An aircraft may, however, appear to be neutral or just stable judged by the action required to trim it at different speeds, by its behaviour in diving or turning, and yet show instability in a tendency to "hunt," to build up a pitching oscillation with a rising and falling I.A.S. But more usually this "phugoid" oscillation damps itself out and the aircraft is completely stable.

6. Stability with Fixed and Free Controls.

The longitudinal stability of an aircraft may clearly be considered in two conditions of flight, either with the controls held rigidly or with the controls left free. It is the second condition that decides how the pilot will like the aircraft, because it determines the nature of the control effort that he must make.

7. Lateral-Directional Stability.

(i) The lateral-directional stability of an aircraft is obtained by correctly proportioning fin area in relation to wing dihedral. It is not sensitive to C.G. position.

(ii) If the fin area is very large, the aircraft may tend to turn away to right or left, banking and dropping its nose, into a spiral dive. This form of instability is technically known as *spiral* instability. It is difficult to detect a mild spiral instability because it is almost impossible to trim an aircraft to fly itself straight for any length of time; stable or otherwise, pilot or autopilot must give continual attention to the controls to steer a straight course. This form of instability is not generally of practical importance.

(iii) If the fin area is too small the aircraft will tend to hunt or " wallow". The motion really involves yawing and crabbing as well as banking, but the banking is most noticeable and the pilot may speak of " *lateral* " instability. This instability may be bad enough to make the aircraft very tiring to fly.

(iv) If the fin area is much too small the rudder may feel unduly sensitive, the slightest rudder movement leading to a violent yaw. The modern trend towards large fins and rudders makes this instability unlikely and an aircraft with this defect could not be accepted for service use. The pilot might call this " *directional* " instability.

(v) Another form of " directional " instability is occasionally met in a quick flattish oscillation or " snaking", arising from some defect in the design of the rudder; and a "lateral" instability due to bad aileron design is conceivable.

(vi) A special kind of instability occurs at the stall when a wing drops. This is easily understood when it is realised that the motion of dropping is equivalent to an increase in angle of attack. Normally increased incidence brings increased lifting power, but when the wing stalls this ceases to be true and the reverse may occur with more or less violence, according to the stalling characteristics of the wing. Normally the ailerons have to fight against a strong resistance to banking, but at the stall the aircraft banks all too easily.

(vii) The handling of this instability at the stall is complicated by the fact that, while the ailerons may still be powerful for the work they have to do, they produce an adverse yawing effect and it is often better to use only the rudder to maintain an even keel, at the expense of loss of direction for the moment; for the dihedral effect of the wings is still effective in causing bank through yaw.

(viii) Pilots may sometimes find themselves in difficulty through inadvertently allowing a considerable sideslip to develop. This may lead to banking and dropping of the nose, accompanied by a tendency of the rudder to lock over— " stabilised yaw ". The prime necessity for regaining control is to get rid of the sideslip by quick, vigorous use of the rudder; but on aircraft with this tendency pilots should be on their guard against allowing much sideslip to develop.

NOTE.—The aircraft must not be expected to return to its original heading after a lateral or directional disturbance. It will return longitudinally or laterally after disturbance under the directing force of gravity, but it possesses no inherent sense of compass bearing.

8. Degree of Stability Desired.

(i) While a high degree of stability tends in itself to reduce manœuvrability, it can be offset by nicely balancing the controls and the resulting aircraft may be pleasanter to handle than one which attains its manœuvrability with less well balanced controls and a lower degree of stability.

(ii) Although slight instability is often tolerated, it is most desirable to have positive stability, especially in conditions of flight that persist for a long time. A main design problem is to avoid a longitudinal instability that would make the aircraft tiring to fly, or in extreme cases, dangerous.

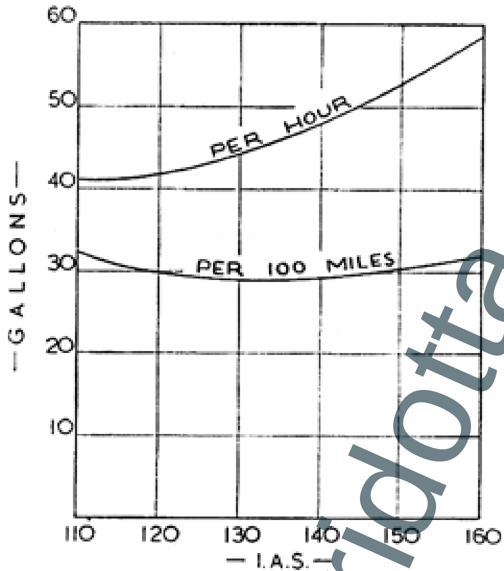
PART I—NOTE C

FLYING FOR RANGE AND ENDURANCE

1. The Best Speed for Greatest Range or Endurance.

(i) The figures below give the fuel consumed by a certain twin engine bomber when cruising at various indicated airspeeds, and these test results are exhibited graphically in the diagram alongside. The two sets of figures and the two curves give respectively the gallons used per hour and the gallons used for 100 air miles at 10,000 ft. Similar results are obtained for other aircraft. It will be seen that the lowest consumption per 100 miles is obtained at a considerably higher speed than that which gives the least consumption per hour, and that neither maximum range nor maximum endurance will be attained by flying as slow as possible.

At 10,000 ft.		
	Gallons per	
I.A.S. m.p.h.	hour	100 mile
110	41	32
120	42	30
130	44	29
140	48	29½
150	52½	30½
160	59	32



(ii) The reason why the lowest consumption of fuel per hour does not occur when flying at the lowest possible speed, is to be found primarily in the way in which the drag of the wings varies with speed. To fly slowly the angle of attack must be large, and the drag of the wings increases rapidly as the angle of attack is increased. From this it comes about that least power is required from the engine at a considerably higher speed than the lowest possible, and so the fuel used per hour will be least when flying well above stalling speed.

(iii) To obtain the maximum air miles per gallon (or least gallons per air mile) the aircraft must be flown considerably faster than this; for so long as the increase in the miles covered in the hour is greater than in the gallons used in the hour the aircraft will do more miles per gallon. For example, in the hour :—

at I.A.S.:—	we use:—	we travel :—	which gives us :—
120 m.p.h.	42 gall.	139 miles	30 gals/100 miles
140 m.p.h.	48 gall.	162 miles	29½ gals/100 miles

(iv) It will be seen from these figures and curves that very little is lost in either range or endurance by flying 10 m.p.h. or so faster than the speed which gives the absolute minimum gallons in each case. So 145 m.p.h. may be taken as a good practical range I.A.S., while 120 m.p.h. is as slow as it is ever worth flying for maximum endurance. The range speeds recommended in Pilot's Notes are on this basis, i.e. about 10 m.p.h. above the absolute optima.

(v) The speed for maximum endurance is about four fifths of the speed for maximum range.

2. The Effect of Altitude on the Best Speed.

(i) The best I.A.S. for range is, in general, the same at all heights; for the drag is least when flying at the best angle of attack, which is the same at the same I.A.S. at every height (at the same load).

(ii) But when, at low altitudes, this I.A.S. can be obtained at minimum r.p.m. without using maximum weak mixture boost, a higher speed is usually better; in fact, the best speed may be the speed that requires the maximum weak mixture boost, if this speed is not very much greater than the best speed at higher altitudes. Advice may be found in the Pilot's Notes

(iii) At the highest altitudes, when the normal best I.A.S. cannot be obtained at the weak mixture engine limits, the best speed is the highest obtainable on weak mixture.

(iv) The best speed for endurance is the same at all heights.

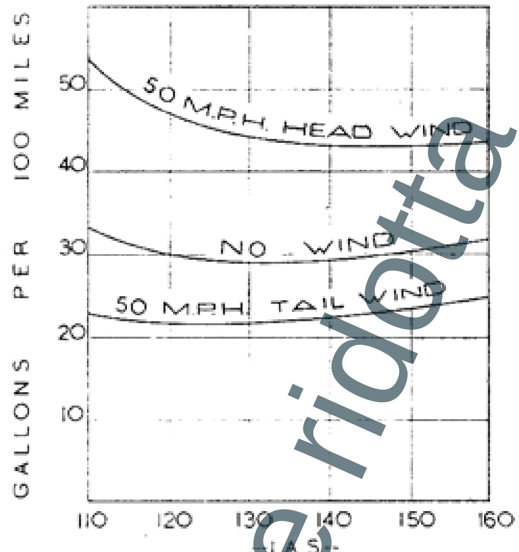
3. The Effect of the Load Carried on the Best Speed.

The best speed for range or for endurance is proportional to the square root of the all up weight; i.e. for a 10% reduction in A.U.W. (e.g. by release of bombs or consumption of fuel) speed should be reduced by 5%. This adjustment can be ignored for short range fighters; for bombers it is good enough to use one speed for the outward and another for the homeward journey. Pilot's Notes indicate how the speed should be varied with the weight at which the aircraft is flying at the time.

4. The Effect of Wind on the Best Speed.

A wind which increases or decreases the ground speed at given I.A.S. has a big effect on the range, and it may seem that the aircraft should be flown faster into a head wind, and conversely; but in fact, unless the wind is very strong, it is not worth making any change. The following figures and diagram show the effects of a 50 m.p.h. head wind and a 50 m.p.h. following ("tail") wind on gallons per mile of the aircraft of the first paragraph.

50 m.p.h. Wind at 10,000 feet			
	Gal/100 mile		
I.A.S. m.p.h.	Tail	Calm	Head
110	23	32	53
120	22	30	47
130	22	29	44
140	22½	29½	43
150	23½	30½	43
160	25	32	44



It will be seen that the recommended speed of 145 m.p.h. is practically the best speed against the head wind, and that it is still quite a good speed with the tail wind. In stronger winds it would be worth while to make a change of about 10 m.p.h.—especially to increase 10 m.p.h. against a strong head wind, if it can be done while still using weak mixture.

5. The Effect of Wind on Range.

(i) The big increase in the fuel used per 100 ground miles against the 50 m.p.h. head wind will have been noted. It should also be noted that this increase (from 30 to 43 gallons at 145 m.p.h. I.A.S.) is not balanced by the reduction (from 30 to 23 gallons) when flying in the same wind in the opposite direction; there is a net increase from 60 to 66 gallons on the double 100 miles.

(ii) It may also be noted that these figures relate to one all-up weight. Actually fuel used per air mile is greater on the outward journey (heavy) than on the return journey (light), and the effect of a given wind will be most adverse when it is against the outward journey (heavy).

6. The Effect of Altitude on Range and Endurance.

(i) The air miles per gallon would be the same at the same I.A.S. at all heights if the engine used the same gallons per horse-power per hour. But, in fact, the *specific consumption*—the gallons used per horse-power per hour—varies with engine conditions. Air miles per gallon tend to be lower at the lower altitudes, and they fall away at the highest altitudes. Variation of air miles per gallon with height is, however, not large in general.

(ii) Account must also be taken of fuel consumed in climbing to the height, and—especially if the climb is not done on weak mixture—the fuel so used is only partially recovered in subsequent descent. But if the climb is made on weak mixture, range from take-off to touch-down will not vary much with the operational height.

(iii) On the other hand, maximum endurance falls the higher the aircraft is flown; for the power required to maintain level flight at the best I.A.S. increases because the aircraft must be flown faster in the rarer air. On this account the endurance decreases roughly as under:—

At 10,000 feet to $\frac{7}{8}$ of that at Sea Level.
" 20,000 " $\frac{3}{4}$ " "
" 30,000 " $\frac{3}{5}$ " "

(This law may be somewhat modified by change of specific consumption as the power changes with change of height, especially with high-powered aircraft at low altitudes.)

7. The Effect of Weight on Range and Endurance.

The fuel used per hour and per mile would be proportional to the all-up weight if it were not for variation of specific consumption. In fact it is commonly found that range is rather less affected by the load carried, a change of 10% in A.U.W. causing a change of 6 to 7% only in the range. The effect on endurance is similar.

8. The Effect of Drag on Range and Endurance.

Range and endurance can be seriously affected by excrescences or holes that add to the drag of the aircraft, and anything the pilot can do to withdraw excrescences or reduce leakage of air in and out of the aircraft will improve his range and endurance. (If the drag is necessarily much increased the best I.A.S. may be appreciably lowered.)

9. Air Miles per Gallon in Climb or Descent.

(i) In a gentle climb on weak mixture, or in a descent under a fair amount of power, most air miles will be covered per gallon at the same I.A.S. as for level flight; but in a glide with little or no engine a rather lower speed will cover the greater distance (best gliding angle).

(ii) When climbing on a rich mixture it is best to gain height as quickly as possible in order to shorten the time spent in rich mixture.

10. The Effect of Air Temperature on Operational Ceiling.

A high atmospheric temperature affects performance in two ways:—

(*a*) It thins the air at a given aneroid height and so increases the true speed at which the aircraft must be flown and the power required to fly it.

(*b*) It reduces the charge drawn into the engine and so reduces the power available.

For both reasons the operational ceiling for given r.p.m. and boost limits is reduced. To maintain the same ceiling the A.U.W. of an aircraft must be reduced 1,000 lb. per 30,000 lb. per 10° C. rise of atmospheric temperature, and conversely.

11. Handling the Engine for Maximum Economy of Fuel.

This aspect is discussed in Part II, Note C. In brief:—

(*a*) If there is a mixture control it must be WEAK

(*b*) Within the engine limitations for weak mixture, use the highest boost and the lowest r.p.m. (provided that the generator charges at the r.p.m. used).

(*c*) Use M. ratio unless flying at or near a height at which S ratio is necessary to maintain the I.A.S.

12. Handling the Aircraft for Maximum Endurance.

(i) The endurance at the recommended endurance speed will be about 15% greater than the endurance at the recommended range speed; but handling at the best speed for endurance may present some difficulty.

(ii) When flying on the absolute minimum of power for level flight the normal ability to manœuvre disappears. Raising the nose will not cause the aircraft to climb, or check descent; and any considerable reduction of speed will have the reverse effect. Height will necessarily be lost on turns if the throttle is not opened slightly. (The recommended speed is higher than that which uses the absolute minimum of power, but it will still give little power of manœuvre).

(iii) No attempt should be made to maintain an exact height; the necessary continual use of the throttle will increase consumption. Height gained or lost should be corrected from time to time as may be necessary by a slight resetting of the throttle.

(iv) Speed should be maintained within 5 m.p.h. up or down. Some aircraft, though stable at higher speeds, become longitudinally unstable at the best speed for endurance and it may not be practicable to fly some aircraft at this speed.

PART I. NOTE D.

AIRCRAFT ICING.

1. Common Icing Conditions.

(i) Ice forms on aircraft most frequently when the air is at a temperature between -1 and $-7°$ C. and contains large supercooled drops of water.

(ii) The normal rate of ice accretion in these conditions is about 1 inch in 10 minutes. A fall in the I.A.S. at given engine conditions in level flight, or a loss of height at given I.A.S., may be noticed when the thickness reaches $1\frac{1}{2}$ inch; the effect on performance only becomes serious when, at a thickness of about $2\frac{1}{2}$ inches, the ice begins to form jagged edges. It is normally possible to fly in icing conditions for 20 minutes or more without the accumulation of ice becoming dangerous.

(iii) The icing layer extends usually to a depth of about 3,000 ft. at a comparatively low altitude, and it may be climbed through without taking on much ice. The best practice is to climb quickly into air at – 8° C. or lower. Alternatively, if the icing layer is sufficiently high, the pilot may descend and fly below it.

(iv) Icing may be detected by careful attention to height and I.A.S. when flying in likely conditions; or by icing of the windscreen. At night a torch can be used to examine windscreen and leading edges of wings.

(v) The slinger ring de-icer for the propeller (if fitted) should be turned on slightly in icing conditions and only turned on fully if it appears that ice on the propeller is causing vibration. Then, after a few seconds, increase r.p.m. to maximum for a few seconds, and then return r.p.m. and de-icer to normal.

(vi) As icing conditions are often accompanied by severe static electricity, especially in cumulus cloud and when hail is falling, aerials should be earthed and reeled in and sets switched off.

(vii) The pitot heater should be on.

2. Icing in Cumulo-nimbus Clouds.

(i) In cumulo-nimbus and large cumulus clouds, associated with cold fronts and squally, showery conditions, ice may build up quickly at temperatures down to – 18° C., or even lower.

(ii) So far as possible these clouds should be avoided.

(iii) When it is not possible to avoid them by night they may be recognised from inside by turbulence, by rain, hail or snow. Icing conditions may extend through more than 5,000 feet in height, but the horizontal extent of the precipitation areas will generally be small and they will be flown through quickly. A quick climb to – 18° C. can therefore generally be made without taking on too much ice.

3. Rain falling in Freezing Air.

(i) Occasionally rain falls into freezing air from milder overlying air, often at a warm front, and an aircraft flying in these conditions will accumulate ice with dangerous rapidity.

(ii) The pilot should either turn back and avoid the rain, or fly up into the cloud and continue into air which is either above or much below freezing point.

(iii) These conditions are not likely to occur above 5,000 feet and they are rare.

4. Use of Pastes.

(i) Kilfrost wing and propeller de-icing pastes reduce the adhesion of ice so that it is more readily dislodged by centrifugal forces, aerodynamic forces, control movements, or vibration.

(ii) The efficacy of pastes depends upon proper smooth application (as advised in A.P. 1464/D173). Their use does not relieve the pilot of the need to avoid icing conditions as far as possible.

5. Further Information.

Reference may be made to:—

A.P. 1931 Meteorological Handbook for Pilots and Observers—Chapter XXII.
M.O. 420 B Ice Accretion on Aircraft.
A.M. Pamphlet 138 Aircraft Icing.

PART I—NOTE E

TRICYCLE UNDERCARRIAGES

1. Main Differences between Tricycle and other Aircraft.

(i) The wing incidence of the tricycle aircraft when resting on its three wheels is much less than that of the conventional aircraft and consequently :—

(*a*) The forward view is generally better for taxying, for the initial take-off run and for the landing run.

(*b*) The ground attitude is one of low lift and low drag, which gives a good take-off acceleration but a poor retardation in the landing run; and effective braking is therefore particularly important.

(*c*) Since the normal landing is made with the nose-wheel but little higher than the main wheels (for reasons discussed below), the landing speed is higher and the landing run correspondingly longer.

(ii) The main wheels of the tricycle aircraft are aft of the centre of gravity, whereas in the conventional aircraft they are forward of the centre of gravity. Consequently:—
(*a*) Impact of the main wheels with the ground tends to pitch the tricycle aircraft forward, reducing wing incidence. The tricycle aircraft will therefore never " balloon off " and the reduced incidence after touch-down reduces the tendency to bounce over an uneven surface.
(*b*) The main wheels being aft of the centre of gravity, give directional stability to the aircraft when the wheels are on the ground, non-castoring wheels having an effect analagous to that of a fin or a rudder held central. So any tendency to swing, especially at high speed, is almost eliminated.

(iii) The nose-wheel of the tricycle allows the brakes to be applied as hard as necessary once the nose-wheel is on the ground without fear of nosing over.

(iv) To summarise:—The tricycle undercarriage makes landing markedly easier, provided that there is ample landing space, and the brakes are in good order. The correct handling is, however, somewhat different and certain special points which must be observed are discussed in the following paragraphs.

2. Ground Handling.

(i) Tricycle aircraft should be parked, especially in a restricted space, with the nose-wheel straight. If this is not done, a sudden unexpected turn may result from the next attempt to taxy forward and may lead to an accident.

(ii) When starting from rest, engines must not be opened up on one side only to produce a turn unless the nose-wheel is set for that direction of turn. To do so would impose a severe side load on the nose-wheel.

(iii) No aircraft should ever be turned on one wheel, since this practice causes severe tyre wear; but with the tricycle the attempt to do this also severely strains the nose-wheel. Always move forward a little before turning.

(iv) Care should be taken when taxying slowly, not to overstrain the nose-wheel by turning too sharply. The castoring range of the nose-wheel is limited.

(v) With toe-operated brakes, it is usually easier to taxy with controls (rudder) locked.

3. Take-off.

(i) The aircraft should be taxied straight a few yards before the throttles are opened in order to ensure that the nose-wheel is straight.

(ii) The nose-wheel should be kept on the ground until considerable speed has been gained. The control column should be central or slightly back. As the take-off speed is approached, move the control column steadily and firmly back until the tail drops and the aircraft leaves the ground. On some types considerable backward pressure may be necessary.

NOTE.—On rough or boggy ground the control column should be held further back to take load off the nose-wheel.

4. Normal Landing.

(i) It is important to check the brake pressure by gauge or by the feel of the brake pedals before coming in to land, since most tricycle aircraft cannot be stopped within the normal airfield without brakes unless the wind is very strong.

(ii) Approach and flatten out in the normal manner, preferably using a little engine.

(iii) Throttle back, and continue to move the control column back just too slowly to maintain a constant holding-off height. This allows the aircraft to sink slowly on to its main wheels in a slightly tail-down attitude. (Note that the landing should not be three-point, but main wheels first.)

(iv) Continue to move the control column back to prevent the aircraft from pitching forward suddenly and to keep some of the weight off the nose-wheel after it has made contact.

(v) The brakes must not be applied until the nose-wheel is on the ground, as this causes a violent pitch forward on to the nose-wheel.

(vi) The brakes should not be applied harder than is necessary, especially on runways, as this causes unnecessary tyre and brake wear; use the whole runway available whenever possible.

5. Slow Landing.

(i) The landing speed can be varied widely and depends upon the extent to which the tail is got down before the main wheels touch.

(ii) If a slow tail-down landing has to be made, it is particularly important to use the elevator control to lower the nose-wheel gently and not to apply the brakes till the nose-wheel is down.

(iii) Very tail-down landings should not be made on large heavy types.

6. Important Points in Landing.

The following must be avoided:—

(*a*) Flying into the ground nose-wheel first.

(*b*) Landing with high rate of descent.

(*c*) Dropping the aircraft on its main wheels in a very tail-down attitude.

(*d*) Braking before the nose-wheel is down.

(*c*) and (*d*) cause the aircraft to pitch forward violently on to the nose-wheel.

PART II

ENGINES AND PROPELLERS

NOTE A.

ENGINE LIMITATIONS

1. Introductory.

(i) The Pilot's Notes for each type of aircraft lay down certain *engine limitations* which the pilot should observe in the handling of the engine. The principal figures are quoted on the Cockpit Data Plate for convenient reference in the air.

(ii) These limitations are based in part upon calculations and in part upon type tests on the bench. They may subsequently be modified in the light of Service experience and operational requirements. While normally the same for any one type of engine in all aircraft, they may vary from one type of aircraft to another.

(iii) The limitations are designed to secure an adequate margin of safety against immediate breakdown and to give the engine a reasonable life between overhauls. Proper handling throughout the life of an engine will improve reliability towards the end of the periods between overhauls, and will also improve the chance of the engine standing up to operational overloads.

2. R.P.M. and Boost.

(i) The engine is stressed, and wear is correspondingly caused both by high r.p.m. (inertia stress) and by high boost (gas pressure stress). Consequently, the two main *power ratings* of the engine involve changes both in the r.p.m. and in boost, e.g.

Rated Power	2,400 r.p.m.	+4 lb./sq. in boost.	
Combat Power	2,800 ,,	$+8\frac{1}{4}$,,	,,

(ii) It should be noted, however, that a reduction of r.p.m.—say from 2,800 to 2,400—at *take-off* or *combat* boost increases the strain on the engine, because :—

(*a*) It reduces the velocity of gas flow and consequent throttling at the valves and gives a higher pressure in the cylinder at given boost, in extreme cases leading to detonation.

(*b*) Inertia stresses partly balance gas stresses.

(iii) On the other hand, the engine gives more power for the fuel used if power is reduced by reducing r.p.m. rather than boost, and it is correct handling to reduce power by reducing r.p.m. as indicated in the following sub-paragraphs (iv) and (v).

(iv) Up to a certain boost the mixture strength can be *weak* (or *economical*) and the fuel is fully burnt. Higher boosts can only be used with a *rich* mixture in which surplus fuel acts as a coolant to prevent detonation. This maximum *weak* mixture boost defines a third (*maximum weak*) *power rating* of the engine. It is generally permissible to obtain the required power for economical cruising at the maximum *weak* mixture boost (or the highest attainable at the altitude) with any r.p.m. from the specified maximum down to the lowest obtainable; if not, Pilot's Notes will quote a lower limit.

(v) When it is necessary to use more power than can be obtained on a *weak* mixture, the same practice may be followed, using the full boost and any r.p.m. down to the figure that will give the power that can be obtained on *weak* mixture, when of course, the boost should be reduced and the r.p.m. raised to the *weak limitations*.

3. Duration and Flight Condition Limits of Use.

(i) The general operation of the aircraft is planned on the basis that the higher engine limitations will only be reached during certain periods of time at a stretch and over certain total fractions of the whole working life of the engine. The pilot is accordingly instructed that specific limitations are to be reached only :—

(*a*) for certain purposes, e.g. :—

take-off and climb, if necessary to 1,000 ft;
climbing to the operational height;
combat bursts of power.

(*b*) for certain periods at a time, e.g. :—
for 5 minutes maximum in take-off;
for 5 minute periods in combat;
for 1 hour of climbing.

(ii) These figures provide a general guide to the reasonable use of the engine. In combat and emergency other considerations may justify the pilot in disregarding these restrictions.

4. Automatic Safeguards.

(i) The engine is normally safeguarded against exceeding the maximum r.p.m. and boost by the constant-speed propeller and the automatic boost control.

(ii) It is possible however, to overspeed the engine by incorrect handling (see Note C), and to overboost American engines with no boost control (Note H).

(iii) Overspeeding in dives occurs with certain propellers and is permissible within the *diving limitations* (see Note D).

5. Temperatures and Pressures.

(i) Serious damage may occur quickly from over-heating. The limitations include permissible cylinder head or coolant temperatures and oil temperatures.

(ii) The installation should be so designed that these limitations will not be exceeded with proper handling of the engine; but :—

(*a*) Cowling systems are not always quite adequate for all conditions.

(*b*) The engine may at times be worked abnormally hard.

(*c*) Defects may develop.

(*d*) The cooling is partly under the pilot's control and unnecessary opening of gills or radiator shutters reduces performance.

The pilot should, therefore, regularly watch the temperature gauges and adjust gills or shutter, or airspeed, or power accordingly (see Note C).

(iii) The oil pressure gauge and the specified *normal* and *emergency* pressures provide a further check on satisfactory lubrication. If the pressure falls to the *emergency minimum* the engine has been seriously overworked or some defect has developed.

6. Running Up and Stopping.

(i) The engine limitations include:—

(*a*) Minimum oil temperature

(*b*) Minimum cylinder or coolant temperature

to be attained before opening up the engine. This is to ensure proper functioning of the lubrication system, proper distribution of the charge, and to prevent damage to the engine by uneven heating.

(ii) Engines should also be run gently before stopping to drain away surplus oil, to leave an adequate oil film, and to prevent damage by rapid and uneven cooling.

APPENDIX

The limitations for supercharged engines with variable pitch propellers were defined by A.M.O. A415/38. (See A.P. 129, Chap. II, 66) in relation to flight operation as under:—

(*a*)	*Maximum*	*for*	*take-off conditions*		(3 min. or to 1,000 ft.)
(*b*)	,,	,,	*climbing*	,,	(30 min. limit)
(*c*)	,,	,,	*level flight*	,,	(5 min. limit)
(*d*)	,,	,,	*cruising*	,,	(maximum with no time limit)
(*e*)	,,	,,	*economical cruising conditions*		(maximum with weak mixture)
(*f*)	,,	,,	*diving conditions*		

The condition of *level flight* (*c*) covers short periods when necessary in combat or emergency, irrespective of whether the aircraft is in level flight, or climbing or descending, and is now called *combat*. The condition of *climbing* (*b*) similarly covers other conditions in which it is necessary to use this power, e.g. in a single-engine return of a twin-engine aircraft. *Cruising* (*d*) denotes continuous operation for an indefinite period and is called *continuous cruising* in A.P.129. Both (*d*) and (*e*) have been quoted as *cruising rich* and *cruising weak* in some Pilot's Notes and *continuous rich* and *continuous weak* in other Notes. The time limits have been increased to 5 minutes for *take-off* and one hour for *climb*.

PART II—NOTE B

STARTING, RUNNING UP AND TESTING

1. Preliminary.

(i) The aircraft should be faced into wind to ensure the best cooling during running up.

(ii) Fuel cocks and engine controls should be set for starting with the exception of the ignition, which should be off.

Throttle .. slightly more open than for normal idling
Mixture .. NORMAL or RICH (if fitted)[1]
Propeller .. for maximum r.p.m.[2]
Supercharger M ratio (if two speed)
Air intake .. COLD

(iii) The engine should be turned over, if possible, by hand two revolutions of the propeller to break down the sticky oil films in cold weather. This turning is always essential with radial or inverted cylinder engines to prevent damage by hydraulic shock if oil or fuel should have drained into the cylinder heads. If resistance to turning indicates leakage of oil or fuel into the lower cylinders, turning should be done with the plugs removed from these cylinders.

(iv) The ignition should then be switched ON.

2. Priming and Starting with Electric Starter[3] (Cold Engine).

(i) The priming pipe line must first be filled. The line may be assumed to be full if an increase is felt in the resistance to pumping. Alternatively, the strokes needed to fill the line may be estimated from their length and the pump capacity; the K40 pump (T handle 40 c.c.) will fill 7 feet of ¼ inch O.D. pipe per stroke, and the A.M. type B (round handle 10 c.c.) 7 feet per 4 strokes.

(ii) Fill the priming pump by withdrawing the plunger, switch on the starter and booster-coil and prime vigorously, pushing the plunger home forcefully and at once withdrawing steadily, giving the pump time to fill and then

[1] For Bendix-Stromberg injection carburettor; see Note H.
[2] Except for certain propellers; see Note D, paras. 2 and 3.
Including Inertia and Direct Cranking Starter (Note H).

at once delivering the next stroke. (It is, however, advantageous to prime when the engine fires even if the pump must be withdrawn too quickly to fill fully.) The engine should start as soon as enough priming has been injected to give a suitable mixture, and this should occur with the number of strokes stated in the Pilot's Notes.

NOTE.—With the American inertia and direct cranking starter the flywheel must first be energized, see Note H.

(iii) Release the starter switch when the engine starts, but keep the booster-coil on and continue priming, though less vigorously, until the engine has picked up speed. The booster coil should then be switched off. The priming pump should be kept full to give further priming should the engine falter.

(iv) When the engine is running satisfactorily on the carburettor and it is clear that further priming will not be needed, push the plunger gently home and screw it down.

NOTE 1.—Priming while turning gets the fuel properly atomised and evenly distributed to the cylinders.

NOTE 2.—The amount of priming required varies with the atmospheric temperature and the normal number of strokes needed is tabulated in the Pilot's Notes. If the engine fails to start with approximately this number of strokes a second attempt may be made without further priming, or with a little more. Much more priming should not be given; some other cause than insufficient priming should be sought.

NOTE 3.—To avoid overheating the starter motor, turning periods must be limited to the period (commonly 20 sec.) stated in the Pilot's Notes, and if the engine fails to start, the prescribed interval (commonly 30 sec.) for cooling between starts must be observed.

NOTE 4.—If the engine fails to start and overpriming is suspected, it should be turned forwards several revolutions, with ignition off and throttle well open, to clear it.

3. Starting with Cartridge or Inertia Starter (Cold Engine).

(i) Prime the engine with the number of strokes specified in the Pilot's Notes, according to the atmospheric temperature, switching on the booster coil and firing the cartridge (or engaging the starter) while the last stroke is being delivered. The pump must be operated vigorously as described in para. 2 (ii).

NOTE.—With the American inertia starter the flywheel must be energized first (see Note H).

(ii) Keep the booster coil on and continue priming, though less vigorously, until the engine has picked up speed. Then switch off the booster coil and stop priming, but keep the pump full to give further priming should the engine falter.

NOTE.—The booster-coil switch is often combined with the cartridge firing switch, or the inertia starter engaging switch; the instruction still holds good.

(iii) When the engine is running satisfactorily on the carburettor and it is clear that further priming will not be required, push the plunger gently home and screw it down.

NOTE.—If the engine fails to start and overpriming is suspected, it should be turned forwards several revolutions with ignition off and throttle well open to clear it.

4. Cold Weather Starting.

(i) In very cold weather engines which have been stopped sufficiently long for the oil temperature to fall below 0° C, are difficult to start because :—

(*a*) the oil thickens and makes the engine hard to turn;

(*b*) the fuel does not so readily vaporize and provide a combustible mixture.

(ii) The Worth system of diluting the oil with petrol has been introduced to make the engine easier to turn. It also safeguards the engine by ensuring an immediate flow of oil to all parts. Operating instructions will be found in Note G.

(iii) Fuel of high volatility may be used in cold weather to provide a combustible mixture without an excess of liquid fuel which might damage the engine and create a risk of fire. This fuel must be used for starting at atmospheric temperatures below 0° C on all installations adapted for its use. The adaptation consists of the insertion of a three-position cock in the line supplying fuel to the priming pumps. The special fuel is drawn through this cock from a can, the cock being turned to the off position after use.

(iv) Engines must in addition be protected from the weather as much as possible.

(v) Fuel and oil system vents must be inspected and any ice or moisture removed.

(vi) The ignition system must be inspected for ice or moisture.

(vii) After starting, the oil pressure should be watched during the first minute. If it does not build up to normal or higher in the first few seconds the engine should be shut down. It may be necessary to drain and refill with warm oil, or to use a mobile defroster to warm the tanks and pipe lines.

5. Warming-up.

The throttle should be opened gradually until the engine is running at a fast tick-over, 1,000 to 1,200 r.p.m. (or at the r.p.m. specified in the Pilot's Notes). Warm up at this speed until the prescribed temperatures (oil, coolant, cylinder head) are reached.

6. Testing and Exercising.

(i) The engine can now be run up for various tests and to exercise various parts. Check that :—

Mixture Control (if fitted) is AUTO RICH (or NORMAL)
Propeller Control is set for take-off r.p.m.
Supercharger gear ratio is M.
Air intake (if variable) is COLD.

The engine should be opened up sufficiently to move the aircraft forward against the chocks, and the brakes should then be applied.

IMPORTANT NOTE.—To avoid overheating the engine, the tests must be made as quickly as possible, especially with air-cooled engines. Gills must be fully open.

(ii) Open up to the maximum boost permitted for operation in *weak* mixture (in RICH setting).

(*a*) Change the supercharger gear to S ratio, moving the lever over smartly. The boost should read the same as before the change, being under automatic control; but the r.p.m. should drop slightly because the supercharger takes more power from the engine in the higher ratio. The r.p.m. drop provides a check that the change has been effected. Return to M. (But see Note 2 to this sub-para., and any special instructions in Pilot's Notes for the type.)

(*b*) Move the propeller control lever well back, watching the r.p.m. There should be a marked fall in the r.p.m. which shows that the propeller is controlling. Move the lever fully forward again.

Note 1.—These tests should be made daily, but not necessarily by the pilot before take-off. In addition to testing the mechanism, changing the supercharger gear removes any sludge from the clutch and exercising an hydraulic propeller fills it with warmer oil.

Note 2.—With Bristol sleeve valve engines (Hercules) the supercharger gear test is to be made at 1,500 r.p.m. only, to safeguard the sleeves against damage by momentary high boost on changing to S ratio. A momentary drop in the oil pressure provides an indication that the change has been effected.

(iii) Now move the throttle to the maximum take-off position and check for satisfactory running, noting the boost and r.p.m.

Note 1.—This take-off power test provides a general test of the ignition. A single ignition test should not be made, as it is not a reliable test of the ignition system on account of the very rich mixture used at this boost and may indicate defects which are not present. The single ignition test should follow as laid down at (iv) below.

Note 2.—Take-off boost is quoted for some engines as so many lb./sq. in. "or Full Throttle". This is because on an average day the throttle valve needs to be fully open to give the prescribed boost and with a low barometer and/or in warm weather the nominal boost may not be attainable.

NOTE 3.—(*a*) During the running up the propeller is virtually in fixed pitch (the blades set at their finest pitch against the fine pitch stop) until the boost rises to 2 to 4 lb/sq. in. below the maximum take-off figure, when the propeller starts "constant speeding". The attainment of take-off r.p.m. at take-off boost provides no proper check on performance; for any small deficiency in power is masked by the propeller adjusting its pitch to absorb less power at the same r.p.m. An accurate check can only be made at the lower boost at which the blades are against the stops, when any deficiency of power will be shown by low r.p.m. because the pitch is fixed.

(*b*) With propellers of small pitch range "constant speeding" is usually attained only after the aircraft has gathered some speed on the take-off and the full take-off r.p.m. are not reached on the run-up. The r.p.m. actually obtained on running up then provide a precise check of power.

(iv) After the take-off power test, reduce to the maximum boost for continuous *rich* operation and test the ignition by switching off each side in turn. The drop in r.p.m. on single ignition should not exceed 5 per cent.

PART II—NOTE C
HANDLING THE POWER UNIT

1. Taxying.

(i) Care must be taken to avoid overheating engines while taxying.

(ii) The aircraft should always be taxied with propeller set for maximum r.p.m., as this will give the greatest tractive effort and the best cooling for the power used.

(iii) Gills or radiator shutters should be fully open.

(iv) The aircraft must not be taxied fast, but sufficient speed should be maintained to keep it in continuous motion and avoid bursts of power to restart movement.

(v) Temperatures should be watched. Oil inlet temperatures, cylinder head or coolant temperatures should not exceed the cruising limitations for the engine. If engines are unavoidably overheated, they should be allowed to cool before take-off.

(vi) When possible, tractors should be used for moving heavy aircraft uphill to or from dispersal points.

2. Take-off.

(i) Engines should not be kept idling longer than can be avoided. Any necessary idling should be done at about 1,000 r.p.m. to minimise fouling of plugs.

(ii) If the take-off is delayed for more than two or three minutes after taxying out, the plugs may have become fouled and the engine(s) must be cleared (one at a time) by opening up to zero boost or as much as possible against the brakes, and the ignition should be tested. Clearing must be repeated if there is further similar delay.

(iii) Take-off boost and r.p.m. are permissible until the aircraft has climbed 1,000 feet or for five minutes, whichever is less. It may not be necessary to use the full permitted boost, or to continue the use of take-off r.p.m. and whatever boost is used up to the height and time allowed. The life of the engine will be prolonged by not doing so. But the power used in take-off should always be continued until the undercarriage is up, safety speed has been reached, and the aircraft is well away from the ground on a gentle climb.

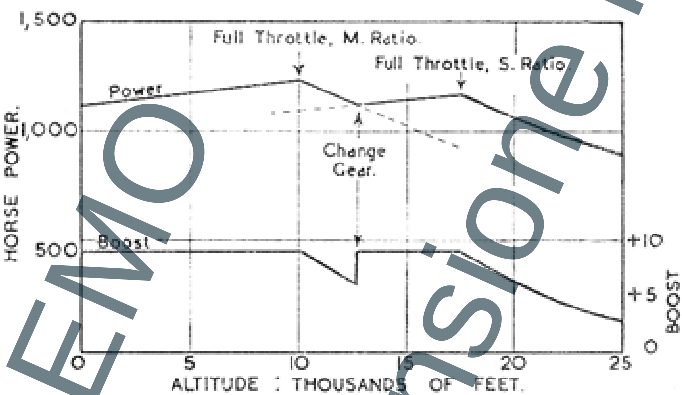
3. The Climb.

(i) The r.p.m. and the boost are automatically maintained[1] at the figures selected by the pilot until the aircraft reaches *full throttle height*, after which the boost falls progressively. The supercharger is capable of giving an excessive boost at low heights and the throttle valve is partly closed by the boost control to limit the boost to the required amount. The valve opens as the aircraft ascends, and so the boost is maintained until the valve is fully open.

[1] See Note H for American engines.

(ii) The boost can be restored by changing the supercharger to S ratio; but the change should not be made until there has been a drop of 2 to 5 lb. per sq. in. in the boost pressure, the amount varying according to the type of engine. For the change should be made at the height at which the engine gives the same power in either ratio and, at the same boost and r.p.m., the engine gives less power in S ratio for two reasons: firstly, more power is consumed in driving the supercharger in S ratio; secondly, the supercharger heats the charge more in S ratio and less weight of charge is drawn in at each stroke.

(iii) Boost will be maintained in S ratio to a second *full throttle height* and then begin to fall. The diagram below shows how the power available varies with altitude in the two supercharger gear ratios.



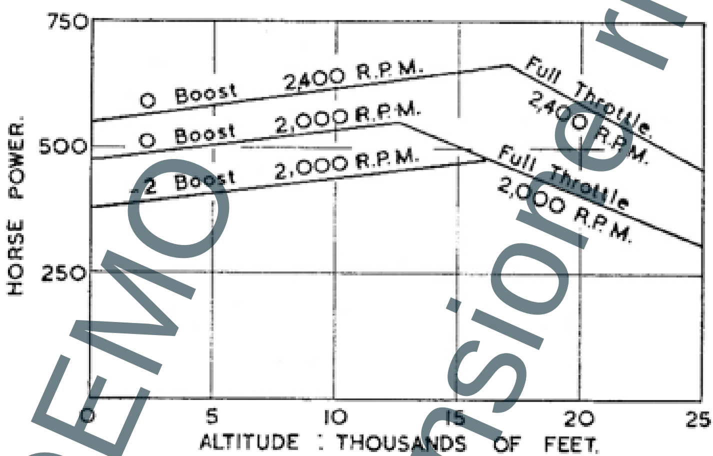
VARIATION OF POWER WITH HEIGHT AT GIVEN R.P.M.

NOTE 1.—Bristol Engines.—As the boost falls (above the full throttle height) the throttle lever should be moved progressively back, "following the boost back with the throttle", so that the lever is never further forward than is necessary to get the maximum obtainable boost. Unless this is done the engine will run on too rich a mixture and will give neither its best power nor the best fuel economy. This rule does not, however, apply in the economical mixture range of boost; or to Merlin engines.

NOTE 2.—Merlin Engines.—The throttle valve cannot open fully unless the throttle lever is advanced to a certain point on the quadrant. It is therefore necessary, when climbing, to advance the throttle lever when the boost begins to fall.

NOTE 3.—The height above which S ratio must be used for maximum power varies with the boost, the r.p.m. and the airspeed.

(*a*) The variation of full throttle height with boost follows from the consideration that, when an aircraft is climbing and the boost begins to fall, every height is *a* full throttle height and each succeeding height is *the* full throttle height for a lower boost than the last.



(*b*) The variation with r.p.m. can be seen from the consideration that raising the r.p.m. speeds up the supercharger and makes it capable of producing any required boost to a greater height.

(*c*) The variation with airspeed arises from the *ram effect* of the air pressure on the forward facing intakes to the carburettor, which considerably helps the supercharger at high speeds of flight. The following figures show roughly how *ram* raises full throttle height :—

True Airspeed ..	100	200	300	400	m.p.h.
Add to F.T. Height	250	1,000	2,250	4.000	feet

4. Economical Flying.

(i) The mixture control (if fitted) must be set WEAK for flying at any boost up to the maximum WEAK limit. The setting should only be RICH at the higher boosts, or when the engine is temporarily throttled back, or for taxying. If there is no manual mixture control, weak mixture will be obtained automatically by setting the boost at or below the *weak* limit.

(ii) The pilot has a choice, in reducing power for cruising at an economical I.A.S., of throttling back or dropping the r.p.m.; the correct choice has a considerable effect on fuel consumption. The throttle lever should be pulled back to the position for *maximum weak* boost and the propeller lever should then be pulled back until the desired I.A.S. is obtained, or the minimum practicable r.p.m. reached, after which further reduction of power must be got by throttling back.

NOTE.—In Merlin engines the throttle valve cannot open fully unless the throttle lever is moved forward of the setting which gives *maximum weak* boost at the lowest altitudes. Therefore, at the higher altitudes the lever must be set forward—up to the *climbing* position if necessary—in order to get maximum permissible, or obtainable, boost for economical cruising.

(iii) S ratio should only be used if the required I.A.S. cannot be obtained in M ratio, or if the r.p.m. required to obtain the I.A.S. in M ratio are near the maximum permissible (100 to 150 r.p.m. less).

5. General Handling.

(i) (*a*) The throttle lever should be moved slowly and evenly. Sudden throttle changes throw an undesirable strain on the engine. Moreover if the throttle is opened too quickly serious overspeeding may result owing to the time required for the propeller to readjust its pitch.

(*b*) The propeller speed control lever should also be moved slowly because, owing to lag in response of the mechanism, the r.p.m. are likely to overshoot the desired figure if the lever is moved too quickly.

(*c*) The supercharger gear change must always be effected smartly and firmly.

(ii) Serious damage may be done through detonation if the engine is subjected to high boost at low r.p.m., and any reduction of r.p.m. at high power actually increases the strain on the engine. Therefore:—

(*a*) For a big increase of power raise the r.p.m. first and, conversely, for a big reduction reduce the boost first.

(*b*) Aerobatics and manœuvres should be performed with a high r.p.m. setting in order that high power can be obtained by simply advancing the throttle lever without risk of damaging the engine.

(iii) The later propellers (of 35° or greater pitch range) will keep the r.p.m. within the normal range during a dive. The r.p.m. setting should be fairly high:—

(*a*) in order that the propeller lever will not require attention on pulling out to level flight or climb;

(*b*) because maximum braking effect on throttling back in the dive will be obtained by a high setting.

If the propeller should fail to control in the dive and the all-out r.p.m. be exceeded, the pilot must endeavour to limit the rise of r.p.m. and the duration of excessive r.p.m. by pulling out, and he should have the throttle at least one-third open. (See note D on 20° propellers.)

(iv) If an engine cuts—through a tank running dry,[1] or through the action of *negative g* on the carburettor during a push-down or a roll—the throttle should at once be closed and slowly re-opened as power returns. If this is not done, the propeller may fine its pitch—in the attempt to maintain high r.p.m. with no power behind it—and then fail on return of power to coarsen pitch quickly enough to prevent serious overspeeding.

[1]See Note H for special precautions with Stromberg injection carburettor.

NOTE.—If the engine does not pick up quickly after a cut when pushing down into a dive, overspeeding can sometimes occur owing to the power of the constant-speed unit being reduced when the propeller is wind-milling at high speed. If this should occur, the aircraft should be pulled out to reduce the I.A.S. as quickly as possible until the C.S.U. regains control.

(v) It is common practice to run an engine on one tank until it cuts, in order to keep a check on fuel consumption. When the fuel is getting low, the pilot should watch for the first signs of cutting (fall of fuel pressure or irregular running) and close the throttle. Turn off the tank and then at once turn on a new tank. Pause for a second or two and slowly reopen the throttle. This procedure will avoid the risk of damage to intakes by backfires.

(vi) On a flight of several hours' duration the supercharger gear should be changed once or twice to remove any sludge that may have accumulated.

6. Engine and Oil Temperatures.

(i) The importance of watching cylinder (or coolant) and oil temperatures and keeping them within the limitations has been emphasized in Note A.

(ii) The cooling of air-cooled cylinders is controlled by the setting of the gills, which in general will be:—

(*a*) Fully open for all ground running.

(*b*) Closed or part open for the take-off.

(*c*) About half open for climbing.

(*d*) More or less closed in level flight.

They must be set according to the conditions of flight to maintain a suitable cylinder-head temperature. They should not be opened more than is necessary because they add considerably to drag as they are opened.

NOTE.—Closing gills for take-off is a precautionary measure against engine failure. If this practice leads to overheating the gills must be partly opened.

(iii) The cooling of liquid-cooled engines is in part regulated automatically, the circulation of the coolant being thermostatically controlled to provide quick warming up and to keep the engine warm on a glide. But the pilot generally has control over the flow of air through the radiator and the setting of this control affects both the cooling of the engine and the performance of the aircraft. Radiator shutters should be open only as much as is necessary for adequate cooling.

(iv) If difficulty arises in keeping the temperature within the limitations on climb, the cooling may be improved by climbing at a higher I.A.S.; the loss in rate of climb by climbing at 10 to 15 m.p.h. above the I.A.S. for best rate of climb will not be large.

(v) Weak mixture climbing must not be practised if it leads to excessive temperatures.

(vi) The oil cooling is automatically regulated (by means of a viscosity or a thermostatic by-pass), but the pilot has sometimes control of the flow of air through the oil-cooler. Excessively high temperature or low pressure indicates that the engine has been overworked, that the oil cooler is not working properly, or that some defect has developed.

NOTE.—*Coring* occurs in some oil-coolers at low atmospheric temperatures, the oil congealing and choking the flow so that the cooling is reduced. It may be possible to thaw a cooler by closing the shutters (if fitted) or by increasing the flow by increase of r.p.m.

(vii) The engine must not be allowed to get cold, or it may not respond when required. The engine will be kept warmer by diving moderately with throttle well open than by gliding with throttle closed. In a long glide gills must be closed and the engine should be opened up at intervals.

7. Landing and Stopping the Engine.[1]

(i) After lowering the undercarriage the pilot should

(*a*) See that the mixture control (if fitted) is RICH, air intake (if variable) COLD and the supercharger in M ratio.

[1] See Note G in respect to oil dilution in cold weather.

(*b*) Set the propeller control for take-off r.p.m. (or as recommended in the Pilot's Notes).

He is then ready for getting full power in any emergency by simply advancing the throttle lever.

Note.—To minimise over-speeding on quick opening up to take-off boost, the control may be set for not more than 5% below take-off r.p.m. On high-powered aircraft, if climbing power is considered ample for a baulked landing, the control may be set for climbing r.p.m.; but if climbing r.p.m. are more than 5% below take-off r.p.m., the engine should only be opened up to climbing boost, or the propeller control should also be advanced.

(ii) After landing, open the gills or radiator flaps for taxying.

(iii) Idle the engine (with the aircraft headed into wind if possible) at about 800 r.p.m. to cool it before stopping. (Air-cooled cylinders should be reduced to between 150 and 200°C.)

(iv) Throttle back and stop the engine by pulling and holding the *slow-running cut-out*, releasing smartly when the engine has stopped.

(v) Switch off the ignition and turn off the fuel.

(vi) Close the cowling gills or radiator shutters.

Note.—Engines fitted with a slow running cut-out (not operated by the master fuel cock) must not be stopped by turning off the fuel.

APPENDIX

1. Boost Control Cut-outs and Over-rides.

(i) Some earlier Merlin engines have a cut-out which renders the automatic boost control inoperative to permit an "emergency" power to be obtained.

(ii) Later Merlin cut-outs retain the automatic control of boost but reset the control so that each position of the throttle lever gives a higher controlled boost.

(iii) A similar device called a *high boost control* or *over-ride* is used with Mercury engines in Blenheim IV and V. Owing to the regulation of mixture strength by means of the throttle lever on this engine the control should only be used in flight with the lever fully forward, and when it is used for take-off the throttle must be opened steadily and fairly quickly to the take-off position after selecting high boost.

(iv) High boost for take-off is obtained in some Merlin installations by moving the throttle lever through a gate and thereby over-riding the boost control and setting the throttle valve to a definite position to give a high take-off boost. A cut-out may be provided in addition to give high boost under automatic control in flight.

2. Automatic Supercharger Gear Change.

(i) An automatic gear change in some installations safeguards the engine against the inadvertent use of S ratio at low altitudes which would quickly wreck the engine.

(ii) The change is effected automatically at a certain altitude; but the gear can be returned from S to M above this height by an over-ride switch.

(iii) The gear may also be returned automatically from S to M ratio if the charge temperature becomes excessive; but it can be reset subsequently by the pilot if and when the excessive temperature no longer occurs.

(iv) A testing switch, with warning light, allows engagement of S ratio on the ground for testing purposes.

PART II—NOTE D

THE VARIOUS TYPES OF PROPELLER

1. Introductory.

(i) There are four main classes of variable-pitch propellers.

(*a*) *Two Pitch*—pitch directly controlled by pilot with two settings only (nearly obsolete).

(*b*) *Constant speed*—pitch controlled by a governor (" constant speed unit "), pilot selecting r.p.m. required.

(*c*) *Constant Speed with Alternative Manual Control*—pitch controlled by governor or directly by pilot (electrical propellers).

(*d*) Classes (*b*) or (*c*) with *Feathering* control also.

(ii) Power to turn the blades in their sockets to change the pitch is derived :—

(*a*) From engine-driven hydraulic pumps; or

(*b*) From batteries and engine-driven generators (electrical propellers and feathering of both electrical and hydraulic propellers).

It follows that only the electrical propellers can have the pitch changed when the engine is not running, except for feathering and unfeathering.

2. Two-pitch Propellers.

The pitch is directly controlled by the pilot and has two settings, FINE and COARSE. The correct use is :—

(1) Start and warm up COARSE.

(2) Change to FINE before running up the engine.

(3) After reaching safety speed reduce the boost to the climb figure and then change to COARSE.

(4) Change to FINE preparatory to landing.

(5) Before stopping the engine change to COARSE; after moving the lever open up the engine sufficiently to change the pitch.

NOTE.—Leaving the propeller in COARSE pitch facilitates inspection and maintenance. The propeller is emptied of oil and, if the pitch is only returned to FINE after the engine oil has warmed somewhat, initial sluggishness is avoided.

3. De Havilland and Hamilton 14 and 20 degree Constant-speed Propellers.

(i) These constant-speed propellers were developed from the two-pitch propellers by introducing the constant-speed governor under the pilot's control of r.p.m. setting. The pilot retains one direct setting of pitch—when the lever is full back (low r.p.m.) the propeller locks in POSITIVE (i.e., fixed) COARSE PITCH.

The same stopping and starting procedure should be followed as for the two-pitch propellers :—

(*a*) Start and warm up POSITIVE COARSE.

(*b*) Change to take-off r.p.m. setting before running up the engine.

(*c*) Set the r.p.m. as required in flight, using POSITIVE COARSE PITCH for cruising if it is found possible to cruise at lower r.p.m. by so doing.

(*d*) Change to coarse before stopping the engine, opening up sufficiently to ensure change of pitch.

(ii) These propellers tend to *sluggish operation* at very low temperatures and they may fail to function after a time below–35° C. Cruising in POSITIVE COARSE PITCH minimises the risk of sluggishness. To prevent or to overcome sluggishness the propeller should be exercised as follows:—

(*a*) Move the control to maximum r.p.m.

(*b*) Slowly return to POSITIVE COARSE.

(*c*) Return to the desired r.p.m.

At extreme temperatures exercising should be done two or three times every quarter of an hour. It should seldom be necessary on Merlin fighters below 25,000 ft. in winter or 30,000 ft. in summer; but sluggish operation may occur at lower heights with air-cooled engines.

NOTE.—The development of sluggishness has been overcome in some installations (Spitfire V) by introducing a bleed to ensure continual circulation of oil.

4. Rotol 20 deg. Constant-speed Propellers.

These propellers are also designed for POSITIVE COARSE setting, but the system of control is different and the special stopping and starting procedure, and the need for exercising at low temperatures, do not apply.

NOTE.—On Fulmar the control is so arranged that the POSITIVE COARSE setting is not available.

5. Diving with Two-pitch and 14 and 20 deg. Constant-speed Propellers.

(i) These propellers, unlike the 35 deg. propellers, have not sufficient range of pitch to keep the r.p.m. within the normal limits in a dive to very high speed. The permissible diving airspeed may therefore be limited by the

INDEX

Abandoning aircraft — *Page*
- Multi-seater aircraft 100, 101
- Single-seater aircraft 101

Aerobatics 5
- Caging gyropilot for 75
- Prohibited manœuvres 5
- R.p.m. setting for 38

Aileron reversal 4

Ailerons, effect at stall 11

Air intake
- Effect on full throttle height 36, 37
- Effect on performance 53
- Icing of 51, 52
- Warm and cold intakes 54, 55

Air miles per gallon 12, 13
- Effect of altitude on 16
- Effect of drag on 16, 17
- Effect of warm air intake on 53, 54
- Effect of weight on 16
- Effect of wind on 15
- Flying for maximum 12, 37
- On climb or descent 17
- On one engine 94

Air temperature
- Effect on amount of priming required 29
- Effect on operational ceiling 17
- Effect on true airspeed 118
- For ice formation on aircraft 18
- For icing up of induction system 52

Alcohol
- For ice prevention in induction system 53
- Injection, use of 55

Altitude
- Effect on best endurance speed 14
- Effect on best range speed 14
- Effect on range and endurance 16
- Effect on rate of descent on one engine .. 93

	Page
Angle of attack	
Effect on drag	13, 14
Effect on normal acceleration	6
Effect on stability	9, 11
Approach	
After engine failure	95, 96, 98
Speed for ditching	105
Use of flaps during	95
Artificial horizon	
Adjustable aircraft datum	66
Caging device on American aircraft	66
Checking before flight	64
Mark IB, elimination of turning error	65
Sperry Gyropilot bank and climb control unit	71, 72
Take-off errors	65
Turning errors	65
Automatic boost control	26, 34
Cut-outs and overrides	41, 42
Automatic Pilot Mark IV	
Controls	67
Operation	67-69
Use after engine failure	69-71
Automatic Pilots	
See Automatic Pilot Mark IV, Minneapolis-Honeywell, Norden S.B.A.E., Sperry Gyropilot	
Backfires	
Starting on warm intake	54
When changing tanks	39, 61
Bendix-Stromberg carburettor	59, 60, 63
Icing in	52, 53
Blacking out	6, 9
Bomb door opening, speed limitations	4
Bomb jettisoning	
After engine failure in flight	91, 93, 98
After engine failure on take-off	89, 90
In ditching	104
Boost control on American engines	58
See also under Automatic	

Page

Boost gauges 59

Boost pressure
- Climb 34-35
- Combat 24
- Conversion from lb./sq. in. to inches Hg. .. 59
- Emergency 41
- Falling due to icing up 53
- Following back on Bristol engines 35
- For maximum range 37
- Limitations 24, 25
- Maximum weak 25, 37
- Take-off 24, 32, 34, 42

Booster coil on American engines 62

Brakes, use of with tricycle undercarriage 22, 23

Bristol engines
- Air intake 52, 54
- Following boost back with throttle lever .. 35
- Oil-heated throttles 52
- Supercharger gear change on sleeve valve engines 32

Bumpy air, flying in 6-7

Carburettor
- Float chamber type, effect of negative g on .. 49
- Flooding 49, 50
- Pressure injection type, effect of negative g on 50
- Icing of 52

Cartridge starting 30

C.G. position
- Effect on stability 7, 8
- Relative to main wheels 21

Clearing engines 34

Climb
- Air miles per gallon on 17
- Engine limitations 24, 25
- Fuel consumption on 16, 17
- Handling the power unit on 34-36
- In weak mixture 40
- I.A.S. 40

Page

Cloud formation, flying near 7

Cold weather starting 30-31, 56-57

Combat limitations 24, 25

Coolant temperature 26
- Control of 39, 40
- For ground running 33, 34
- Minimum for run up 27
- When descending 40

Coring 40

Cumulo-nimbus clouds, icing in 19

Cylinder temperature 26
- Control of 39, 40
- For ground running 33, 34
- For stopping engine 41
- Minimum for run up 27
- When descending 40

Deicing paste 20

Detonation 25, 53

Dinghy
- Boarding 112-113
- Radio 114-115
- Release 112
- Single-seat 113-114

Direction indicator, checking before flight .. 64

Directional instability 11

Ditching
- Approach 105
- Gauging height 107
- Gauging wind direction 107
- Gauging wind strength 107-108
- Impact 108
- Near shipping 109
- Personal equipment, pilot's 104-105
- Preparation for 104, 109-111
- Single-seat fighters 109
- Stations 111
- Use of engines 106
- Use of flaps 105
- Use of lights 105

	Page
Diving	
Braking effect of propeller	38
Engine limitations	44, 45
Recovery from	9
R.p.m. setting for	38, 45, 46
Speed limitations	3
Stability and trim	9
Drag	
Effect on range and endurance	16-17
Of cooling gills	39
Of wings	13
Electric starting	28, 61, 62
Endurance	
Best speed for	12, 14
Effect of altitude on	16
Handling for maximum	17-18
Engine	
Control settings :—	
For landing	40-41
For starting	28
For testing and exercising	31
Cutting out	
Due to reduced or negative *g*	49-50
With Stromberg carburettor	61
Failure during flight, twin-engined aircraft	
Altitude for least rate of descent	93
Best speed for maintaining height	93
Engine handling	92, 93, 94
Immediate action on	92
Landing on one engine	95-96
Mislanding	96
Reducing drag	93
Use of Automatic Pilot Mark IV after	69-71
Use of Minneapolis-Honeywell after	84
Use of Norden S.B.A.E. after	79-80
Use of Sperry Gyropilot after	75-76
Failure during take-off, twin-engined aircraft	
Before becoming airborne	90
Use of engine	91
When airborne and above safety speed	90
When airborne but below safety speed	90

Engine—*cont.* — *Page*
- Failure on four-engined aircraft
  - At take-off .. 97
  - Detection .. 98
  - In flight .. 98
  - Landing .. 98
- Handling .. 25
  - For fuel economy .. 17, 37
  - For ice prevention .. 54, 55
  - When on fire .. 116-117
- Life .. 24
- Limitations .. 24-27
- Running up .. 27, 31, 32
- Stopping .. 27, 40-41

Exhaust gas analyser .. 60

Factor of safety .. 3

Feathering
- Electric propellers .. 47-48
- Hydromatic propellers .. 46-47
- Practice .. 48-49
- Rotol hydraulic propellers .. 47

Fin area .. 10-11

Fire at engine
- During take-off .. 117
- Extinguishing .. 116-117
- Landing with .. 116, 117

Flaps
- Approach for landing .. 95
- Ditching .. 105
- Single-engine landing .. 95-96
- Speed limitation for lowering .. 4

Flow-meter .. 60

Flutter .. 4

Flying controls, locking by gyropilot .. 73

Fuel consumptions .. 12, 13
- On climb .. 16, 17
- Specific .. 16

Fuel economy .. 12-18, 37

	Page
Fuel jettisoning	
After engine failure	91
For ditching	104
When on fire	117
Fuel tanks, changing over	39
Full throttle height	34, 35
Reduction with iced air intake	51, 53
g	6-7
g negative	49, 50, 51
Generator	17, 49
Gill settings	39
For running up	31
For taxying	33
On glide	40
Gyro Instruments	
See artificial horizon, direction indicator	
Gyropilots	
See Autopilots	
Hand turning of engines	28, 62, 63
High volatility fuel	31
I.A.S.	
Effect on wing loading	6
For highest air miles per gallon	13, 14, 15
For least rate of descent	91, 93, 94
For lowest gallons per hour	14
On climb	40
Ice accretion	
Effect on performance	18
Ice guards	
Gapless	52
Gapped	51
Icing conditions, aircraft	18-20
Icing, detection of	19
Icing conditions, engine	
Air intake	51
Detection of	53
Induction system	52
Idling engines	34, 41

Page

Ignition tests 32, 34
Inertia and direct cranking starter 62-63
Inertia starter 61-62
Inverted flying 5, 49-51
Kilfrost paste, use of 20
Landing
- Engine control settings for 40-41
- On one engine 95-96
- With tricycle undercarriage 22-23

Life jackets ("Mae West") 103, 104, 111
M ratio
- For economical cruising 37
- For testing 31, 32
- For single-engine return 93, 94

Manœuvrability 8, 12
Manœuvres
- At minimum power 18
- Caging gyropilot for 75
- Prohibited 5
- R.p.m. setting for 38

Mercury engines
- Boost override 41
- Regulation of mixture strength 35, 41-42

Merlin engines
- Air intake 51, 52
- Boost control cut-out and override 41, 42
- Position of throttle lever for max. weak boost 37
- Throttle lever on climb 36

Minneapolis-Honeywell Automatic Pilot
- Description 80-82
- Flight adjustments 83
- Operation 82-83
- Use after engine failure 84

Mislanding after engine failure 96
Mixture control
- Chandler Evans, Chandler Groves, and Holley carburettors 60-61
- Holley injection carburettor 59, 60
- Rich mixture 25, 37

	Page
Mixture control—*contd.*	
Bendix-Stromberg injection carburettor	59
Weak mixture	25, 37
Mixture strength at high altitudes	59, 60
Non standard loads	7
Norden S.B.A.E.	
Adjustment of stabiliser dashpot	79
Description	76-77
Operation	77-79
Tendency to sideslip	79
Use after engine failure	79-80
Oil cooler	40
Oil dilution	30, 55-57
Period of effectiveness	57
Procedure	56
Over-dilution	57
System	55-56
When to use	56
Oil pressure	
Emergency minimum	26, 50
Under negative *g*	50-51
When starting engine	31
Oil temperature	26
For dilution	56
Minimum for run up	27
When descending	40
Operational ceiling	17
Overpriming	29
Overspeeding propeller	
In dive	38, 45, 46
On take-off	41
When engine cuts	38, 50
Oxygen apparatus	
Check before flight	87
Economiser	86
Endurance	88
Mark VIII regulator	85-86
Mark X regulator	86
Operation	86
Operation in bombers	87-88
Operation in fighters	87

	Page
Parachute	
Alighting	103
Opening of	102
Sideslipping	102
Swinging	102
Turning	102-103
P.D.I.	
See Minneapolis Honeywell Automatic Pilot, description	
Norden S.B.A.E., description	
Pigeons	115
Pitot heater	19
Plugs, fouling	34
Power, reduction of	24-25, 38
Pressure cabins, use of oxygen in	85
Priming	28-30
With Bendix-Stromberg injection carburettor	59
Propeller, constant speed	
De Havilland and Hamilton 20°	44, 45
Electric propellers	45-46
Electric propellers, feathering	47-48
Hydromatic propellers, feathering	46-47
Rotol hydraulic propellers, feathering	47
Rotol 20° propellers	44
Propeller control settings	43-44
Propeller, exercising	32, 44
Propeller failures	
Electric propellers	100
Fractured pipe	99-100
Locked propeller	98-99
Propeller icing	19
Propeller overspeeding	
See overspeeding	
Propeller, pitch during run up	33
Propellers, sluggish operation of	32, 43, 44
Propeller speed control lever, handling	38, 43-46, 61
Propeller, testing C.S.U.	32
Propeller, two-pitch	43, 44-45

Page

Radiator shutter setting 40
For taxying 33, 41

Ram effect 36
Loss on warm air intake 53
Loss with iced air intake 51

Range
See air miles per gallon

Rate of descent in single-engined flight 93

Refrigeration icing 52

Rich mixture 25, 37

Rough running with non automatic American carburettors 59, 60

R.P.M.
Diving 38, 44, 45, 46
For maximum range 37
For oil dilution 56
For warming up 31
Limitations 24-25
Mislanding 41
Take-off 34

Rudder
Handling when engine fails 90, 92
Harsh use of 5
On single engine approach 96
Use at stall 11

S ratio, use when flying for maximum range .. 37
See also supercharger gear change

Safety speed 89
On four-engined aircraft 97

Sea rescue 114

Single ignition test 33
On American engines 61

Slow-running cut-out 41

Sperry Gyropilot
Adjustment of speed valves 74
Changing course 74-75
Description 71-72
Engaging Gyropilot in flight 74
Level flight, type A2 Gyropilot 75

	Page
Sperry Gyropilot—*cont.*	
Operating limitations	75
Retrimming	74
Testing before flight	73
Use after engine failure	75-76
Spinning	5
Stability	
Lateral and directional	10-12
Longitudinal	7, 8-10
Stall	9, 11, 89
Starting engines	
See cartridge starting, cold weather starting, inertia and direct cranking starters, inertia starters, oil dilution, priming.	
Stromberg carburettor	
See Bendix Stromberg.	
Suction	64
Checking	65
For operation of Sperry gyropilot	73
Supercharger	34-35
Supercharger gear change	
Automatic	42
During long flight	39
On climb	35
Testing	32
Testing American engines	61
Take-off	
Handling power unit	34
Handling power unit on Mercury and Merlin engines	41-42
Limitations	24, 25-26
Power test	32-33
With tricycle undercarriage	22
Taxying with tricycle undercarraige	21
Telltale lights	
See Minneapolis Honeywell Automatic pilot, description; Norden Stabilised Bombing Approach Equipment, description.	
Throttle icing, in Bendix-Stromberg carburettor	53

	Page
Throttle lever	
Advancing on climb on Merlin engines ..	36
Following back boost on Bristol engines ..	35
Handling	37, 38, 39, 50
Handling on American engines	58, 59
Setting for maximum weak boost on Merlin engine	37
Throttle valve	34
Tricycle undercarriage	
Ground handling of	21
Landing	22-23
Take-off	22
Trimming tabs, use of	8, 9
True airspeed	118
Turn and bank indicator, checking before flight	64
Turns	
Stability in	9-10
Tightening in	9
Under automatic control :—	
Automatic Pilot Mark IV	67, 68
Minneapolis Honeywell Automatic Pilot	82
Norden S.B.A.E.	78
Sperry Gyropilot	74-75
When flying on one engine	91
Undercarriage	
Speed lowering limitations	4
See also tricycle undercarriage	
Undershooting on single-engine approach ..	95, 96
Warming up	31
After unfeathering	48
Use of warm air intake	54
Weak mixture	25, 37
Climbing in	40
Weight	
Effect on range	15, 16
Limitations	4
Wind	
Effect on best range speed	14-15
Effect on range	15

CORRELATION WITH FIRST EDITION

The following will assist readers to find subject matter in this edition from references to the Note numbers of the first edition.

First Edition *Note Number*	*Present Edition* *Part*	*Note*
A.P.2095/1 para. 3, 4	II	B para. 1–6
1 ,, 5–12	II	C (and A)
2 ,, 2–7	II	D
2 ,, 8–10	II	C Appendix
2 ,, 9	II	E
3	II	H
4	II	G
5	III	A
6	II	H para. 4, 5
7	II	F
8 ,, 1–5	I	B
8 ,, 6	I	A para. 7
9	IV	F
10	IV	G
11 ,, 2, 3	II	D para. 6, 7
12	IV	A, B, C
13	I	C
14	III	C
15	II	B para. 1–5
16	III	B
17	I	E
18	II	E
19	I	A
20	IV	H
21	IV	B para. 3, 4
22	IV	J

C2481 Wt.8028/N545 70M 5/43 C.P. Ltd. Gp. 784