Part IV
HANDLING

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Preliminary Checks

1 Preparation for flight

Carry out the Safety Checks, Internal Checks and Cockpit Checks in the Flight Reference Cards.

Starting, Taxying and Take-off

2 Starting the engines

NOTE: The normal starting order is 3, 2, 1, 4.

(*a*) Before starting confirm:

External supply, battery, generator and rotary transformer controls set as required by the method of starting (see Part III, para. 18).

Instrument master switch .	ON
Throttle/HP cocks . . .	Fully closed
LP master cocks . . .	ON
Fuel pumps	Two ON each side Fuel pressure warning lights out
Engine starter selector switch	To engine to be started
Engine starter master switch	START
No. 2 radar inverter . .	ON

(*b*) *Starting*

Press the starter button. Check that it remains in and that the green starting cycle indicator light illuminates. Without delay move the throttle/HP cock lever to the idling position (just through the gate). The engine should light up within four to eight seconds of pressing the starter button. Check that the fire warning light remains out and that the indications of oil pressure and JPT are normal. During the starting cycle the JPT may rise momentarily up to 660°C, but should not exceed 500°C when RPM have stabilised at the idling figure.

(*c*) When the engine reaches self-sustaining speed, or after 22 seconds (whichever is the less), the starter button should reset and the green indicator light should go out. However, the starter motor may not be operated again to start the remaining engines until starting cycle time of 36 seconds has elapsed.

(*d*) When all engines are idling normally return the starter master switch to SAFE.

(*e*) *Failure to start*

(i) After a failure to start, if the HP cock is closed without delay there should be no need to "blow through" the engine. If in doubt excess fuel may be removed by motoring over the engine in the same way as for starting, but with the HP cock closed and the starter master switch at ISOL.

(ii) When the engine start button is depressed, if the hold-in relay does not operate, no further attempt to start must be made and existing engines must be shut down immediately. External or internal power must be switched off and the engine start relays examined for overheating or fire.

(*f*) Carry out the Checks After Starting in the Flight Reference Cards.

3 Taxying

(*a*) The aircraft should always be taxied with the flying controls locked and with four engines running. If it is necessary to taxy with less than four engines running, all radar equipment load shedding should be carried out appropriately.

(*b*) On level concrete, 5,000 to 6,000 RPM on all engines will be required to start the aircraft moving. Once moving sufficient thrust for taxying on level surfaces may be obtained with all engines idling. Total fuel consumption while taxying with all engines idling is approximately 80 lb per minute.

(*c*) It is generally better to use the handbrake in conjunction with the nosewheel steering, since the toe brakes are quite sensitive, and uneven application will tend to interfere with the nosewheel angle selected, thus preventing continuous smooth taxying and putting unnecessary strain on the nosewheel unit. If the steering system becomes unserviceable, direction can be controlled without difficulty by using the toe-brakes independently, so achieving differential braking. Whenever toe-brakes are not being used, or not being applied, care must be taken that the weight of the feet is not on the toe-pedals, otherwise a small amount of brake will be inadvertently and continuously applied with consequent overheating of the brake units.

(*d*) As soon as possible check the operation of the 1st pilot's hand-brake. Whilst taxying check the brake systems as follows:—

(i) Co-pilot test hand-brake and toe-brakes on No. 1 system.

(ii) Check No. 2 system pressure and change to No. 2 system.

(iii) 1st pilot check toe-brakes.

(iv) Check No. 1 system pressure and change to No. 1 system.

Frequent checks of hydraulic pressures must be made whenever the aircraft is being taxied.

(*e*) When taxying in strong cross-winds, any tendency to weather-cock may be corrected by use of the nosewheel steering. Should it be necessary to taxy on icy surfaces, a marked reduction in nosewheel steering effectiveness must be anticipated, and directional control should be maintained by careful use of the toe-brakes.

(*f*) Owing to the tandem main wheel units, severe damage can be caused if the aircraft is allowed to pivot round one unit and great care must be taken to avoid this. The minimum turning circle that can safely be achieved is about 100 feet. These facts reinforce the recommendation to avoid use of toe-brakes with steering since if differential brake is applied in support of full nosewheel steering, the turning circle will be extremely small. When the aircraft is parked, deformation of the main wheel tyres produces " flats " in the tyre periphery. The extent of the flats will depend on the weight and the length of time the aircraft is parked. At high weights the flats can be of considerable size and in such cases, to avoid stresses due to shaking of the airframe, taxying should be cautious.

4 Take-off

NOTE: 1. The second pilot should operate the engine, undercarriage and flap controls and check for engine unserviceability; this will allow the first pilot to concentrate fully on the steering and subsequent take-off. Normally all changes in power, undercarriage and flap selection should be called by the first pilot and actioned by the second pilot.

NOTE: 2. Engine running on the ground at full power should be kept to a minimum.

(*a*) Carry out the Pre-Take-off Checks in the Flight Reference Cards.

(*b*) Align the aircraft on the runway and hold the hand-brake fully on ; leave the parking catch off. The brakes should be held by the right hand and the steering wheel grasped in readiness by the left hand.

(*c*) Open the throttles to 7,000 RPM, but avoid holding this power for longer that 5 seconds whilst the aircraft is at rest. Check that the JPT and oil pressure indications are normal, and that the throttles are synchronised. Poor throttle synchronisation may be an indication of swirl-vane malfunction. If an engine is suspect open it, together with the adjacent engine, to full power where de-synchronisation will be more evident. For a given RPM the throttle lever of a defective engine will tend to trail behind that of a serviceable engine. If throttle de-synchronisation is accompanied by a lower JPT than normal, or if there is any overspeeding, the take-off must be abandoned and the suspect engine stopped. In temperate climates, any JPT below 580°C at full throttle opening should be considered abnormal.

(*d*) Release the brakes and open the throttles. Check that the required RPM are obtained on all engines and that there is no over-speeding when full power is selected. Maintain directional control by use of the nosewheel steering until rudder control becomes sufficiently effective, normally 70 knots. Check acceleration during the take-off in accordance with previous calculations (see Operating Data Manual).

NOTE: As soon as possible during the take-off run a comparison check should be made of the air speed indicators.

(*e*) The following unstick speeds are recommended:

Take-off weight (lb)	Unstick speed (kts)
90,000	103
100,000	108
110,000	113
120,000	118
130,000	123
140,000	128
150,000	132
160,000	137
170,000	141
175,000	144

(*f*) The aircraft accelerates quite rapidly, particularly at medium and low weights. Care should be taken to avoid harsh backward movement of the control column which may result in the aircraft being pulled off the ground too quickly or in an exaggerated nose-up attitude. At about 25 knots before the unstick speed the control column should be eased back steadily in order to raise the nose-wheel at 10-15 knots before unstick speed and to fly the aircraft off the ground at the correct unstick speed. If the maximum safe angle of climb is required after take-off, speed should be allowed to increase to 20 knots above the unstick speed and this speed maintained until clear of any obstacles. For distance to unstick and to 50 feet see the Operating Data Manual.

(*g*) There is no difficutly in taking off cross-wind but pilots should be ready to counteract, on the steering, the tendency for the aircraft to turn into wind when the brakes are released ; also, the nosewheel steering should be used to control direction up to 90 knots before change is made to rudder control.

(*h*) *Safety speed*

There is very little tendency to swing after an engine failure and the safety speed will always be below the unstick speed. Action after an engine failure will depend on the speed attained and the available length of runway in which to stop. For refusal speeds, reference should be made to Part 2 of the Operating Data Manual.

5 Assisted take-off

(*a*) After aligning the aircraft on the runway open the throttles to 8,000 RPM against the brakes. To ensure that the extra thrust is not lost until after the aircraft has reached 50 ft., and depending upon the aircraft weight, runway slope and weather conditions, the water methanol master switch should be switched ON eight to ten seconds after releasing the brakes. After switching on, check that the indicator lights come on and that the RPM rise on all engines. The normal take-off technique should be used.

(*b*) The cutting in of the water-methanol is not very marked, and is unlikely to be felt, but the cut-out at the end of the time of injection is sudden and quite marked. As soon as water-methanol injection has ceased, the master switch must be switched off.

6 After take-off

When comfortably airborne apply the brakes for four seconds, release them and raise the undercarriage. When the undercarriage. is locked up, select the required climbing power and raise the flaps as required. Speed must not exceed 190 knots before the flaps are fully raised. When it is necessary to turn after take-off before the flaps can be fully raised, the turn should be made at 180 knots with the flaps at 20°. In order to avoid an excessively steep climbing attitude being required to maintain speed below 190 knots until the flaps are raised, engine speeds may be temporarily reduced according to the AUW. Normal climbing power of 7,800 RPM should be set at weights above 130,000 lb, 7,600 RPM is recommended for weights below 130,000 lb and 7,400 RPM for weights below 110,000 lb. The change trim is the undercarriage retracts is negligible, but as the flaps are raised a fairly strong nose-up trim change should be anticipated and trimmed out by use of the TPI control. The final stage of flap travel is very slow and a particular check must be made to ensure that they are fully raised before increasing speed for the climb. Carry out the After Take-off Checks in the Flight Reference Cards.

7 Circuit practice

To prevent overheating of the electrical equipment involved and to allow cooling of brake components, the undercarriage and flaps should be left down when practising circuits. To avoid exceeding limiting speeds the engines should be throttled to about 7,200 RPM after take-off and the aircraft climbed at 160 to 170 knots.

Handling in Flight

8 Climbing

(*a*) On starting the climb, one or both of the cabin air supply switches should be switched on. Once the undercarriage and flaps are up, acceleration is fairly rapid and there is a progressive nose-up change of trim which should be countered with the TPI control. The aircraft is easy to trim on the climb and holds the trimmed speed well.

(*b*) For normal training purposes, climb at 250 knots until this speed is co-incident with 0·73M and thereafter continue to climb at 0·73M. The intermediate power setting of 7,800 RPM or 635°C JPT should be used but a limitation of 30 minutes continuous use must be observed. After 30 minutes engine speed must be reduced to 7,600 RPM or less. If, for operational purposes, maximum rate of climb is required, the following speeds and RPM should be used.

RPM	*Height (ft.)*	IAS	
		Below 130,000 *lb*	*Above* 130,000 *lb*
7800	SL	275	315
,,	10,000	275	300
,,	20,000	275	275
,,	30,000	250	250
,,	40,000	220	220
,,	45,000	0·75M	0·75M

(*c*) The RPM tend to creep slightly on the climb and should be adjusted with the throttles. At intermediate power above about 40,000 feet it will be necessary to adjust the throttles to keep within the JPT limit.

9 General flying

(*a*) Unless otherwise determined by operational or training requirements, a normal cruising speed of 0·75M is recommended at heights where this does not exceed the maximum IAS limitations. At all times at least one pilot and one rear crew member must have their oxygen masks on and correctly fastened. Throughout the flight periodic checks must be made of each crew member's oxygen supply equipment, and the functioning and indications of all aircraft systems in use.

(*b*) The aircraft has no vices and is generally easy and pleasant to fly. Due to the artificial feel system the controls, despite being power-operated, have the inertia and response characteristics of heavy aircraft fitted with conventional controls.

(*c*) The artificial feel must always be engaged when flying with the power controls in operation, otherwise, due to the ability of the pilot to apply unrestrained power control the aircraft can very easily be overstressed even to the extent of a complete structural failure. The power control failure warning lights must be checked frequently in flight and if any of them come on the appropriate motor must be tripped without delay.

(*d*) At speeds up to about 200 knots all controls are reasonably light. As speed is increased they become progressively heavier until, near the limiting speed, only small aileron movements are possible and even gentle manœuvres require considerable pilot effort.

(*e*) The nose does not form a good reference point during turns, and initial movement of it is difficult to detect. Cross-reference with the flight instruments should be made to ensure that the required attitude is maintained during a turn. This is most important when turning at high Mach numbers (see Part IV, para. 13(*e*)).

(*f*) *Trimming*

(i) *Tailplane and elevator*. Longitudinal trimming, whether the power controls are *in or out*, is done with the variable incidence tailplane. Accurate longitudinal trimming takes some care, but when properly trimmed the aircraft holds its speed well. It will probably be found best to use the coarse motor for climbing, descents and circuits, and the fine motor for cruising. The elevator out-of-trim warning lights must be kept out at all times in flight, using the manual trim tab. The only exceptions to this are during turns and in flight in bumpy conditions when, provided the TPI is not being used to supplement stick movements, flickering of the lights can be ignored.

NOTE: To avoid strain on the actuator, tailplane trimming should not be achieved by a series of flicks on the control switches. Out-of-trim conditions should first be fully corrected with the stick and then the resultant load felt by the pilot trimmed out by a sustained application of the TPI control switches.

(ii) *Rudder and ailerons*. When flying with the power controls engaged, trimming of the rudder and ailerons is done by using the artificial feel trimmers. The manual trim tabs must not be used and should be left at neutral.

When flying in manual control trimming of the rudder and ailerons is done by using the manual trim tabs. The feel unit trimmers must not be moved.

(*g*) *Airbrakes*. The airbrakes are either in or out and have no alternative system. They may be operated at any speed. They are effective at high speed but at low speed little effect can be noticed. Extension of the airbrakes produces moderate buffeting at high speeds, the buffeting decreasing with lowering speed until below 150 knots it becomes insignificant. Airbrakes out produce a nose-up change of trim up to 0·8 M, decreasing to neutral at 0·84 M, thereafter becoming progressively nose-down. If during the operation of the airbrakes the circuit-breaker trips it may be reset after making an opposite selection with the airbrakes selector lever. If on the next operation the circuit-breaker is again tripped, further use of the airbrakes must be abandoned.

(*h*) *Changes of trim*

Lowering undercarriage . .	Negligible (but moderately heavy nose-up when in manual control)
Raising undercarriage . .	Negligible
Lowering flaps	Nose-down, strong between 15 and 25 degrees
Raising flaps	Strong nose-up
Extending airbrakes . . .	Strong nose-up (up to 0·8 M)
Retracting airbrakes . . .	Strong nose-down
Opening bomb doors . .	Slight nose-down
Closing bomb doors . . .	Slight nose-up
Throttling back . . .	Moderately light nose-down
Air spoilers out or in . .	Negligible

10 Flying in turbulence

(a) Speed in turbulence

In conditions of severe turbulence, speed should be maintained at about 220 knots up to 38,000 feet, reducing by four knots per 1,000 feet above this height. These figures apply at all weights.

(b) Low altitude turbulence

The aircraft is designed as a high altitude bomber and is not intended for prolonged low altitude operation. Flight at low altitudes, particularly in turbulent conditions or at high speed, must be kept to the minimum.

(c) High altitude turbulence

In cases of severe turbulence at high altitude (cobblestone effect), directional and lateral control becomes very difficult and use of aileron or rudder can readily result in the attempted corrections becoming out of phase with the oscillations, with consequent increase in amplitude of the aircraft motion. Flight in these conditions must not be continued and a gentle climb or descent should immediately be made to clear the turbulence, the vertical extent of which is normally very limited. Elevator control in these conditions remains satisfactory.

11 Stalling

(a) Approximate stalling speeds (knots)

Undercarriage up or down.

Weight (lb)	*Flaps up*	*Flaps 20°*	*Flaps 40°*	*Flaps 55°*
80,000	94	83	80	74
100,000	105	95	91	90
120,000	116	105	100	99
130,000	120	108	104	103
140,000	124	113	108	108
150,000	130	118	112	111
160,000	134	120	116	115
167,000	138	124	118	117

(*b*) Behaviour near and at the stall can vary slightly between individual aircraft and will also depend on weight, the configuration and the method by which the stall is executed. Nose and wing dropping and degree of buffet may be gentle or severe but in all cases the standard method of recovery will allow complete recovery in 800 feet or less. Airbrakes do not affect the stall, nor is the behaviour altered by the CG being forward or aft. The general characteristics of stalling are given below.

(*c*) *Undercarriage and flaps up*. Slight buffet begins some 12 knots before the stall. As the stick is pulled back and speed reduced there may be a tendency to lateral rocking which can be held with aileron; meanwhile the buffet will increase in intensity and can eventually become extremely marked with pronounced vertical shaking of the aircraft as the stall becomes imminent. As the aircraft stalls, the nose and probably a wing, normally the port, will drop; sometimes the wing-drop occurs just before the stall. Recovery is effected by relaxing the backward pressure on the stick, and levelling the wings ; the latter will probably require the use of rudder since the ailerons are not very effective near the stall. Buffeting will persist for a considerable period during the recovery.

(*d*) *Undercarriage and flaps down.* The undercarriage has no effect on the stall, but flaps, apart from reducing the stalling speed, also reduce the pre-stall buffet. With 30 degrees or more of flap, there is virtually no stall warning, and the first indication of the imminence of the stall will be a high rate of sink.

(*e*) *Stalling in turns.* If the aircraft is stalled during turns it will almost invariably roll out of the turn, and recover when the back pressure on the stick is released. Occasionally an aircraft will roll into the turn when stalled, but this is most likely to happen when the turn is being done at a very low speed. Recovery action as in (*c*) above is effective. The stall warning buffet occurs only a few knots above the stall and, again, flaps have the effect of reducing the stall warning.

(*f*) *Inadvertent stalling.* Inadvertent stalling is very unlikely to occur, since from straight and level flight the stalling attitude will be pronounced nose-up, which should be readily detected by one or other of the pilots on either the natural or the artificial horizon. In turning flight, considerable G will be required to stall the aeroplane unless the pilot is lax enough to have a very large angle of bank with little forward speed.

(*g*) *Practice stalling.* It is recommended that stalling practice is generally confined to the stage where the onset of buffeting or obvious lessening of lateral control is established. Relaxation of the backward pressure on the stick at this stage will allow recovery with small loss of height. Full stalling should be kept to the absolute minimum, so that severe buffet is avoided. Repeated buffet can cause damage to the airframe itself, as well as to the delicate radar and electronic equipment.

12 Application of G

At high altitudes the application of G induces buffeting which increases in intensity with G until a severe harsh shaking of the aircraft occurs. This harsh shaking can be encountered within the G limitations (Part II, para. 2 (*c*)) depending on aircraft weight, height and Mach number. If this severe shaking is encountered, G must be reduced immediately because of the risk of structural damage. Reference should be made to the Operating Data manual, Section 10, Fig. 1.

13 High speed flight

NOTE: The machmeter is subject to error and should periodically be checked against IAS and altitude (see Part I, fig. 17).

(*a*) The behaviour of the aircraft is quite normal when flying at high speed, within the limitations, at low altitudes. With increase in speed there is a progressive nose-up change of trim accompanied by increasing heaviness of the controls, especially the ailerons. Manœuvring becomes difficult at high speed and there is not much danger of the G limitations being exceeded through physical operation of the controls. The tailplane incidence control, however, will have a powerful effect especially if the coarse control is selected, and care must be taken in its use. If turbulence is encountered at high speed, shaking of the airframe is likely to be considerable and speed must be reduced to that quoted in Part IV, para. 10.

(*b*) It is possible to exceed the IAS limitations in level flight and if this is done inadvertently recovery should be made by first throttling back and then extending the airbrakes. When the air-brakes are extended near the limiting speed it will probably prove impossible to prevent the aircraft gaining 400 to 500 feet in height before sufficient control can be applied to regain level flight.

(*c*) *Trim change with Mach number.* As Mach number is increased to 0·8 there is a slight nose-up change of trim ; this trim change persists with increase in Mach number, being moderate above 0·8 M, until 0·84 M is reached when it suddenly becomes quite marked. Unless this sudden change is anticipated it may cause sufficient G to bring on severe buffet. Extension of airbrakes causes a nose-up change of trim which reduces to negligible effect at about 0·84 M. At 0·86 M the effect of airbrake extension is reversed, i.e. there is a nose-down change of trim. The rolling effect with rudder reverses above 0·82 M, i.e. left rudder causes the aircraft to roll to the right.

(*d*) *Buffet.* At 0·8 M compressibility buffet is just noticeable ; it becomes moderate with increase of speed, and will become severe with application of G. Flying in conditions of moderate or severe buffet should not be persisted in. The aircraft gains speed rapidly during a dive and it is easy to exceed the limit.

(*e*) *Turning at high Mach number*

Application of G when turning at Mach numbers over 0·78 M will produce buffet which, depending on weight and amount of G applied, may be severe enough to cause vertical shaking of the whole aircraft. If this severe buffet is encountered recovery must be made at once and repetition avoided otherwise structural damage may result. At speeds up to 0·72 M the aircraft can be stalled in a turn within the limitation of 2·5 G. Approach to the stall will be marked by buffet and at the stall the aircraft will pitch nose-up and roll out of the turn. If the nose is allowed to drop during a turn acceleration into buffeting conditions is fairly rapid. Should this happen recovery should be effected gently to avoid aggravating the buffet with application of positive G.

14 Bombing and astro-navigation

It is recommended that the auto-pilot be used to control the aircraft during bombing runs and whilst taking lights for astro-navigation.

15 Descending

NOTE: Descents must not be made using the wing fuel tanks alone if fuel is low.

The maximum rate of descent will be achieved by closing the throttles, extending the airbrakes and maintaining the maximum permissible Mach number and IAS. The maximum rate of descent should only be used in case of emergency or for training purposes. Under normal flying conditions, a normal rate of descent, which is more acceptable for Air Traffic Control procedures, may be obtained by closing the throttles, extending the airbrakes and descending at 0·75 M until this is co-incident with 240 knots, and thereafter maintaining 240 knots. This configuration will give an average rate of descent of 3,500-4,000 feet per minute. If the engine anti-icing system is used, minimum engine speeds of 6,000 RPM or 6,600 RPM as appropriate (see Part III, para. 35) must be maintained, and speed should be increased to 250 knots to maintain an acceptable rate of descent under these conditions. In order to avoid misting or icing of the windscreen and side panels when low altitudes are reached, both cabin air switches should be selected ON prior to descending. The TPI may be selected to COARSE or FINE motor for the descent but should be selected to COARSE motor before reaching 2,000 feet.

Circuit Procedure and Landing

16 Approach and landing

(*a*) Carry out the Pre-Descent or Joining Checks in the Flight Reference Cards.

NOTE: If the fuel filter de-icing system has been used in flight, or the aircraft has descended through icing conditions, the fuel filter de-icing switch should be selected ON for a period of two minutes at the bottom of the descent.

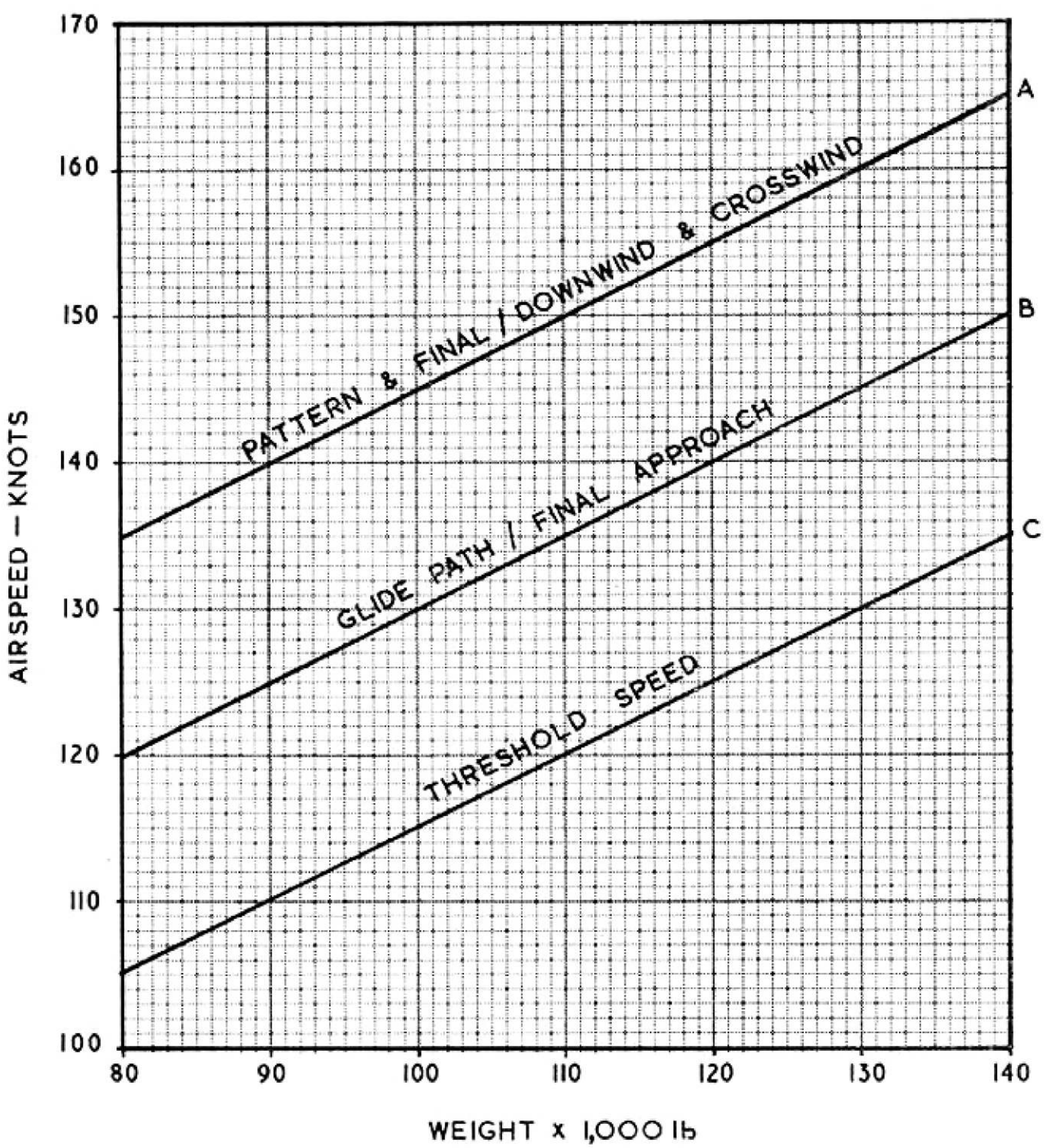
(*b*) *Checks before landing*

Join the circuit at 190 knots and lower flaps to 20 degrees. Maintain the speed at 170 knots until on the downwind leg then reduce to speed A on the graph opposite and carry out the Pre-Landing Checks in the Flight Reference Cards.

(*c*) *Approach and landing*

Approach speeds are shown on the graph opposite. During the initial stage of an instrument approach, or on the downwind leg of a visual circuit, reduce to appropriate speed for the AUW shown at A. Maintain this speed until ½ mile before interception of the glide path, or until opposite the downwind end of the runway during a visual circuit, and then lower flap to 40°. At AUW's in excess of 110,000 lb speed must be reduced to 150 knots before selecting 40° flap. Commence descent to maintain the correct glidepath, or turn onto the final approach, and reduce to the correct glide path/final approach speed shown at B. This speed should be maintained until full flap is selected. Full flap should not be lowered until 200 to 300 feet above the ground. The effect of full flap on speed is marked ; if lowered early the resultant drag effect will necessitate an increase in power ; if lowered too late there will be little time for trimming out the nose-down trim change before touch-down. After selection of full flap, speed should be adjusted so that the runway threshold is reached at 105 knots for weights up to 80,000 lb; for every increase of 10,000 lb add five knots to this speed. If a landing is to be made using 40 degrees of flap, speed should be reduced progressively during the approach until the runway threshold is reached at the correct speed for weight as quoted above. At approximately 50 feet the engines should be throttled back in order to lose residual thrust before the aircraft is checked in the normal manner and touch-down made on the main wheels. When landing on a wet runway a firm touch down should be made. The nosewheel should be lowered gently on to the runway and, when all wheels are firmly on the ground, the nosewheel steering should be used for directional control.

APPROACH SPEEDS



(d) Crosswind landing

It is recommended that the crab technique is used, the aircraft can then be comfortably controlled in crosswinds up to a 20 knot component. When landing in higher crosswinds extra care must be taken in correcting the drift immediately prior to touch-down. Lower the nose-wheel on to the runway immediately after touch-down, so that steering is available at once. If the side-slipping technique is used in high crosswinds there is a risk of insufficient aileron control being available for gust correction.

(e) Downwind landing

In conditions of poor visibility and/or low cloud base, it may be necessary to land on the instrument runway even though a downwind component exists. In this event the landing run will necessarily be increased. Tests indicate that a large safety margin exists at weights up to 110,000 lb in a downwind component of 10 knots on a 9,000 foot runway. In emergency the following downwind components would be acceptable at weights up to 110,000 lb:

6,000 foot runway — 10 knots
9,000 foot runway — 15 knots

For safety margins to be adequate it is assumed that touch-down is made in the first 1,200 feet of runway, that the nosewheel is lowered as soon as practicable and that firm braking is then applied immediately.

(f) Flapless landing

Because of the increased risk of scraping the rear fuselage on the ground, the practice of flapless landings is not recommended. If, because of any malfunction, a flapless landing becomes necessary, weight should be reduced to 98,000 lb or less and the landing made on a runway of 9,000 feet or more length. A straight-in (instrument) approach is recommended, using a 2° glide-path if available. If a visual circuit is necessary, a slightly longer approach than normal should be made, and bank angles should be limited to 30°. Carry out the pre-landing checks and lower the undercarriage in the normal manner. The normal pattern speed should be used and maintained for the initial approach. During the approach attitude will be considerably more nose-up than when flap is lowered, and forward visibility may be improved if the seat is raised. Aim to cross the threshold with power reducing, at 10 knots above the recommended normal threshold speed, for weights up to 98,000 lb, and 15 knots above the recommended speed for higher weights. A prolonged hold-off should be avoided. The nosewheel will be very high after touchdown, and should be lowered so that normal braking action may be used as soon as possible.

17 Braking

(*a*) When the nosewheel has lowered on to the runway the brakes can be used continuously and the maxaret units will prevent wheel locking. The landing run can be cut to less than half normal by using continuous full brake, but this procedure causes rapid brake wear and should not normally be used.

(*b*) The aircraft must be firmly on the ground before applying the brakes. *There is a delay of three or four seconds between applying the brakes and the brakes coming on.* If the aircraft 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 a bounce, they will not lock unless the skid or bounce continues for more than four seconds.

(*c*) Every effort should be made to avoid overheating the brakes, and braking should, therefore, be judicious according to the length of the runway. Landings involving heavy braking should not be made at intervals of less than 10 minutes and if, while taxying after such landings, heavy differential use of the brakes is made, the time interval should be doubled.

(*d*) When landing on short runways, or under circumstances where it is necessary to apply brakes shortly after touchdown and at high speeds, extra care must be used when braking. If the control column is forcibly pushed forward to lower the nosewheel and held there while braking action is started, weight may be taken from the rear main wheels causing them to lift from the runway. This may lead to locking of the rear main wheels and consequent damage to tyres. To avoid this occurrence, after the nosewheel has been lowered onto the runway, apply steady and progressive brake pressure. At the same time ease the control column steadily back so as to place increasing weight on the rear main wheels, and so that the control column is pulled fully back if full brake pressure is applied. This technique may cause slight reduction of nosewheel steering effectiveness, and pilots should anticipate this.

18 Overload and emergency landings

(*a*) (i) The normal maximum weight for landing is 110,000 lb. The maximum permissible weight for overload landing is 138,000 lb.

(ii) The pattern, approach and threshold speeds appropriate to the AUW should be used. If the AUW is greater than 110,000 lb, necessitating a reduction of pattern speed before 40° of flap may be extended, the reduction of speed and lowering of flap may be delayed, at the captain's discretion, until the turn onto final approach is completed. The stalling speed is reduced by five or six knots when flap is lowered from 20° to 40°. At AUW's greater than 120,000 lb the recommended pattern speed is higher than 155 knots, and therefore flying at the recommended pattern speed with 20° flap allows a greater margin above the stalling speed than flying at 150 knots with 40° flap. At high AUW's and particularly if one or more engines are inoperative, angles of bank should be restricted, if possible to 20°, when flying at circuit and approach speeds.

(*b*) *Rate of descent on touchdown*

(i) The design velocity of descent on touchdown, for which the aircraft and loading points have been stressed, is 11 feet per second at 95,000 lb, which is 660 feet per minute. It will be appreciated that a landing at this rate of descent would be a very heavy landing indeed and is in fact equivalent to continuing the ILS glide path right onto the runway.

(ii) If the weight is increased, and particularly if any load is carried on LP6 or 7, or there is fuel in the transfer tank, the rate of descent on touchdown must be reduced. For instance, at weights up to 138,000 lb with a full load on LP6 or 7, or if the transfer tank is full, the rate of descent must not exceed 8·8 feet per second (528 feet per minute). Again, this would be a very heavy landing.

(iii) From observation and experience it appears that almost all landings with Valiants are made at a rate of descent on touchdown of between 2 and 4 feet per second, the lower figure being a good smooth landing. The pilot has no means of checking these figures other than judgement, and consequently, although the figures are given for information and comparison, whenever an overload landing is to be made, and particularly with stores or fuel in the rear fuselage, every endeavour should be made to make a normal smooth landing.

(*c*) *Emergency landing*

Landings at weights above 138,000 lb will only be made in extreme emergency, when lack of time, mechanical failure or other circumstances make it impossible or impractical to jettison underwing fuel or stores. In this event a smooth gentle touchdown must be made, keeping the rate of descent on touchdown as low as possible.

(*d*) *Use of brakes*

The effectiveness of the wheel brakes is limited by their heat absorption capacity, and this is a function of aircraft weight and the speed at which the brakes are applied. If the brakes are applied at too high a speed for a given weight, overheating will occur, leading to brake fade and possibly complete loss of all braking force. This may be accompanied by fire. The table below shows the maximum speeds at which brakes should be applied at two weights on wet or dry runways. The " normal " speed is that at which brake damage should not occur. The " emergency " speed is that at which brakes may be applied if brake damage is acceptable. If higher speeds are used the brakes will fade and fail before the aircraft has been brought to rest. It must be emphasised that a " preliminary prod " at the brakes serves no useful purpose ; best results are achieved by using aerodynamic braking until the speed falls to the required figure and then putting the brakes full on and leaving them on. The landing run will be reduced if the HP cocks are closed immediately after touchdown.

	138,000 *lb*		175,000 *lb*	
	Normal	*Emergency*	*Normal*	*Emergency*
Wet Runway .	111	—	92	114
Dry Runway .	99	—	88	110

NOTE: The above figures are for ICAN sea level conditions. Further information, including correction factors for wind, temperature, etc., are given in the Operating Data Manual. Where no figure is quoted above, the maximum braking speed is above the touchdown speed.

19 Instrument approach

(*a*) On reaching the initial approach altitude reduce speed to a maximum of 190 knots and lower 20 degrees of flap. At 170 knots lower the undercarriage. The range of approach speeds versus aircraft weight given in the graph of para. 16(*c*) are recommended and will have to be used on those approaches down to 200 feet AGL, so that the aircraft can be landed on the correct touchdown point. The initial pattern should be flown at the speeds shown by line A which are never more than 15 knots above the approach speed line B, so that lowering flaps from 20 degrees to 40 degrees on intercepting the glide path will be sufficient to establish the required rate of descent and the correct approach speed without the need to alter the power settings substantially.

(*b*) The procedure for auto-ILS approaches is detailed in Part III, para. 54. The procedure for ILS approaches is in AP 129, Vol. I, Part 2, Section 4, Chap. 2, and for Zero-Reader—ILS in Chap. 3. The procedure for GCA is in AP 129, Vol. I, Part 3, Section 1, Chapter 2.

20 Going round again

This presents no problems. At normal weights with all engines operating it is not necessary to use full power. The flaps should be raised as soon as possible, at least to the 20 degrees position. The undercarriage may be left down or, if desired, raised at the same time as the flaps.

21 Roller landings

(*a*) When carrying out roller landings it is not normally necessary to lower the nosewheel on to the runway. However, if it is intended to reduce speed during the roll to below 90 knots, or in strong cross-wind conditions, the nosewheel may be lowered to assist in maintaining directional control.

(*b*) When opening the throttles particular care must be taken up to 5,000 RPM and pilots should be prepared for a difference in response from each engine. Check at 7,000 RPM that symmetrical thrust is being obtained before opening the throttles further.

(*c*) Care must be taken to avoid adopting an exaggerated nose-up attitude as the aircraft accelerates. It is recommended that the aircraft is held on the ground until 10 knots below the calculated threshold speed for the weight.

22 After landing

In conditions of strong or gusty winds head the aircraft into wind. Carry out the After Landing Checks in the Flight Reference Cards.

23 Closing down

Carry out the appropriate Shut-down Checks in the Flight Reference Cards.

Flying in Manual

24 General

If failure of the powered flying controls occurs or is induced for practice purposes the aircraft can be flown under manual control without difficulty providing care is taken not to exceed the limitations in these circumstances (see Part II, para. 4(*a*)).

25 Full manual reversion

Any power control motor which fails must be tripped without delay by operating the appropriate trip button.

(*a*) On reversion to manual, the change-over on the elevators and rudder is smooth, and there should be practically no trim change if the elevator out-of-trim lights have been kept out. It is most important that the out-of-trim lights are kept out in flight. On the ailerons a wing-down trim change may develop rapidly but only a small movement of the tab is needed to restore lateral trim. When flying in manual, the manual trimmer tabs must be used for trimming the ailerons and rudder, the tailplane being used for longitudinal trim, and the elevator manual trim tab used to keep the out-of-trim lights out.

(*b*) On reversion to manual the appropriate artificial feel units should not be disconnected. On no account may the feel unit trimmers be moved as an out-of-trim condition may result when re-engaging power. Also, if the feel trimmers are moved, they will move the controls which will have to be trimmed by the manual tabs. All controls are heavy, particularly at speeds approaching and above 200 knots. It is recommended that, when flying in manual, a speed of 240 knots should not be exceeded. When manœuvring, the necessary control movements should be anticipated since the considerable physical effort required causes aircraft response to movement of the controls to seem sluggish, thus making the precise selection of bank a little difficult. The trim tabs are very effective, and should not be used as servo controls except in emergency.

(*c*) *Trim changes*

Extending airbrakes	Strong nose-up
Lowering flaps	Strong nose-down
Lowering undercarriage	Moderate nose-up

(*d*) *Landing*

Not more than 40 degrees flap should be used. All controls are heavy and it is essential to use the tailplane to trim out the trim changes. A strong pull is required to flare-out just before landing, and care is necessary to avoid a heavy landing. Trim changes should be trimmed out as quickly as possible ; some attempt should even be made to anticipate them.

26 Practice flying in manual

(*a*) Reversion to manual control for practice flying may be made at any speed between the recommended final approach speed and 240 knots. However, it should be borne in mind that the manual aileron and rudder trim neutral positions correspond to a speed of 170 knots, and these controls may be slightly out of trim at any other speed. To revert to manual control the following drill should be carried out:

Ensure speed is below 240 knots, and trim the aircraft to fly hands off.

Check elevator trim lights out. Check elevator trim tab not more than one division forward.

Check aileron and rudder manual trim tabs neutral.

Trip out aileron 1 and elevator/rudder 1 motors.

Trip out aileron 2 motor and correct for any trim change by using the aileron manual trimmer.

Trip out elevator/rudder 2 motor.

(*b*) If there is any indication of malfunctioning of the controls after reverting to manual, *immediately* re-engage power by re-selecting the instrument master switch ON. Such a case will occur if there is a defect in the manual reversion valve. This will be indicated by a slack movement of about four inches at the controls without any corresponding movement of the control surfaces. Re-engaging power will immediately free the controls, enabling the aircraft to be returned to base.

(*c*) Before re-engaging power trim the aircraft at a speed of 240 knots or less, then select the instrument master switch ON. In cases of necessity power may be re-engaged at any speed, but the likelihood of being out of trim should be anticipated. Provided that the aileron and rudder feel trimmers have not been moved and the elevator trim lights are out, the out-of-trim when re-engaging power will be small at all speeds.

Asymmetric Flying

27 Asymmetric flying

Since the engines are so close inboard, asymmetric flying presents little handling problem even when two engines on the same side are out. The loss of one generator will not make any material difference to the electrical system but with the loss of two generators, load shedding will be necessary. The loss of any engine will affect the airframe de-icing, and may affect the cabin pressure depending upon altitude.

28 Re-lighting an engine in flight

Re-lighting must not be attempted above 35,000 feet or at more than 200 knots IAS.

Master cock on.
HP cock off.

Press the re-light button for four seconds, open the HP cock, bringing the throttle back to the gate, and keep the re-light button pressed until the RPM or JPT start to rise. If the engine has not re-lit after 30 seconds maximum, release the re-light button and close the HP cock. In emergency a second attempt may be made to re-light, but the flaps must first be lowered to 20 degrees for five minutes to ensure that any excess fuel is drained away. A descent of at least 10,000 feet is recommended before the second attempt and the appropriate re-light fuse should be examined for serviceability.

29 Asymmetric landing

An asymmetric landing should be treated in the same way as an ordinary landing except that the RPM of the good engines will be higher.

30 Asymmetric going round again

This presents no difficulty, even with two engines on one side failed at the maximum normal landing weight; however, the decision to overshoot should be made as early as possible, and in any event before a height of 200 feet above runway level is reached. Until the decision to land has been made the airspeed must be maintained above the critical speed, and flap extension restricted to 40°. When going round again full power should be applied and the flaps raised to 20°.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