PART III
HANDLING

MANAGEMENT OF SYSTEMS

56. **Management of the fuel system**

(a) The L.P. and H.P. cocks must be ON and except for starting and taxying after landing the booster-pump switches should be ON (unmodified aircraft) or at AUTO or MANUAL (modified aircraft) at all times when the engine is running.

(b) Fuel is supplied to the engine from the front tanks by the booster-pumps. The front tanks are kept full with fuel transferred by air pressure from the rear tanks via the centre tanks. With the booster-pump switches ON (unmodified aircraft) or set at AUTO (modified aircraft), equal flow should be provided from both front tanks.

(c) When the centre and rear tanks are empty and the front tank has less than 60 gallons (460 lb.) the aircraft C of G is further aft than when all tanks are full. The furthest forward C of G is reached when the front tanks are full and the remaining tanks are empty.

(d) *Unusable fuel*

(i) Providing slow forward throttle movements and small changes in attitude are made the engine will continue to run satisfactorily down to zero gauge readings, but at low fuel states steep climbs and/or sudden application of full power should be avoided,

particularly when overshooting, as this will cause fuel in the tanks to move away from the booster-pumps resulting in a possible fuel starvation and flame extinction. Therefore at low fuel states minimum power consistent with safety should be used, steep attitudes avoided and a glide approach planned. If a flame-out occurs, a relight may be obtained by adopting a nose-down attitude and pressing the relight button.

(ii) The amount of unusable fuel increases with sudden forward acceleration and/or nose-up attitude: rig tests reveal the following:—

Angle between fuel surface and fuselage datum	Unusable fuel galls. per side
10°	16
20°	26
30°	30

On a normal take-off, the angle between fuel surface and aircraft datum is approx. 23°, at which angle approx. 27 galls. per side are unusable.

(e) *Unequal tank emptying*

(i) *Unmodified aircraft*

If unequal emptying occurs to the extent of 20 gallons (150 lb.) or more with both booster-pumps ON and circuit-breakers in, adjust the fuel contents level by switching off the pump on the side with the lower fuel state. If this is unsuccessful assume that one pump has failed. (See (f) below.)

(ii) *Modified aircraft*

If unequal emptying occurs (to the extent of 100 lb. or more) with both pump switches at AUTO either balance control or booster-pump failure has occurred. If the pump on the low side is switched OFF and the low pressure warning indicator remains black, balance control failure has occurred.* Fuel balancing must then be obtained by use of the individual booster-pump switches between the MANL

and OFF positions, i.e., switching off the pump on the side with the lower fuel state. When the fuel contents are level both pump switches should be set to MANL.

*NOTE.—This test is valid only in aircraft *not* fitted with booster-pump failure warning lights. In aircraft fitted with the lights, balance control failure is indicated by unequal emptying, with the failure lights OUT.

(f) *Booster-pump failure*

(i) To check if a pump has failed, switch OFF the pump on the low contents side when the low pressure warning indicator should show white. (Later aircraft may be fitted with two booster-pump failure red warning lights, one for each pump. With these fitted the low pressure indicator will not show white if this check is made.)

(ii) If a booster pump fails, reduce r.p.m. to approximately 6,500, switch OFF both pumps and accept the fuel feed provided by tank pressurization and gravity. Open the throttle until the minimum r.p.m. to maintain height is obtained or engine roughness is encountered, whichever occurs first. If necessary reduce altitude and r.p.m. until a satisfactory combination is obtained and return to base. With both pumps OFF, maximum level flight conditions should be obtainable at sea level, but (if possible) it is advisable to avoid using excessively high r.p.m. If the fuel state permits, the serviceable booster-pump should be switched ON prior to landing.

(iii) With both booster-pumps OFF, fuel cavitation may occur in the engine pumps, causing engine roughness or loss of r.p.m. This is more likely to occur at high fuel flows, high fuel temperatures, high altitude, or in a climb and immediately afterwards.

(iv) The engine will not run with one side of the fuel system empty unless the booster-pump on the side containing fuel is operating. Therefore if a booster-pump fails in flight it is important to land while both sides of the fuel system still contain fuel.

(g) *Transfer failure*

(i) The fuel transfer indicators should remain black throughout the flight. If one or both show white, air pressure failure has occurred and steep dives should be avoided due to the possibility of collapsing the tanks. Should an indicator show white before transfer is complete, any fuel remaining in the rear and centre tanks will be unusable and the associated contents gauge will only indicate the fuel in the front tanks (770 lb. (100 gallons) max. per tank). In these circumstances if the gauge registers more than the total contents of a front tank a faulty gauge should be suspected and only the front tank fuel should be relied on as being available to the engine. The booster-pump on the side with air transfer failure should be switched OFF until the contents gauge of the other side indicates an equal amount; then reset the switch to AUTO (modified aircraft), or ON (unmodified aircraft).

(ii) If the rear and centre tanks fail to transfer, leading to an extreme aft C of G, the aircraft should be restricted to gentle manœuvres only, and landed as soon as possible.

57. **Engine handling**

(a) *On take-off.* An acceleration effect on the r.p.m. indicator during take-off may cause the engine speed to under-read by up to 100 r.p.m. This coupled with the effect mentioned in (c) below may cause the r.p.m. at the start of the climb to read as much as 150 less than the static ground figure. This effect should gradually disappear as the climb progresses.

(b) *On the climb*

(i) During a climb to 45,000 ft. at full throttle the governed r.p.m. may increase by up to 100. This increase may cause the j.p.t. to exceed the limitations unless the throttle is used. It should not be necessary to reduce r.p.m. to below 7,900 to keep the j.p.t. within limits.

(ii) At intermediate throttle positions different combinations of forward speed and ambient air temperature may cause r.p.m. to vary from plus 300 to minus 150 of those selected.

(c) *High I.A.S. at low altitudes*

High forward speeds at low altitude may reduce the maximum attainable r.p.m. by as much as 100.

(d) *Engine surges*

If, when increasing to max. r.p.m. or under continuous r.p.m. conditions the engine shows any sign of excessive j.p.t. or instability i.e. a rapid drop in r.p.m., and/or a general rumbling accompanied occasionally by a loud bang, close the throttle immediately to reduce the possibility of flame-out and dive the aircraft. Re-open the throttle slowly and smoothly checking engine response. Repeat this drill until engine response returns to normal Do not assume flame-out has occurred unless r.p.m. fall below 3,000. (See para. 91 (b).) This type of surge is only likely to occur at high altitudes, low I.A.S. and temperature conditions of less than $-50°C$. A surge may also occur at altitude at higher I.A.S. when positive G is applied.

58. **Management of the engine anti-icing system**

NOTE.—1. Pending completion of trials, use of the system is at present prohibited.
2. The system should be regarded as a means of protection during climb and descent only and is not designed for prolonged use in level flight.
3. With the system in operation a loss of thrust and fuel economy will occur. At full throttle it may be necessary to reduce power to keep the j.p.t. within limits.

(a) *Level flight*

Climb or descend out of the icing level.

(b) *Climb*

Open the throttle to the desired r.p.m. and when above 7,200 switch ON the system. Avoid unnecessary throttle movements (which if essential must always be made slowly). Switch OFF the system when clear of icing.

(c) *Descent*

Reduce r.p.m. to 6,100 and switch ON the system. Descend as quickly as possible. R.p.m. between 5,800 and 6,600. When clear of icing switch OFF the system and allow 10 seconds before making any large throttle movements. Check engine response before landing.

(d) *Landing*

If icing conditions persist down to sea level, engine r.p.m. must be maintained above 5,800 until finally committed to a landing. If an overshoot is necessary, open the throttle as slowly as possible.

59. **Management of the flood flow system**

NOTE.—Pending modification action to improve the system, MANUAL flood control must not be selected below 15,000 ft. at r.p.m. exceeding 7,000.

(a) For all normal conditions of flight the FLOOD AIR-FLOW CONTROL switch should be at AUTO. To prevent windscreen misting MANUAL should be selected:—

(i) When cruising for prolonged periods at high altitude and low engine r.p.m. e.g., more than 15 minutes above 30,000 ft. at 7,200 r.p.m. or less (see (b) below).

(ii) For descents using less than 7,000 r.p.m. after high altitude cruising until misting has cleared or misting danger has passed. (See (c) below and NOTE.)

(b) If misting occurs above 30,000 ft. when cruising at 7,200 r.p.m. or above, keep both the FLOOD AIR CONTROL and the CABIN TEMP. CONTROL switches at

AUTO and select full heat on the CABIN TEMP. SELECTOR.

(c) If descending with r.p.m. above 7,000 keep the FLOOD AIR CONTROL switch at AUTO and select HOTTER on the CABIN TEMP. CONTROL.

STARTING, TAXYING AND TAKE-OFF

60. **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. The main and nosewheel oleos should be checked for extension, the tyres for cuts and creep and the brake leads for security and leaks. The elevator accumulator gauge in the port side of the fin should read 1,575 lb./sq. in. Remove the pressure head cover.

61. **Cockpit and pre-start checks**

(a) On entering the cockpit and before strapping in, check that the flight instruments and radar supply circuit-breakers are in and the test switch is at NORMAL FLIGHT (see para. 17 (b)). Check emergency oxygen bottle pin removed. Check that the hood rail locking indicators (15) 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.

(c) Put on the battery master switch, ensure that the turn and slip indicator starts up, then check the cockpit from left to right:—

NOTE.—The starred items are directly connected with engine starting.

Item	*Check*
Undercarriage emergency air pressure gauge (9)	Pressure 1,800-2,000 lb./sq. in.
Flaps emergency air pressure gauge (10)	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).
Tail plane actuator and hood motor circuit-breakers (6) (7)	In.
Radar test switch (8)	Switch to TEST. Check aurally that the stand-by inverter starts up, and that the gyro instruments start erecting. Switch to NORMAL.
Cockpit pressure warning test switch (5)	Switch to TEST check cockpit altimeter warning light comes on. Switch to NORMAL.
Cockpit pressurization switch (3)	ON (In conditions of high humidity, to avoid internal misting on take-off, leave OFF until 5,000 ft. is reached).
Cockpit temperature control (2)	Auto.
Cockpit temperature selector (1)	As required.
Flood flow control switch	AUTO.
*L.P. cock (13)	ON.
*H.P. cock (32)	Set ON and press relight button. (If serviceable a clicking sound is heard.) Set OFF.
Throttle damper (18)	Adjust as required.
*Throttle	Closed.

Item	*Check*
Hood control switch and clutch selector (22)	Clutch FREE, check manual operation of hood. Clutch LOCKED. Switch as required.
Undercarriage emergency selector (25)	Ensure selector not pulled up.
Flaps emergency selector (41)	Ensure selector not pulled out.
Undercarriage position indicator (37) and selector buttons (39)	Day/Night switch. Bulb changeover switch. Three green lights. Undercarriage warning light out. Down button fully in
Hydraulic pressure warning light (42)	On.
Power control switches (44)	Both OFF.
Hood jettison handle (34)	In.
Flight and engine instruments	Condition.
Generator failure warning lights (62)	On.
*Ignition switch (63)	ON (normally locked on).
Windscreen de-icing switch (51)	OFF.
Fire warning light (52)	Off. 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 (59)	ON (Normally spring-loaded in the ON position).
Fuel pressure warning indicator (60)	Black until engine master switch is on.
Cockpit altimeter (54)	Reading.

Oxygen (57)	Main and emergency supplies connected. Contents and delivery. Stopcock ON. Air inlet NORMAL OXYGEN. Test for mask leaks. Blinker operation. Emergency switch central.
*Engine anti-icer switch	SHUT.
Fuel contents gauges (67)	Contents with ENG. ON/OFF switch at ENG. OFF. Fuel transfer indicators white (if pressure is still in the system these will be black and contents gauges will read full).
*Fuel booster-pump and engine starter circuit-breakers (76) (77)	All in.
*Fuel booster-pump switches (68)	OFF.
External light switches (83)	As required.
Oxygen emergency selector (82)	Down.
Anti-G control (72)	Switch ON. Check pressure 1,800-2,000 lb./sq. in. Test. Then as required.
Flying controls	Full and free movement.
Brakes	On. Check pressure at each wheel.

62. **Starting the engine**

(a) Starter master switch	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 2,750 r.p.m. The sequence should take about 30 seconds and during this time the j.p.t. may momentarily exceed the idling limit (550°C. max.)

(c) When r.p.m. have stabilised, 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. In all cases allow one minute to elapse 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 a quick start is required, the starting cycle can be halted and the circuit reset by switching the starter master switch OFF and then ON. A second attempt may then be made without waiting for the engine to stop. If it is suspected that an excess of fuel has collected in the engine, a second cartridge should be fired, with the igniter switch and the H.P. cock off. In each case the engine master switch should be ON.

(iii) If the cartridge fires but the starter button does not hold in, it may be possible to obtain a light-up by immediately pressing the *relight* button. *Do not* push the starter button back into position, otherwise the next cartridge will be fired. Delay in pressing the button, however may cause excessive j.p.t.

(iv) If the safety relief valve sticks open, as indicated by intermittent clouds of black or yellow smoke from the turbine exhaust and no r.p.m. indication, wait until the cartridge stops burning and then fire a second cartridge.

(v) A period of at least 10 minutes must elapse between firing the third successive cartridge and reloading the breech.

63. **Checks after starting**

Fire warning light	Out.
Set 3,700 r.p.m. and check:—	
Generator warning lights	Out.
Fuel transfer	Indicators black.
Booster-pump switches	With both switches OFF the low pressure indicator should show white. Set each switch ON in turn and check that the L.P. indicator shows black. Leave both switches ON. (On modified aircraft check each switch in both the AUTO and MANL. positions). Warning lights (when fitted) out. L.P. indicator black throughout check.
Instruments	Correct functioning. Compare Mk. 4F compass with E.2 Switch on pressure head heater and G.45 camera if required. Erect artificial horizon.

Hydraulic pressure	3,000 ± 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	Select power control switches ON. Engage controls by moving the control column through its full traverse (using two hands if necessary) until free movement is felt. Indicators black.
Flaps	Check operation.
Tailplane actuator	Test through full range on emergency, lower cover then check on normal and set at 1½° nose-down.
Rudder and aileron trimmers	Check and set neutral. Lock engaged.
Airbrake	Check operation with test switch.
V.H.F.	Frequency selected.

64. **Taxying**

(a) Taxying is normal for a nose-wheel aircraft.

(b) Fuel consumption is about 2 gallons per minute whilst taxying.

(c) R.p.m. must be kept 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.

65. **Checks before take-off**

Trim	Tailplane 1½° nose-down. Rudder—neutral Ailerons—neutral, lock on.
Fuel	Booster-pumps ON. 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.
Instruments	Check and set.
Oxygen	As required—Reaching mask. Blinkers operating.
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.

66. **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.* If, after take-off or at any other stage of a flight, automatic Manual reversion occurs or temporary automatic disengagement of the locking pawls causes control column jamming, *immediately* switch off aileron and elevator Power. Do not attempt to re-engage Power; return to base.

(a) Having aligned the aircraft apply the brakes, open the throttle smoothly and check that the engine is functioning correctly (see (h) 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 70 knots the rudder becomes effective.

(c) Ease the nosewheel off at about 95 knots and hold it just off the runway, taking care not to achieve an excessively nose-up attitude. At 120-140 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 40° 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. It is recommended that flaps should not be used during formation take-offs.

(h) *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.

HANDLING IN FLIGHT

67. **Climbing**

NOTE.—If cockpit pressure has been set to OFF for take-off, switch it ON at about 5,000 ft.

(a) (i) *Best rate of climb*

Climb at maximum power within the j.p.t. and r.p.m. limits; recommended speeds are:—

Height, in feet	*Mach No.*
Sea Level	0.75
10,000	0.80
20,000	0.85
22,000 and above	0.86

(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 7,800 r.p.m. 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.

68. **General flying**

(a) *Flying controls*

(i) *Ailerons (in power).* The ailerons are light and effective throughout the speed and mach number range, giving a high rate of roll. (See para. 72.)

(ii) *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.

(iii) *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.

(iv) *Rudder.* The rudder is light and effective at low I.A.S. but becomes progressively heavier as speed increases.

(b) *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. 73.)* 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. It should be noted that normally with the controls in power the tailplane angle will rarely be above 0° and will generally be between 1° and fully 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.

(c) *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 I.M.N. 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.

(d) *Flaps*

(i) *At high mach number*

If 0.9M is inadvertently exceeded with any amount of flap lowered longitudinal control will be lost due to the decreased effectiveness of the tailplane and elevator, and the nose-down change of trim above 0.91M.

(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.

(e) *Changes of trim*

Increase of power	Nil.
Operation of undercarriage	Negligible except when ailerons are in manual (see para. 85).
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.

(f) *Flying at forward C. of G.*

In the forward C. of G. condition (i.e. when ammunition is carried) the nosewheel and aircraft unstick speeds are increased from approx. 95 knots to 105 knots and 120 knots to 130 knots respectively. The stick forces required to manœuvre the aircraft in the pitching plane are slightly increased at forward C. of G. because slightly larger elevator deflections are required. At very high I.A.S. and mach no. when jack stalling occurs the amount of G it is possible to obtain is reduced.

69. **Flying at reduced speed**

(a) Fly at 180-200 knots using 20° flap.

(b) 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.

(c) 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.

70. **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 ft.

(a) Buffet speeds at 25,000 ft., throttle fully closed, are:—

(i) *Full ammunition and 260 gallons fuel remaining (Max. landing weight approx.)*

Undercarriage and flap up	130 knots
Undercarriage down and flap up ...	130 knots
Undercarriage down and full flap ...	120 knots

(ii) *No ammunition and 100 gallons fuel (Normal landing weight)*

Undercarriage and flap up	125 knots
Undercarriage down and flap up ...	125 knots
Undercarriage and full flap	115 knots

(b) Above 30,000 ft. buffet occurs at approximately 135-140 knots, with the throttle fully closed, undercarriage and flap up.

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

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

(e) (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.

(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.

71. **High speed stalling**

(a) (i) High speed stalling is subject to the over-riding restriction of para. 55 (c) whereby pilots must not exceed +7G.

(ii) At airspeeds above 0.9M between 10,000 and 30,000 feet 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.

(iii) 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 co-incident 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.

(b) *With full-power elevator*

NOTE.—The information contained in (a) (i)—(iii) 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 manœuvring at high I.A.S. 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 manœuvring at high mach numbers as it is easy to pull into the pitch-up inadvertently due to the stick force remaining light.

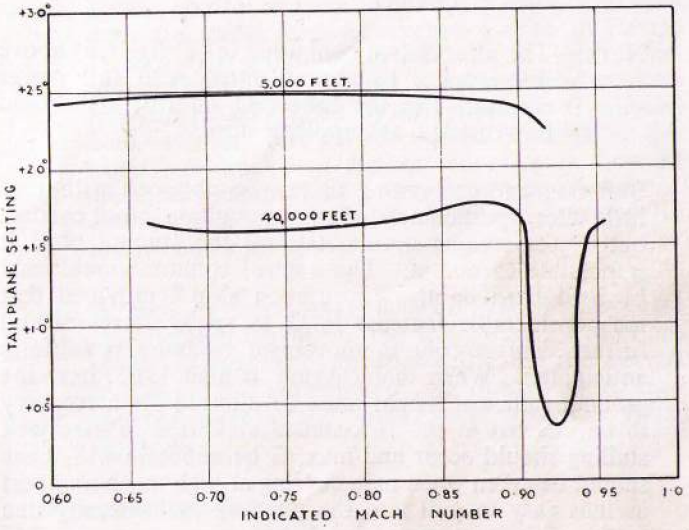
72. **Flying at high I.A.S.**

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

(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.

73. **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.



TYPICAL TAILPLANE ANGLES TO TRIM

NOTE.—Tailplane settings are in degrees nose-down.

(b) *Trim changes.* From the diagram it can be seen that 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 indicated 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 No. 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 2° 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 effect directional trim.

(e) *Recovery.* To recover, pull maximum elevator force and retrim to 1°. The aircraft will recover from the dive slowly, and as the nose comes up to the horizon retrim the tailplane to 1½° 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 feet when manœuvring near limiting G and/or "blackout threshold."*

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

All the information and recommendations given in para. 73 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.

75. **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.

76. **Spinning**

(a) Intentional spinning is prohibited. The following information is provided to acquaint pilots with the spin characteristics and recovery action in case the aircraft is spun inadvertently.

(b) The behaviour varies between spins to the left and spins to the right. The aircraft is reluctant to spin to the left unless pro-spin controls are applied at the stall, in which case the nose will rise, the left wing drop, and the aircraft will hesitate before falling into a spin in an attitude approximately 40° nose-down. The first one or two

turns may be steady, but during succeeding turns the rate of rotation which is slow becomes unsteady and there is marked pitching and rolling. Periodically, the nose rises and the rate of rotation momentarily ceases, the aircraft then falls and rotates rapidly through approximately 60° before nosing-up and hesitating again. In comparison, the aircraft spins more readily and smoothly to the right. The attitude is steeper and the rate of rotation though faster is steadier. When spinning in either direction, the ailerons should be held neutral as out-spin aileron will cause the spin to become erratic.

(c) Normal recovery action is effective, particularly if it coincides with the aircraft's hesitation. However, when rotation ceases the controls should be centralised immediately, otherwise the aircraft may enter a spin in the opposite direction. This is important when recovering from a spin to the left. If a spin occurs with undercarriage and flaps down they should be retracted.

(d) Care should be taken during recovery action to ensure that the ailerons are central as out-spin aileron may hinder or prevent recovery. In-spin aileron is powerful in checking the spin, but great care must be taken to prevent development of a spiral in the same direction or spin in the opposite direction.

CIRCUIT PROCEDURE AND LANDING

77. **Circuit procedure**

NOTE.—460 lb. (60 gallons) of fuel should be allowed for the circuit and landing. (But see para. 56(d)).

(a) *Circuit speed*

6,500 r.p.m and 20° of flap 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. If the airbrake has been used to decelerate, after selecting airbrake in, allow three seconds to elapse before selecting undercarriage down.

(b) *Checks before landing*

Airbrake	IN, indicator black
Undercarriage	DOWN below 230 knots Three green lights
Brakes	Pressure, operation, OFF Main supply 3,000 ±150 lb./sq. in. At each wheel 1,500 lb./sq. in.
Flaps	As required Fully down on finals
Fuel	Contents Booster-pumps ON (AUTO or MANL on modified aircraft)
Harness	Tight and locked

(c) *Final approach*

(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. (105 gallons) or less fuel remaining 130

At maximum landing weight

No ammunition, 2,300 lb. (300 gallons) fuel remaining 135

Full ammunition, 1,600 lb. (210 gallons) fuel remaining 135

78. **Landing**

(a) As the touch-down point is approached the rate of descent should be checked and the aircraft flown gently onto 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 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 down-going wing. The nose wheel can be held off at speeds down to 70 knots, but the shortest run is achieved by putting the nose wheel firmly on to the runway and applying the brakes.

(b) *Braking*

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

(i) *Aircraft without maxaret units*

It is recommended that very gentle continuous braking be applied initially, increasing pressure carefully so as to avoid locking the wheels; this is especially important on wet runways. If nose wheel judder occurs towards the end of the landing run the brakes should be released momentarily.

(ii) *Aircraft with maxaret units*

When the nose wheel 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.

(c) *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 not be stalled on but placed firmly on to the main wheels and the nose wheel then 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 centralise the rudder before applying brake. If the cross-wind is gusting strongly the approach speed should be increased by 5 knots.

79. 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	6,750	40°	170/180
Base leg	6,750	40°	170/180
Glide path	6,750	Full	150/160

80. 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.

81. Checks after landing

Brake pressure	Sufficient
Flaps	Up
Cockpit pressure	Off
Camera master switch	Off
Pressure head heater	Off
Both booster-pumps	OFF

82. Stopping the engine

Close the throttle

When the r.p.m. have stabilised at 2,700 to 2,800, turn off the H.P. cock, then check:—

All electrics	Off
Battery master switch	Switch off
Hood clutch selector	FREE
L.P. cock	OFF when engine stops rotating
Ejection seat	Replace the safety pin before leaving the cockpit.

FLYING IN MANUAL

83. Selecting Manual

(a) It is structurally safe to fly in Manual within the speed limitations of Para. 55 (b) and, in emergency, Manual could be selected at any altitude or forward speed. However, in view of the extreme heaviness of the controls and the lack of manœuvrability at the higher airspeeds in Manual, it is recommended that practice flying in Manual should be carried out above 10,000 ft. at about 250 kts. or 0.8M, if above 40,000 ft. Manual selection should be made in straight and level flight. Before selecting, trim the aircraft longitudinally, check that the aileron trim indicator is at neutral, and disengage the aileron trim control locking lever.

(b) *Reversion of full-power elevator to Manual*

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 the aircraft is in trim in power the trim changes on reversion to Manual are usually slight. If the tailplane and elevator are incorrectly rigged, however, these changes may be large. Therefore for practice flying in Manual it is recommended that Manual should be selected initially at a safe height and low airspeed.

84. **Flying in Manual**

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.

85. **Landing in Manual**

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 because of a nose-up change of trim, full retraction being deferred to a safe height.

86. **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.

87. **Clearing false anchorages (ailerons)**

If false anchorages occur as described in para. 23 they should be cleared in the following way:—

(a) *One-way restriction*

The control column should be moved rapidly over its full movement in the direction of unrestricted travel. If the airspeed is below 250 knots, this can be done without producing excessive aircraft roll.

(b) *Both-ways restriction*

Firstly, at 175 knots with full flap down, by a heavy two-handed effort, the control column should be forced from side to side thus obtaining a small amount of free travel. Then, having obtained about three to four inches of free travel, the control column should be exercised rapidly and vigorously from side to side until the piston rods slide, enabling the pawls to engage in the slots.

NOTE.—If it is not possible to clear a false anchorage, Manual should be selected immediately and the controls left in Manual.