PART III

HANDLING

43. **C.G. data**

(i) *Clean aircraft, without ammunition*

The aft limit is 13.85 in. aft of datum. The C.G. position will move aft after take-off, and the aft limit will be reached when approximately 40 gallons (320 lb.) fuel have been used. The C.G. then moves progressively forward about 1 in., reaching its most forward position when about 70 gallons (560 lb.) of fuel remain, after which it again moves slightly aft.

(ii) *Empty tip tanks, no ammunition*

Similar conditions obtain to those of (i) above. The aft limit is extended to 14.19 in. aft of datum due to the weight of the tip tanks.

(iii) *Full tip tanks, no ammunition, with or without full pylon tanks*

(a) *Without pylon tanks*

The aft limit is 16.19 in. aft of datum, which position is reached on take-off. The extension of aft limit from (ii) above is possible because as fuel is used from the tip tanks the C.G. moves rapidly forward until transfer is complete. The C.G. then moves as in (i) above.

(b) *With pylon tanks*

The C.G. position is slightly forward of (a) above on take-off; thereafter the same conditions apply.

(c) *Failure of tip tanks to transfer*

If fuel fails to transfer from the tip tanks the C.G. will not move very far forward. At altitudes above 20,000 ft. some instability and elevator hunting may be experienced and stick force per G will be very low. It is recommended that the sortie be abandoned.

(iv *Effect of carriage of ammunition and R.P's*

(a) Carriage of ammunition brings the C.G. considerably forward of those noted above.

(b) The forward C.G. in all configurations is 8.82 in. aft of datum. This position is reached when 70 gallons (560 lb.) fuel remain and full ammunition and 8×60 lb. R.P's are carried.

44. **Pilot's External checks**

(i) Before starting the external checks, look inside the cockpit and ensure that the undercarriage selector lever is fully down, and that there is sufficient brake pressure and oxygen.

(ii) The outside of the aircraft should be checked systematically for obvious signs of damage, security of panels, filler caps, doors, mudguards, aerials and external tanks. The engine intakes should be checked for freedom from obstructions, the jet pipe for wrinkling and the turbine for damage. The main wheel oleos should be checked for equality of extension, the tyres for cuts, wear and creep and the brake leads for damage. The pressure head cover, undercarriage ground locks and aileron clamping blocks must be removed.

45. **Checks before starting**

(i) Strap in and then make the necessary ejection seat and anti-G suit connections and have the seat safety pin removed and stowed.

(ii) Put the battery isolation switch ON, ensure that the turn and slip indicator starts up, then check the cockpit from left to right.

ITEM	CHECK
Crowbar (1) tank spanner and control locks (2)	Securely stowed
Rebecca Mk. 7 (28)	OFF
Cockpit pressure control wheel (3)	OFF
Aileron trim cut out circuit breaker (4)	In
Pylon tanks and bomb jettison lever (17)	Fully down and clip engaged
Undercarriage emergency retraction switch (5)	Wired OFF
Emergency lights switch (6)	Check then OFF
Cockpit lights	As required
Flaps (16)	Check operation with hand-pump
Airbrake selector lever (14)	IN
L.P. Cock (13)	ON
H.P. Cock (7)	Closed
Throttle	Closed
Elevator trimmer (12) and indicator (27)	Check operation. Set neutral
Aileron trim switch (8)	Operate. Check trim light (26) for correct operation. Set neutral. Light out
Aileron power warning light (11)	On
Relighting switch (19)	OFF
Oil temperature gauge	Reading
Aileron selector (20)	Check operation. Selector up and locked—POWER
Undercarriage indicator (21)	Three green lights Test bulb changeover

Fuel pressure warning light (25)	On
V.H.F. (24)	As required
Undercarriage warning light (29)	Out
Fire warning light (31)	Out
Fuel contents gauge (34)	Contents
Fuel transfer indicators (36)	White
Brakes	ON. Check pressure (39) sufficient and equal at each wheel.
Cockpit pressure warning light (40)	Out
Oxygen (41)	ON. Contents. Supply. Check HIGH and LOW flow Emergency cock wired OFF
Anti G-valve (42)	OFF
De-icer pump (43)	Locked off
Hood jettison lever (35)	Fully forward
Hood seal cock (52)	OFF
Generator failure warning lights (47)	On
H.P. fuel pump isolating switch (55)	OFF
Hydraulic failure audio warning switch (45)	ON
Rebecca Mk. 7 circuit breaker (56)	In
Other switches (49)	As required
Generator isolating switches (61)	On
Generator field circuit breakers (61)	In
Oxygen selector valve (64)	Wire locked ECON. (with type H mask) P.B. (with type J mask)

Mk.4F compass circuit breaker (62)	In
Wing tip tanks jettison lever (65)	Fully down and clip engaged
Aileron spring strut adjuster (66)	If doubt exists as to setting, turn fully to one side and wind back 2½ turns

46. **Management of the fuel system**

The internal, wing-tip and pylon tanks all feed the engine automatically. Two fuel transfer indicators show white when the respective wing-tip tanks are empty or at any time when fuel is not being transferred from these tanks. The indicators show black when fuel is being drawn from the wing-tip tanks. The booster pump must be switched on before starting and left on at all times when the engine is running. If the booster pump fails, the pressure warning light should come on, but engine failure is unlikely. Above 20,000 ft., however, it may not be possible to obtain maximum r.p.m. and large fluctuations in r.p.m. may be experienced.

47. **Starting the engine**

(i) *Checks before starting*

Engine starter master switch (50)	ON. Check Mk. 4F compass and artificial horizon
Booster pump switch (54)	ON Check fuel pressure warning light out

(ii) *Starting the engine*

(a) Open the H.P. cock and press the starter pushbutton (37) to fire the cartridge. The r.p.m. should rise rapidly and when light-up has occurred the j.p.t. starts to rise.

(b) A faster start can be obtained by setting the throttle about half-way open; if this is done the jet pipe

temperature must be carefully watched and the throttle eased back when the temperature starts to rise.

(c) If the engine does not start correctly it will be in one of the following circumstances:—

(1) If a cartridge does not fire, close the H.P. cock and wait at least 15 seconds before re-opening it. The starter pushbutton will be held electrically in the depressed position and will return to the starting position only at the end of the automatic starting sequence. The remaining cartridge may then be fired after re-opening the H.P. cock.

(2) If the engine does not rotate or does so at low r.p.m. and there is a heavy discharge of yellow smoke from the starter exhaust for a period of approximately 10 seconds, the safety disc has probably blown. The H.P. cock should be closed and the cause of failure rectified before attempting a further start.

(3) If the engine rotates but the r.p.m. subsequently drop and *remain at approximately 1,200 r.p.m.* the H.P. cock must be closed at once.

(4) If the engine rotates but the r.p.m. show a progressive drop, indicating that the engine has not lit, the H.P. cock must be closed before the r.p.m. have fallen to 800, otherwise serious damage may occur should the engine light up at this low r.p.m.

(iii) No attempt should be made to restart until the compressor has stopped turning.

(iv) Two successive failures to start indicate a fault which should be investigated before a further start is attempted.

(v) After any failure to start, it is essential that the ground crew depress the tail and remove surplus fuel from the jet pipe; if fuel has been drained on to the ground, the aircraft should be moved to another position.

(vi) The cartridge breeches should not be reloaded until they have cooled down. Expended cartridges can, however, be removed and the breeches left open to assist in cooling.

(vii) Expended cartridges should not be left in the breeches for more than eight hours.

48. **Checks after starting**

Engine idling speed	2,800-3,200 r.p.m.
J.p.t.	450° idling maximum
Engine fire warning light	Out

To avoid draining the batteries, open up to generating r.p.m. (approx. 4,400) and then check:—

Generator warning lights	Both out
Aileron power warning light	Out

49. **Checks before taxying**

(i) Flight instruments	Check and set Compare Mk.4F compass with E.2
Hydraulics	Test flaps and airbrakes
V.H.F.	As required
Pressure head heater	As required
Brake pressure	Pressure 450 lb./sq. in or sufficient for taxying and supply increasing

(ii) *H.P. pump isolating check*

At idling r.p.m. put the fuel pump isolating switch to ON; there should be an increase in r.p.m. If no increase occurs, return the switch to OFF and open up to 6,000 r.p.m. Again set the switch to ON; if there is still no increase the system is unserviceable and the aircraft should not be flown. Return the switch to OFF and check that r.p.m. return to the original figure.

NOTE—If a *reduction* in r.p.m. occurs during either test, the aircraft should not be flown.

50. **Taxying**

The brakes are powerful and must be used with care. On wet or icy surfaces it is easy to lock the wheels and great care must be used under these conditions.

51. **Checks before take-off**

Trim	Neutral
Airbrakes	IN
Fuel	H.P. and L.P. cocks on Contents Booster pump on Pressure warning light out H.P. pump isolating switch as required (See para. 52 (vi))
Flaps	Up, or 30° if full tip tanks are carried
Instruments	Check and set Mk. 4F compass switch ON Pitot head heater ON
Oxygen	ON
Hood	Shut and handle locked Lanyard (if fitted) attached to handle Hood seal cock OFF
Harness	Tight and locked
Flying controls	Aileron selector in POWER Warning light out All controls full, free and correct movement

52. **Take-off**

NOTE.—The shortest take-off run is obtained by using 30° flap and opening the throttle fully before releasing the brakes; this procedure is recommended if full tip tanks are carried. At aft C. of G. positions (e.g., wing-tip tanks full), trim $\frac{1}{2}$° nose down. Care must be taken not to raise the nose too high during the take-off run to avoid the possibility of a failure to accelerate.

(i) Align the aircraft on the runway, with the nosewheel straight, release the brakes and open the throttle smoothly to full power.

(ii) To keep straight initially it may be necessary to use gentle braking until, at about 50 knots, the rudders become effective.

(iii) Ease the nosewheel off the ground at about 80 knots, taking care not to touch the tail on the ground. The aircraft should be flown off at about 110 knots at normal load and at about 120 knots at maximum load. Because of the possibility of a wing drop the aircraft should not be pulled off the ground below the recommended speeds.

(iv) When comfortably airborne apply the brakes momentarily and raise the undercarriage.

(v) If used, raise the flaps, turn on the hood seal and cockpit pressure.

(vi) If the isolating switch has been set to ON for take-off, it must be returned to OFF at a safe height and preferably before it has been necessary to throttle back. With the switch ON, the maximum r.p.m. are liable to hunt between approximately 9,900 and 10,400. This hunting can be unpleasant but is not dangerous. It can be eliminated by throttling back to 10,000 r.p.m. which will take the governors out of action. If the switch is left ON whilst climbing it will be necessary to throttle back considerably to prevent overfuelling and a resultant increase in the j.p.t. and r.p.m. If the switch is returned to OFF after the throttle has been partially closed, a rapid drop of up to 2,000 r.p.m. will be experienced. If returned to OFF with the throttle fully open the r.p.m. drop should not exceed 50.

(vii) If applicable, check that fuel is transferring from the drop tanks.

53. Climbing

(i) The recommended climbing speeds at the various loadings, using 10,250 r.p.m. reducing to 10,100 above 20,000 ft., are:—

Altitude	Clean or with tip tanks fitted but empty		Tip tanks full		Tip and pylon tanks full	
	Knots	*M.N.*	*Knots*	*M.N.*	*Knots*	*M.N.*
Sea level	360	0.54	350	0.53	320	0.48
10,000 ft.	335	0.60	320	0.59	300	0.55
20,000 ft.	305	0.66	295	0.65	275	0.61
30,000 ft.	270	0.71	260	0.70	250	0.67
40,000 ft.	220	0.71	210	0.70	210	0.70
45,000 ft.	195	0.71	185	0.70	185	0.70

(ii) After take-off the aircraft may be allowed to accelerate to the recommended speed while climbing, provided that this is reached below 5,000 ft. This technique results in a very small increase in time to height.

(iii) While climbing, the r.p.m. will increase slowly and must be checked periodically to ensure that the maximum permissible r.p.m. are not exceeded. The j.p.t. may reach the maximum and, should this happen, power will have to be reduced.

(iv) Above 40,000 ft. it is important that the correct speeds be maintained; should the speed fall below that recommended, the rate of climb will be severely affected and speed can only be regained by diving the aircraft.

54. Engine handling

At high altitudes the throttle should be moved very carefully, as the engine is sensitive to the smallest movements. Harsh movements, particularly when opening the throttle, will cause excessive jet pipe temperatures and possible flame extinction.

55. General flying

(i) The aircraft is pleasant to fly at all loads and speeds. At high altitudes care is needed to maintain a given airspeed or trimmed condition and, at the highest altitudes, once speed is lost, it can only be regained at the expense of height. At low speeds lateral rocking occurs which is difficult to damp out with aileron alone, but it can be controlled by combined use of aileron and rudder.

(ii) *Flying controls*

(a) *Ailerons in POWER*

The powered ailerons make the aircraft light and pleasant to control laterally. As artificial feel is provided by a spring strut in the aileron circuit, the force required varies with aileron deflection and not with speed. Above 375 knots the aileron power control stalls progressively with increase in speed so that although the initial response is immediate the rate of roll is limited by the power control stall restricting the amount of aileron applied.

(b) *Elevator*

For small movements in the lower speed range the elevator is light and effective but becomes very heavy with increased movements. As the mach number is increased it loses its effectiveness.

(c) *Rudder*

The rudder forces, light initially, become moderately heavy at high speeds.

(iii) *Trimmers*

(a) *Ailreon*

There is practically no lateral trim change with speed; any adjustment which is required should be made with the spring strut adjuster.

NOTE.—The electrically operated trim tab for use in manual control must be in the neutral position whenever the ailerons are in POWER.

(b) *Elevator*

The elevator trimmer increases in sensitivity as speed increases and must be used with caution at high indicated airspeeds. At high mach numbers it becomes considerably less effective.

(iv) *Airbrakes*

The airbrakes are relatively ineffective at low speeds; but are effective at high indicated airspeeds. Buffeting and some pitching must be expected. When pylon tanks are fitted extension of the airbrakes produces a strong nose-up pitch and associated control column snatch.

(v) *Changes of trim*

(a) Undercarriage down	Slight nose down
(b) Flaps down 0°-30°	Slight nose up
(c) Flaps down beyond 30°	Strong nose up

The strong nose-up change of trim when flaps are lowered necessitates a large forward movement of the control column.

(d) Airbrakes on extension	Nose-up trim change followed by a nose-down trim change, then a return to trimmed condition
(e) Airbrakes on retraction	Characteristic behaviour described above

56. Flying at reduced airspeeds

(i) Reduce speed to 150 knots and lower 30° flap.

(ii) *With hood open*

The hood can be opened in flight provided a speed of 150 knots is not exceeded. The hood winding handle must be grasped tightly to stop the hood from running backward violently on to its stops.

57. **Flying in turbulent conditions**

The recommended speed for flying in conditions of severe turbulence is 330 knots up to 20,000 ft., thereafter reducing progressively to 220 knots at 40,000 ft. and above.

58. **Cockpit pressurisation**

(i) In certain atmospheric conditions and cockpit pressure control settings it is possible that appreciable quantities of visible water vapour will enter the cockpit through the gallery pipe and louvre. This can be overcome by re-adjusting the setting of the control wheel.

(ii) In conditions where hood misting is anticipated the control wheel should be at HOT, the r.p.m. should be kept as high as practicable and the position of the louvre adjusted to give maximum flow through the gallery pipe.

(iii) If the pilot wishes to reduce temperature at high altitudes the control wheel should be moved to MIX or COLD since movement to the REDUCE position may result in a reduction of cockpit pressure.

(iv) On the ground the control wheel should not be at COLD or MIX since this may result in overheating of the cold air unit.

(v) The hood seal cock should be OFF during take-off and landing, since in the event of a crash the external hood release mechanism cannot be operated with the seal cock ON.

59. **Stalling**

(i) Stalling speeds are found to vary considerably, dependent on the way the stall is approached (small amounts of G increase the stalling speed considerably), and the condition of the aircraft. The precise stalling speed at certain weights and in certain configurations is difficult to determine due to fluctuation of the A.S.I. needle at speeds around 90 knots.

(ii) The following are the approximate stalling speeds in knots for a typical aircraft:—

	U/C and flaps UP	U/C and flaps DOWN
Typical service load (Full tip tanks, full internal fuel and ammunition)	105	90-95
Typical landing weight (Empty tip tanks, 100 gallons fuel and no ammunition)	100	85

(iii) With the throttle closed there is little or no warning of the approach of the stall in any configuration. At the stall the nose will drop gently and a wing may drop slowly. This may be accompanied by mild buffeting, increasing in intensity as the control column is held back, and fluctuations of the A.S.I. needle. If the aircraft is stalled with the throttle partially open, simulating typical approach conditions, considerable buffeting is usually experienced before height is lost and any wing dropping is rather more violent. There is no tendency to spin.

(iv) Use of the airbrakes does not affect the stalling characteristics or speeds.

(v) At any time when G is applied, warning of the approach of a stall is given by buffeting, and continued movement of the control column results in either wing dropping. Recovery is immediate on release of the backward pressure on the control column.

60. **High speed flying**

(i) The high mach number characteristics may vary slightly from aircraft to aircraft. They also depend, particularly at high altitude, on the angle of dive (rate of increase of speed), on G, and on the condition of the aircraft.

(ii) The elevator trim can be used at any combination of airspeed, mach number and height. It must, however, be used with care at high indicated airspeeds.

(iii) The carriage of wing-tip and pylon tanks does not affect the high mach number characteristics.

(iv) The characteristics described below may be experienced at higher or lower indicated mach numbers than those stated due to variation of machmeter pressure error.

(v) *Behaviour above 25,000 ft.*

(a) The I.M.N. at which the nose-up trim change occurs must not be exceeded intentionally.

(b) This nose-up trim change will occur at approximately 0.88M above 35,000 ft. and approximately 0.86 below 35,000 ft. The typical behaviour up to 0.88M is described below:—

0.81 - 0.83M	Nose-down change of trim.
0.84M	Slight right wing heaviness, requiring only a small aileron movement to hold. Nose-down change of trim marked.
0.87M	Nose-down change of trim ceases. Slight airframe buffet commences. Slow nose-up change of trim. A push force on the control column has little effect and the mach number drops fractionally when the nose-up trim disappears.

(c) Above 35,000 ft., if the angle of dive is steepened sufficiently to overcome the nose-up change of trim which occurs at about 0.88M, a progressive nose-down trim change occurs which is difficult to overcome, due to the poor elevator effectiveness which becomes apparent above 0.89M. With the control column held fully back, with a heavy pull force, recovery is slow. Should this condition be reached, care must be taken to ease the stick forward when the nose-up trim change with decreasing mach number (at about 0.88M) is reached, otherwise an excessive pitch-up will result.

(vi) *Behaviour below 25,000 ft.*

(a) The I.M.N. at which the nose-up trim change occurs must not be exceeded intentionally.

(b) Similar characteristics to those given in (v) above are likely to occur, but at lower mach numbers. If the angle of dive is sufficient to overcome the nose-up trim change at these altitudes, there is a possibility that the I.A.S. limitation will be exceeded, due to the delayed recovery caused by the poor elevator effectiveness at mach numbers in excess of those at which the nose-up trim change occurs.

61. **Aerobatics**

(i) Until experience is gained the following minimum speeds are recommended:—

Roll	270
Loop	370
Roll off the top	370
Climbing roll	400 plus

(ii) Aerobatics are permitted when full tip tanks are carried. An accelerometer reading of $+6\frac{1}{2}$ G must not be exceeded.

(iii) The negative G traps in the fuselage tank ensure a supply of fuel for 10 seconds of inverted flight.

62. **Spinning**

Intentional spinning is prohibited. The spinning characteristics are straightforward and if an unintentional spin occurs, normal recovery action should be taken.

63. **Checks before landing**

Brakes	Check pressure Off
Airbrakes	In
Undercarriage	Down Three green lights

Fuel	Contents H.P. pump isolating switch OFF (except in an emergency)
Flaps	As required
Harness	Tight and locked
Hood	Closed Hood seal OFF

64. **Approach and landing**

NOTE.—Sixty gallons (480 lb.) fuel should be allowed for approach and landing. Below this fuel state, large changes of attitude should be avoided.

(i) R.p.m. should not be reduced below 5,000 on the approach until certain of making a landing, since below that r.p.m. thrust response is relatively slow when the throttle is opened.

(ii) The turn onto the final approach should be made at about 130 knots and the runway threshold crossed at the following speeds:—

At normal landing weight (empty tip tanks, fuel approx. 100 gallons 800 lb.) ... ... 100 knots

At emergency landing weight ... ... 105 knots

(iii) When full flap is lowered the marked nose-up change of trim requires a large forward movement of the control column to correct it.

(iv) The landing is straightforward. A large and rapid change of attitude should be avoided. After touchdown the brakes should be applied with care to avoid locking the wheels, particularly on a wet runway. Continuous and progressive braking is recommended.

65. **Instrument approach**

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

	R.P.M.	Flaps	Airspeed knots
Downwind	8,000	one quarter	145
Base leg	8,000	one half	120
Glide Path	7,000	one half*	115

* When the runway is visible flaps may be lowered fully and airspeed reduced for landing.

66. **Overshooting**

(i) Open the throttle smoothly to the power required. Normally the use of full power is unnecessary and 9,000 r.p.m. will generally be sufficient.

(ii) Raise the flaps; the slow rate of retraction enables any tendency to sink to be easily checked.

(iii) Raise the undercarriage.

(iv) The trim changes when raising flap are pronounced but can be held without retrimming (although the trimmer may be used if desired).

67. **Checks after landing**

Flaps	Up
Brakes	Pressure sufficient for taxying
Cockpit pressure control	OFF

68. **Stopping the engine**

Allow the engine to idle for 30 seconds and then turn off the H.P. cock. Check:—

Electrical control panel	All switches off
Battery isolation switch	Off
Oxygen	Off
Chocks	In position
Brakes	Off
Ejection seat	Safety pin in position

NOTE.—If the aircraft is to remain on the ground for a long period before the next flight, the L.P. cock should be closed when the engine has stopped running. This will prevent fuel seeping through the distributor which would otherwise be the cause of hot starts.


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