

PART III

HANDLING

MANAGEMENT AND USE OF SYSTEMS

53. Management of the fuel system

- (a) The fuel booster pump should be on at all times in the air. If it fails or is switched off, the fuel pressure warning light will glow; in normal flight, engine failure is unlikely to result but above 20,000 feet full r.p.m. may be unobtainable and large fluctuations in r.p.m. may be experienced.
- (b) The rate of fuel transfer should be sufficient to maintain the level in the fuselage tanks to within 240–320 lb. (30–40 gallons) of fuel at all altitudes and engine powers. There is sufficient air pressure to effect fuel transfer from the tip tanks when the indicators on the instrument panel show black. They should show white when transfer is completed or when the transfer pressure is insufficient, but see para. 4(a) NOTE. As soon as tip tank transfer is complete, the jettison switch must be set to JETTISON.
- NOTE.—1. In rapid descents, it is usual for the indicators to show white intermittently *before* transfer is complete.
2. The jettison switch must be at JETTISON at all times when the tip tanks are empty.
- (c) When descending rapidly from high altitudes, the total contents fuel gauge will under-read but should re-adjust itself shortly after resuming level flight.
- (d) A negative G trap in the fuselage tank ensures sufficient fuel for about 10 seconds flight with negative G. Flight in attitudes near the vertical should also be restricted to 10 seconds for the same reason. If less than 480 lb. (60 gallons) remain, the aircraft should be restricted to normal flying attitudes only.
- (e) Between 10 and 20 gallons of fuel are unusable, the amount increasing with tail-down attitudes.

(f) *Fuel jettison*

Provided that all is clear astern, fuel may be jettisoned from the tip tanks at any time. It takes approximately one minute to jettison all fuel and there may be a slight nose-down trim change during the process. The jettison switch should be left at JETTISON until after stopping the engine, when it should be moved to CLOSE.

(g) *Tip tanks transfer failure*

In case of unsatisfactory transfer of one tip tank, the aircraft will become very one wing heavy. Every attempt should be made to jettison fuel from the faulty tank before a landing is attempted. If transfer from a tip tank is faulty, denoted by one-wing heaviness or by one indicator showing white well before the other, it may not be possible to jettison the contents of the faulty tank, due to lack of air pressure. In such cases, the jettison switch should be left at JETTISON and, if time is available, some of the contents of the faulty tank may be partially emptied by alternately climbing and diving the aircraft. It may also be possible to transfer about the first quarter of the contents of a tip tank by gravity.

54. **Engine handling**

- (a) Although the engine r.p.m. may be within limits before take-off, forward movement of the aircraft may result in a creep-back in r.p.m. of up to 150. This will not appreciably affect the take-off. Take-off should not be attempted if the r.p.m. on run-up are less than 10,150 or if, during take-off ground run, they fall below 10,050.
- (b) During the climb, the r.p.m. show a marked tendency to increase above the limitations. Great care should be taken to avoid exceeding the r.p.m. limitations when operating at high altitude.
- (c) All throttle corrections in the air should be made slowly and smoothly, particularly at high altitudes or when increasing power from low engine settings.

- (d) With variations in airspeed, the r.p.m. will alter from those set—particularly at high altitudes—and constant small throttle corrections are necessary. If, at any time, the jet pipe temperature or engine speed reaches the appropriate limitation, power must be reduced or airspeed increased.
- (e) With the isolating switch ON, throttle movements must be made carefully. Whenever possible, and especially above 20,000 feet, engine accelerations should be so controlled that the j.p.t. does not exceed 725°C. In an emergency, below 20,000 feet, slam accelerations are permissible from 6,500 r.p.m.; they must not be attempted above 20,000 feet.

55. **Management of the pressurising and demisting systems**

- (a) The control wheel for regulating the supply and temperature of the pressurised air must be set to OFF, HOT or REDUCE when the aircraft is on the ground with the engine running, in order to avoid overheating the cold air unit. COLD or MIX must not be selected on the ground.
- (b) Unless the cockpit is kept pressurised, severe internal misting and icing is likely to occur at high altitudes and on descending. Therefore, it is recommended that the cockpit is pressurised before take-off.
- (c) Engine idling r.p.m. should normally be sufficient to maintain full cockpit pressure at any altitude. Misting may occur if power is low for long periods, due to the reduced supply of hot air available to the hood and windscreen through the gallery pipes. The supply may be increased by:—
 - (i) Partially closing the main louvre, thus diverting the supply to the gallery pipes.
 - (ii) Increasing engine r.p.m.
- (d) If a reduction in cockpit temperature is desired at altitude, MIX is to be preferred to REDUCE, otherwise the reduced volume of air entering the cockpit may adversely affect the pressure differential.
- (e) During a rapid descent, the cockpit pressure warning light may come on temporarily.

56. Management of the electrical system

- (a) Before starting the engine, test the main and standby inverters as follows:—

GROUND/FLIGHT switch (88)	FLIGHT
Voltmeter (64)	Needle out of red sectors
Inverter circuit breakers (at 65)	Made
FLIGHT INSTRUMENTS switch (48)	ON. Check inverter aurally and note that A/H and Mk. 4B compass erect. Then switch OFF.
INVERTER B switch (at 87)	ON. Check inverter aurally and note that A/H and Mk. 4B compass erect. Then switch OFF

- (b) Combined ground idling and taxiing time should be kept to a minimum, to avoid battery failure. In the air, engine r.p.m. should not be allowed to fall below 6,500, except in an emergency or when A.I.10 is not in use.

57. Management of the wing-fold mechanism

- (a)
- Spreading*

Move the inboard spread/fold lever up and aft. When the wings have spread, move the outboard wing locking lever up and aft, ensuring that it is fully home. Check that the locking pin indicators on the wings are flush. Check that the magnetic indicators are black, if electrical power is available.

- (b)
- Folding*

Move the outboard wing locking lever fully forward and down. Check that the locking pin indicators protrude from the wings and that the magnetic indicators show white. Move the spread/fold lever forward and down and the wings will fold.

- (c) The control column should be held central while folding or spreading the wings.

- (d) Severe stresses are placed on the wing-fold mechanism when taxiing with the wings folded, especially if the tip tanks are full; the aircraft must be moved at slow walking pace over smooth surfaces only. Taxiing with wings folded must be kept to a minimum and should normally be avoided.

STARTING TAXIING AND TAKE-OFF

58. External checks

The outside of the aircraft should be systematically checked for obvious signs of damage, security of panels, filler caps, doors, wheel fairings, wing-fold mechanism and tip tanks. The engine intakes and tank vents should be free of debris; the jet pipe should be checked for wrinkling and the turbine and compressor blades for damage. The screws on the fairings forward of the intake should be checked for security. Oleos should be checked for equal extension and the tyres for creep, excessive wear or cuts and brake leads for damage. The pressure-head cover, the undercarriage ground locks and the external locks for the control surfaces must be removed. The elevator trimmer tab position should be checked (with the elevator held central). Check that the hood external locking handle is flush and that the hood is prevented from accidental closing by the knob marked HATCH STRUT RELEASE (74) on the starboard wall.

59. Internal checks

NOTE.—Switches are not always marked ON/OFF but normally the ON position is either fully forward or up.

Enter the cockpit and check that the hood rear hinge release ring is fully aft, the observer's headrest is fully aft and all the observer's radar switches are off. Strap in and make the necessary oxygen and R/T connections. Then, before switching on electric power, check:—

Tip tank jettison switch (11)	CLOSE (tip tanks full) JETTISON (tip tanks empty)
Undercarriage selector lever (33)	DOWN. Handle pushed into slot

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R.A.T.O.G. master switch (44)	Off
R.A.T.O.G. safety switch (44)	Engaged (to starboard). Yellow warning light (46) out
Hood jettison lever (61)	Fully down
Hood jettison detonator safety pin	Removed and stowed
Armament switches	Safe or off
Rudder pedals	Adjust. Equal both sides
Hood	Lock closed (handle up, locking catch fully forward)

NOTE.—When opening or closing the hood, it is advisable to support it. This is essential in strong winds.

Then:—

All circuit breakers (six) (65, 66, 67)	Made
GROUND/FLIGHT switch (88)	FLIGHT
Wing-fold levers (2, 3)	Corresponding to the position of the wings (up for spread). Levers locked in their gates (<i>serious damage may occur to the wing locking mechanism unless this is so</i>). Magnetic indicators as appropriate
Cockpit lamps (1, 4, 5, 83)	As required
Signal discharger switch (27) (if fitted)	Off
V.H.F. (26)	OFF, channels selected
I.F.F. F and D switches (6)	OFF
Cockpit pressurisation (24)	OFF
Arrester hook lever (25)	Up. Catch engaged. (If the hook is not fully up, it <i>must</i> be raised by the hand-pump before starting, to avoid heat damage.) Green light out

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H.P. cock (12)	ON (up). Press relight button. (If serviceable, an irregular clicking sound should be heard)
Flap selector lever (22)	UP
Throttle (14)	Freedom of movement. Friction adjusted
Airbrakes (16)	IN
Elevator trim (20)	Test through range, set neutral
L.P. cock (21)	ON (up)
Wheel brakes	On. Check pressure at each wheel (150 lb./sq. in. max.)
Aileron gear change	Halfway position
Undercarriage emergency retraction switch (19)	Off (cover wired closed)
Aileron trimmer (17)	Check operation. Set neutral visually
Windscreen wiper (28)	PARK
E.2A compass (32)	Serviceability
Flap indicator (31)	Serviceability
Undercarriage indicator (30)	Three green lights. Test change-over
Undercarriage warning light (29)	Out
Machmeter	Serviceability
Generator warning light (35)	On
Turn and slip switch	NORMAL
Radio altimeter (34)	Off
Flight instruments	Serviceability
Oil temperature gauge (63)	Reading within limits
Emergency lamp switch (38)	OFF
Fuel transfer indicators (49)	White
G.G.S. control switch (40)	Off

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Fire warning light (45)	Press adjacent button to test (post-Mod. N.779) Pull to test (pre-Mod. N.779)
SUNNY/CLOUDY switch (42)	As required
SALVO/PAIRS switch (43)	As required
Guns/R.P. switch (47)	OFF
Fuel contents gauge (41)	Reading appropriately
FLIGHT INSTRUMENTS switch (48)	Check operation of flight instruments then OFF
Fuel pressure warning light (50)	On
FUEL PUMP SWITCH (62)	On. Check warning light goes out
FUEL PUMP EMERGENCY switch (51)	Off
CABIN PRESS LOW light (52)	Out
Oxygen (54, 70)	Selector to P.B. or ECON as appropriate. Contents and delivery. LOW flow selected. EMERGENCY toggle OFF. Reaching mask. Observer's off if flying solo
MICROPHONE switch	ON
STARTER MASTER switch (57)	ON
Windscreen de-icing pump (59)	Locked in
STICK SHAKER switch (89)	On
CARRIER/AIRFIELD switch	AIRFIELD
PITOT HEAD heater switch (at 87)	Off
INVERTER B switch (at 87)	Check operation of flight instruments then off
All other switches	Off

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Hydraulic handpump	Check operation against flap indication, after exhausting main accumulator
Clear vision panel	Locked
60. Checks before starting	
H.P. cock	ON
L.P. cock	ON
Throttle	2 ins. open
FUEL PUMP SWITCH	ON. Red warning light out
STARTER MASTER switch	ON
GROUND/FLIGHT switch	FLIGHT
61. Starting the engine	
(a) (i) Press the starter button.	
(ii) The r.p.m. will rise rapidly to approximately 1,500 r.p.m., when light-up should occur. The r.p.m. will then rise until idling speed is reached. If light-up does not occur until the r.p.m. have fallen below 1,000, excessive j.p.t. may result, in which case the H.P. cock should be set OFF before the limit is reached.	
(b) If the engine does not start correctly, it will be in one of the following sets of circumstances. The pilot should carry out whichever instructions are applicable.	
(i) <i>Cartridge fails to fire</i>	
If a cartridge does not fire, close the H.P. cock and wait at least 15 seconds before reopening it. Should the first cartridge fail to fire, the starter pushbutton will be held in electrically and will return to the starting position only at the end of the automatic starting sequence. The remaining cartridge may then be fired after reopening the H.P. cock.	
(ii) <i>Engine fails to rotate</i>	
If the engine does not rotate or does so at low r.p.m. and there is a heavy discharge of yellow smoke from the starter exhaust for a period of approximately 10 seconds, the safety disc has probably blown. The H.P. cock should be closed and the cause of failure rectified before attempting a further start.	

(iii) *Failure to light up*

If the starter accelerates the engine normally but the r.p.m. continue to drop below 1,100 without any indication of light-up, the H.P. cock must be closed before the r.p.m. have fallen below 1,000. If the engine is allowed to light up below this speed, there is a risk of damage to the tailplane from possible torching and, in any event, the start will be slow and laboured, with a risk of exceeding the j.p.t. limitations. Also, if the r.p.m. are allowed to drop below 1,000 before closing the H.P. cock, a wet start is likely on the next attempt.

- (c) Two successive failures to start indicate a fault which should be investigated before a further start is attempted.
- (d) After failure to light up, all surplus fuel must be allowed to drain from the jet pipe.
- (e) The cartridge breeches should not be reloaded until they have cooled down; expended cartridges can be removed, however, and the breeches left open to assist in cooling. The starter master switch must be off during reloading.

62. **Checks after starting**

- | | |
|-------------------------|--------------------------|
| (a) Fire-warning light | Out |
| R.p.m. | 3,000 ± 200 r.p.m. |
| J.p.t. | Below 450° C. |
| Generator warning light | Out |
| Voltmeter | Reading |
| INVERTER B switch | ON. Instruments erecting |
| Intercomm. | ON and NORMAL |
| V.H.F. | On |
| Downward ident. lights | As required |
- (b) While at idling r.p.m. switch on the FUEL PUMP EMERGENCY switch; this should result in an increase in r.p.m. If a decrease is observed the aircraft must not be flown. If there is no increase at idling, repeat the check at 6,000 r.p.m., return the switch to off and check that the r.p.m. drop to the original figure. If there has been no increase, or if there has been a decrease in r.p.m., the aircraft should not be flown.

(c) Then before taxiing out check:—

Hydraulics	Wings spread, indicators black, visual indicators flush. Locking levers both up. Check operation of airbrakes and flaps
Flying controls	Full and free movement
Pneumatic pressure	Sufficient (450 lb./sq. in. max.)
Instruments	Check and set
Mk. 4B Compass	Synchronise and check with E.2A. Correct variation set on master unit

63. **Taxying**

Check that there is equal braking effect in each wheel (150 lb./sq. in. minimum). Due to the rudder centralising spring, considerable foot force is necessary to apply rudder for differential braking when taxiing; otherwise taxiing is easy on dry surfaces. The brakes are powerful and, when manoeuvring on wet or slippery surfaces, great care should be taken that the wheels do not lock.

64. **Checks before take-off**

- (a) *Free take-off*
- | | |
|----------------------|--|
| Trimmers | All neutral |
| Aileron gear setting | Halfway position |
| Airbrakes | IN |
| Wings | Spread and locked. Indicators black. External indicators flush with wing top surfaces. Both levers in their gates in the fully up position. Wing fold doors closed |

Fuel	H.P. and L.P. cocks fully on Contents Booster pump ON H.P. fuel pump isolating switch as required Tip tank fuel jettison switch CLOSED (JETTISON if tanks empty) 30°
Flaps	FLIGHT INSTRUMENTS switch ON
Instruments	INVERTER B switch ON Artificial horizon erect Turn indicator functioning PITOT HEAD heater switch ON Mk. 4B compass synchronised with E.2A
Oxygen	ON, connected — reaching mask, EMERGENCY toggle OFF, low flow selected (high flow if cockpit altitude likely to exceed 25,000 ft.)
Hood	Shut and locked, catch engaged, seal inflated Direct vision panel closed Pressurisation wheel OFF, HOT or REDUCE
Harness	Tight and locked

(b) *R.A.T.O.*

The following alterations and additions should be made to the check list above:—

Trimmers	Elevator 1 div. nose-down
Flaps	45°
R.A.T.O.G. safety switch	Disengaged (to port)
	Yellow warning light on

65. **Take-off**(a) *Free take-off*

- (i) Line up with the nosewheel straight and apply the brakes. Increase r.p.m. to above 6,000 and switch on the FLIGHT INSTRUMENTS switch and the API. Then open up smoothly to full power and release the brakes.

- (ii) During the early stages of the take-off the rudder is ineffective and small amounts of brake must be used if it is necessary to correct the aircraft's heading. The tendency to wander from the take-off path is slight, however, even in strong crosswinds.
- (iii) Between 90–100 knots, depending on the A.U.W. and C.G. position, raise and hold the nosewheel clear of the ground. A strong pull-force is required initially.
- (iv) The aircraft should be flown off at between 115 and 125 knots. It does not unstick cleanly and, though it may be pulled off at lower speeds, this may lead to temporary one wing heaviness, particularly in crosswinds.
- (v) When comfortably airborne, brake the wheels and retract the undercarriage. Then raise the flaps. There may be a small resultant nose-down trim change but normally the trim change due to flap retraction from 30° is counteracted by the nose-up trim change as the undercarriage retracts.
- (vi) Set cockpit air conditioning as required and check that the wing-tip tanks transfer indicators are black. Check engine and flight instruments.
- (vii) If the fuel pump isolating switch has been set ON before take-off, switch it off while still at full throttle and *at circuit height*, otherwise over-fuelling will occur. If the throttle is not fully open when this is done, a rapid drop in r.p.m. will occur, corresponding to the amount the throttle has been moved from the fully open position.

NOTE.—If the isolating switch is on for take-off, the maximum r.p.m. are liable to hunt between approximately 9,900 and 10,400 r.p.m. This hunting, although unpleasant, is not in itself dangerous and can be eliminated by throttling back to 10,000 r.p.m., i.e., below the governed range. If Ghost Mod. 1129 is incorporated, r.p.m. hunting should not occur.

(b) *R.A.T.O.*

NOTE.—It is preferable to fire the rockets slightly late rather than early, to ensure full flying speed when burning ceases. Attention is also drawn to A.P. 2802B, Volume I, Section 6, Chapter 1.

- (i) Align the aircraft in the direction of take-off, set the R.A.T.O.G. master switch on and obtain a check that the two amber warning lights on either side of the nose come on.
- (ii) Run up to full power against the brakes. When releasing the brakes use extra care in keeping the aircraft straight. Fire the rockets at 65–70 knots by sliding up the firing switch; the rockets should fire simultaneously within half a second.
- (iii) Raise the nosewheel at approximately 95 knots; the aircraft becomes airborne at 105–115 knots, depending on the A.U.W. Take care not to adopt too steep an attitude during the ground run, as this reduces the acceleration provided by the rockets.
- (iv) The aircraft becomes airborne just before the rockets cease burning and it is then necessary to apply a firm backward pressure on the control column, to prevent the aircraft sinking.
- (v) When at a safe height, raise the undercarriage and flaps, set the R.A.T.O.G. master switch off and engage the safety switch.
- (vi) The rocket carriers may be jettisoned at speeds below 175 knots in straight and level flight.

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66. Climbing

- (a) The recommended climbing speeds for maximum rate of climb, using 10,250 r.p.m. reducing to 10,100 r.p.m. above 25,000 feet are:—

Altitude feet	Tip tanks empty		Tip tanks full	
	Knots	Mach. No.	Knots	Mach. No.
Sea level	355	0.54	350	0.53
5,000	345	0.57	340	0.56
10,000	330	0.60	325	0.59
15,000	320	0.63	315	0.62
20,000	305	0.66	300	0.65
25,000	290	0.69	285	0.68
30,000	265	0.71	260	0.70
35,000	240	0.71	235	0.70
40,000	215	0.71	210	0.70
45,000	190	0.71	185	0.70

- (b) After take-off, the aircraft may be allowed to accelerate to the recommended speed while climbing, provided that it is reached below 5,000 feet.
- (c) Above 40,000 feet, it is important that the correct speeds are maintained; should the speed fall below that recommended, the rate of climb will suffer and it may be found necessary to assume level flight to regain climbing speed.
- (d) During the time that fuel is being used from the aft compartment of the tip tanks, the C.G. will move forward fairly fast and small amounts of nose-up trim will be required to maintain the climbing speed.

67. Flying controls

(a) Ailerons

Response below 115 knots is sluggish and full control movement may be required when landing, particularly in rough weather. As speed increases up to 300 knots, the ailerons become progressively more effective but become heavy above this speed. At altitudes above 40,000 feet, the ailerons are light and effective at normal operating speeds.

(b) Elevator

The elevator is very heavy at all speeds and manoeuvres involving its use may at times be arduous. Above about 0.8M, both the elevator and trimmer become progressively less effective and, by 0.84M, full use of the elevator or trimmer has little effect. It is recommended that the elevator trimmer setting is not altered in this region of reduced control, because of the large changes of trim which may occur when speed is eventually reduced and the trimmer re-asserts itself.

(c) Rudders

The rudder centralising forces are assisted by a powerful spring. The rudder lacks feel and effectiveness at low speeds but becomes more effective at high speeds. Directional control in all conditions of flight is, however, adequate.

(d) *Trimmers*(i) *Aileron*

The aileron electrical trimmer has little effect at low speeds, becoming progressively moderately effective at high speeds. On aircraft fitted with variable-ratio gearing, LOW should not be used at high I.A.S. or M.N., as the aileron forces may be excessive. Pilots making their first flights in these aircraft should take off in LOW.

(ii) *Elevator*

The elevator trimmer is powerful and should be used carefully at high airspeeds.

(e) *Airbrakes*

Use of the airbrakes causes mild buffet and small aileron oscillations at speeds above about 150 knots. They are moderately effective at speeds above 250 knots. Below this speed they become progressively less effective and have no noticeable effect below 150 knots. There may be some small longitudinal oscillations of the aircraft as they are selected but changes of trim at all speeds are small.

(f) *Changes of trim*

- | | |
|---------------------------|----------------|
| (i) Flap down—one quarter | Nose-up |
| Flap down—full | Strong nose-up |
| Undercarriage down | Slight nose-up |
- (ii) With airbrakes out, there is a slight nose-up change of trim at low airspeeds, which becomes more marked at higher airspeeds.
- (iii) When full flap is lowered, the strong nose-up change of trim will necessitate a large forward movement of the control column to counteract it.

68. **Night flying**

Night flying presents no particular problems but right-hand circuits are difficult to judge, due to visual distortion. The maximum speed for lowering the landing lamp is 175 knots. This speed limitation also applies with the lamp in the extended position.

69. **Flying for endurance**

The speed for maximum endurance is 150 knots but control is more comfortable at 175 knots, which latter speed gives a slight decrease in endurance.

70. **Flying at reduced speed**

- (a) Reduce speed to 160 knots. If the flaps are lowered to 30° speed may be further reduced to 130 knots (140 knots with full fuel).
- (b) In conditions of severe icing, the direct-vision window may be opened at speeds below 240 knots but it is not effective in increasing the view straight ahead. Before opening the panel, the gyro gunsight should be retracted to avoid damage and the panel then removed entirely and handed to the observer.
- (c) Visibility in rain is poor and, unless a windscreen wiper is in use, night landings are hazardous.

71. **Flying in conditions of severe turbulence**

- (a) There is normally considerable wing flexing with and without fuel in the tip tanks; this is particularly apparent when flying in turbulent conditions.
- (b) Speeds should, if possible, be kept within the following band:—
- | | |
|------------------------|--|
| (i) Up to 15,000 feet | 300–360 knots |
| (ii) Above 15,000 feet | |
| Upper limit | 0.72M |
| Lower limit | 300 knots at 15,000 feet,
reducing to 205 knots at
40,000 feet |
- (c) It should be noted that, even within this speed band, control may be marginal in severe turbulence above 30,000 feet.

72. **Stalling**

- (a) Stalling speeds at the same weight may vary considerably from one stall to another and between one aircraft and another, depending particularly on the technique used.

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- (b) On some aircraft stall speeds under *approach* conditions may occur slightly *above* those of engine-off stalls; this may be due to a change in the air flow characteristics as power is applied. Normally, however, these speeds are approximately the same and may even be slightly less under *full power* conditions.
- (c) At the lowest speeds obtained, there may be some A.S.I. fluctuations at the stall.
- (d) The stalling speeds in knots, engine on and engine off, are within the following speed bands:—

Loading	U/C and flaps up	U/C and flaps fully down
1 crew, 100 gallons	95-105	85-95
2 crew, full ammunition, 130 gallons ..	100-110	90-100
2 crew, full ammunition, full internal fuel (maximum landing weight)	105-115	95-105

- (e) At all weights and with flaps down there is no adequate warning of the stall. It usually occurs with mild buffet and a tendency for either wing to drop gently. If full aileron is used to raise it, the stall of that wing may be completed but, if small aileron angles are used, the wing-drop may be held. The rudder is almost ineffective at the stall and full movement is necessary to correct yaw when it occurs. There is no tendency to spin, however. Recovery is straight-forward and is effective immediately stick pressure is released. There will be a rapid rate of descent following the stall and this will continue until the airflow re-establishes itself some 20 knots above the speed at which the stall occurred.
- (f) Use of flap causes buffet and this masks any pre-stall warning that may be present.
- (g) With flaps up, a strong pull-force is required to hold the nose up as the stall is approached.
- (h) Airbrakes do not alter the stall speed significantly but may lead to slight aileron buffet and wing heaviness on one side; this first becomes apparent some 5-10 knots above the stall.

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- (j) If either or both the wing fold doors are open on one side, wing heaviness occurs some 10 knots above the stall and the stall of that wing occurs 5 knots earlier.
- (k) *G-stalling*
It is difficult to G-stall the aircraft, particularly at low and medium altitudes, due to the high stick forces involved. At high altitudes, the onset of the stall may be preceded by an increase in aerodynamic noise and by slight buffet. With further backward stick movement, either wing may tend to drop and, at the same time, the elevator pull forces to hold the aircraft in the turn may lighten. Recovery is immediate on releasing the stick.

73. Spinning

- (a) Practice spins up to two turns are permitted. The nature of the spin is unusual, in that the aircraft apparently performs a series of rolls whose axis, in the first two turns, is only slightly inclined to the horizontal. Because of this, it is possible for rotation to cease in the inverted position. Inappropriate use of the controls may then result in an inverted spin.
- (b) Recovery is standard, *with the ailerons central*. As soon as rotation ceases, centralise the rudder. If recovery is unduly delayed, ensure that the stick is laterally central. If difficulty is still experienced, pull the stick right back and apply a little out-spin aileron, then move the stick fully forward in this displaced position. If rotation ceases when inverted, forward movement of the stick should not be continued beyond the central position until the aircraft has been rolled out. *Do not* pull through from the inverted position, because of the great loss of height and rapid increase in M at altitude.

74. High speed flying

NOTE.—1. The mach number limitation of 0.85M can be exceeded very easily, particularly at heights above 40,000 feet. Pilots are advised to investigate the high speed flying characteristics with great care.

2. The mach number limitation of 0.85M above 15,000 feet can be exceeded in a 10° dive at 10,100 r.p.m. when above 40,000 feet and in a 15° dive at heights between 30,000 feet and 40,000 feet. Acceleration from 0.80M to 0.85M is very rapid.
3. The airbrakes have little or no deceleration effect at 40,000 feet and above and throttling back produces only a slow deceleration at these high altitudes.
4. The elevator becomes progressively less effective above 0.80M and ceases to be effective as a means of applying more than small values of G above 0.83M.
5. The high mach number characteristics vary to an appreciable extent from aircraft to aircraft; they also depend, particularly at high altitudes, on the angle of dive (i.e. rate of increase in speed), on G and on the condition of the aircraft.

(a) *Clean aircraft*

- (i) The mach number limitation is 0.85M above 15,000 feet and 0.83M below 15,000 feet.

(ii) *Above 40,000 feet*

The first sign of compressibility is at 0.80M, when the elevator begins to lose effectiveness. As 0.82M is reached, a gradual nose-down trim change develops which, because of elevator ineffectiveness, cannot always be held (see para. 67 (b)). As speed increases, further deterioration in elevator and trimmer effectiveness occurs and at 0.85M there is mild buffet and lateral unsteadiness, together with an easing of the nose-down trim change. Should 0.85M inadvertently be exceeded, there is a nose-up trim change between 0.85M and 0.87M and, in shallow dives, this may take the form of an uncontrollable nose-up pitch with little warning of its onset. The G associated with this may cause temporary wing dropping but a measure of lateral control is usually possible up to 0.88M. If the dive is comparatively steep (i.e. over 25°), the nose-up pitch may be transient and the aircraft may

continue in the dive and accelerate beyond 0.88M. Above this mach number there may be aileron oscillation, which can be severe at times, together with uncontrollable wing dropping. Yaw *towards* the down-going wing may be effective in helping to raise the wing when flying in the region of the shock stall. Recovery from a steep dive in these conditions may not be achieved until considerable height, possibly 20,000 feet or more, has been lost.

(iii) *25,000 feet–40,000 feet*

Up to 0.84M, the trim changes and elevator fade characteristics are the same as in (a) (ii) above but initially the nose-down trim change may be stronger. However, the lessening of the nose-down trim change may occur at a slightly lower mach number than it does above 40,000 feet and may develop into a nose-up trim change above 0.84M, leading in some cases to a violent nose-up pitch at about 0.86–0.87M. Because of the nose-up pitch, this mach number cannot normally be exceeded, except in dives over 30° .

(iv) *Below 25,000 feet*

In this height band the mach number characteristics do not vary appreciably between aircraft. At about 0.82M a moderate nose-down trim change develops and may revert to a nose-up trim change as the limit of 0.85M is reached. At high mach number/I.A.S. combinations above 0.83M there is hood roar and tail buffet may be considerable.

(b) *With R.P.s*

- (i) The mach number limitation is 0.80M at all heights.
- (ii) The limitation is lower than that for clean aircraft, because of the marked increase in elevator heaviness and the loss of effectiveness which occurs slightly in excess of 0.80M. There is also an increase in elevator heaviness at high airspeeds; aiming accuracy is likely to suffer at speeds in excess of 420 knots. The increased stick forces encountered at high airspeeds are not considered dangerous when pulling out from attacks made at speeds above 420 knots.

- (c) *Recovery*
Recovery from high speed dives should in all cases be initiated by extending the airbrakes and throttling back.

75. **Aerobatics**

- (a) The aircraft is fully aerobatic with full tip tanks.
(b) Until experience is gained, the following are the recommended minimum speeds (in knots) for aerobatics:—

Slow roll	270
Barrel roll	270
Loop	370
Roll off	370
Climbing roll	400 plus

76. **Descent**

- (a) *Descent with airbrakes IN*

Maintain a speed of 0.67M in the descent to 25,000 feet (270 knots below 25,000 feet), with the engine set as near as possible to 7,000 r.p.m. to ensure a sufficient charging rate. Start the descent at a point which will ensure that 85 gallons remain at circuit height. (See para. 53 (c).) This allows for 15–20 minutes loiter at sea level at about 160 knots and a safe margin for joining the circuit and one overshoot and landing, plus a 15–20 gallon allowance for unusable fuel.

- (b) *Descent with airbrakes OUT*

Descend as in (a) above but with the airbrakes OUT.

CIRCUIT PROCEDURE AND LANDING

77. **Checks before landing**

Airbrakes	IN
Arrester hook	Up, light out
Undercarriage	Locked down, selector lever in slot. Three green lights
Brakes	Check pressures. Off
Fuel	Contents
Flaps	Fully down on final approach
Harness	Tight and locked
Radar	Off

78. **Approach and landing**

- (a) Reduce speed to below 220 knots before lowering the undercarriage and to below 190 knots before lowering the flaps to 30°. The nosewheel may not lock down until speed has been reduced to 150 knots.

- (b) Make the turn on to the final approach at 130–140 knots and select full flap on the final approach. Cross the runway threshold at 110–120 knots, depending on the weight. At speeds below 110 knots the drag characteristics are such that if a rate of sink is allowed to develop a large r.p.m. increase is required to check it. To ensure prompt and even response to throttle opening, it is recommended that the r.p.m. are kept above 7,000 until the decision to land has been made.

- (c) If the surface is free from bumps and is dry, very small amounts of brake may be applied directly the nosewheel is on the ground. Braking may then be slowly increased as speed is reduced. If touchdown speeds are normal and it is necessary to pull up quickly, continuous braking may be used provided the brake drums are cold at touchdown. However, intermittent braking may be required to prevent overheating if the brake drums are hot at touchdown, or if the landing weight or speed is abnormally high.

- (d) If the surface is in poor condition or is wet, or when a landing at an abnormally high speed is inevitable, very careful braking is required if wheel locking is to be avoided. There is little indication that the wheels are locked, except a slight tendency to yaw, together with decreased braking effect. In these circumstances, the brakes should always be used intermittently as a guard against wheel locking and a 50 per cent longer landing run should be expected. (See para. 80. Flapless landings.)

- (e) *Going round again*

- (i) With full flap and undercarriage down, it is easy to go round again from ground level using 9,000 r.p.m.; using this technique, there is less vibration before flaps are raised and the stick is in a more central position. Full power may be preferred, however, especially at night, in order to clear the ground quickly and to raise the undercarriage and flaps safely. With full power, the stick may be near its forward limit.

- (ii) 1. Increase power as required.
 2. Raise the undercarriage as required.
 3. Raise the flaps to 30°. The nose-down trim change as the flaps retract may cause loss in height and they should not therefore be selected up until the aircraft is at least 200 feet above ground level.

79. Instrument approach

The following speeds and approximate power and flap settings are recommended for use during instrument approaches, with the undercarriage down. The figures apply with wing-tip tanks empty.

	R.P.M.	Flap setting	Airspeed knots
Pattern ..	7,500	One quarter	145
Final ..	7,500-8,000	One half	120-125
Glide path ..	6,500-7,000	One half*	115-120

* When the runway comes into view, lower the flaps fully and reduce air-speed to 115 knots.

80. Flapless landing

- (a) The aircraft must be *at the minimum all up weight* before a flapless landing is attempted.
- (b) Make the turn on to the final approach at 140 knots, reduce speed early and make a long flat approach. Cross the threshold at 125 knots. Below this speed, a strong pull force is required to hold the nose up, particularly in the engine-off condition and this may lead to difficulty if the speed is allowed to drop much below 125 knots on the approach.
- (c) The landing run is considerably longer than usual, and *at least 2,000 yards will be required on good surfaces*. Be prepared to use airfield arrester gear when available.

81. Cross-wind landing

Particular care must be taken not to lock a wheel when landing in a cross-wind. Apply the brakes very gently at the beginning of the landing run.

82. Checks after landing

Flaps	Up
Brakes	Pressure sufficient for taxiing
Cockpit pressurisation	OFF
PITOT HEAD heater switch	Off

83. Shut-down procedure

Allow the engine to idle for approximately 30 seconds to stabilise engine temperatures, lower the flaps fully, then:—

V.H.F.	OFF
Booster pump	OFF
H.P. cock	OFF
Tip-tank jettison switch	CLOSE
All other switches	Off
Chocks	In position
Brakes	Off
MICROPHONE switch	Off
Oxygen	Off
Hood jettison detonator	Safety pin in position
External control locks	In position
Wings	Wing-fold selector lever corresponding to position of wings. Wing fold struts in place
L.P. cock	OFF when engine has stopped turning. (This will prevent seepage of fuel to the combustion chambers and subsequent hot starts)
GROUND/FLIGHT switch	GROUND when generator warning light has come on and the engine has stopped
Flaps	Lower fully



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