Part III

Chapter 2—Taxying, Take-off and Handling in Flight

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1 Taxying

(*a*) As visibility from the cockpit is restricted it is advisable to inspect the area before entering the aircraft, particularly if it is intended to taxy in confined spaces. Particular note should be taken of objects likely to be blown by the jet efflux. The forward view from the cockpit is very good, but it is impossible to see the wing tips. However, it is possible to see the wing tips from the windows of the rear cabin, and whenever possible the rear crew members should maintain observation whilst taxying.

(*b*) Before taxying the checks in the Flight Reference Cards must be carried out. In particular, the H2S scanner must be stabilised or secured, the brake pressure gauges must be checked and the GROUND STEERING MASTER switch must be selected ON.

(*c*) The thrust required to overcome the inertia of the aircraft in order to start taxying varies with the AUW and the surface. At normal operating weights and on level surfaces approximately 60-65% RPM will be required. Once the aircraft is in motion sufficient thrust for normal taxying on level surfaces will be obtained with all engines idling but slight increases of thrust will be required on uphill gradients. As soon as possible check the functioning of both pilots' wheelbrake controls, and also the nosewheel steering. The nosewheel steering control handwheel should be pulled out to its most comfortable position, and control will be effected by turning the handwheel in the desired direction. A moderate hand-force is required and the maximum deflection of the nosewheel is approximately 45° in either direction. Any intermediate deflection may be obtained by off-setting the steering handwheel by the requisite amount and holding it there. When the handwheel is released a centring spring returns it to the neutral position and the nosewheel will be free to caster. Differential braking may be used to assist in tight turns but care must be taken to avoid scuffing of the inner undercarriage tyres. It is possible to turn 180° on a 50 yard wide runway fairly comfortably. However, at heavy weights, sharp or fast turns must be avoided. Very little assistance can be gained by using asymmetric thrust in turns.

(*d*) The brakes are effective but care should be taken to avoid overheating by excessive use. This applies particularly when prolonged or repeated differential braking is required. Frequent checks of the brake pressure gauges must be made whenever the aircraft is being taxied. If it is desired to stop the aircraft, close the throttles apply even and increasing pressure to the brake pedals, and do not operate the parking brake lever until the aircraft has been brought to rest. Check the illumination of the PARKING BRAKE ON light whenever the parking brake is applied.

2 Take-off

(*a*) Complete the pre take-off checks shown in the Flight Reference Cards, before entering the runway.

(*b*) Align the aircraft with the runway and hold it stationary by applying even pressure to the brake pedals. Open the throttles evenly, noting that all engines accelerate normally. If the throttles are opened quickly one or more engines may lag initially. The brakes should be capable of holding the aircraft stationary until all four engines reach 88% RPM and must be considered unserviceable if they do not. At 88% RPM release the brakes and, as the engines reach maximum power, check:

RPM	Not exceeding 104%
EGT	Not exceeding 690°C
Oil pressure	Not less than 28 PSI (normal 40 PSI)
CSDU oil temperature	Not exceeding 95°C
LP overspeed warning light	Out
Electrical power circuits	Functioning normally

(*c*) At all weights the acceleration when the brakes are released is impressive and there is a slight tendency to swing into any cross-wind. This can easily be controlled by use of the nosewheel steering. When the brakes are released, the weight on the nosewheel is reduced (the nosewheel rises if the CG is appreciably aft) and the control column should be held half forward to improve the effectiveness of the nosewheel steering until the rudder becomes effective at 90 knots. During the later stages of the take-off run acceleration becomes very rapid, especially at the lighter weights. The aircraft is not to be rotated until 20 knots below the recommended unstick speed. If the nose is raised at lower speeds, a reduction in acceleration and consequent lengthening of the take-off run will result. A light pull force is normally required to raise the nose although this will vary with the CG and elevator trimmer setting. A further slight backward movement of the control is required to fly the aircraft cleanly off the ground.

(*d*) *Recommended unstick speeds*

Take-off weight (lb)	Unstick speed (knots)
120,000	120
130,000	125
140,000	130
150,000	135
160,000	140
170,000	145
180,000	150
190,000	153
200,000	157
223,000	167

3 Safety speeds

(*a*) *Single engine failure during take-off*

Using rudder alone 105 knots is the minimum speed at which the aircraft can be kept straight should an outboard engine fail during the take-off run. A small amount of aileron should be applied as the aircraft subsequently becomes airborne to prevent a roll towards the dead engine. As safety speed will always be below unstick speed, the decision to abandon or to continue the take-off will depend on the results of previous calculations made using the Operating Data Manual.

(*b*) *Failure of two engines during take-off*

The safety speed with two engines on one side flamed out is 155 knots. At this speed full rudder and approximately one quarter aileron is required to hold the aircraft straight. Should a single engine fail during take-off, a minimum speed of 155 knots should be attained before consideration is given to stopping the adjacent engine.

4 Accelerated stop procedure

(*a*) In all cases where the take-off run has to be aborted the following actions are to be taken:

(i) Close the throttles.

(ii) Select airbrakes out.

(iii) Stream the tail brake parachute at or below maximum streaming speed.

(iv) Apply maximum continuous braking at or below pre-calculated speed.

(v) Inform ATC " aborting ".

(*b*) A further take-off is not to be attempted until the brakes and tyres have been allowed to cool, checked and recorded as serviceable in the F700 and the reason for aborting the take-off has been fully investigated.

5 After take-off

At normal operating weights, using maximum power on all four engines, the aircraft climbs away after take-off at a steep angle, and the speed increases rapidly to 200 knots. It is recommended that, when safely airborne and clear of any obstructions, all engines are throttled back sufficiently to enable CLIMB to be selected on the EGT controller and then the throttles re-opened fully. The initial climb-away should be made at 200 knots. When safely clear of the ground retract the undercarriage (manual application of wheel-brakes is not required) and select the flaps UP, taking care not to exceed the appropriate limiting speeds before they are retracted. (The limiting speeds are 235 knots for the undercarriage and 225 knots for the flaps). The change of trim as these controls retract is negligible. While carrying out the after-take-off checks the speed may be increased to 240 knots but should not exceed 250 knots until the AAPP intake has been retracted. As speed increases there is a slight nose-up change of trim which may be easily countered by normal use of the elevator trimmer.

6 Climbing

(*a*) Climb at 250 knots increasing to 300 knots at 10,000 ft. From the height at which 300 knots coincides with 0·84M, climb at this mach no. until 45,000 ft. is reached at which height speed should be increased to 0·86M. Fuel selections and in-flight checks should be carried out as required.

(*b*) When maximum rate of climb is required the engines should be left at full throttle with the EGT control selected to TAKE-OFF (5 mins. limit) and the aircraft climbed at the speeds recommended in (*a*) above.

(*c*) If a cruise climb is to be carried out, the engines should be adjusted to the settings computed for the prevailing conditions. The maximum intermediate power setting is 103·0% RPM and 665°C for 2 hours. The maximum continuous power setting is 101·5% RPM and 630°C EGT.

7 Cruising flight

(*a*) The aircraft cruises comfortably at 0·86M at which speed, even at high altitude, about 20° bank is available for manoeuvring purposes before the onset of buffet. The engines are fitted with compressor bleed valves which open automatically to improve engine handling at the lower RPM but at the cost of increased fuel consumption. Hence, if it is important to conserve fuel, the valves must remain closed, and this can be achieved by operating all engines at a minimum of 87% RPM at altitudes up to 51,000 feet, thereafter increasing by 1% RPM per 1,000 feet.

(*b*) Aircrew should ensure that the flying clothing and personal safety equipment worn is of a standard to allow for an increase of 2,000 feet in cabin altitude caused by the loss of a pilot's escape hatch. Throughout the flight periodic checks should be made of each crew member's oxygen supply equipment and the functioning of all systems in use.

8 Flying controls

(a) Ailerons

The ailerons are effective throughout the permitted speed range. The stick forces required increase with increase of airspeed and with increase of control deflection. Although there is a gradual deterioration throughout the speed range, adequate control is available under all normal approach conditions. The aileron trimmer is effective in use and provides more than adequate trim for all normal flight conditions.

(b) Rudder

The rudder is effective at all speeds above about 80 knots but response is noticeably poor below 90 knots. The rudder pedal forces are heavy compared with the forces required for movement of the ailerons and elevators. Pedal forces increase with speed and deflection and at the maximum permissible speeds the forces are heavy. Response to rudder trimmer selections is quick and effective and at high airspeeds the rudder trimmer should be used with care. Adequate trim control is available for all normal flight conditions.

(c) Elevators

The elevators are effective with good response throughout the speed range. Response to elevator trimmer selections is quick and the trim should be selected in small " blips ". Due to poor longitudinal stability at the extremes of the performance envelope the aircraft is difficult to trim. The trim load indications on each pilot's panel may be used to assist in fine trimming.

(d) Auto-stabilisers

(i) *Roll and yaw dampers*

With the roll damper and either yaw damper on, lateral and yawing oscillations following any disturbance in level flight are quickly and effectively damped. If the roll damper is inoperative, damping is still effective but slightly slower in effect. With both yaw dampers and the roll damper inoperative, any lateral or yawing disturbance may be followed by dutch rolling. At low mach numbers, particularly below 0.85M, this may be divergent and take some time to damp out manually. At high mach numbers, dutch rolling may be reduced in amplitude due to the aircraft's stability characteristics, but small oscillations may persist for a considerable time. At high altitudes, dutch rolling is more likely to occur and be more pronounced. It is therefore recommended that at all times in flight the roll damper and one yaw damper are selected to ON and the other yaw damper selected to STANDBY.

(ii) *Auto-mach trimmer*

As speed is increased above 0·83M, a progressive nose-down trim change will occur, requiring increasing nose-up trim selections by the pilot. If the auto-mach trimmer is selected ON, above 20,000 feet and as speed increases above 0·8M, ±0·01M the auto-mach trimmer will cause a progressive up-elevator selection to be made requiring a progressive push-force by the pilot to maintain level flight. The push force may be held reasonably comfortably by the pilot throughout most of the speed range and may be trimmed out easily. If the auto-mach trimmer is not operative, an increasing pull-force is required as speed increases, and this becomes quite heavy at the higher mach numbers. Therefore it is recommended that the auto-mach trimmer is switched ON at all times above 20,000 feet and before speed is increased above 0·79M. If the auto-mach trimmer is not operative, speed must not be increased above 0·90M.

NOTE: No pitch damper is fitted.

(e) Airbrakes

The airbrakes may be extended at any airspeed, and to any extent from the fully closed to the fully open position. There is no immediate change of trim associated with their extension, but the ensuing reduction in airspeed causes the characteristic nose-down trim changes. They are very effective at high airspeeds and remain sufficiently effective at low airspeeds to permit drag control at approach speeds. Extension at high airspeeds or high power settings produces light aircraft buffet.

(f) Flaps

The limitations, of 225 knots when the flaps are selected to TAKE-OFF and 195 knots when the flaps are selected to DOWN must be observed. Following the selection of flaps from UP to TAKE-OFF or DOWN there will be a delay of approximately 10 seconds, during which time the flaps are travelling rearwards, before any change of trim is noticed. Changes of trim are slight except when full flap is lowered. In this case, a moderate nose-up trim change occurs.

(g) Bomb doors

The bomb doors may be opened or closed at any airspeed within the permitted speed range. The time for opening or closing will depend on whether one or two hydraulic pumps are operating. During bomb door travel, slight pitching oscillations may be experienced but the ultimate trim change is negligible. Moderate airframe buffet which will vary considerably with bomb-bay configuration, will be felt whenever the bomb doors are open particularly at higher airspeeds. If constant power is maintained there will be a slow reduction in speed of 0·01 to 0·02M.

(h) Undercarriage

The airspeed limitation of 235 knots must be observed whenever any component of the undercarriage is not fully retracted. Raising or lowering of the undercarriage produces no significant trim change. There is a " thump " as each undercarriage unit locks down and slight airframe buffet may be felt whenever the undercarriage is extended. The undercarriage should not be lowered when the aircraft is side-slipping to avoid possible damage due to sideloads on the undercarriage door mechanism.

9 High speed flight

(a) Auto-mach trimmer operative

With the auto-mach trimmer operative, when the speed is increasing a progressively heavier push force is required on the stick to maintain altitude without re-trimming, i.e. the aircraft behaves as if it were stable throughout. The stick force can be held or trimmed out as desired, but trimming above 0·90M is not recommended because, if the auto-mach trimmer should fail and the actuator retract fully, a strong nose-down moment would occur. However, during an emergency descent, elevator trimming is permitted up to 0·92M, to lessen the high stick forces which would otherwise occur with reduction of altitude. The aircraft is pleasant to fly at high mach number, but accelerates rapidly in dives and in response to increased thrust, and care must be taken to avoid exceeding the maximum speed of 0·92M. Lateral control is good within the permitted speed limitations, but deteriorates beyond them (see para. 9(*c*) below) and to allow a margin for inadvertent increase of mach number, bank angles must not exceed 30° at speeds greater than 0·90M.

(b) Auto-mach trimmer inoperative

If an auto-mach trimmer failure occurs in flight, retract the actuator if necessary, by blipping the control switch to RESET until IN is indicated, then switch off to prevent a sudden nose-up moment occurring should the actuator extend again. With the auto-mach trimmer inoperative, pitch instability occurs between about 0·83M and 0·92M at all positions, and with increasing speed a progressively heavier pull force is required to control the aircraft without retrimming. The stick force may be trimmed out if desired, but the speed must not be allowed to exceed 0·90M unless exceptional circumstances require it. In the latter event, elevator trimming is allowed up to the maximum permissible speed of 0·92M. With the auto-mach trimmer inoperative, the aircraft is safe and not difficult to fly at high mach number, but the machmeter must be watched continuously to avoid exceeding the limitations; bank angles must not exceed 30° at speeds greater than 0·90M.

(c) Flight outside limitations

Because of the ease with which the aircraft may be accelerated, care must be taken not to exceed 0·92M. However, in case this speed is exceeded inadvertently the following description of flight at higher mach numbers is given. Beyond 0·92M, the aircraft is stable in pitch, but the pilot is unlikely to be aware of the fact, unless the auto-mach trimmer is inoperative and even then, only when the aircraft has been trimmed at about 0·92M. Light airframe buffet commences in level flight at 0·91 to 0·92M, increasing initially to moderate intensity then reducing as 0·95M is approached. The buffet may decrease or disappear in gentle turns, though further application of G will result in onset of a different kind of buffet, harsher in character and increasing in intensity with G. Above 53,000 feet the onset of buffet may be delayed. At all altitudes, there is a decrease of aileron effectiveness as speed increases. The deterioration becomes more rapid with increasing mach number and decreasing altitude, particularly below 40,000 feet. At 0·95 to 0·96M, the amount of aileron deflection which the PFCU's are capable of applying becomes very limited and the entire PFCU output may, in some instances, be required to hold the wings level. The benefit derived from forcing the control wheel against the over-travel spring is only small. Above 0·93M, the sense of roll induced by side slip is reversed and application of top rudder lowers a depressed wing instead of raising it. In certain conditions, the rolling movement resulting from application of top rudder can completely counteract that produced by the ailerons. To avoid the possibility of instinctive and unwitting application of top rudder at high mach number, the rudder pedals should be freed if 0·92M is exceeded with any bank applied. If the limiting speed is exceeded it is important to reduce speed as rapidly as possible by throttling back, extending the airbrakes and carefully applying up-elevator. If any degree of bank is present, corrective aileron should be applied as soon as the mach number has fallen sufficiently for this to be possible.

(d) Manoeuvring

When manoeuvring the aircraft, reference must be made to the accelerometer to avoid exceeding permitted values of G. At speeds above 0.80M and altitudes up to 40,000 feet, maximum permitted values of G may be reached at any AUW without encountering buffet, but at higher altitudes buffet may occur first, and this overrides the G limitations. At onset, buffet is generally light, but between 0·82 and 0·85M, it occurs more suddenly and is harsher in character than at other speeds. Below 0·85M, buffet onset is often accompanied or closely followed by a rolling tendency in either direction; this is controllable by use of the ailerons. Above 0·85M, the rolling tendency is not present at buffet onset. At all mach numbers, up to tht maximum permitted, recovery from the buffet onset conditions is simple and straightforward. Penetration into the buffet is not permitted, but in case this region is entered inadvertently, the following description of the behaviour is given. Buffet intensity increases with further application of G and, if penetration continues, heavy or very heavy buffet will be experienced. At all mach numbers this may be accompanied by stick lightening i.e. successive equal increments of G require smaller pull-force increments to apply them. The rolling tendency also becomes more marked and may be experienced at speeds above 0·85M once buffet has reached a moderate level. For reasons of lateral control, bank angles must not exceed 30° at speeds above 0·90M, and pilots must be prepared for a reduction in aileron effectiveness above 0·92M, particularly at altitudes below 40,000 feet. The rudder pedals should be freed if 0·92M is exceeded with any bank applied.

◀ *(e) Flight at high* IAS *and low altitude*

At low altitudes speed may be increased rapidly in level flight up to the limiting airspeed and care must be taken to avoid exceeding this speed. The airbrakes provide an extremely effective control at high IAS.

(f) Use of flying controls during manoeuvres at low altitude

(i) Rapid entry to and exit from turns (ie simultaneous application of elevator and aileron) at any speed causes significant amounts of sideslip with consequent high fin loading. Coarse use of rudder to assist either entry to or recovery from such turns must be avoided because rudder application increases this sideslip and the resultant fin loading. ▶

(ii) At speeds in excess of 300 knots the ailerons become progressively heavier and less effective hence the available rate of roll is reduced due to aeroelastic effects. The elevator, however, remains powerful and the aircraft responds to elevator movements more rapidly. Therefore, when manoeuvring at high speeds extreme care must be exercised to avoid over-controlling in pitch. Coarse use of elevator can cause substantial elevator angles to be applied which together with any sideslip present and any coarse aileron application can cause high fin loading with the attendant risk of structural failure.

(iii) Additionally, in flight above 250 knots care must also be taken to avoid " check manoeuvres " in which excessive tail loads can be produced by the pilot making a large movement of the control column in pitch and then returning it to neutral before G builds up.

(iv) At higher speeds, extreme care must be exercised to avoid exceeding the G limitations, particularly during turns.

10 Handling at high altitudes at low mach numbers

NOTE: For the purposes of this paragraph " flight at high altitude " may be defined as flight above an altitude at which 0·82M can be maintained in level flight with 87% RPM set.

(*a*) At very high altitudes the IAS is less for a given IMN, so that stick forces are less, the incremental G which can be pulled before encountering buffet is less, and the aircraft is closer to the stall. Hence coarse application of the controls must be avoided when operating the aircraft near its ceiling at low IAS. This is particularly necessary in the case of the elevator where large forward stick movements can quickly result in negative G limitations being exceeded, and large rearward movements in rapid penetration to heavy buffet, and possibly into the region of longitudinal instability. Special care should, therefore be taken during flight at high altitude and low IAS.

(*b*) If the above precautions are observed, the aircraft will not enter the unstable region without adequate buffet warning. If, however, due to mishandling or severe turbulence when flying near the critical condition, instability is encountered, an incipent pitch-up may occur. This can be corrected by positive but not violent forward movement of the stick, and subsequent control movements should be gentle until the normal flight condition is regained. If, however, the nose continues to rise against the forward movement of the stick, a full pitch-up may develop. To correct a full pitch-up (a pitch change of up to 50° may be experienced) the stick must be held fully forward until the nose has fallen below the horizon and the IAS has increased above the value prior to the incident. After this, recovery from the ensuing dive should be carried out as gently as possible, thereby avoiding the possibility of a second pitch-up. The likelihood of the latter is greatly increased if it is attempted to catch the nose on the horizon, and no such attempt must be made. If the above action is not taken early enough the aircraft may stall and then possibly enter a spin or a stable stalled glide (Superstall). The latter condition is most easily recognised by the extremely high rate of descent (up to 10,000 or 15,000 FPM) combined with low IAS, with the nose remaining on or near the horizon, and with all controls apparently useless. In either event, the stick should be held fully forward and full rudder applied against any rotation. Ailerons should remain about neutral and power should be reduced. The aircraft should then recover. If, however, the above recovery action is ineffective, the braking parachute should be streamed. Because of the very high aircraft incidence, this will produce a large nose-down moment and unstall the aircraft. The parachute is likely to break away during the ensuing dive, recovery from which should be as described above.

11 Approach to the stall

NOTE: Stalling is not permitted, and speed must not be reduced below the onset of pre-stall buffet or threshold speed, whichever is the higher.

(*a*) *Clean configuration*

With wings level, pre-stall buffet will occur at 10 to 25 knots above the threshold speed for the weight. This buffet is barely discernable and may not be noticed in anything other than smooth air until speed is reduced by a further 10 knots, when light buffet commences. From 5 knots below to 5 knots above threshold speed a third stage of buffet becomes apparent, this consists of occasional moderate to heavy thumps superimposed on the high frequency light buffet. Elevator forces remain very light throughout the approach to the stall and a recovery may be made immediately by gently pushing the control column forward.

(*b*) *Undercarriage down. Full flap extended*

In the landing configuration, slight variation caused by the undercarriage and flaps may mask the onset of buffet until the speed is reduced to 10 knots below the threshold speed. At this point, heavier buffet will occur, changing to a spasmodic vertical shaking as speed is further reduced.

(*c*) Flight tests at 125,000 lb. AUW at speeds of 120 knots clean and 115 knots in the landing configuration have shown that all controls remain effective but aircraft response, especially to rudder movement, is greatly reduced. During the light buffet stage recovery is immediate if the control column is moved forward and power increased.

(*d*) *Stalling in turns*

Approach to the stall in turning flight is indicated by the onset of light buffet which is followed by moderate buffet. It is possible for buffet to be encountered before the G limitations are reached. Recovery, action, which is effected by reducing the backward pull on the control column, must be taken as soon as buffet is experienced.

12 Descending

(*a*) *Normal* QGH *descent*

Close the throttles, ensuring that if above 45,000 feet, the inboard engines are maintained at 90% RPM, select airbrakes fully out and descend at 0·84M/240 knots. The rate of descent is approximately 4,000 feet per minute.

(*b*) *Cruise descent*

Close the throttles, ensuring that the inboard engines' RPM does not fall below 90% above 45,000 feet, and descend at 210 knots.

(*c*) *Maximum rate descent*

If it is necessary to make a maximum rate descent, close the throttles, extend the airbrakes fully and descend at 0·92M/290 knots. The descent angle is steep and care must be taken to avoid exceeding the maximum speed limitations. Under instrument conditions it may be found advantageous to monitor the standby artificial horizon as well as the Director Horizon. During flight tests a descent from 53,400 feet to 40,000 feet took about 2 minutes at 160,000 lb.

13 Flying in turbulent conditions

The recommended speeds for flight in turbulent conditions are 220-250 knots or 0·87M. At these speeds, in moderate or severe turbulence, large aileron deflections may be required. Care should be taken that these deflections are applied slowly and smoothly. It is possible that lateral control could be marginal under these conditions.

14 Handling with underwing tanks fitted

The handling is generally the same as in the clean configuration with the following exceptions:

(*a*) Except near the maximum altitude, buffet may occur in straight flight as early as 0·88M, increasing in intensity with speed, and being particularly marked below 40,000 feet. Buffet may decrease or disappear in turns, though further application of G will result in onset of a different kind of buffet, harsher in character and increasing in intensity with G.

(*b*) At speeds below 0·88M, buffet onset occurs in turning flight somewhat earlier than in the clean configuration, and the intensity increases much more rapidly with increasing G. The rolling tendency and stick lightening are again apparent but only above 0·84M after the onset of buffet. Both effects are particularly marked in the region 0·84 to 0·86M, and are accentuated when G is being applied rapidly.

(*c*) Flight tests have shown the existence of an early buffet onset, sometimes accompanied by a rolling tendency, considerably below 0·88M which occurs only when flying near the maximum altitude for the AUW in straight and level flight or in very gentle turns below 0·85M. The effect is noticeable only when attempting to cruise under the conditions in which it occurs; it disappears if altitude is reduced, and the aircraft may then be manoeuvred up to the buffet referred to in (*b*) without encountering early buffet at all.

(*d*) With fuel in the underwing tanks, the rolling inertia is increased and a given rate of roll takes longer to build up and longer to correct, thus giving the impression of a reduced rate of roll.
(*e*) With one tank full and the other empty adequate aileron trim is available to hold wings level at speeds above 170 knots. At lower speeds corrective aileron, in addition to full aileron trim is necessary, but control is adequate. In this configuration, corrective rudder is also necessary if a slam acceleration is made when taking overshoot action. It must be remembered that with asymmetric fuel, the direction of swing reverses on changes from decelerating to accelerating flight and *vice versa*.

(*f*) On approaches to the stall at any flap setting, it has been found that the wing rocking tendency which some aircraft exhibit is likely to be more pronounced when underwing tanks are fitted.