PART IV

HANDLING

STARTING, TAXYING AND TAKE-OFF

66. External checks

The outside of the aircraft should be checked systematically for signs of damage and for security of panels, filler caps, doors and the like. The engine intakes and boundary layer ducts must be free from obstruction and the jet pipe free from distortion. Check the main and nosewheel oleos for extension, the tyres for cuts and creep and the brake leads for security and leaks. Check the elevator accumulator gauge in the port side of the fin reads 1,575 lb./sq. in. and that the ailerons accumulator gauge in the starboard wheel bay reads 900 lb./sq. in. (1,575 lb./sq. in. if Mod. 690 not embodied). Remove the pressure head cover.

67. Cockpit and pre-start checks

(a) On entering the cockpit and before strapping in, check that the drogue gun safety lock and emergency oxygen bottle pins are removed, that the flight instruments and radar supply circuit-breakers are in and the test switch is at NORMAL FLIGHT. Check that the hood rail locking indicators (89) have their pointers in line with the centres of the pins.

(b) Strap in, adjust rudder pedals, and connect radio, oxygen and anti-G suit; have the seat safety pin removed and stowed. Then check:—

Undercarriage selectors (43)	Down button fully in
Armament switches	Safe or off
Battery master switch (77)	ON
Undercarriage emergency air pressure gauge (7)	Pressure 1,800–2,000 lb./sq. in.
Flaps emergency air pressure gauge (8)	Pressure 1,800–2,000 lb./sq. in.

Wheel brakes accumulator air pressure gauge (11)	Minimum pressure 750 lb./sq. in. (1,550 lb./sq. in. on unmodified aircraft)
Tailplane actuator and hood motor circuit-breakers (5) (6)	In
Radar test switch (9)	Test standby inverter. Switch to NORMAL
Cockpit pressure warning test switch (10)	Operate and check warning light
Cockpit temperature selector (1)	As required
Cockpit temperature control (2)	AUTO
Cockpit pressure master switch (3)	ON
Flood flow control switch (4)	AUTO
Hood rails indicator	Locked
L.P. cock (16)	ON
Bomb fuzing switch (13)	OFF
Bomb/R.P. switch (12)	Gated centrally
H.P. cock (36)	Set ON and press relight button. (If serviceable an irregular clicking sound is heard) Set OFF
V.H.F. (17)	Both sets OFF. Set selector as required
Hood control switch and clutch selector (19)	Clutch FREE, check manual operation of hood Clutch LOCKED Switch as required.
Throttle damper (18)	Adjust as required
Throttle (20)	Closed
H.P. pump isolating switch (33)	NORMAL
J.p.t. controller (31)	Locked ON
Tailplane interconnection switch (29)	OFF

Undercarriage emergency selector (39)	Ensure selector not pulled up
Radar ranging switch (37)	OFF
Hood jettison handle (27)	In
Undercarriage position indicator (42) and selector buttons (43)	Day/Night switch Bulb changeover switch Three green lights Undercarriage warning light out Down button fully in UP button not twisted to EMERGENCY
Hydraulic pressure warning light (at 45)	On
Power control switches (45) (46)	Both OFF. Central if Mod. 452 is embodied
Flaps emergency selector (44)	Ensure selector not pulled out
Flight and engine instruments	Condition. Reset accelerometer (48)
Generator failure warning lights (70)	On
Ignition switch (73)	ON (normally locked on)
Pressure head heater switch (74)	OFF
G.G.S. switch (55)	OFF
E.2 compass (57)	Serviceability.
Fire warning light (58)	Out Pull out spring-loaded button to test, then reset. Do not allow button to spring back in. (If test switch fitted, use that in lieu of above check)
Audio warning cut-out switch (65)	ON (Normally spring-loaded in the ON position)
Fuel pressure warning indicator (66)	Black until engine master switch is on
Cockpit altimeter (60)	Condition
Oxygen (82)	Main and emergency supplies connected

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Oxygen
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	Contents and delivery 100% selected, Mk. 17D NORMAL selected, Mk. 17E Check for mask leaks by pressing EMERGENCY switch in central position Blinker operation
Emergency lamp switch (85)	OFF
Engine anti-icing switch (84)	Off
Fuel contents gauges (80)	Contents with ENG. ON/OFF switch (103) at ENG. OFF Fuel transfer indicators (102) white (if pressure is still in the system these will be black and contents gauges will read full)
Fuel booster-pump switches (86)	OFF
Booster-pump failure warning lights (87) (when fitted)	On
Cockpit lighting dimmer switches (83)	OFF
Navigation lights switch (101)	OFF
Emergency oxygen selector (100)	Down
Anti-G control (88)	Switch ON. Check pressure (91) 1,800–2,000 lb./sq. in. Test (90) Then as required
Fuel booster-pump and engine starter circuit-breakers (94) (95)	All in
Flying controls	Full and free movement. Rotate spring feel trim fully in both directions. Check stick moves laterally in same sense. Return to neutral
Brakes	On. Check pressure at each wheel

68. **Starting the engine**

(a) Starter master switch (72) — ON. Check aurally that No. 1 inverter starts up, the gyro instruments erect and the fuel pressure warning indicator shows white. (If residual pressure remains in the system the indicator may remain black)

H.P. cock — ON

Press the starter button without delay.

(b) As the cartridge fires, the r.p.m. will rise rapidly to 1,500, pause and then rise again to the idling figure of 3,000 ±100 (2,750±100—Mk. 115). The sequence should take about 30 seconds and during this time the j.p.t. may momentarily exceed the idling limit 525°C. (530°C. Mk. 115).

(c) When r.p.m. have stabilized, check that the j.p.t. has returned to normal and the oil pressure is registering (off the stop).

(d) *Failure to start*

(i) If the cartridge does not fire close the H.P. cock immediately. It must not be assumed that the breech is empty and the time switch should be allowed to run out (30 seconds) before attempting a further start. If the second and third cartridges fail to fire, have the defect investigated.

(ii) If the cartridge fires, but the engine fails to light up, close the H.P. cock without delay. If it is suspected that an excess of fuel has collected in the engine a second cartridge should be fired with the ignition switch and the H.P. cock off. This procedure entails a 30-second delay whilst the time switch runs out. A third attempt may be made after an interval of at least 30 seconds as controlled by the time switch.

(iii) If due to a circuit fault the starter button does not hold in, irrespective of whether a cartridge is fired or not, a period of at least 30 seconds must elapse before the button is again pressed.

(iv) If the pressure relief valve sticks open, as indicated by intermittent clouds of black or yellow smoke from the starter exhaust without r.p.m. indication wait at least until the time switch runs out (30 seconds) and then fire a second cartridge.

(v) The run of the time switch must not be shortened by the use of the master switch, otherwise overspeeding of the starter may occur.

69. **Checks after starting**

Fire warning light	Out
Set 3,700 r.p.m. and check:—	
Generator warning lights (70)	Out
Fuel transfer indicators (102)	Black
Booster pump switches (86)	Check, then OFF
Instruments	Correct functioning. Check A/H (press fast erection if necessary). Set Mk. 4B compass and altimeter. Pressure head heater ON
Hydraulic pressure	2,850±150 lb./sq. in. on both centre needle of triple pressure gauge and brake acc. gauge. Pressure at each wheel brake 1,500 lb./sq. in. (min.). Warning light out
Elevator and ailerons	Engage. Magnetic indicators black
Tailplane actuator and tailplane interconnection	ON and test
Rudder and aileron trimmers	Check and set neutral. Lock engaged
Airbrake	Check operation with test switch (15)
V.H.F.	Channel selected D.M.E. (if fitted) switch to STANDBY

NOTE.—1. To check the correct functioning of the hydraulic failure warning light and audio warning, exercise the stick laterally several times and select full flap simultaneously to exhaust hydraulic pressure. The light should come on and the audio warning sound when pressure falls below 650 lb./sq. in. When pressure rebuilds check that the flying control magnetic indicators are still black. If the flying controls revert to Manual during this check they should be re-engaged as appropriate.

2. If a check on low geared Manual aileron (Mod. 457) is required apply full lateral stick deflection and switch to Manual, observing a decrease in aileron angle. Re-switch to Power and check aileron reverts to its original position.

70. **Taxying**

(a) Taxying is normal for a nosewheel aircraft.

(b) Fuel consumption is about 15 lb. per minute whilst taxying.

(c) Whilst it is desirable to keep r.p.m. above 3,700 whenever possible to avoid discharging the batteries and to prevent No. 1 inverter cutting out with the subsequent loss of the Mk. 4F compass, artificial horizon and oil pressure gauge, the aircraft should not be taxied at a speed which requires excessive use of the brakes as this causes overheating of the tyres and reduces their life.

71. **Checks before take-off**

Trim	Tailplane. Clean aircraft—Neutral. With 38° flap and/or inboard stores—1° Nose-up. With 38° flap and outboard stores—½° Nose-up
	Rudder—Neutral. Ailerons—neutral, lock on. Spring feel—neutral

Fuel	Booster pumps ON or AUTO (MANL with ungauged wing tanks and/or drop tanks). Warning lights (when fitted) out. Fuel pressure indicator black. H.P. cock ON and locked. L.P. cock ON
	Transfer indicators black
	Contents
Flaps	Up (38° if carrying stores)
Instruments	Check and set. Pressure head heater ON
Page 71 Para. 71 (cont.) A.L.3 Oxygen	ON. 100% (Mk. 17D), NORMAL (Mk. 17E)
	Reaching mask. Blinker annunciating
	EMERGENCY switch central
Harness	Tight and locked
Hood	SHUT (not OFF)
	Clutch LOCKED
	Cockpit pressure ON (OFF in conditions of high humidity)
Hydraulics	Flying controls in power. At 4,500 r.p.m. apply full aileron and elevator and ensure that the magnetic indicators remain black
	Warning light out

72. **Take-off**

WARNING.—*A check that the power controls indicators are black must always be made immediately before take-off at not less than 4,500 r.p.m.* At any other stage of a flight, if either automatic Manual reversion or any form of stick jamming occurs with Power selected ON, immediately switch Power OFF. Do not attempt to re-engage Power; return to base and land in Manual.

(a) Having aligned the aircraft apply the brakes, open the throttle smoothly and check that the engine is functioning correctly (see (j) below). When the aircraft begins to creep

forward at between 7,200 r.p.m. and full throttle, depending on brake condition, release the brakes and open up to full throttle. At full power, check that the oil pressure is at least 15 lb./sq. in. If the aircraft creeps forward before 6,800 r.p.m. is reached, the brakes should be considered unserviceable and the aircraft should not be flown.

(b) Normally there is no tendency to swing. In cross wind conditions, gentle intermittent braking is necessary to keep straight until at about 90 knots the rudder becomes effective.

(c) Ease the nosewheel off at about 120 knots and hold it just off the runway, taking care not to achieve an excessive nose-up attitude. At about 150 knots, depending on weight, apply gentle back pressure to unstick.

(d) Until experience is gained the lightness of the ailerons may lead to overcontrolling, resulting in lateral rocking as the aircraft leaves the ground.

(e) When comfortably airborne apply the brakes and raise the undercarriage. There is no noticeable change of trim, but the nosewheel locks up with a distinct thud. *Retraction must be complete before 230 knots may be exceeded.* To ensure that the wheels do not rotate in their bays when the undercarriage is locked up, keep the brakes on until the red lights go out.

(f) As the aircraft accelerates to climbing speed it will be necessary to trim out the increasing nose-up change of trim.

(g) *Use of flap for take-off*

Only a short reduction in take-off distance is achieved by using 38° flap. In this configuration lateral rocking is more pronounced; a strong nose-up change of trim and a small amount of sink occur when the flaps are raised.

(h) *When carrying stores*

The nosewheel can be eased off at 125 knots and the aircraft flown off at 145–150 knots, the unstick distance being approximately 1,550 yards. When safely airborne immediately raise the undercarriage and then the flaps in 10° increments retrimming after each selection; delay in raising the flaps will result in an increasing nose-down change of trim as speed increases.

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(j) *Manual reversion*

(i) Should Manual reversion occur on take-off it is safe to continue the take-off, circuit and landing. Using the recommended trim settings, a strong pull force is required to raise the nosewheel but the aircraft will be in trim at 160 knots.

(ii) It is recommended that because of there being a possible hydraulic failure, undercarriage and flaps (if the latter have been used for take-off) are left down, care being taken not to exceed the maximum permissible speed.

(k) *Inability to achieve full take-off power*

Malfunctioning of the variable-incidence swirl vanes can result in the vanes remaining in the 40° position, thus preventing maximum thrust being obtained. If this occurs the take-off should be abandoned. It is important to ascertain as soon as possible whether the engine is functioning correctly. Indications of incorrect swirl vane operation are:—

(i) Take-off r.p.m. can be reached before the throttle is fully open.

(ii) At full throttle max. r.p.m. may be exceeded but with brakes on, the aircraft will not creep forward as it normally tends to do when correct take-off power is obtained. The j.p.t. will in all probability not exceed 580°C.

(iii) When the brakes are released, poor acceleration will at once be evident.

If, at maximum A.U.W., the take-off is abandoned at a speed of 100 knots the aircraft will take approximately 750 yards to stop from the point at which the brakes are applied. If the length of runway remaining is short, turn off the H.P. cock.

HANDLING IN FLIGHT

73. **Climbing**

NOTE.—If cockpit pressure has been set to OFF to prevent misting, switch it ON at about 5,000 ft.

(a) *Best rate of climb*

(i) Climb at maximum power within the j.p.t. and r.p.m. limits at 430 knots until 0.87M is reached. Thereafter maintain 0.87M.

(ii) For the best rate of climb, it is important to keep to the recommended speed especially at high altitudes. Above 30,000 ft. the rate of climb will fall off quickly if the airspeed is reduced to below that recommended, and it will take a long time to regain speed without losing height.

(b) *Normal climb*

If maximum rate of climb is not essential set 7,950 r.p.m. (7,800—Avon 115) using the same airspeeds as above. It

may be necessary to adjust the throttle as height is gained to maintain the selected r.p.m.

74. **Flying controls**

(a) *Ailerons*

The ailerons are light and effective throughout the speed and mach number range, giving a high rate of roll. (See para. 84.) The aileron spring feel trim should normally be used to counteract any out-of-trim forces which may occur in Power. It should not normally be used when flying in Manual.

(b) *Elevator*

(i) *Power-assisted elevator (in power).* The control is light and effective up to 450–500 knots, but at higher speeds it becomes heavy and loses some of its effectiveness. Above 0.92M there is a marked decrease in control effectiveness and a substantial heavying up.

(ii) *Full-power elevator (in power).* The force required for any manœuvre depends on the distance the control column is displaced from the "zero-load" position. It follows therefore that when large elevator deflections are required, e.g. at low airspeeds and very high mach numbers, the stick forces are relatively heavy; at high airspeeds, however, since only small deflections are usually required, the stick forces are light. The control feels light, is effective and should be used cautiously until its characteristics are known and its effectiveness appreciated. However, elevator effectiveness is somewhat limited by jack stalling. This condition occurs when the air load on the elevator equals the jack output force and restricts movement of the control column rearwards. When manœuvring jack stalling will occur at a mach number in excess of 0.97 and may occur at speeds in excess of 500 knots at forward C. of G.

(c) *Rudder*

The rudder is light and effective at low airspeed but becomes progressively heavier as speed increases.

(d) *Trimmers and tailplane*

NOTE.—Do not fly with the thumb on the tailplane control switch as this may cause intermittent making

and breaking of the contacts which may damage the switch. Care must also be taken not to operate the switch inadvertently during manœuvres, as this may result in excessive G being applied. If the normal trimmer fails, the standby control should be used; this operates at about one-third the speed of the normal control. The aileron trimmer must not be used whilst the controls are in Power, and it should be locked in the neutral position.

(i) *With power-assisted elevator fitted*

For general sustained flight the tailplane trimmer should be used in the normal manner. When manœuvring at high speeds the tailplane trimmer may be used to supplement the elevator pull force, *but this force must never be completely trimmed out.* (*See para. 85.*) Should both trimmers fail, the aircraft can be controlled throughout the speed range in Power with the tailplane at the fully nose-down position. With the tailplane at the fully nose-up position, the push force required becomes excessive above 250 knots or 0.87M. The aircraft can be landed in Power with the tailplane at either extreme without undue difficulty. Normally with the controls in Power the tailplane angle will be between $\frac{1}{2}^\circ$ and 1° nose-down. The full traverse will, however, be required with the controls in Manual.

(ii) *With full-power elevator fitted*

The tailplane trimmer should be used in the normal manner, the angle is usually between 1° and fully nose-down. When manœuvring at high airspeed the stick forces are light and little use of the trimmer is required. For sustained flying, however, the stick forces should always be trimmed out; if this is not done and inadvertent manual reversion occurs the stick force may be too high for the pilot to hold. If both elevator trimmers fail, the aircraft can be flown throughout its speed range with the trim at full nose-down, but at full nose-up the elevator is not sufficiently powerful to stop the nose rising at speeds in excess of approximately 420 knots. The aircraft can be landed in Power with the tailplane at either extreme without undue difficulty.

(iii) *With follow-up tailplane fitted*
The tailplane gives an improvement in manœuvring capabilities above 0.9M. Handling characteristics are otherwise normal, but it should be noted that the tailplane remains fully operative with the elevator in Manual. The tailplane interconnection can be selected ON or OFF at any speed provided that the aircraft is trimmed for hands off flight whenever either selection is made. The aircraft should be flown in the trimmed condition whenever possible.

(e) *Airbrake*

(i) The airbrake may be used throughout the speed range, with undercarriage up. The trim changes are as follows:—

(ii) On selection of the airbrake at 550 knots and above a slight nose-down change of trim occurs but this reverts to a slight nose-up change and when the airbrake is fully extended the aircraft is almost back in trim.

(iii) At high mach number and high altitude no appreciable trim change occurs on extension of the airbrake up to 0.96M; moderate buffeting occurs, and this is most marked between 0.95M and 0.96M. Above 1.0M a slight nose-up change of trim occurs.

(f) *Flaps*

(i) *At high mach number*
As speed is increased from 0.9M to 0.93M a marked nose-down trim change occurs; lowering flap also produces a marked nose-down change of trim, the degree of out of trim increasing with the amount of flap selected and with speed. At speeds above 0.92M elevator and tailplane effectiveness decreases. Pilots will realize therefore that if 0.9M is exceeded with flap lowered, or flap is lowered inadvertently at speeds in excess of 0.9M, longitudinal control will be very substantially reduced and in the worst condition may be lost completely. If control is lost with any degree of flap lowered the flap should be raised immediately.

(ii) *At high airspeed*
If speed is increased inadvertently beyond 350 knots with flaps extended, the increasing airloads decrease the flap angle which results in a nose-up change of trim.

(g) *Changes of trim*

Increase of power	Nil
Operation of undercarriage	Negligible except when ailerons are in Manual (see para. 97)
Flap down	Strong nose-down above 200 knots
Airbrake	High I.A.S. slight transient nose-down, then slight nose-up Above 0.98M slight nose-up At low I.A.S. negligible

75. **Flying at forward C.G.**

In the forward C.G. condition (i.e. when ammunition is carried) the nosewheel and aircraft unstick speeds are increased from approximately 120 knots to 125 knots and 150 knots to 155 knots, respectively. The stick forces required to manœuvre the aircraft in the pitching plane are slightly increased at forward C.G. because slightly larger elevator deflections are required. At very high airspeed and mach number, when jack stalling occurs, the amount of G it is possible to obtain is reduced.

76. **Flying with external stores**

(a) *Flying with drop tanks on inboard and outboard pylons*

(i) At speeds below the permitted maximum the handling characteristics are similar to those for the clean aircraft. During combat manœuvres with fuel in the tanks it is recommended that aileron movement is restricted to half of full movement to avoid an excessive rate of roll.

(ii) *Pressure errors*
The presence of a drop tank on the port outboard pylon has a material effect on the pressure error, resulting in under-reading of the airspeed indicator and machmeter as compared with clean aircraft. (See para. 115.)

(iii) *Practice Manual flying*
Practice selection of flying controls to Manual must not be made when carrying external stores, other than

empty inboard drop tanks, because the presence of such stores increases the difficulty of re-selecting Power.

(b) *Flying with RP's*

Aileron movement becomes restricted at 0.97M when carrying RP's. When drop tanks are carried on the inboard pylons as well it is difficult to exceed 0.98M.

77. **Flying for endurance**

The recommended speed is 180 knots.

78. **Flying at reduced speed**

(a) Fly at 180–200 knots using 23° flap (2 notches down).

(b) Lateral rocking may occur between 200–250 knots with the flaps fully down. If the rocking becomes excessive the flaps should be raised. Any lateral rocking which occurs below 200 knots is easily controlled with the ailerons.

79. **Flying with the hood open**

The hood may be opened fully below 200 knots but at about 150 knots excessive vibration sets in. This vibration is reduced if the hood is closed to the halfway position, i.e. about level with the pilot's shoulders. In this position the noise level is high and rather distracting but landings can be made without undue inconvenience.

80. **Flying in severe turbulence**

The recommended speeds for flying in conditions of severe turbulence are:—

Condition	*Altitude*	*Speed*
Level flight or climbing	Below 25,000 ft. Above 25,000 ft.	350 knots 0.83M
Descending (airbrake out, flap 23°)	Above 35,000 ft. Below 35,000 ft.	0.83M 280 knots

81. **Low speed stalling**

NOTE.—Because the rate of descent is very high and because it is possible to induce an inadvertent spin when the aircraft is fully stalled, stalling practice is not to be continued beyond the buffet stage nor below 25,000 feet. R.p.m. should not be allowed to fall below 4,500

(a) Pre-stall buffet speeds at 25,000 ft. throttle fully closed, are:—

(i) *Full ammunition and 1,600 lb. fuel remaining (Max. landing weight approx.)*

Undercarriage and flap up	140 knots
Undercarriage down and flap up ..	140 knots
Undercarriage down and full flap ..	130 knots

(ii) *No ammunition and 800 lb. fuel (Normal landing weight)*

Undercarriage and flap up	135 knots
Undercarriage down and flap up ..	135 knots
Undercarriage down and full flap ..	125 knots

(b) Above 30,000 ft. buffet occurs at approximately 140–145 knots, with the throttle fully closed, undercarriage and flap up.

(c) If extended wing leading edges are fitted the intensity of pre-stall buffet is increased but the stalling speeds are little affected.

(d) Use of the airbrake increases the buffet but does not affect the stalling speeds or other characteristics.

(e) Under typical approach conditions, the buffet speeds quoted above are not appreciably affected, but the height lost during recovery is reduced.

(f) (i) Although the aircraft must not be deliberately fully stalled in flight, the characteristics are described here to assist pilots who inadvertently enter the fully stalled condition.

(ii) If the control column continues to be held back after the buffet stage is reached a nose-up change of trim may occur, which will vary in degree from aircraft to aircraft. Either wing may tend to drop but can be

controlled by the ailerons. Continued backward pressure on the control column at this point will lead to a further reduction in forward speed accompanied by a very high rate of descent. In this condition the elevator is relatively ineffective and response is slow. If extended wing leading edges are fitted there is less tendency for either wing dropping or yawing to occur.

(iii) A spin or spiral may develop, and in any case considerable height will be lost. Large deflections of the ailerons near the stall will cause the aircraft to yaw in the direction of the downgoing aileron and will increase the possibility of a spin or spiral developing.

82. **High speed stalling**

(a) (i) High speed stalling is subject to the overriding limitation of +7G (accelerometer reading).

(ii) At airspeeds above 0.9M between 10,000 and 30,000 feet, if Mod. 533 is not embodied, an accelerometer reading of +4G must not be exceeded; at airspeeds below 0.9M in that height band, G must not be applied beyond the buffet stage.

(b) *Pitch-up (pre-mod. 533 aircraft)*

During turns and pull-outs adequate stall warning is given by buffeting at all heights. If the backward pressure is continued inadvertently after the stall warning a momentary pitch-up and sudden increase in G may occur. Above 0.9M between 10,000 and 30,000 ft. the pitch-up, if experienced, may be coincident with the buffeting and may be severe enough to exceed +7G, and it is for this reason that the restriction of +4G accelerometer reading is imposed. Above 30,000 ft. it is not possible to achieve high accelerometer readings. Below 10,000 ft. the maximum allowable acceleration of +7G accelerometer reading may be applied at the higher mach numbers without G stalling the aircraft. No pitch-up is therefore experienced.

(c) *Pitch-up (post-mod. 533 aircraft)*

With extended wing leading edges fitted the G limitations are +7 and −3¾ at all heights and speeds. Pitch-up may still occur to a reduced degree when G is applied at speeds above 0.9M in the height band 25,000–30,000 ft. If this occurs, however, it is still possible to maintain some degree

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of longitudinal control. Buffeting is considerable and wing dropping may occur.

(d) *Jack stalling (full-power elevator)*

NOTE.—The information contained in (a), (b) and (c) above also applies to aircraft fitted with full power elevator, and the following information should be regarded as supplementary.

Buffeting and/or limiting G can be obtained with very little effort, particularly when ammunition is not carried, but if jack stalling occurs it limits the amount of G it is possible to obtain. The control column should only be held hard on the "restriction stop" provided that the considerable increase in G as speed decreases and further control column movement becomes possible is anticipated. When manoeuvring at high airspeed near the ground, sufficient height must be allowed for a recovery to be effected, in the jack-stalled condition, in case jack stalling should occur and max. G be unobtainable. Care should be taken when manoeuvring at high mach numbers as it is easy to pull into the pitch-up inadvertently due to the stick force remaining light.

83. **Spinning**

NOTE.—If a spin occurs with undercarriage and flaps down raise them immediately. If normal recovery action fails, jettison external stores, if carried, before emergency recovery is attempted. Because of the cranked stick pilots should familiarise themselves with its position corresponding to neutral aileron. The control column when aligned with a white circle on the instrument panel adjacent to the A.S.I. indicates the neutral aileron position.

(a) Intentional spinning is prohibited. The following information applies to aircraft with or without extended wing leading edges and is provided to acquaint pilots with the spin characteristics and recovery actions in case the aircraft is spun inadvertently. Spins may be entered inadvertently from harshly executed manoeuvres if aileron and/or rudder are applied in the presence of buffet. A normal spin will usually result. An inverted spin is only likely to result from manoeuvres such as a loop or roll off the top when the speed on the top has become too low; thus the likelihood increases at high altitude. It is recommended that the above spin-prone conditions be avoided.

(b) (i) When a normal spin occurs, the first three or four turns are somewhat oscillatory in attitude due to the curvature of the flight path. Thereafter the spin becomes fairly regular and no change has been apparent in spins of up to twelve turns.

(ii) The aircraft recovers steadily within two turns when standard recovery action is taken—i.e. opposite rudder and stick forward, aimed at the white datum. It should be noted that there is an instinctive tendency to oppose the spin with aileron (outspin aileron) unless a conscious effort is made to hold the aileron neutral. If any outspin aileron is left on, the aircraft may not recover, the spin becomes relatively fast and regular taking about 3 seconds per turn in an attitude some 60° nose-down from the horizon; recovery, however, occurs consistently within two turns after the ailerons have been centralised.

(iii) The standard of recovery is relatively insensitive to elevator position or tailplane setting. However, the elevator position does markedly affect the steepness and rate of rotation of the spin, both increasing with forward movement of the stick.

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(iv) Due to the large variation in the time taken for one turn of a spin depending on whether the aircraft is doing the normal slow and erratic intentional spin or the faster type encountered during abortive recoveries, it is not possible to state a typical height loss per turn other than that this may vary from 1,000 to 3,000 feet. However, typical rates of descent are much less variable and average around 24,000 ft./min. when the flight path approaches the vertical. The height required to regain level flight from the time autorotation ceases is in the order of 6,000 to 10,000 feet.

(c) *Normal spin*

(i) *Normal recovery*

1. Apply full rudder opposing the direction of the yaw. (The turn needle indicates direction of yaw.)
2. Move the control column progressively forward, making sure that the ailerons are neutral by aiming at the white circular datum, until rotation ceases.
3. Immediately rotation ceases and not before, centralise the rudder.
4. Ease out of the ensuing dive.

NOTE.—As the control column is moved forward the rate of rotation usually increases momentarily before ceasing.

(ii) *Emergency recovery*

If after two turns normal recovery action is unsuccessful take the following action:—

1. Jettison external stores.
2. Maintain full rudder opposing the yaw (the turn needle indicates the direction of the yaw) and control column fully forward.
3. Apply in-spin aileron, i.e. moving the control column laterally in the direction of the roll.
4. Maintain recovery action and be ready to centralise rudder and ailerons immediately the spin ceases.
5. Ease out of the ensuing dive.
6. If complete disorientation is experienced the controls should be released as a last resort. The spin will usually cease but the standard of recovery is marginal.
7. If recovery has not been effected by 10,000 ft. abandon the aircraft.

(d) *Inverted spin—recovery*

(i) Apply full rudder opposing the direction of yaw (as observed visually or indicated by the turn needle).
(ii) Allow the control column to return to the neutral position fore and aft.
(iii) Laterally deflect the stick fully in the direction of roll (i.e. in the same sense as the applied rudder).
(iv) Maintain these actions for at least five turns or until rotation ceases.
(v) Centralise all controls after recovery and ease out of ensuing dive.
(vi) If recovery action is ineffective jettison the hood.
(vii) If recovery has not been effected by 10,000 feet, abandon the aircraft.

84. Flying at high airspeed

(a) When flying at high airspeed all control movements must be smooth and progressive. The tailplane trimmer must be used very carefully.

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(b) At the highest airspeeds the rate of roll is reduced because the hydraulic system is not powerful enough to displace the ailerons fully against the increased airflow.

85. Flying at high mach number (with power-assisted elevator)

(a) *General*

The maximum speed in level flight at full throttle is 0.93 to 0.95M. From 40,000 feet and above the aircraft will exceed sonic speed in a 30° to 40° dive at full throttle. Transonic dives must not be started below 25,000 feet.

(b) *Trim changes*

As speed increases to about 0.90M there is a progressive nose-up change of trim. Between 0.90M and 0.96M a nose-down trim change followed by a nose-up trim change occurs, the aircraft being almost back in trim again by 0.96M. At higher speeds as the aircraft becomes supersonic the trim again changes to slight nose-down.

(c) *Changes in stick force, and tailplane and elevator effectiveness*

(i) The stick forces at high mach number vary with the associated airspeeds. If these are sufficiently low the forces are moderate up to approximately 0.90M. At higher mach numbers, however, the stick forces increase markedly.

(ii) As the mach number is increased beyond 0.92 the tailplane and elevator become less effective. This is particularly evident at transonic speeds when even large elevator deflections have a delayed and reduced response. The tailplane may be used to assist recovery from high speed dives but the elevator pull force must never be completely trimmed out. (See para. (f) and warning.)

(d) *Transonic flights*

Practice transonic flights should be made by putting the aircraft into a 30° to 40° dive with the tailplane trim set at $1\frac{1}{4}$° nose-down. At 0.98M as the aircraft becomes supersonic the control column may move forward about one to two inches, there may also be some rudder movement, but this does not affect directional trim.

(e) *Recovery*

To recover, pull maximum elevator force and retrim to $\frac{1}{2}$° nose-down. The aircraft will recover from the dive slowly, and as the nose comes up to the horizon retrim the tailplane to 1° nose-down. Recoveries can be made without using tailplane trimmer, but if the dive has been entered with full nose-down trim set, it will be necessary to retrim. Recovery must not be effected by use of the tailplane trimmer alone. The airbrake may be used during recovery; it should be extended when recovery is initiated and retracted as the nose comes up to the horizon.

(f) *Cumulative effect of changes in trim, tailplane and elevator effectiveness, and stick forces*

As speed becomes subsonic and falls to 0.97M, it is necessary to ease forward on the control column to avoid an increase in G. This is because of the trim changing to nose-up, the tailplane and elevator effectiveness increasing and the stick forces decreasing quite suddenly. This is also

the case as speed falls through 0.91M, where the change of trim is more marked.

WARNING.—It is for the reasons given in sub-para. (f) that, when G is being applied at high mach numbers during turns and dive recoveries, great care must be taken to ensure that the stick force is never completely trimmed-out, otherwise an unexpected increase in G may result before retrimming can be effected. *This is particularly important below 10,000 ft. when manœuvring near limiting G and/or "blackout threshold".*

86. Flying at high mach number (with full-power elevator)

(a) All the information and recommendations given in para. 85 except the reference to stick forces also apply to aircraft with the full-power elevator. The following information should be regarded as supplementary. As the aircraft becomes supersonic there is no forward movement of the control column. When recovering from supersonic dives jack stalling will restrict movement of the control column rearwards. The tailplane trimmer may be used to assist recovery, but it should be used carefully, because as speed falls through 0.96M and again through 0.91M it is necessary to anticipate the increase in G caused by the trim changing to nose-up and the tailplane and elevator becoming more effective.

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(b) Recovery from supersonic dives at low altitudes, using maximum obtainable elevator angle, may lead to minor damage of the elevator skin. Additionally a transient rudder buzz may be experienced over the speed range 0.97–0.98M. To avoid risk of structural damage, therefore, recovery from supersonic dives must be completed by 20,000 ft.

87. Aerobatics

(a) Until experience is gained, the following speeds, in knots, are recommended:—

Roll	350
Loop	425
Roll off	450
Vertical roll	500

(b) It is recommended that until experience is gained, loops are started in the height band 10,000 ft. to 15,000 ft.

CIRCUIT PROCEDURE AND LANDING

88. Circuit procedure

NOTE.—620 lb. of fuel should be allowed for the circuit and landing. (But see para. 59 (d).)

(a) *Circuit speed*

6,500 r.p.m. and 23° flap (2 notches) give a comfortable speed of 170/180 knots. To reduce speed for joining the circuit, flap, within the limitations, can be used successfully to augment the airbrake. Do not select more than one hydraulic service at a time and allow the cycle of each hydraulic operation to be completed before the next service is operated. The undercarriage should only be selected down when the wings are laterally level.

(b) *Checks before landing*

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Airbrake	IN, indicator black
Undercarriage	DOWN below 230 knots Three green lights
Flaps	As required Fully down on finals
Fuel	Contents Booster-pumps ON (AUTO or MANL. on unmodified aircraft)
Harness	Tight and locked
Brakes	Pressure, operation, off Main supply 2,850±150 lb./sq. in. At each wheel 1,500 lb./sq. in.

NOTE.—1. The brake lever should be held on for 2–3 seconds. If the system is serviceable both brake needles should remain at maximum pressure. If a hydraulic pipe is fractured a lower than normal pressure will be indicated initially and this will decrease at a rate depending on the size of the fracture. The check should not be repeated because at each operation hydraulic oil will be lost.

2. Landing in Power with symmetric or asymmetric stores presents no difficulty. However, if a landing is to be made with RP's when gun ammunition is expended not more than 38° flap should be selected; with full flap there is insufficient nose-down trim available.

(i) Turn across wind at 160 knots aiming to lower full flap on the final stages. Steep approaches are not recommended.

(ii) To ensure immediate engine response maintain at least 4,500 r.p.m. until finally committed to a landing. Under conditions of high wind or gustiness it is more comfortable if the speeds below are increased by 5 knots.

(iii) The recommended speeds, in knots, at the runway threshold:—

At normal landing weight

No ammunition, 800 lb. or less fuel remaining	130

At maximum landing weight

No ammunition 2,300 lb. fuel remaining ..	135
Full ammunition, 1,600 lb. fuel remaining ..	135

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89. **Landing**

(a) As the touchdown point is approached, the rate of descent should be checked and the aircraft flown gently on to the ground at about 5–10 knots less than the runway threshold speeds. Holding off may result in an excessive nose-up attitude with the likelihood of scraping the tail cone and the subsequent danger of dropping a wing; if the latter occurs, corrective aileron may be effective in raising the wing, but will cause the aircraft to yaw markedly in the direction of the downgoing wing. The nosewheel can be held off at speeds down to about 70 knots, but the shortest run is achieved by putting the nosewheel firmly on to the runway and applying the brakes.

(b) *When carrying stores*

Enter the threshold at 140 knots and fly the aircraft on to the ground at 130 knots.

(c) *Braking*

NOTE.—The effectiveness of the braking system is greatly decreased on very wet or icy runways. If wind conditions are favourable it may be advantageous to use aerodynamic braking.

When the nosewheel has been lowered on to the runway the brakes can be used continuously and the maxaret units will prevent wheel locking; however, to prolong the efficiency and life of the brakes, braking should be judicious according to length of landing run available. The landing can be cut to less than half normal by using continuous full brake once the aircraft is firmly on the ground, but

this procedure causes rapid brake and tyre wear and should not normally be used. The aircraft must be firmly on the ground before applying the brakes. If it is allowed to touch down with the brakes on, the maxaret units will not operate and the wheels will lock; however, if once having started turning, the wheels should stop because of a skid or bounce, they will not lock unless the skid or bounce continues for more than 4 seconds. After a landing involving heavy braking, ten minutes should elapse before the next landing. If the intervening period of taxying has also required prolonged use of the brakes, twenty minutes should elapse before the next landing. Observe the same precautions in brake tests. On wet runways the landing run may be decreased by lowering the nosewheel on to the runway, applying the brakes and pulling the control column right back. The brakes must be in use while the back pressure is applied.

(d) *Going round again*

Open the throttle smoothly to the power required, raise the undercarriage, and at a safe height raise the flaps and retrim as necessary.

90. **Instrument approach**

The following are the recommended airspeed, power and flap settings for an instrument approach with the undercarriage lowered:—

	R.P.M.	Flaps	Airspeed (knots)
Down wind	6,600	23°	170/180
Base leg	6,600	23°	170/180
Glide path	6,600	Full	150/160

91. **Flapless landing**

A very long shallow powered approach should be made and the threshold crossed at the normal speed. Even when the throttle is closed, speed decreases very slowly. The aircraft should therefore be placed firmly on to the runway as soon as possible, the nosewheel lowered on, the brakes applied, and, if necessary, the H.P. cock set off. The landing run is very much increased.

92. **Cross-wind landing**

For cross-wind landings the "crab" technique should be used. In light winds no difficulty should be experienced in touching down, but in strong cross-winds full rudder may be required to correct the crabbing. The rudder has a delayed reaction which will require anticipation. The effect of full rudder is to produce a marked roll which must be counteracted with aileron. When the crabbing has been corrected the aircraft should be flown gently on to the ground and the nosewheel lowered on immediately to decrease the angle of attack of the wings and thus reduce the tendency for the cross-wind to lift the into-wind wing. Care should be taken to centralize the rudder before applying brake. If the cross-wind is gusting strongly the approach speed should be increased by 5 knots.

93. **Checks after landing**

Brake pressure	Sufficient
Flaps	Up
Cockpit pressure	Off
Camera master switch	Off
Pressure head heater	Off
Both booster-pumps	OFF
Tailplane	Set to neutral. TAILPLANE switch OFF
D.M.E.	OFF
V.H.F.	One set OFF

94. **Stopping the engine**

Close the throttle. When the r.p.m. have stabilized at 3,000±100 (2,750±100 Avon 115) turn off the H.P. cock, then check:—

Powered controls switches	Both OFF
All electrics	Off
Battery master switch	Off
Hood clutch selector	FREE
Ejection seat	Replace safety pins before leaving cockpit

FLYING IN MANUAL

95. **Selecting Manual**

(a) (i) It is structurally safe to fly in Manual within the speed limitations of para. 58 and in emergency Manual could be selected at any altitude and airspeed. However, until experience is gained, it is recommended that selection of Manual and subsequent practice flying in Manual should be carried out above 10,000 ft. This is because of the out of trim forces which may be present when Manual is selected and the extreme heaviness of the controls and lack of manœuvrability when in Manual.

(ii) Before selecting Manual, ensure:—

Airspeed	250 knots or 0.80M if above 40,000 ft.
Tailplane	In trim
Aileron and rudder trim indicators	Neutral
Aileron and rudder trim lock	Disengaged

(b) *With full-power elevator*

The elevator forces are slightly higher on aircraft fitted with the full-power elevator because of the additional force required to overcome the feel spring. Provided that the aircraft is in trim in Power, the trim changes on selection of Manual are usually slight. If the tailplane and elevator are incorrectly rigged, however, these changes may be large. Because of this possibility, when practice flying in Manual is to be carried out, the first selection to Manual should be made above 10,000 feet and at a low airspeed.

96. **Flying in Manual**

(a) The elevator forces are high but tolerable and no difficulty should be experienced with longitudinal control. The ailerons are heavy and require considerable effort to produce only small deflections. Reaction of the aircraft to aileron deflection is slow and delayed, therefore all necessary aileron movements must be anticipated. The rudder, the further effect of which is marked, can be used

to assist control in the rolling plane but should be used with care at low airspeeds. The aileron and rudder trimmers are effective. The former can be used to assist in applying angles of bank. At low airspeeds aircraft response to even full deflection is slow and delayed and must be anticipated. At high airspeeds however aircraft response is rapid and positive.

(b) *When carrying stores*

Because of the increased inertia, lateral control is less effective; this is particularly noticeable on the approach when lateral rocking due to either turbulence or over-controlling is difficult to damp out. In gusty or severe cross-wind conditions consideration should be given to jettisoning the stores before attempting to land. Due to the increased turbulence below the wing and the tendency of the ailerons to up-float the likelihood of obtaining a false anchorage when reverting from Manual to Power is increased. Should either inboard or outboard tank fail to feed, the tanks must be jettisoned if a Manual landing is to be made.

(c) *Effect of asymmetric fuel flow*

If Manual control is selected at 250 knots when one wing tank is empty and the other full, a maximum single-handed force will be required to restrain the wing-low tendency. The amount of trim to counteract this tendency varies with airspeed, little being needed at high speed but maximum at approximately 190 knots. If speed is gradually reduced below 190 knots an increasing stick force, up to a maximum of 8 lb. is required to maintain wings level. This asymmetric load condition is likely to cause false anchorages on reversion to Power. Before reselecting Power the aircraft should be trimmed hands off at 250 knots. When a correct reversion to Power is achieved the aileron trim should be set to neutral otherwise, if an inadvertent reversion to Manual occurs, or if Manual is again selected at a later stage of the flight when the second wing tank has emptied, the previously applied trim will produce a wing-low tendency, the severity depending on the amount of trim applied and the airspeed.

(d) *Trim changes*

Increase and decrease power	Nil
Operation of undercarriage	Roll in either direction (depending on which main leg lowers first, see para. 97)
Flaps down	Strong nose-down especially above 200 knots
Flaps up	Strong nose-up especially above 200 knots

97. **Landing in Manual**

(a) Until pilots have considerable experience of flying in Manual control, practice landings should be made only in ideal conditions, i.e. a steady wind down the runway. Because any asymmetric lowering of the undercarriage is liable to cause lateral control difficulties, the undercarriage must be lowered at a safe height. A wider than normal circuit should be made, followed by a long straight powered approach. When the airspeed is below 150 knots with undercarriage and full flap down, aileron buffet can be felt on the control column. If an overshoot has to be made, because of lateral control difficulties near the ground, the undercarriage should not be raised until a safe height is reached. Flaps must only be selected up to a mid-position (4 notches) because of a nose-up change of trim, full retraction being deferred to a safe height.

(b) *With external stores (see also para. 96 (b))*

If the drop tanks are full or partly full they must be jettisoned before landing. Landing with any asymmetric loading other than one empty inboard drop tank must not be attempted. Trials have shown that with a nominal 1,000-lb. weight on an inboard pylon the wings cannot be held laterally level at speeds below 180 knots. In turbulent conditions symmetrically loaded RP's must be jettisoned if practicable; otherwise great care must be taken and not more than 38° flap must be selected.

98. **Reselecting Power**

Before reselecting aileron and/or elevator power, the aircraft must be trimmed, laterally and longitudinally, in straight and level flight at the same airspeed and approximate altitude as when Manual was selected. Immediate re-engagement is more likely on the elevator than on the

ailerons; it is therefore preferable to reselect elevator before ailerons. After reselection check that the appropriate magnetic indicators are black.

WARNING.—1. If a false anchorage occurs which it is not possible to clear, select Power Off. Return to base and land in Manual.

2. If, when Manual is selected following a false anchorage, the control remains jammed (indicating that Manual reselection is impossible) the aircraft must be abandoned.