AUSTRALIA

DEPARTMENT OF Transport Australia

Aviation Safety Digest

Courtesy of *Pilot Press*, copyright drawing.

111/1980

DEPARTMENT OF Transport Australia

Contents

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P.O. Box 84, Canberra, ACT 2600.

Subscriptions may also be lodged with AGPS Bookshops in all capital cities.

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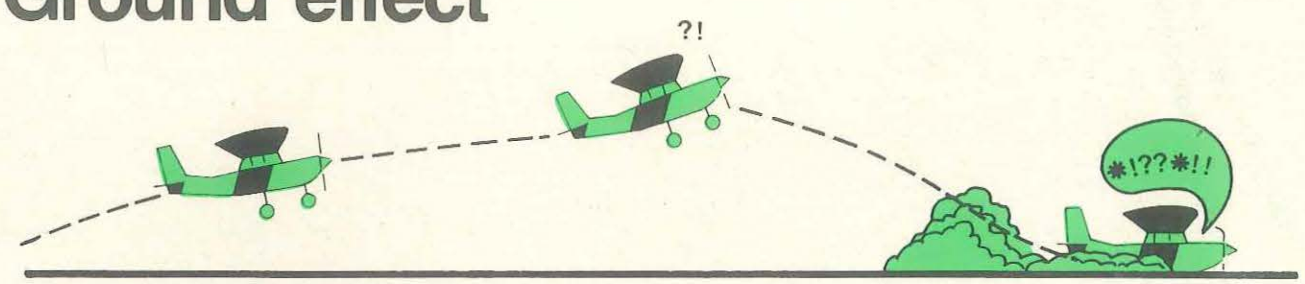
Reader contributions and correspondence on articles should be addressed to:

The Assistant Secretary (Air Safety Investigation),
Department of Transport,
P.O. Box 1839Q,
Melbourne, Vic. 3001.

RM77/30217(7) Cat. No. 80 3114 X

Printed by Ruskin Press, 552-566 Victoria Street, North Melbourne, Victoria.

Ground effect



It is possible to fly an aircraft a few feet above the ground at an airspeed lower than that required to sustain level flight at an altitude only slightly higher. This is the result of a phenomenon called **ground effect** — apparently better known than understood by many pilots. In terms as non-technical as possible, we will here define and discuss the major problems associated with this rather complex subject.

What is ground effect?

It is not possible, nor would it serve our purpose, to attempt in the space available a discussion of the aerodynamics of ground effect. In simple terms, it is the result of interaction between wing airflow patterns and the surface of the earth. All airfoils such as wings, rotor blades, etc. produce tip vortices and exhibit distinct airstream downwash characteristics when developing lift. The vertical components of such tip vortices and downwash velocities are progressively reduced as the airfoil nears the surface, and at touchdown are almost completely cancelled by surface interference. This alteration in airflow pattern decreases **induced** drag (the drag produced by lift). The closer the airfoil to the surface, the greater the reduction. Induced drag, at a height of approximately one-tenth of a wing span above the surface, may be 47 per cent less than when the aircraft is operating out of ground effect. It is this decrease in drag which explains basic aeroplane reactions when in ground effect.

How does a reduction in induced drag affect performance?

To the pilot, the reduction in drag means increased performance. That is, lift will increase with no increase in angle of attack, or the same lift can be obtained at a smaller angle of attack. This can be useful since it allows the pilot to either decrease angle of attack/power to maintain level flight, or as on most landings, to maintain wing lift while reducing power. A word of caution is in order, however. A full stall landing will require several more degrees of up elevator deflection than would a full stall when done free of ground effect. This is true because ground effect usually changes horizontal tail effectiveness in aircraft of conventional configuration.

Up to what altitude can ground effect be detected?

A pilot is unlikely to detect ground effect if his height above the surface exceeds the aircraft's wing span. In fact, there is appreciable ground effect only if height is less than half the wing span. At this or lower altitudes, ground effect is quite pronounced.

What major problems can be caused by ground effect?

Floating during landing is, in part, a result of ground effect. An aircraft will continue to remain airborne just above the surface at a speed which would have produced an immediate stall had the aeroplane been a bit higher. Therefore, a pilot may run out of both runway and options if he carries excess speed in the approach, or does not allow for at least a small margin of float after the flare from a normal approach.

Another, and perhaps more serious problem, can develop during take-off and climb out, especially when using a runway of marginal length. Deluded into believing that he has climb-out capability simply because he was able to get in the air, a pilot may raise the gear the instant he is airborne or initiate an immediate climb. For a few feet all may go well, but he may really have only marginal climb performance even in ground effect and, therefore, an acute need for added thrust as he begins to move out of ground effect. On moving out of ground effect, even if it only slightly increases the effectiveness of the elevators, the nose will usually tend to pitch up. At the resultant high angle of attack, the pilot finds he cannot climb, or even worse, may begin to sink. Desperately holding his nose-high attitude in a futile effort to gain altitude, he steadily mushes or stalls back to the runway or into obstructions if no excess power is available to correct the situation. Add high gross weight, high density altitude and a bit of turbulence to this scene and an accident is even **more** likely.

Airspeed indicator unreliability in ground effect is another, though less critical problem. Usually it will indicate slightly higher as you leave and slightly lower as you enter ground effect.

Just remember, ground effect is always there; it may prolong the glide or permit an aircraft to get airborne with insufficient power to sustain flight outside the area of ground effect. If this occurs the pilot must allow the airplane to accelerate while still in ground effect, before attempting to continue the climb. Panic attempts to force a climb can only make lift/climb problems worse ●

(Acknowledgement to the U.S. Federal Aviation Administration for VFR Pilot Exam-o-gram No. 47)

"Pilot continued VFR flight into adverse weather . . ."

The following reports on two more weather related accidents highlight the type of occurrence which continues to cause the greatest loss of life in Australian aviation accidents.

The pilot had bought a Cessna 172 about four months prior to the accident, after qualifying for his Private Pilot Licence. On the day of the accident he intended to fly the aircraft from Woomera to Parafield with a refuelling stop at Port Pirie. After arrival at Parafield he was to meet his wife and daughter in Adelaide and then catch an RPT flight interstate.

At 1153 hours local he telephoned the Parafield briefing office and obtained the appropriate meteorological forecasts for the flight. The forecasts indicated that, in the area covering the Woomera-Port Augusta sector, there would be scattered to broken stratus, strato-cumulus and cumulus cloud, and visibility would generally be 40 kilometres, reducing to 10 kilometres in rain showers and 4000 metres in drizzle. The forecast for the area south of Port Augusta was similar.

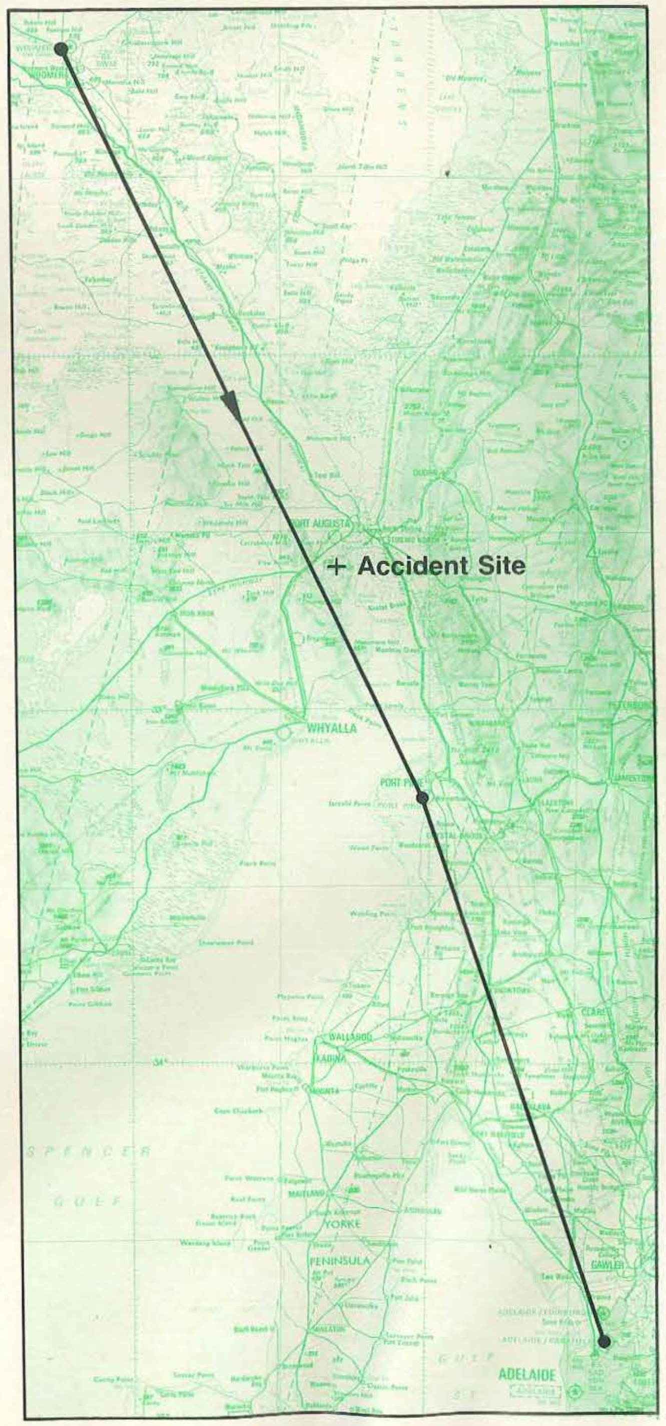
A short while later the pilot again called the briefing office and submitted a private category, VFR flight plan. He was advised that Parafield was closed to VFR operations and that 30 minutes holding was required because of weather. The pilot advised that he would recheck the Parafield weather before departing Port Pirie.

The aircraft departed Woomera at 1255 hours with the pilot and a friend on board and, eight minutes later, the pilot established HF radio communications with Adelaide Flight Service Unit. At 1344 hours he made an 'all stations' call indicating that he was five miles north west of Port Augusta and overflying below 5000 feet. Shortly afterwards he passed his Port Augusta position to Adelaide with an estimate for Port Pirie at 1418 hours. He then transferred to the Adelaide FSU VHF frequency and established communications.

At about this time at the Port Augusta aerodrome there was overcast strato-cumulus cloud, base approximately 2000 feet, and to the south there was a line of drizzle and associated stratus cloud lying east/west and moving north. The hills to the south of the aerodrome were covered in mist and stratus cloud. Similar weather conditions were observed by two persons fishing from a boat situated at the head of Spencer Gulf some six nautical miles south of Port Augusta. The fishermen heard a single-engine aircraft approach from the north and intermittently observed it through breaks in the low overcast. It made several turns in their vicinity and then headed towards the hills to the west. The engine noise then increased and they finally observed what appeared to be the wing of an aircraft bounce into the air from the ground. The engine noise stopped suddenly at that time.

At 1357 hours the call sign of the aircraft was heard on the Adelaide FSU VHF frequency and the voice was shrill and urgent. Calls to the aircraft did not produce any response and Search and Rescue alerting was initiated. The wreckage was located by a searching aircraft at 1550 hours.

Detailed examination of the wreckage did not reveal evidence of any defect or malfunction which might have contributed to the accident. The damage to the aircraft, together with ground impact marks, indicated that the aircraft struck the ground at high speed in a steep nose-down, right wing-down attitude, consistent with it being in a spiral dive.



The pilot had flown a total of 120 hours, of which 65 had been on this type of aircraft. He had flown 22 hours in the last three months ●

During the morning, a Beech Sierra had been flown from a property near Trangie, NSW, to Bankstown Airport, with the owner/pilot and his cousin on board. After lunch, the pilot attended the Bankstown briefing office and obtained the appropriate meteorological information for the return flight. He submitted a VFR flight plan which nominated a Sartime of 1900 hours local time, tracking via Katoomba then direct to his destination, below 5000 feet.

The forecasts indicated occasional thunderstorms in the area, broken to scattered stratus and cumulus cloud, and visibility deteriorating in rain and thunderstorms. From the briefing office, the thunderstorms over the ranges were visible and were drawn to the attention of the pilot by the duty Flight Service briefing officer.

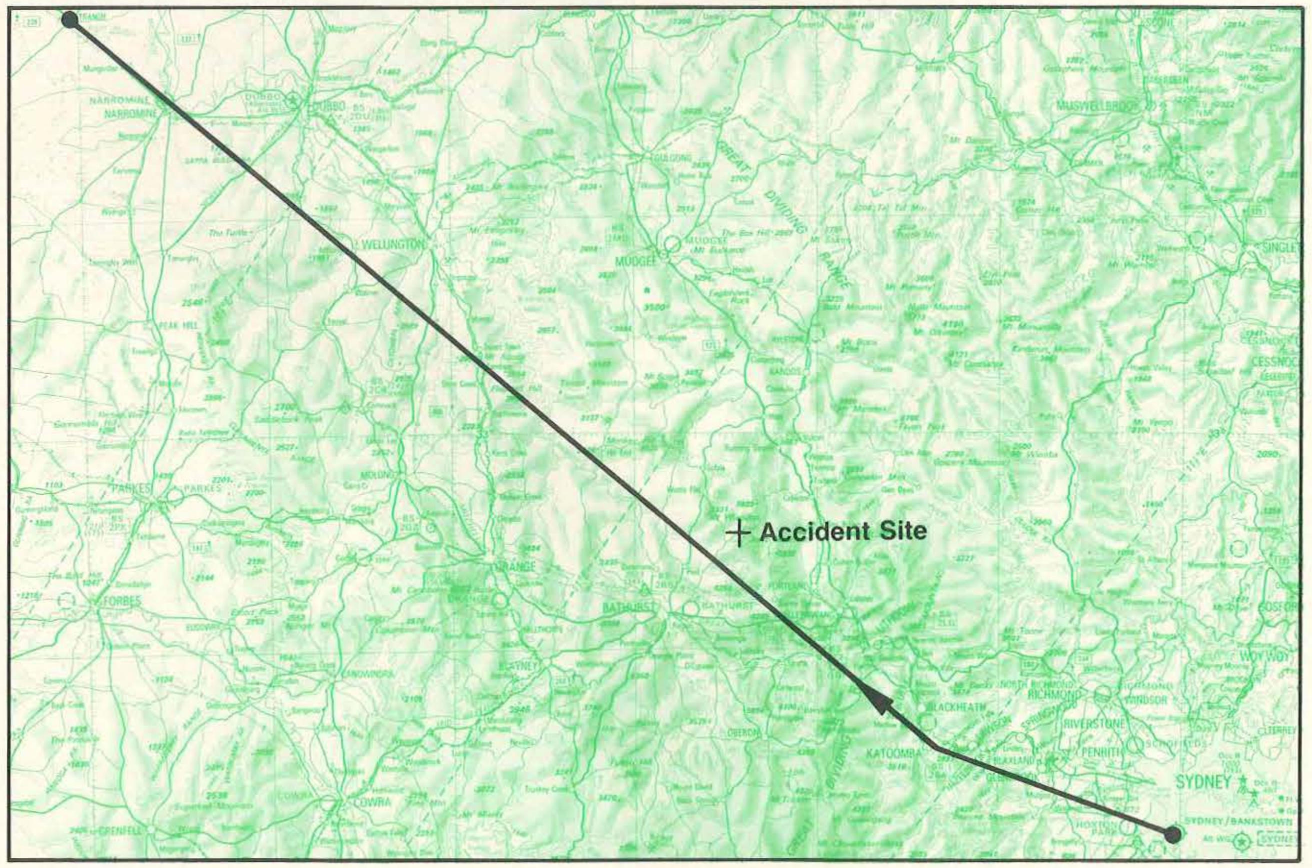
The aircraft departed at 1544 hours and the pilot established radio communications with Sydney Flight Service Unit. He subsequently reported over Katoomba at 1606 hours, below 5000 feet and estimating abeam Bathurst at 1632 hours. At 1616 hours he changed to the appropriate FSU frequency and established satisfactory communications. A minute later a broken transmission was received by the FSU, apparently from the Beech Sierra, '. . . up to three five zero zero but quite clear to the north'. No further communications were received from the aircraft. When the pilot did not notify his arrival by the nominated Sartime, Search and Rescue alerting action was initiated.

The aircraft wreckage was located by searching aircraft on the following day. It was situated on the densely timbered, eastern slopes of a mountain range, about 450 feet below the top of the range and three nautical miles north from the summit of Mount Horrible. This location is north east of the flight planned track.

At the time of initial impact with trees, the aircraft was on a south westerly heading, in level flight and banked about 15 degrees to the right. Examination of the wreckage was limited by the extent of destruction arising from impact damage and subsequent fire. No evidence was found of any defect or malfunction which may have contributed to the accident.

A meteorological post-analysis indicated that, during the afternoon on which the accident occurred, an active cold front moved eastward over the planned track of the aircraft between Wellington and Katoomba. The front passed Mount Horrible during the hour immediately prior to the accident and, in post-frontal precipitation, there would have been areas of cloud down to ground level. Ground witness evidence confirmed the passage of the front and the presence of extensive low cloud enveloping the high ground near the accident site.

This pilot was not inexperienced, having flown a total of 200 hours, all of it on this aircraft, but he did not hold an instrument rating. In the last three months he had flown about 30 hours ●



Year	Accidents			*Pilot continued VFR flight into adverse weather conditions*		
	Total	*Fatal*	*Fatalities*	*Total*	*Fatal*	*Fatalities*
1971	218	14	34	13	7	22
1972	179	20	43	4	2	3
1973	219	15	26	10	4	13
1974	234	17	39	11	5	18
1975	190	12	27	3	2	5
1976	243	19	53	9	6	21
1977	221	19	43	7	5	15
1978	249	27	58	7	5	11
1979	243	19	35	4	2	9
TOTAL	1996	162	358	68	38	117

Notwithstanding that the preceding type of accident is the cause of the greatest loss of life in Australian aviation, a misconception apparently exists among pilots that this is the most common type of accident. This conclusion had been reached because of the number of reports of such accidents printed in the *Aviation Safety Digest* and the emphasis they had been given.

As can be seen from the accompanying table, pilots continuing VFR flight into adverse weather conditions is not a major cause of accidents. In fact of the 1996 accidents in the period, there were only 68 which were assigned this factor, i.e., only 3.4 per cent of the total accidents. However, this category of accident does result in a very high fatality rate. In the 38 fatal accidents recorded in this category, a total of 117 lives were lost. That is 32.7 per cent of all fatalities in Australian general aviation accidents.

Of these 38 fatal accidents, 32 were flown by private licensed pilots and 35 were in the private class of operation. Seasonally, more than one third of these accidents occurred in autumn, with winter, summer then spring being the relative order of frequency. A breakdown of pilots' ages, experience and other factors showed no significant trends of relationships.

What does all this mean?

At the Australian Symposium on General Aviation Safety, sponsored by the Royal Aeronautical Society and held at the University of New South Wales in May 1980, there was considerable discussion about this kind of weather related accident.

Arising from the discussion, delegates raised several points which are worthy of consideration by members of the industry. In particular, it was claimed that the average private pilot does not have a good understanding of the limitations of himself and his aircraft when faced with deteriorating weather, forecast or unforecast. He is not likely to really appreciate his distance from cloud and the radius of turn of his aircraft at cruising speed. Therefore, he may well find himself in a situation where he enters cloud while attempting to avoid it.

To help overcome this problem it was suggested that pilots should undertake some dual instruction with an instrument rated instructor who can demonstrate to them such things as judging distance from cloud, radius and rates of turn in various configurations and what the pilot could expect to experience if he did inadvertently enter cloud.

Other delegates expressed the view that a lot of pilots had difficulty in understanding weather forecasts and in relating those forecasts to the conditions they could expect to encounter along track. The suggested cure for the first part of this problem was a change in the presentation of forecasts. The format of area forecasts, in particular, is currently being reviewed jointly by the Bureau of Meteorology and the Department of Transport to ensure that pilots receive these forecasts in the most logical and understandable form. To overcome the second part of the problem requires the pilot to obtain instruction in the more practical aspects of meteorology rather than just learning enough to pass Departmental licence examinations. After all it could save your life, so perhaps the extra effort is worth it.

Another problem which was discussed at the symposium, but is not solely related to this type of accident, was the pressure under which a pilot operates once he receives his unrestricted licence. The pressures referred to are those which tend to impel him to complete the flight, and the problem appears to be compounded when passengers are carried. It is possible that the two fatal accidents described earlier contained elements of such pressure. In the Port Augusta accident the pilot was not under any apparent pressure from his passenger, but he did have an RPT flight to catch with his family later in the day. In the other accident it would appear that the pilot and his passenger had completed their business and had not planned an overnight stay in Sydney. Perhaps they were overly keen to return home and get on with their normal business. Whether or not such factors were significant in these two accidents must remain speculative, but it is a fact that pressures of this type do occur from time to time and all pilots should think carefully before commencing any flight with an element of risk.

Another delegate at the symposium, representing an operator with a fleet of single engine Cessnas in Papua New Guinea spoke of the potential cost of a fatal accident. Even if the personal tragedy aspects are put to one side and only the economic consequences of the accident are considered, the cost to the organisation could be as high as half a million dollars. Liability payments to families of deceased passengers; life insurance and workers compensation payments to the pilot's family; participation in Search and Rescue and accident investigation; the cost of recruiting, screening, orientation training, checking out and establishing a replacement pilot, together with the cost of obtaining and equipping a replacement aircraft could easily reach this sum.

In its safety program, the organisation was asking its pilots to assess the risk factor associated with a flight. This assessment will require a perception of
— the chance of failure, and
— the consequence of failure.

Having established these, the pilots can then answer the question, **'Is it worth it?'**

Perhaps we should all try the same technique ●

DURSTIN by Russ Day (courtesy of *Flight Crew* magazine Spring 1980)

Churchill Fellowships

The Winston Churchill Memorial Trust was established in Australia in 1965, the year in which Sir Winston Churchill died. The principal object of the Trust is to perpetuate and honour his memory by the award of Churchill Fellowships.

The aim of the Trust is to give opportunity, by the provision of financial support, for Australians from all walks of life to undertake overseas study, or an investigative project, of a kind that is not available in Australia.

There are no prescribed qualifications, academic or otherwise, for the award of a Churchill Fellowship. Merit is the primary test, whether based on past achievements or demonstrated ability for future achievement, in any walk of life. The value of an applicant's work to the community and the extent to which it will be enhanced by the applicant's overseas study project are important criteria taken into account in selecting Churchill Fellows. However, Fellowships will not ordinarily be awarded in cases where the primary purpose of the application is to enable the applicant to obtain higher academic or formal qualifications, nor to those in a vocation which offers special opportunity for overseas study.

Churchill Fellows are provided with a return economy class overseas air ticket and an Overseas Living Allowance to enable them to undertake their approved study project. In special cases they may also be awarded supplementary allowances including a Dependants' Allowance. Fifty one Churchill Fellowships were awarded for 1981 at a total budgeted cost of $450,000.

All Churchill Fellows are presented, at an appropriate ceremony, with a certificate and badge identifying them as such. The certificate bestows upon the recipient the prestige of being a Churchill Fellow and opens many doors overseas that would otherwise be closed to a private individual.

It is more than 10 years since a Fellowship was awarded for study associated with the aviation industry. This could be an opportunity for a member of the industry to help others in aviation as the result of their endeavour and the assistance provided by a Churchill Fellowship.

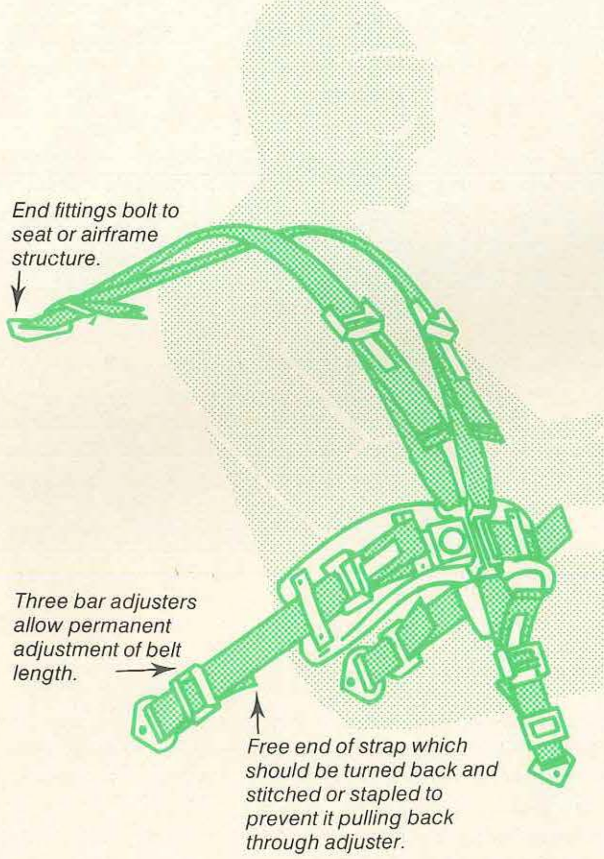
Applications

The Trust is calling for applications from Australians, of 18 years and over from all walks of life, who wish to be considered for Fellowships tenable in 1982.

Completed application forms and references must reach the Trust by 28 February 1981. Applicants should send their name and address now, with a request for a copy of the information brochure and application forms, to either the appropriate state capital city or the Canberra office:

The Winston Churchill Memorial Trust (M)
G.P.O. Box 498 ADELAIDE S.A. 5001
P.O. Box 6209 Hay Street East PERTH W.A. 6000
G.P.O. Box 1260N HOBART TAS. 7001
P.O. Box 2147 DARWIN N.T. 5794
P.O. Box 478 CANBERRA CITY A.C.T. 2601 ●

Seat belt adjustment problem



The photograph above shows the harness as found on a Bellanca. Note the limited accessibility, and the fact that this is on the more accessible side, adjacent to the large entry door. The free end of the strap should be passed back through the adjuster, which is too far up from the end fitting.

The following text from an incident report, while of special interest to aerobatic pilots, has general application.

'While adjusting my harness before taxiing for an aerobatic training flight, I found that I could not tighten the lap strap sufficiently. I shut down the engine and inspected the strap where it was attached to the airframe. A comparison with the front harness showed that the rear one was incorrectly secured and I found that I could work the strap loose by pulling it upwards. The strap had either been incorrectly attached to the aircraft or it had worked loose since its attachment. The other lap strap for the rear seat was similarly faulty. I attached the rear straps correctly, checked the front straps thoroughly and proceeded with the flight. I have since notified the operator and club instructors about the incident because the consequences of a similar, future occurrence in an aerobatic aeroplane could be somewhat embarrassing.'

The accompanying illustrations and the following text from Airworthiness Advisory Circular 87-5 outline the problem and the solution to it.

'A hazardous situation may be created if repeated, incorrect adjustment of some general aviation seat belts is carried out. On most types, the shorter webbing length which carries the buckle includes a fitting for connection to the floor anchorage and an adjuster which enables the buckle to be correctly located at the side of the wearer. The total length of this section of webbing is such that normally an ample amount exists for the adjuster to remain secure. Personal adjustment of the belt should be carried out on the other webbing strap, i.e., on the side of the belt connector, so that appropriate buckle location is maintained.

Occasionally it may be necessary to make a small adjustment on the buckle side when the seat is shifted to extreme positions. This again introduces, by itself, no special hazard in view of the free length of webbing normally available. However, the free ends of many of these straps are not sewn over, and if repeated and incorrect personal adjustments have been carried out on the buckle side the webbing may require only a small amount of slip before the end will pass through the adjuster and render the restraint system ineffective. It is therefore advisable to check, before buckling up, that the buckle is located at the side of the occupant and that a safe free length of webbing protrudes through the adjuster' ●

Dirt strips: excessive brake wear

Photograph shows pads worn down past the rivets and several with cracks. Darkening of some of the pads is the result of oil contamination.

A Piper Aztec was operated around south eastern Queensland and regularly flew into comparatively short, dirt strips. On the day of the accident the pilot commenced flying at 0620 hours local time and by midday had completed six flights totalling about three hours flying with an average break of 15 minutes between flights.

At 1200 hours the aircraft took off from 1050 metre station strip with the pilot and three passengers on board. The purpose of the flight was to inspect the boundary of an adjoining property. The inspection was completed in about 10 minutes and the pilot rejoined the circuit for an approach to the north westerly strip. The wind was light and variable so he elected to land up the slight slope.

A short field approach with full flap was made at 70 knots and touchdown occurred 150 metres into the strip. About halfway along the strip the pilot applied light braking. He gradually increased the braking pressure until nearly 700 metres of the strip had passed. By now he had applied maximum braking but there was a noticeable lack of retardation.

As the aircraft approached the end of the strip, it became obvious to the pilot that it was not going to stop. He steered the aircraft clear of two other aeroplanes parked by the side of the strip and the Aztec hit the post and wire fence at about 20 knots suffering substantial damage, mainly to the right wing. The occupants were uninjured.

The investigation of the accident included close examination of the aircraft braking system. Functional checks revealed that the braking system appeared to be operating normally. The aircraft log books indicated that the brake pads were replaced at the last 100 hourly inspection, which occurred about 60 hours prior to the accident. Inspection of the brake pads revealed however, that they were worn beyond acceptable limits. This wear had been progressively compensated for by the automatic brake adjusters and braking efficiency had apparently not been affected until the landing on which the accident occurred. A contributing factor was a slight oil weep from the left hand, rear brake caliper assembly. This would have caused an accumulation of dirt around the braking mechanism which accelerated the rate of wear.

Reference to the Company Operations Manual showed that visual inspection of the wheel brake system was not called for in the Pilot's Daily Inspection Schedule, nor was this a requirement of the Aircraft Owner's Handbook. The Daily Inspection Schedule in Air Navigation Order 100.5.1 Appendix 4 also does not require a specific inspection of the wheel brake section.

In view of the lack of specific directions for wheel brake visual checks between periodic inspections, consideration was given to amending the Daily Inspection Schedule. It was concluded, however, that the excessive wear revealed during this investigation would be restricted to aircraft making a large number of landings, on unsealed strips, which involved high brake usage. In addition, the inspection would be impractical on aircraft fitted with drum brakes or wheel spats. Rather than include a specific requirement in the applicable publications it is strongly recommended that operators ensure that their pilots are aware of the additional brake pad wear which is likely to occur when operating from dirt strips. Any visible sign of oil weeps from the brake actuators should also be attended to in order to reduce accelerated wear of the brake pads and discs ●

Vision 4 — what meets the the eye . . . real or illusion?

The fourth article in a series concerning the physiological, psychological and environmental factors that affect visual efficiency.

'Human error' and 'approach and landing' are phrases frequently used in describing causes of aircraft accidents. Statistics reveal that about 85 per cent of aircraft accidents involve human error as a contributing factor. In addition, about 50 per cent of all accidents occur during the approach and landing phase.

Your primary role in the cockpit is making decisions. In order to do this you must sense and process information. Potential sources of error range from limitations in your senses and perceptual mechanisms to inadequacies in procedures and methods prescribed for the flight crew. This article will briefly present some characteristics related to sources of information processing error during the approach and landing.

Your senses receive physical stimuli and encode information; perception interprets information and attaches meaning to it. Most of the information which you receive comes to you through your eyes; some comes from instrument displays in the cockpit, but a large amount is obtained from outside the cockpit, often under conditions which may be far from ideal. Indeed, certain conditions may prevent the necessary information from even reaching the eye. More often a signal reaches the eye but the brain misinterprets and you 'see' something else; in other words you experience a visual illusion. We will discuss only the illusion, or false perceptions, associated with direct vision.

Visual illusions are potentially common in flying and result from the incorrect interpretation of what you see. This may be due to there being too few visual cues so that you have to fill in the rest of the picture by drawing on your preconception of the situation, by 'seeing' what you think you 'ought' to see, or simply by guessing. It may also occur when cues presented to the normally master sense, vision, are weak and are in conflict with relatively strong responses by other senses, particularly those of balance and orientation, which have sensors in the inner ears.

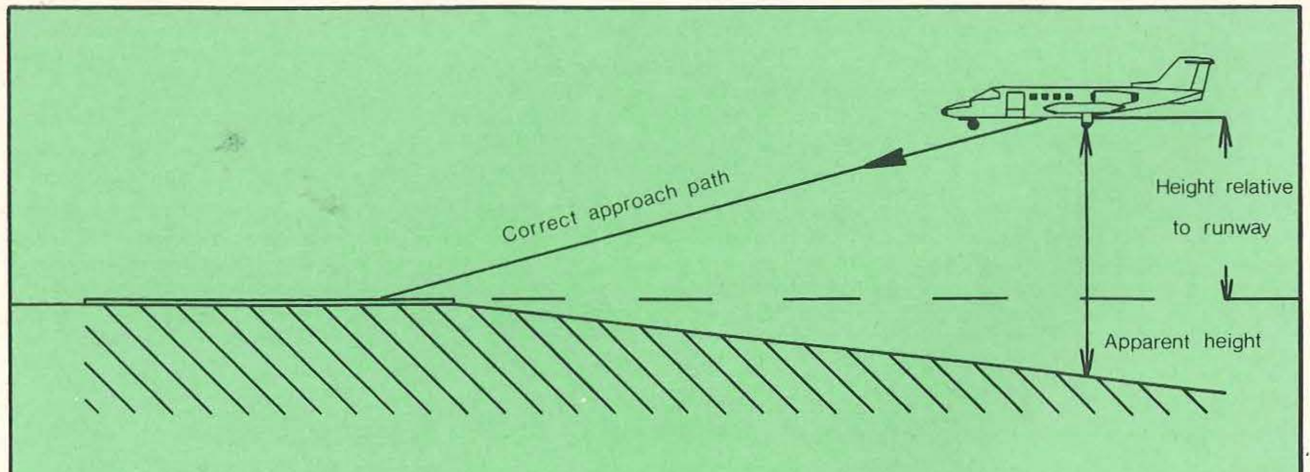
The purpose of this article is to draw your attention to some of the circumstances in which visual illusions may be experienced and to the hazards which the illusions may introduce on the approach to land. Increased awareness of these factors will enable you to recognize and compensate for most visual illusions and so reduce the risk of an accident.

Visual illusions during the landing approach may be caused by one or any combination of the following features:

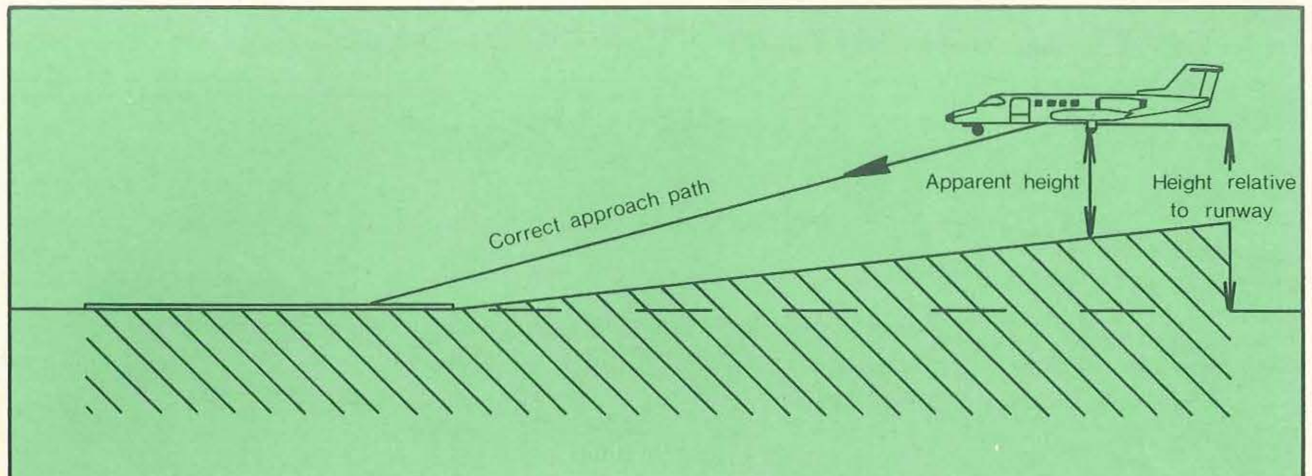
- Sloping approach terrain
- Sloping runways
- Runway width
- Rain on the windscreen
- Featureless approach terrain
- Runway lighting intensity
- Shallow fog
- Rain showers
- Darkness
- Black hole effect

Sloping approach terrain

Normally, when a pilot makes a visual approach he subconsciously judges the approach path from a combination of the apparent distance of the aircraft from the runway and its apparent height above the approach terrain. If the ground under the aircraft slopes upwards towards the threshold an illusion may be created, particularly during the early stages of the approach, that the aircraft is too high (see Figure 1). Conversely, ground which slopes downwards towards the threshold gives the impression that the approach path is too flat (see Figure 2).



Upsloping approach terrain (Figure 1)



Downsloping approach terrain (Figure 2)

Sloping runways

Through the regular use of ILS glide paths and VASIS, with three degree glide slopes, pilots become accustomed to the complementary angle of 177 degrees between the runway and the approach path (see Figure 3). Additionally, from experience, pilots come to know with considerable accuracy the amount of power required to maintain the correct approach path to the point of touchdown. If, however, the runway slopes upwards from the landing threshold and the 177 degree relative angle is maintained, a visual approach will be lower than it should be, by about the same amount as the runway upslope, and the 'usual' power setting will be inadequate to meet the requirements of the flatter approach. If the runway has a downslope, the converse applies, so that by maintaining the 177 degree angle relative to the down-sloping runway, the approach to the touchdown point will be steeper and the 'usual' power setting in excess of that required.

Runway width

The ability to use the apparent convergence — due to perspective — of two parallel lines to estimate their length is well known. Increasing or decreasing the distance between the lines, however, can create the illusion of shortening or lengthening them. On the approach, a pilot bases part of his judgement on a mental comparison of the runway before him with the 'normal' view of the runway to which he is accustomed. Variations in the runway width, therefore, can be misleading. For example, the wider the runway, the shorter it appears; moreover, the width can also have an effect upon the apparent height of the aircraft in relation to the runway, a wider runway making an aircraft appear lower than it is.

Rain

Heavy rain can affect the pilot's perception of distance from the approach or runway lights by diffusing the glow of the lights and causing them to appear less intense. This may lead him to suppose that the lights are farther away than in fact they are. On the other hand, only a little scattering due to water on the windscreen can cause runway lights to bloom and double their apparent size, with the result that the pilot believes that he is closer to the runway than he actually is, leading possibly to a premature descent. Similarly, rain on the windscreen can cause illusions as a result of light ray refraction. For instance, even though an aircraft is correctly aligned on the approach path it can appear to the pilot to be above or below the correct glide slope, or left or right of the runway centre line, depending upon the slope of the windscreen and other circumstances. The apparent error might be as much as 200 feet at a distance of one mile from the runway threshold.

Featureless terrain

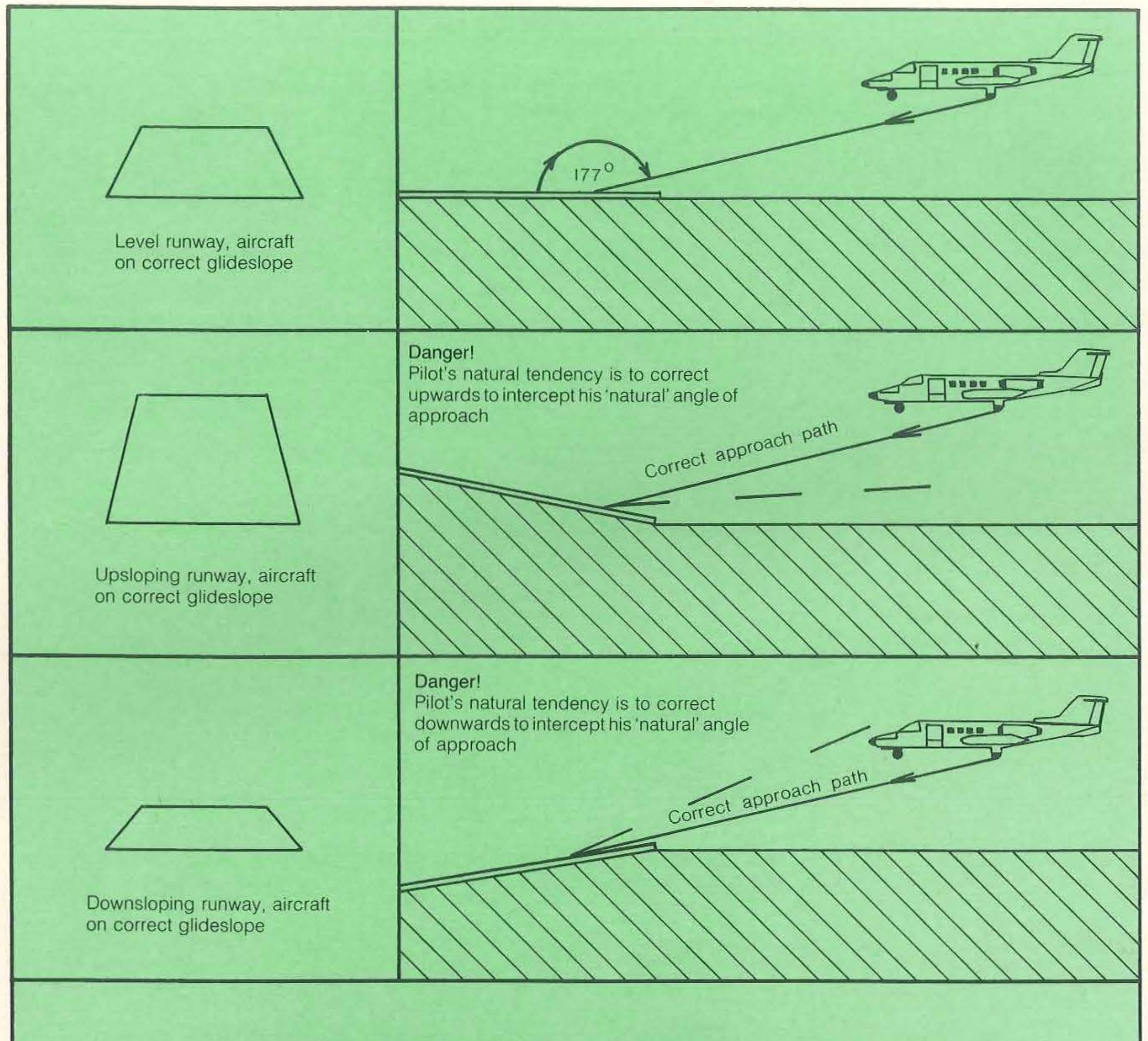
Visual descents over calm seas, deserts or snow, or over unlit terrain at night, can be hazardous even in good visibility. The absence of external vertical references makes judgement of height difficult and the pilot may have the illusion of being at a greater height than is actually the case, leading to a premature or too rapid descent. Height above the runway is also made more difficult to judge if, because of snow for example, there is no contrast between the runway surface and surrounding terrain. The problem is compounded if the descent is made into the sun or in any conditions which reduce forward visibility.

Runway lighting intensity

Because bright lights appear closer to the observer and dimmer lights farther away, the intensity of the approach and runway lighting can create illusions. Thus, on a clear night, the runway lights may appear closer than they actually are, particularly when there are no lights in the surrounding area.

Shallow fog, haze

In shallow fog or hazy conditions, especially at night, the whole of the approach and/or runway lighting may be visible from a considerable distance on the approach even though Runway Visual Range or meteorological reports indicate the presence of fog. On descent into such a fog or haze layer, the visual reference available is likely to diminish rapidly, in extreme cases reducing from the full length of the approach lights to a very small segment. This is likely to cause an illusion that the aircraft has pitched nose up, which may induce a pilot to make a corrective movement in the opposite direction. The risk of striking the ground with a high rate of descent as a result of this erroneous correction is very real.



Sloping runways (Figure 3)

Rain showers

A weather feature which may reinforce a pilot's visual indications that he need not apply power to reach the runway or to arrest a high rate of descent is an isolated rain shower. A heavy rainstorm moving towards an aircraft can cause a shortening of the pilot's visual segment — that distance along the surface visible to the pilot over the nose of the aircraft. This can produce the illusion that the horizon is moving lower and, as a result, is often misinterpreted as an aircraft pitch change in the nose up direction. A natural response by a pilot would be to lower the nose or to decrease, not increase, power.

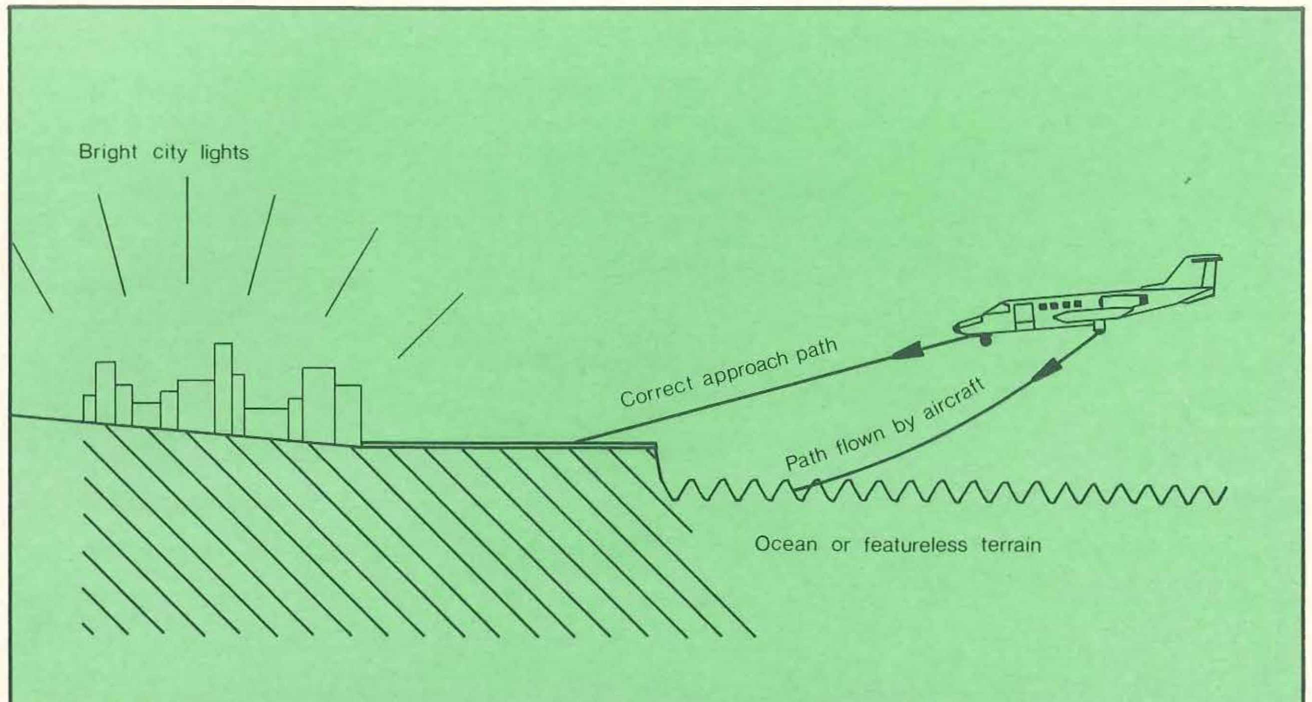
Darkness

The greatest illusion potential exists at night. Darkness provides excellent camouflage and the eye loses much of its efficiency. Normally used cues such as shadows, colour and detail are not available. Lights must compensate for this loss, but lights usually lack sufficient definition to provide more than an outline, an incomplete stimulus to which the pilot may or may not react correctly. At the other end of the scale we have a profusion of lights. Large airfield complexes have so many lights that frequently there is considerable difficulty experienced in just finding the runway.

Black hole effect

This illusion can occur on a clear night with no visible horizon. The aircraft approaches the runway over the sea or other featureless, unlit terrain towards an aerodrome with bright city lights behind it. Visibility is so good that there is little need to rely on the instruments except to check the airspeed. The straight-in approach is totally uneventful until the aircraft lands short of the runway, possibly by several miles. What could have gone wrong?

Tests have shown that under these circumstances a pilot relying on a visual approach will tend to fly along the arc of a circle centred above the pattern of city lights with its circumference contacting the terrain. Such a path results from maintaining a constant visual angle subtended at the eye by the nearest and farthest city lights. When deceptive conditions are present, such as up-sloping city terrain, this kind of approach path can go to critically low altitudes. The lack of foreground lighting results in the pilot being denied important closure information without his awareness and consequently the aircraft lands short.



Black hole effect (Figure 4)

Avoiding the problem

Be aware of the circumstances in which visual illusions may occur and be prepared to take corrective or alternative action. Learn to recognise impending situations which may place the safety of the aircraft and its occupants in jeopardy.

Study aerodrome charts, maps and other applicable reference material to determine runway slope, the slope of terrain around the aerodrome, the relative position of the aerodrome and surrounding features, the aerodrome approach and runway lighting in use, etc., etc.

Anticipate the need for rain repellant on the windscreen and use as appropriate, before departure.

Wherever available use ILS or VASIS to monitor the glide slope. If a DME is located at the aerodrome use the 'rule-of-thumb' 300 feet per nautical mile for your descent profile, but remember to take into account the relationship of the DME beacon to the threshold of the runway in use.

If the nominated runway has no precision approach aids, consider the need to request an alternative runway with precision aids. When no precision aids are available fly a full circuit, never a straight-in approach. The aircraft can be more accurately positioned at 600 feet on a two mile final having flown a full circuit than on a straight-in approach without aids. It may also be possible to position the aircraft at a known point, such as over a locator, at the correct altitude and approach configuration. The pilot should then obtain a visual image of the runway and maintain this image throughout the approach. If none of the foregoing procedures are possible, consideration should be given to diverting to a more suitable aerodrome.

On two-pilot operations use the monitored approach technique. One pilot flies the instrument approach while the pilot who is to land the aircraft monitors the approach and gains 'experience' of the ambient conditions before taking over control.

During single-pilot, IFR operations the pilot should use the autopilot as the pilot flying the approach. While flying a coupled approach, the 'real' pilot should try to gain experience of the conditions. The autopilot should remain engaged as long as possible until the pilot has obtained a good visual picture, and a safe landing is assured.

On all operations, avoid landing expectancy; be prepared to go around or carry out a missed approach if there is any doubt about the safety of the landing.

Wherever possible, pilots should receive training flights to aerodromes where it is known that conditions can be conducive to visual illusions.

In conclusion, remember that illusions must be expected in flying. Also that it is human nature to want to believe our own senses rather than instrument indications. Knowledge of illusory sensations will help because our responses are determined more by the meaning we attach to stimuli than by the stimuli themselves. It is ultimately on the basis of knowledge and self discipline that we make decisions and select our responses.

How sharp are your eyes? Did they catch **the the** title? ●

Systems knowledge — the landing gear

Although referring specifically to a particular group of aircraft, this article contains lessons applicable to the operation of any aircraft fitted with retractable landing gear.

The following brief reports are only a few from the records involving landing gear problems. Far too often the investigation into an accident or incident reveals that the pilot had an inadequate understanding of a particular system. This is especially true in accidents involving the landing gear. Fortunately, this type of accident does not usually result in fatalities or serious injuries, but there is always a high risk that some other fault may compound the seriousness of the accident. If an accident can be avoided by a better understanding of the system operation, then surely it is worth the slight effort required on the part of the pilot to achieve this understanding.

This article deals with the retractable landing gear systems fitted to a range of Beech and Cessna aircraft, including the Beech 33, 35, 36, 55, 56, 58, 60 and 95 series, and the Cessna 310, 320 and 340 series. The normal and emergency operation of the system and some of the failures which have led to accidents will be discussed.

● After making an aerial inspection of the landing area, the pilot of a Beech Bonanza continued the circuit at 500 feet AGL. Turning base she selected the landing gear down, heard and felt the doors opening and the motor operating, and noticed an increase in drag. Neither the landing gear warning lights nor the nosegear mechanical indicator were checked. The approach was continued with 25 degrees of flap selected and after rounding out, the Bonanza landed on the open gear doors, the flaps and the lower fuselage surface. The pilot and four passengers were uninjured.

Subsequent investigation revealed that the landing gear motor had an intermittent fault and the circuit breaker had popped after the doors opened. As is so often the case, the landing gear warning horn system was also found to be faulty.

The commercial pilot had flown more than 200 hours on the Beech 35 since her conversion only three months earlier.

● Just after taking off on a test flight to check the pressurisation system, the pilot of a Beech Duke selected the landing gear up. It appeared to retract normally and the aircraft accelerated, however, the unsafe gear warning light remained on. The pilot selected the gear down and heard a pronounced 'clunk'; the main gear locked in place but the unsafe light was still illuminated and the nose gear down light was out. He checked the nose gear light bulb but it appeared to be serviceable.

After cancelling the flight plan and informing the tower of the problem, the pilot tried cycling the gear and using a manual extension but all without success. The aircraft was flown past the tower for company engineers to inspect the landing gear and it was observed that there was a rod hanging down behind the partly extended nose gear.

The tower advised the pilot that the grass emergency strip was available. He decided to conduct a flapless, gear up landing because of his concern that the Duke might nose over if the mainwheels were left down. He also considered that damage could be minimised by leaving the flap up and landing on the flat centre section of the fuselage, on the soft, grass surface.

The pilot briefed the passengers for the landing and evacuation, and had them sit in rear facing seats. After two low runs to check the approach, the aircraft landed smoothly and slid to a stop.

Investigation revealed that the nose gear extend/retract rod had failed at a welded joint. This was subsequently determined to be an isolated occurrence. Because of his handling of the situation, the pilot reduced the risk to his passengers and damage to the aircraft to an absolute minimum. After recovery, it was found that the only damage to the aircraft involved the propellers and various protuberances under the fuselage, such as pitot tubes and radio aerials.

● Shortly after take-off, the pilot of a Beech Bonanza selected the landing gear up. He heard the motor operate briefly then stop. The red gear up light did not illuminate and the mechanical indicator showed the nose gear to still be extended.

Being unsure of the exact position of the gear, the pilot advised Sydney Flight Service of the problem and sought the assistance of another aircraft which was operating in the area. Occupants of the other aircraft indicated that the Bonanza's gear appeared to be down and locked.

When the pilot conducted a trouble shooting check, he found the landing gear motor circuit breaker had popped. Further checks revealed that the emergency extension handle was engaged. One of the passengers was holding a camera tripod which had apparently bumped the handle. With the handle engaged the landing gear motor had stalled causing the circuit breaker to pop.

After resetting the breaker, the pilot was able to operate the gear normally. The aircraft then continued on its flight to Sydney.

● A Beech Baron had joined the circuit and when the speed reduced to 130 knots the pilot selected the landing gear down. As well as the normal noises associated with the landing gear extending, the pilot heard 'a dull crack like the sound of a cover flap opening'. Because the aircraft had recently undergone maintenance including the fitment of some landing gear parts, he suspected that some of the parts may have been a tighter fit than before.

The gear down indicator checked normal and on final approach, after receiving a landing clearance, the pilot again checked that the gear was indicating down. The aircraft was flared, touched down smoothly and all appeared normal.

As the speed reduced, the left wing dropped slowly and the pilot realised that the gear was collapsing. He tried stopping the aircraft using light braking but it did a gentle ground loop to the left through 180 degrees and came to rest.

It was subsequently determined that the left main gear actuating rod failed early in the extension cycle and the left gear remained only partly extended. Because the gear warning lights are not actuated by the gear legs, but by the position of the gear motor actuating arm, the pilot did not receive any visual warning of the unsafe condition of the left main landing gear.

Fortunately the damage to the aircraft was not extensive and there were no injuries suffered by the two occupants. The accident does however highlight the point that the pilot was not fully familiar with the landing gear system. Had he understood the operation of the indicating lights he may have been more concerned about the noise he heard. If so he could have had the gear checked by visual observation and then have been prepared for an abnormal landing. The accident occurred at a controlled aerodrome equipped with rescue and fire fighting facilities but these had not been alerted prior to the aircraft landing.

● A Cessna 310 was on descent to destination. With the airspeed indicating between 150 and 160 knots, the pilot lowered the landing gear. When a nosegear down light was not forthcoming, the pilot recycled the gear three times but still failed to obtain a nosegear down and locked indication. Following a manual extension by the pilot, ground observers confirmed that the nosegear was only partly extended.

A Distress phase was declared and after the emergency services were positioned, the aircraft touched down on the mainwheels. The nosegear folded back into the well and the aircraft slid to a stop. None of the four occupants was injured.

Subsequent specialist examination of the buckled nose gear main drive tube resulted in the conclusion that the tube had failed because the landing gear was selected down at a speed in excess of the 141 knots gear limiting speed.

The aircraft under discussion in this article represent nearly 40 per cent of more than 1100 general aviation aircraft on the Australian register which are fitted with retractable landing gear. It is not surprising therefore, that they feature prominently in reports of accidents involving landing gear collapse or a wheels up landing. They are not more susceptible to landing gear problems than others, as accident involvement remains approximately in proportion across all types and models.

However, as there are so many aircraft in this particular group it is well worth looking at them collectively. They share a similar type of landing gear system, and the design and operation is essentially the same. In discussing the system we shall differentiate between the two makes wherever possible. Ensure that you resolve any doubts by referring to the Owner's Manual or Pilot's Handbook for the appropriate type.

Description of the system

Mechanical

The diagram shows that the heart of the system is an electric motor and gearbox located in the centre section of the wing/fuselage, under the cabin floor. The output from the gearbox operates pushrods to each main gear and the nose gear. Also fitted to the gearbox is a manual hand crank for use if electrical operation fails. It should be noted clearly that the gearbox and pushrods are utilised for both the electrical and manual operation of the landing gear. The handle for the handcrank is located in the centre of the aircraft cabin floor, just behind the pilots' seats and the main spar in Beech aircraft, and just below the right front edge of the pilot's seat in Cessna aircraft.

The landing gear legs are each mounted on a pivot shaft and are raised and lowered by action of the pushrods which are connected to the geometric down lock on each leg. There is also a mechanical uplock fitted to each leg. The nosegear is sometimes fitted with a mechanical indicator, visible at the front of the cockpit.

Electrical

The landing gear is controlled by a switch on the instrument panel. The gear position indicator lights are adjacent to the selector switch and, for gear down, show one or three green lights. The other light indications vary from one model to another as follows:

Make/Model	*Gear up*	*In transit/unlocked*
Beech 33, 35, 36, 55, 95	Red	None
Beech 58, 60	None	Red
Early Cessna 310	Red	None
Later Cessna 310, 340	None	Red
Cessna 320	Amber	None

It is possible that individual aircraft could have different arrangements. Before attempting to operate any aircraft ensure that you know what indicating system is fitted to that individual aircraft and what each indication means. The lights are usually dimmable and fitted with a press-to-test function.

If the throttle is retarded below about 12 inches Hg manifold pressure and the gear is retracted, a warning horn in the cockpit will sound intermittently.

A safety switch on one of the main gear legs opens the control circuit when the strut is compressed thus preventing inadvertent retraction of the gear with the aircraft firmly on the ground. Circuit breakers protect the motor and the visual and aural warning and control systems.

Operation of the system

Normal

Before flight the emergency lowering handcrank should be checked to ensure that the handle is correctly stowed. This action disengages the handle from the gearbox worm and stops the handle rotating when the landing gear is operated electrically. Injury to occupants and damage to the gearbox can arise if the landing gear is operated electrically with the handcrank engaged and could lead to a total failure of the gear system.

With battery power on and the gear down, the green light(s) should be illuminated, and the warning horn silent. Any other gear indicating lights can be checked by the press-to-test function.

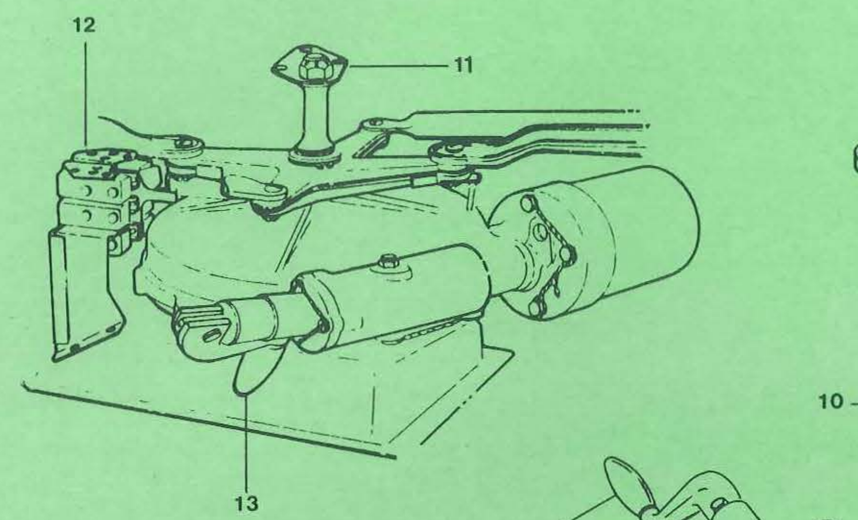
After take-off, when the aircraft is well clear of the ground, the selector switch is raised to the UP position. Electrical power is supplied to the gear motor which turns the gearbox actuator arm. Simultaneously, the down lock on each leg is unlocked by its pushrod. The green light(s) extinguish and the gear retracts. If fitted, the in-transit light illuminates.

Towards the end of the retract cycle the landing gear doors, which remain open while the gear is extended, are closed mechanically, the uplocks engage and the motor is shut off by a travel limit micro-switch on the gearbox. At that time the transit light extinguishes and/or the gear up light illuminates.

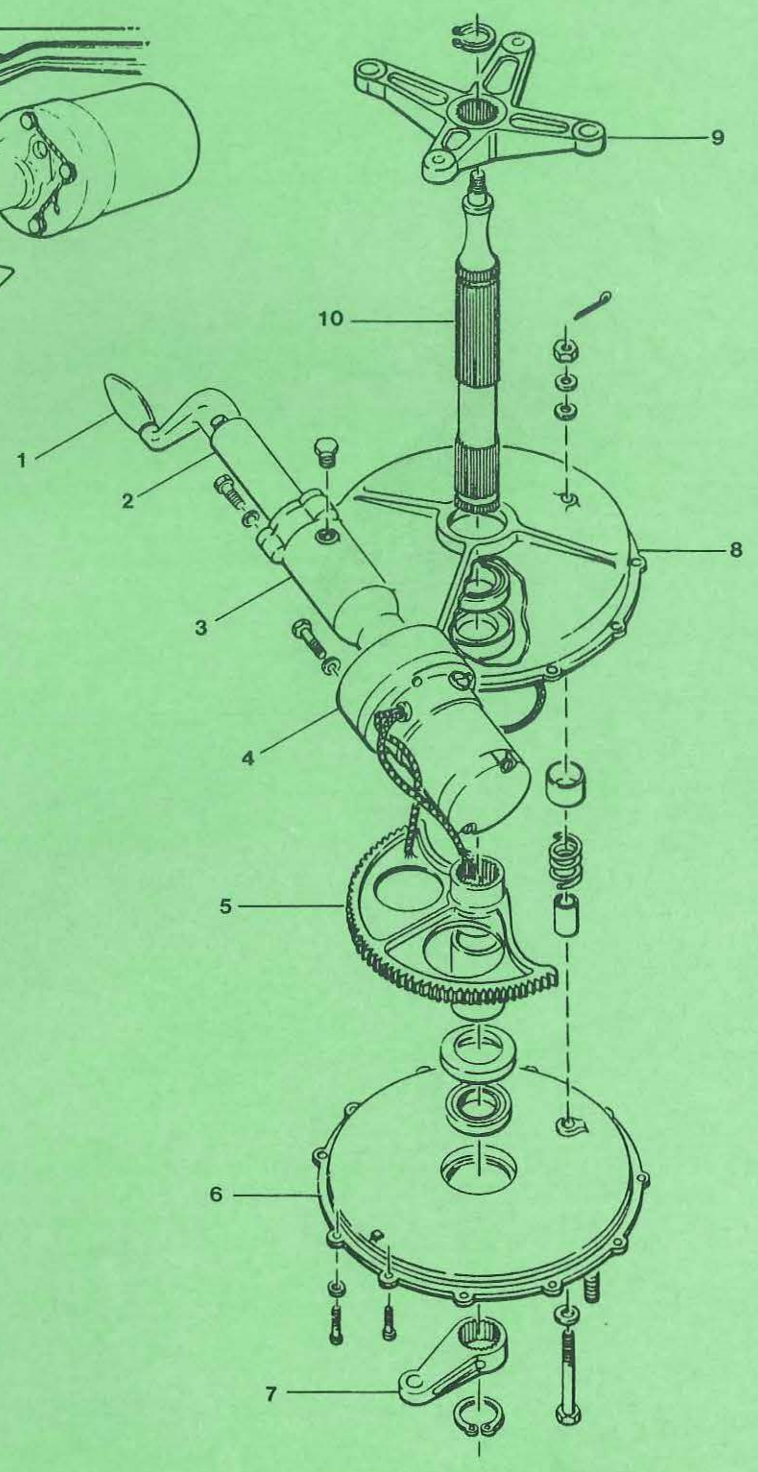
The extension cycle is the reverse of the retraction cycle.

Emergency lowering

The manual extension of the landing gear is described in the Emergency Procedures section of the appropriate Owner's Manual or Pilot's Handbook; however, it will be useful to discuss this procedure more fully than given there.



General view of the landing gear actuator assembly



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Exploded view of the actuator assembly

Diagrams from the Illustrated Parts Catalogue for the Beechcraft Baron 58P

- Circuit breaker, check IN first with gear selector DOWN. If the gear does not extend, pull OUT. This will prevent electrical power operating the gear motor while the handcrank is being used, thus avoiding the possibility of damage to the gearbox and injury to the person operating the handcrank.
- Landing gear selector switch, DOWN (Beech) or NEUTRAL (Cessna). In the unlikely situation that an electrical fault could cause power to bypass the circuit breaker and drive the gear motor, it will not be driven in the opposite direction to the handcrank thus preventing damage to the gearbox.
- Engage the handcrank
  By lifting the handle on its pivot, the handcrank shaft engages the worm gear in the gearbox.
- Turn anti-clockwise (Beech) as far as possible (approximately 50 turns). This winds the landing gear down. If the handle is turned clockwise, the gear will be retracted. The opposite direction of rotation applies for Cessnas.
- Fifty turns is approximately the total required to extend the gear from the fully retracted position. If a failure occurs in an intermediate position fewer turns will be required to reach the fully extended position. It is essential that the handle is turned in the correct direction until it will turn no further.
- If the electrical system is operative, check the landing gear position lights and the warning horn after ensuring that the circuit breaker is in. Also check the mechanical nose gear indicator, if fitted.
- Disengage the handcrank.
  Note: Always keep the handcrank handle stowed when not in use. This will prevent inadvertent engagement if the handle is accidently knocked.

Do not retract the landing gear manually. The manual extension system was not designed to cope with the stress imposed by trying to raise the landing gear. The weight of the gear may cause a failure of the handcrank mechanism if retraction is attempted thus preventing possible future extension prior to landing. If the landing gear fails to retract after take off, select it down, check it by whatever means are available and land.

System limitations — malfunctions

There are several factors which limit the operation of the landing gear system and should be understood by the pilot.

Gear position lights — Beech aircraft, except 60 series

The gear position lights are operated by micro-switches mounted on the gear box. They show the position of the gear box actuator arm, **not** the position of the gear legs. It is possible to obtain 'down and locked' lights even though the landing gear, or part of it, is not fully extended. The nose gear mechanical indicator overcomes some of this problem. Visual inspection from the ground will indicate if the main gear is down. Do not rely on noises or trim changes of the aircraft to ascertain the position of the landing gear.

Manual extension

Always comply fully with the emergency procedures printed in the Owner's Manual and refer to any placards fitted to the aircraft. Practice the procedure before you need it in an emergency.

Early retraction

If the landing gear is selected up before the wheels are clear of the ground it is possible to bend one or more of the operating pushrods. If this is not too severe, the gear will probably retract normally, but when extended it will not lock down. As previously explained, because the micro-switches are on the gearbox of most Beech aircraft the gear down light indications will be normal but the nosegear mechanical indicator will not show fully down if the nosegear pushrod was bent. Another consequence of bent pushrods on all makes and models can be the failure to operate the electric motor cutout limit switch; this can result in serious gearbox damage. If the gearbox is damaged the handcrank will obviously be useless.

As there is no inflight cure for this situation if it arises, the pilot will be faced with an emergency landing. In this case prevention is the answer — do not retract the gear until the aircraft is well clear of the ground. If you suspect that the gear may have been retracted early, perhaps damaging the mechanism, declaring an emergency and proceeding to the nearest controlled aerodrome will allow you to at least obtain a visual inspection by the control tower before landing; emergency services can then be standing by.

Late extension

If the landing gear has not been extended by late final approach, and the pilot recognises the situation in time, he should commence a go-around. If this is not possible, it is probably better to leave the gear retracted and minimise damage to the aircraft. Landing on a partly extended landing gear will result in a gear collapse and more damage than landing on the undersurface of the wing and fuselage.

Electrical failures

These usually occur when the load on the system is highest i.e., during the retraction cycle. If a total electrical failure occurs you may initially think that the retraction cycle was completed as there are no light indications. Fluctuating or zero reading fuel gauges and other electrically powered instruments will confirm a total electrical failure. If the failure occurs during the retraction cycle the handcrank will not require 50 revolutions to obtain the gear down and locked.

Wind it in the appropriate direction as far as possible and, if electrical indications are not restored, try to obtain a visual check of the gear before landing. Always use the mechanical nosegear position indicator, if fitted, to determine the nosegear position.

Initial actions if an electrical failure is suspected will, of course, be to check all circuit breakers, the ammeter and other applicable indicators.

Mechanical failure

If during gear extension or retraction strange sounds are heard that are considered to be associated with the gear system do not assume that, because the indicating lights appear to be normal, the system is fully operable. On extending the gear again consideration should be given to obtaining a visual confirmation of the landing gear position.

General consideration

Never intentionally silence the landing gear warning horn. If repeated sounding of horn is distractive, such as during periods of dual instruction, the instructor should conduct a comprehensive briefing prior to beginning the exercise. If an unsatisfactory situation arises during flight, he should take over control, correct the situation and rebrief the pupil. Solo pilots should **never** silence any warning alarms.

If at any time the integrity of the landing gear is in doubt, treat it as unsafe, declare an emergency and obtain the maximum possible assistance.

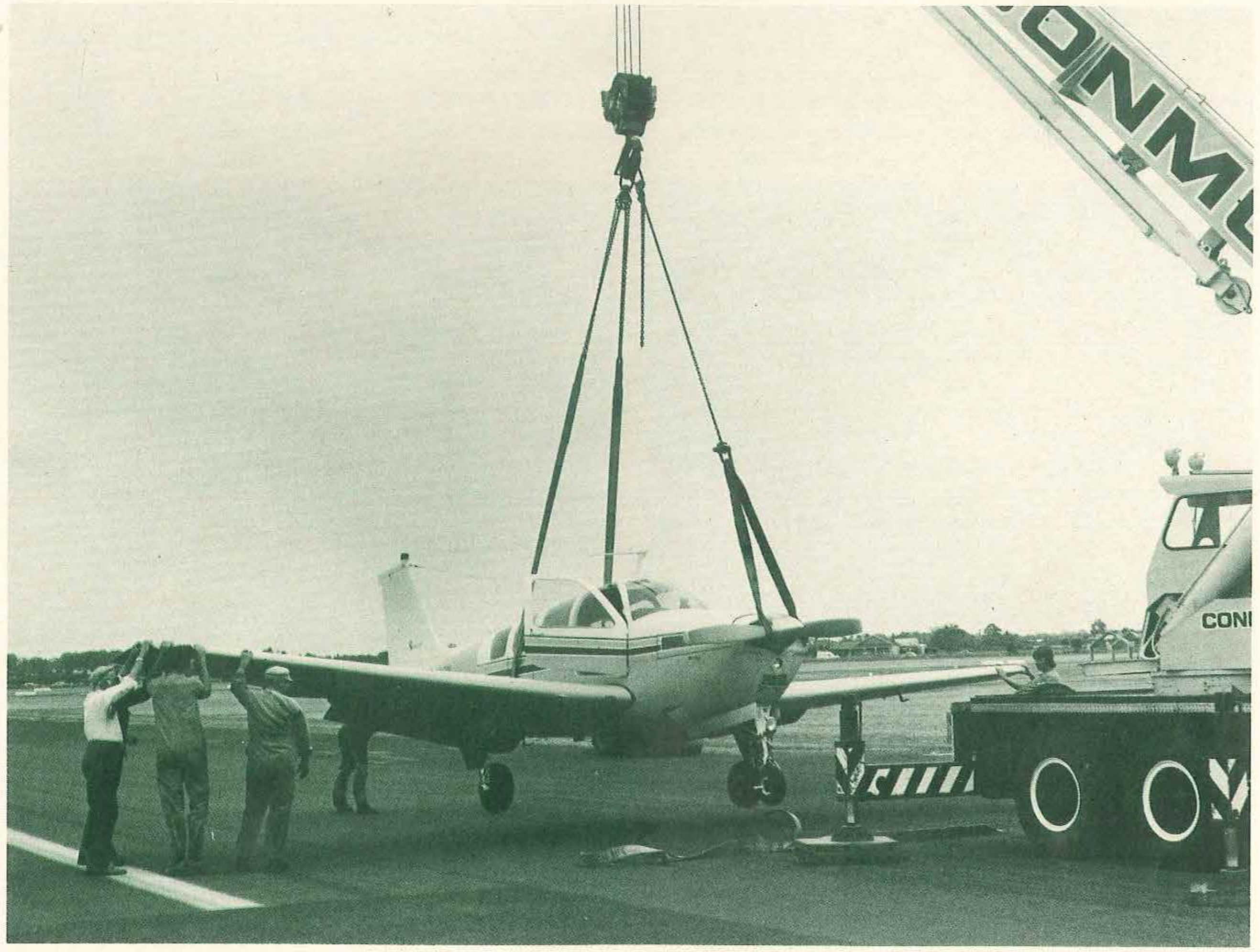
Do not panic. History shows that gear up landings do not result in excessive damage to the aircraft or risk to the passengers, particularly if the odds have been stacked in your favour.

Prevention of inadvertent wheels-up landings

The preceding information has been mainly directed at overcoming problems associated with mechanical failure. Another major cause of wheels-up landings is the pilot forgetting to lower the landing gear. We recommend the following tried and proven procedures to prevent inadvertent wheels-up landings or inadvertent retraction after landing:

- Carry and use a comprehensive checklist.
- On downwind leg, or at the final approach fix inbound, make it a habit to **complete** the prelanding checklist. This will ensure that action has been taken to lower the gear, and it increases your awareness so you can recheck the gear indicators before landing.
- After selecting the gear, check the indicators. This applies to any control in the aircraft e.g., after selecting the boost pump on, check the fuel pressure.
- Complete the landing roll and turn off the runway before operating any levers or switches, unless good operating practice calls for such action. Doing this will ensure that the landing gear strut safety switch will be actuated, thus deactivating the retract system. After rollout, you will be more composed and less likely to misidentify switches and levers. Too often the landing gear is retracted instead of the flaps when the aircraft was on a long runway that did not require the maximum braking effort after touchdown.

Learn as much as you can about the aircraft you are flying. Knowledge is your primary asset in overcoming undesirable situations ●



Fuel starvation in Hughes 500 helicopters: missing fuel tank vent fairing

The pilot had planned a ferry flight in a Hughes 500 helicopter from Kununurra to Derby, in north western Australia, a distance of 306 nautical miles. The estimated elapsed time for the flight was 170 minutes with the fuel endurance nominated as 260 minutes.

Fuel carried on the aircraft consisted of 240 litres usable in the aircraft system and about 200 litres in an unapproved, auxiliary fuel system which consisted of a 200 litre drum strapped to a wooden cradle with two electric fuel pumps attached to it. The assembly was placed on the floor in the rear passenger compartment and loosely restrained by two cables attached to floor hard points. The pumps were connected by hose to a fitting on the aircraft tank filler neck inside the cabin and were electrically powered through the utility power switch on the pilot's instrument panel. They transferred fuel from the auxiliary fuel tank into the aircraft tank.

After departing Kununurra the flight proceeded normally for about two hours. The pilot then selected on the auxiliary fuel system and the flight continued without incident for another 25 minutes. At this time, as the aircraft approached Derby at about 1000 feet altitude, the engine failed. The pilot commenced an autorotation approach at 60 knots to the only clear area available. He reduced groundspeed to zero about 10 feet above the clearing and then descended vertically, attempting to cushion the landing with the remaining rotor RPM.

Touchdown was heavy, the right skid broke and the helicopter rolled slowly to the right, coming to rest on its side. After turning off the fuel and electrical switches the pilot evacuated the wreckage. Later, when he felt assured that there was no risk of fire, he returned to the cockpit and was able to advise Derby Flight Service Unit, by radio, of his situation.

Subsequent examination of the wreckage revealed that the two section, bladder type, aircraft fuel tank had collapsed and contained only one litre of fuel. There was no evidence of fuel leakage from the aircraft system nor of spillage from it after the accident.

The auxiliary fuel system was still inside the aircraft and contained about 140 litres of fuel. There was evidence in the wreckage and on the surrounding ground that fuel had spilled from the auxiliary fuel tank vent after the aircraft had come to rest on its side. It was also found that the wires supplying the electrical power to the auxiliary fuel system were broken, however, it could not be positively established when these breaks occurred.

The major part of the plastic cover over the aircraft fuel system vent, known as the fuel tank lower vent fairing and normally located on the underside of the fuselage, was missing. A detailed search of the wreckage and surrounding area failed to find it. Examination of the fracture surfaces of the remaining fragments still attached to the aircraft indicated that the fairing had been missing for some time.

Consideration of the expected fuel consumption rate for the flight gives some insight into the cause of the engine failure. The aircraft fuel gauge is calibrated in pounds and this unit will be used in the following discussion. The total capacity of the aircraft fuel system is 412 pounds of Avtur. In flight, the pilot anticipated a consumption rate of 164 pounds per hour at cruise power settings of 50 psi torque and 700 degrees Celsius turbine outlet temperature. Allowing about 10 pounds for ground running and hover, prior to departure, the total expected endurance from the aircraft fuel system was 147 minutes.

The pilot reported that he selected on the auxiliary fuel system two hours after departure. At the planned fuel consumption rate this should have left about 75 pounds of fuel in the aircraft tank, however, the pilot reported that there was 150 pounds indicated and this reading did not change after the auxiliary system was selected on. The engine failed about 25 minutes later. This was nearly coincidental with the consumption of the total usable fuel in the aircraft tank at the anticipated consumption rate.

It is obvious that the fuel remaining indication of 150 pounds, reported by the pilot, was incorrect and the pilot was lulled into a false sense of security when the indication did not change after he selected on the auxiliary fuel system. He interpreted the static reading of 150 pounds to indicate that the engine was consuming fuel at the rate it was being delivered. In fact, it was established after the accident that the auxiliary fuel pumps had about 50 per cent more output than the engine fuel consumption.

Following this and two previous accidents involving Hughes 500 helicopters suffering fuel starvation, the manufacturer was contacted to ascertain the effect of losing the fuel tank vent fairing. Based on wind tunnel tests conducted very early in the development of the aircraft it was determined that, without the fairing, the differential pressure across the fuel cell bladder could be expected to cause it to collapse as fuel is drawn from the tank and would at some point prevent the float arm of the fuel level sender from dropping, thereby giving an erroneous fuel remaining indication. The manufacturer further advised that because of the problem of blockages to the vent they introduced a

Underside of the wreckage showing the location of the lower vent fairing

Close up view of the vent fairing fragments still attached to the aircraft

The auxiliary fuel system which was fitted to the helicopter modification which adds another vent below the right hand door. This modification is not mandatory and was not fitted to any of the three aircraft involved in accidents in Australia.

The fuel tank vent fairing extends away from the skin of the aircraft and is a positive head device that prevents the collapse of the bladder. The collapsed bladder condition can also arise if the fuel vent becomes clogged with mud or dirt, insect nests or any other obstruction. Tests conducted by the manufacturer proved, however, that the entire fuel supply can still be consumed except for about the last litre. The Daily Inspection schedule requires that the vent fairing be inspected to ensure it is free from obstructions. Although not specifically stated, such an inspection clearly implies that the fairing be in place and undamaged.

From the evidence available it is concluded that during the flight under discussion the auxiliary fuel system did not function and the pilot did not detect this, partly because of the incorrect fuel remaining indications. The incorrect fuel indications resulted from the loss of the fuel tank vent fairing causing a collapse of the aircraft fuel tank.

Some of the factors which combined to cause this accident were:

- Loss of the fuel vent fairing prior to this flight commencing
- Erroneous fuel remaining indication
- Failure of the auxiliary fuel system to supply fuel
- Engine failure following fuel starvation, over unsuitable terrain.

There were a number of ways that the accident might have been avoided:

- Detection of the missing fuel vent fairing during the preflight inspection should have resulted in the broken fairing being replaced. The loss of the fairing in itself did not jeopardise the safety of the flight, but the incorrect fuel indication which resulted was a factor in the accident.
- Although the reason for the auxiliary fuel system failing to operate was not positively determined, there is a high degree of probability that failure of the electrical cable had occurred. Approval of the auxiliary fuel system would have ensured that it was properly restrained and that the wires providing the electrical power to the pumps were properly routed and protected to avoid damage.
- More careful monitoring of the fuel consumption should have detected the error in the fuel remaining indication. At the time the auxiliary fuel system was selected on there was twice as much fuel remaining indicated as there should have been, at the anticipated consumption rate of the engine.
- Better knowledge of the auxiliary fuel system capability would have allowed the detection of the non-operation of the system which was capable of providing about 80 pounds of fuel per hour more than the engine consumption rate. By carefully monitoring the fuel remaining gauge, after selecting on the auxiliary system, the pilot should have detected that the fuel remaining indication was not increasing. This would have provided him with time to conduct a precautionary landing before expiration of the fuel from the aircraft tank.

The main safety lesson of importance to pilots and operators of Hughes 500 helicopters is to ensure that the fuel tank vent fairing is free from obstructions and **undamaged, prior to flight. Although not a mandatory modification, fitment of the additional vent would appear to be a useful safeguard. It could be argued that there is inadequate emphasis in the various manuals of the importance of the fairing, however, the very inclusion of a specific check in the manuals denotes some measure of importance.**

Although this accident report concerns particular components on a particular aircraft, the lessons to be learned apply to all aircraft and all pilots. Ensure that you know all about the aircraft you are flying, particularly those items which are highlighted in its operating instructions and manuals, and think about what is happening all the time, not just occasionally. Finally, before making any selection or operating any control, consider the existing situation, anticipate the changes that will occur and ensure that those changes **do** occur. If not, seek out the reason for any variation ●

From the incident files

Lake LA-4 nose gear retraction

There have been several occurrences over the last few years involving a problem with the retraction of the nose gear on the Lake amphibian. This aircraft has a castoring, non-steerable nose wheel which retracts forward into a well. Under normal circumstances, and provided the shimmy damper is not overtightened, the wheel aligns itself fore-and-aft during retraction. If, however, this does not occur and retraction is attempted with the wheel turned to the extreme left or right position, it may jam against the wheel well door.

This extreme displacement prior to retraction, although infrequent, may occur when the aircraft enters the water from a beach or ramp, particularly if the hard surface is rough. Pilots should be aware that the situation may arise, and it is important that use is made of the gear inspection mirror on the left hand float to ensure that the nosewheel is aligned fore-and-aft before attempting retraction ●

Do you raise the flaps during the landing roll? Why?

There appears to be a rather widespread misunderstanding amongst general aviation pilots about the need or otherwise to raise the flaps during the landing roll. Too many pilots automatically raise them without thinking about the need to do so. Consequently there are a number of accidents reported in which the pilot of a retractable landing gear aircraft raised the gear instead of the flaps.

This bad habit apparently begins during the early training days on fixed gear aircraft and carries on to more sophisticated types. During transition to retractable gear aircraft the pilot who has developed this habit immediately places the safety of the aircraft in jeopardy. Add to this the difference in manufacturers' cockpit layouts and the risk of an accident becomes even greater.

The following brief report is a typical example of the inadvertent gear retraction type of accident.

The pilot had purchased a Beech 95 Travel Air and prior to taking delivery of it had arranged for the necessary endorsement training. When this was completed he flew the aircraft to a nearby aerodrome to fit a new battery and to refuel.

He submitted a flight plan for the return trip to his home base which was a licensed aerodrome with an 1100 metre sealed main runway. The flight was without incident and the pilot joined the circuit to land on the easterly runway. Prelanding checks were completed and the aircraft touched down with full flap selected.

The pilot reported that when the aircraft's speed had reduced 'to about 30 knots, towards the end of the landing roll' he leaned over to the right and 'without thinking, flipped the gear lever up'. He immediately realised what he had done, however, the nosegear collapsed, the propellers contacted the runway and the aircraft slid to a stop on the nose section and partly retracted main wheels.

During the investigation the pilot, who had nearly 1000 hours experience, indicated that during his 10 years ownership of a single engine, fixed gear taildragger, he had developed the habit of selecting the flaps up early on the landing roll. The pilot had subsequently flown a few hundred hours on Piper twins before purchasing the Beech. The flap and gear selectors are reversed in these aircraft. He admitted that during his endorsement on the Travel Air he had reached across to retract the flaps on the landing roll but was in fact reaching for the gear lever. The instructor had warned him to pay more attention to what he was doing.

Examination of the runway revealed that the propellers first contacted the tarmac 383 metres from the threshold and the aircraft stopped 165 metres further on. Information gained during the investigation of many similar accidents suggests that, from the distances involved on this occasion the unintentional gear retraction more likely occurred at a speed of 50-60 knots which is hardly near the end of the landing roll.

It is obvious from the accident report that the pilot suffered from too many years preconditioning to have avoided this accident. Unfortunately, the experience during his endorsement training was inadequate to overcome this preconditioning.

To try and help pilots prevent this bad habit from developing, we shall look at the requirements for landing performance, the manner in which it is determined and the presentation of the landing performance information to the pilot.

Documentation

There are basically three publications to which a pilot may refer to obtain performance information for the aircraft he is flying. These are:

The owner's manual
The pilot's operating handbook
The flight manual

The owner's manual and pilot's operating handbook are produced by the aircraft manufacturer. They include performance information applicable to an aircraft of the same make and model, in good condition, flown by a test pilot, using average piloting techniques. The information in these publications should be used only as a guide. The approved take-off and landing information, together with the limitations applicable to the aircraft, and information on weight and balance, are contained in the flight manual produced by the Department of Transport and issued for each aircraft on the Australian register.

It is a requirement of the Air Navigation Regulations that the flight manual be carried in the aircraft at all times. From the information contained in it a pilot can determine the suitability of an aerodrome for the operation of his aircraft, or the maximum weight at which he can operate the aircraft from a given runway or strip.

Establishing the flight manual landing performance

The landing performance given in the flight manual is based upon the demonstrated performance of the aircraft type. The technique used in establishing the landing distance is such that the aircraft is flown at an approach speed of 1.3 times the stalling speed, in a glide, through the 50 foot screen height above the runway threshold. After touchdown, maximum wheel braking is used to bring the aircraft to a stop. Retraction of flap is not allowed.

The landing weight chart is based on the use of a short, dry grass surface but is also applicable to sealed and gravel strips. The landing performance is demonstrated for the full range of aircraft weight, ambient temperature, pressure altitude, wind component and runway slope.

After the landing performance has been demonstrated it is factored by 1.15 for aircraft 2000 kg in weight and below, to 1.43 for aircraft above 4500 kg, with linear variation in between. The purpose of factoring the demonstrated performance information is to allow for variations to be expected, because of age and condition, between aircraft of the same make and model, and variations in pilots' handling techniques and abilities.

Example of landing performance

We will use the landing weight chart for the Beech Travel Air to illustrate. The approximate conditions pertaining at the time of the accident were:

Pressure altitude	2000 feet
Temperature	20° Celsius
Aircraft weight	1600 kilograms
Wind component	+ 5 knots
Runway slope	zero

From the landing weight chart the landing distance required is 490 metres. Therefore, on the landing when the accident occurred, there was a margin of 610 metres available. If we ignore the factoring, the demonstrated landing distance from 50 feet over the threshold to stop becomes approximately 425 metres, which provides a margin of 675 metres. If we go further and assume that the aircraft was to touch down on the threshold, the demonstrated landing distance would be further reduced. Quite obviously, the pilot had absolutely no reason, on this landing, to be concerned about the braking performance of his aircraft considering the distance available in the conditions prevailing, and therefore had nothing to gain from retracting the flaps.

Manufacturers' recommendations on flap retraction

Examination was made of the owner's manuals and pilot's operating handbooks for a wide range of general aviation aircraft built by the three major U.S. manufacturers. The recommendations for flap retraction on landing vary, both between different makes and the different models produced by each company.

In general the manufacturers state that the flaps should be retracted, after all wheels are on the ground, when maximum braking efficiency is required. In the majority of manuals there is no requirement to retract the flaps during a normal landing, however, nearly all of them referred to this procedure in short field landings. We will discuss short field landings later.

Some manuals went as far as recommending that the flap should not be retracted until the aircraft had left the active runway. Cessna suggests that, for the 310 and larger aircraft, 'the flap aids in decelerating the aircraft', while Piper, in the Seneca manual, states that 'this will avoid reaching for the gear handle instead of the flap handle by mistake, and will permit full attention to be given to the landing and landing roll'.

Short field landings

In preparing this article, consideration was given to the definition of a short field landing. The consensus of opinion was that a short field landing was one where the landing distance available was about the same as the landing distance required, in the conditions prevailing. For example, from the Beech Travel Air landing performance chart, in ISA conditions, nil wind and maximum landing weight on a level runway, the landing distance required is again 490 metres. This is considerably less than the runway length available at any general aviation or other government aerodrome, and the vast majority of licensed aerodromes and training ALAs. However, a pilot is likely to encounter strips of such a short length at other ALAs.

It becomes obvious from the preceding paragraph that a lot of pilots in the general aviation industry will be most unlikely to need to operate in accordance with short field landing techniques during their normal operations. When it does become necessary to operate into a short field, such pilots should ensure that their technique is up to standard and their flying is more accurate than that needed to land on a 1500 metre sealed runway.

Recommendations

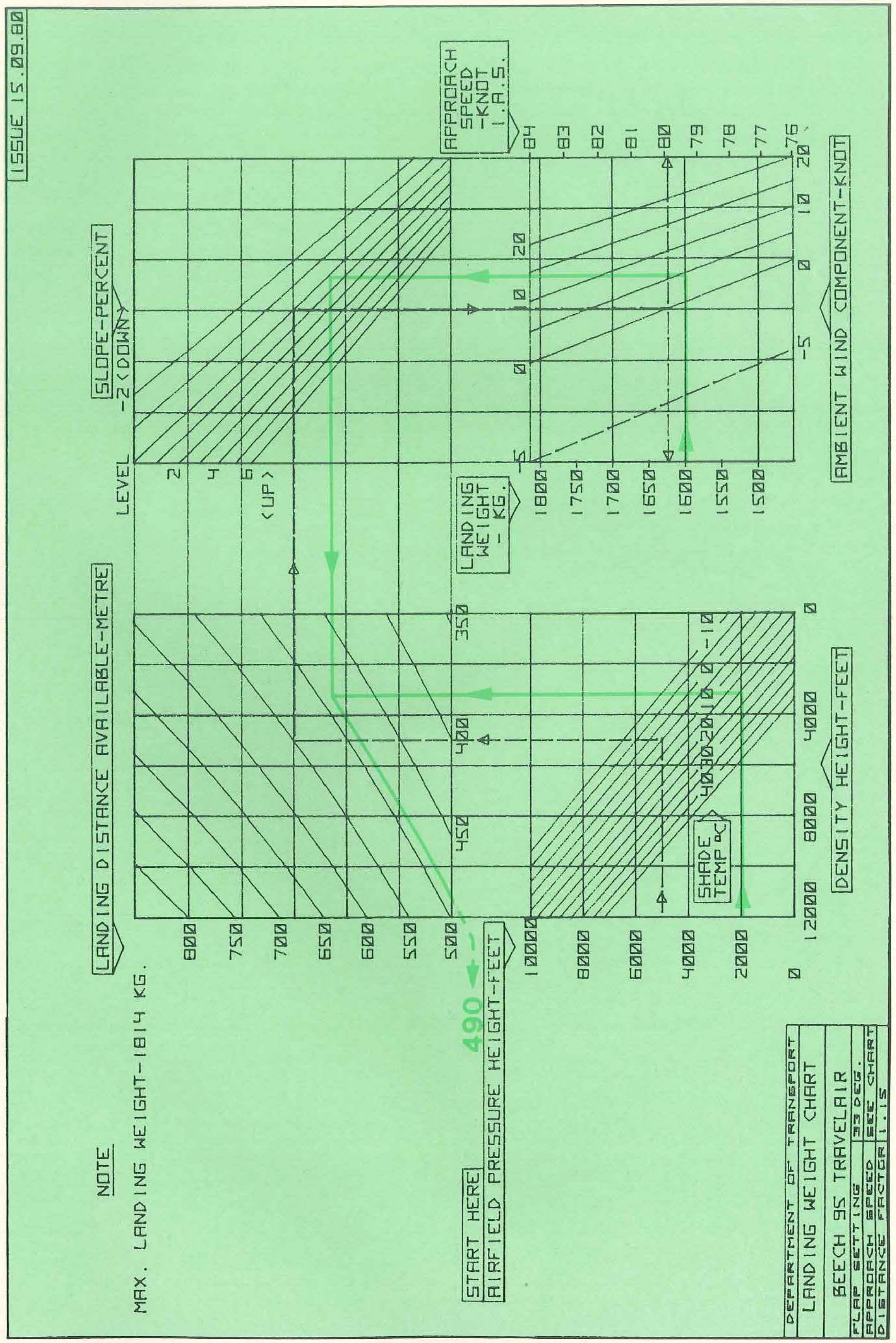
From the flight manual establish the landing distance requirement for the worst conditions you are likely to encounter. For instance at maximum AUW for landing, 30°C, 1000 feet AMSL and 5 knots tailwind, this distance may be 700 metres. For longer strips, treat the landing as normal. For shorter strips, firstly double check the landing performance chart and if the strip length is about the same as the landing distance required, treat as a short field landing.

If flap retraction is considered to be necessary after touchdown prepare for it in the circuit. Plan your actions, positively identify the flap lever and recite the procedure in your mind. After touchdown, again positively identify the flap lever after all wheels are on the ground and only then select the flaps up.

If you do not regularly fly into aerodromes with short strips it may be advisable to undergo a check ride with an instructor before undertaking such an operation.

During training, or a check flight, get the instructor to take you to an ALA with a short strip. Six hundred metres of gravel strip looks considerably different from 1200 metres of grass or sealed runway. You will gain a far better appreciation of the limits of your own techniques and ability if you practice at a suitable location, with an instructor who can correct any problems.

The landing roll is not the time to be dividing your attention between controlling the aircraft and conducting unimportant tasks. Leave your after landing checks until you have turned off the runway and it is unlikely that you will make any erroneous selections ●



Unlocked seat — loss of control during ground manoeuvring

A Cessna 180 agricultural aircraft had been used for seeding operations at a Queensland property. On completion of the day's flying, the pilot landed at the station strip and parked at the north eastern end. After a short break, he intended to taxi the aircraft about 500 yards along the strip to refuel and load some gear prior to returning to his base.

Before entering the aircraft, the pilot slid the seat back to clear away some seed from around it and the rudder pedal area. He then slid the seat fully forward and cleared away some more seed from underneath it. The pilot moved the seat fully backwards again, entered the cockpit and adjusted the seat to its normal fore/aft position. Because he was only intending to taxi a short distance he did not check that the seat adjustment had locked correctly.

After starting the engine, the pilot turned the aircraft sharply to the right using about half throttle and right brake. As it lined up on the strip the pilot applied hard left brake to stop the aircraft turning further, at which time his seat slid backwards.

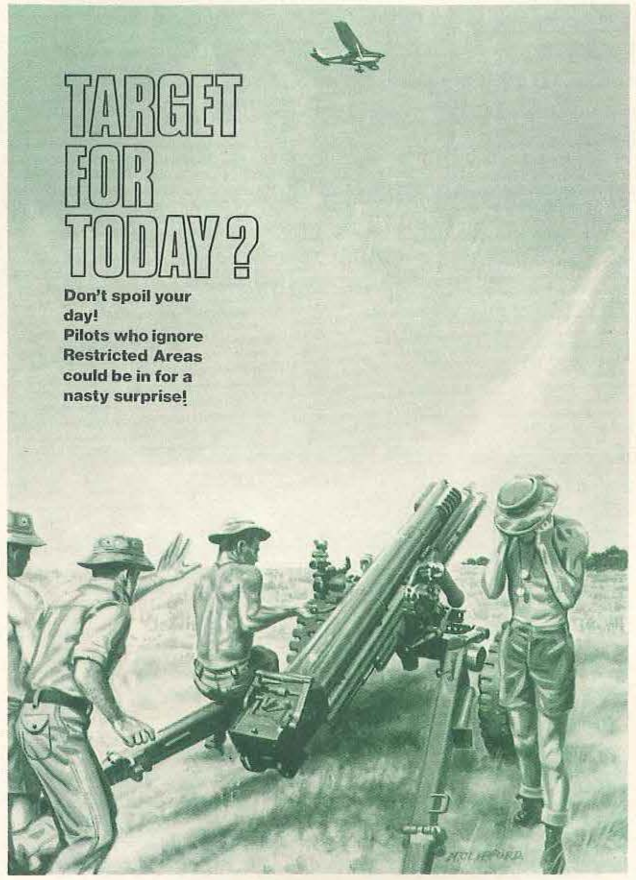
Under the influence of the high power setting and the wind coming from the left, the aircraft swung back across the strip. The pilot struggled to pull himself up but before he could operate the throttle or mixture controls the aircraft was sliding sideways along the strip. The right hand landing gear struck a mound and folded under the fuselage. After the aircraft slid to a stop on its right hand side, the pilot turned off the fuel and electrics, and evacuated the cockpit. The aircraft suffered considerable damage.

Subsequent inspection of the aircraft revealed no defects in the seat adjustment mechanism, and it was concluded that the mechanism had not been properly engaged.

Any comment needed? ●

Note: *Some of our readers may be confused by the fact that, in spite of the substantial damage suffered by the aircraft, this occurrence was classified as an incident rather than an accident. As defined in the Air Navigation Regulations, an accident can only occur when persons have boarded an aircraft 'with the intention of flight'. Because the pilot of this Cessna 180 was merely repositioning the aircraft along the strip, the occurrence was classified as an incident.*

Flight through restricted areas



Some of our readers will remember the poster from *Aviation Safety Digest 87*. The message it contained related to aircraft entering restricted airspace when there was gunnery practice in progress. Fortunately, to date no aircraft has been damaged in Australia because of this, mainly because of the vigilance of the range safety officers in charge of firing, who have called for a check fire until the intruder passed.

In 1979 there were 21 reported cases of aircraft entering restricted areas associated with ground firing of guns and explosives. Of these, 13 resulted in subsequent identification of the aircraft involved but the remaining eight remained unidentified. The unfortunate part about failing to identify these aircraft is that the offender probably remains unaware of the danger to which he exposed himself, his passengers and the aircraft.

Analysis of those incidents in which the aircraft was identified did not reveal any cases of blatant disregard of safety; rather, they revealed a definite lack of understanding by the pilot of the risk involved and the way in which that risk could have been avoided. In some cases, this unnecessary exposure to risk was caused by the use of incorrect or outdated charts; in other cases a lack of adequate preflight preparation; while others involved inaccurate navigation.

In most cases, prevention is the answer and this can be achieved by adequate preflight preparation. When planning the flight, check the route on the appropriate RNC or VEC, and ascertain the proximity of restricted airspace. Refer to the AIP En Route Supplement section on Prohibited, Restricted and Danger Areas for details on vertical limits and hours of operation of the appropriate area. If the area activity is notified by Notam ensure that you request the information at briefing, or, if this is not possible, in flight by radio when approaching the restricted area. When planning an alternative route, because the direct track passes through an active area, ensure that you plan via easily identifiable check points that will ensure an adequate margin for navigational error.

If you find that you are having navigational difficulties in the vicinity of a restricted area, advise the ATC or FS station you are working at that time. It may be possible to have the ground firing stopped until your position is identified as safely clear of the area. It would be most undesirable to be the first civilian pilot in Australia to be shot down by ground fire in a restricted area.

Four of the unidentified intrusions during 1979 are described below. Were you one of the pilots involved?

On 24 February, at 1050 hours local, a blue and white Cessna type was observed to fly from south west to north east through Restricted Area 538D (Singleton, NSW). The area was active up to 9000 feet. A check fire was given immediately to all units firing on the range as the aircraft was in danger.

On 27 March, at 1610 hours local, a silver, single engine, fixed undercarriage, high wing aircraft was observed by the range safety officer to fly through Restricted Area 259A (Port Wakefield, S.A.) while firing was in progress.

On 15 August, at 1148 hours local, the range safety officer reported that a Piper-type aircraft, white with a red stripe and heading towards Moorabbin, had passed through Restricted Area 329 (West Head, Vic.)

On 19 September, at 0922 hours local, a greyish white, single engine aircraft was observed at about 200 feet AGL on a northerly heading over the range at the southern end of Restricted Area 635 (Greenbank, Qld.)

If you were the pilot-in-command of any of these aircraft you can be thankful that the range safety officer in each case performed his duties with the necessary degree of vigilance, because it is obvious that the pilot did not. If you want to avoid the risk of being hit by groundfire, be alert for active restricted areas ●

Flight safety — a team effort

The whole purpose of compiling a flight plan is frustrated unless several criteria are satisfied. Important among these are the pilot's knowledge of the obligations and limitations of his licence, adequate monitoring of the flight progress, and careful attention by Departmental officers to their duties. An incident which occurred some months ago included breakdowns in the areas mentioned above. Fortunately it also included a measure of luck which prevented the incident from becoming an accident.

The pilot planned the flight in a Cessna 310 from Albury to Adelaide via a property in north western NSW and Broken Hill. The flight was planned throughout as private category in accordance with the Visual Flight Rules. The pilot held a Private Pilot Licence without an instrument rating.

The only deviation from plan on the first two sectors occurred when the pilot had some difficulty locating the station property. This added an extra 30 minutes to the flight. Later in the afternoon he flew to another property nearby, took on about 135 litres of fuel from a drum, and departed for Broken Hill.

There was some difficulty in obtaining fuel at Broken Hill, but finally the pilot was able to arrange for 150 litres to be added to the aircraft. This was the maximum allowed to the pilot because of the shortage of Avgas. He estimated that this would give him a total of about 230 litres which would be just sufficient for the flight to Adelaide plus 45 minutes fixed reserve. While the aircraft was being refuelled the pilot attended the Briefing Office. Adelaide at that time was closed to VFR operations and required 30 minutes holding fuel because of the forecast. As it was late in the afternoon, the pilot decided to remain overnight at Broken Hill.

The next morning the pilot again attended the Briefing Office. Current area and terminal forecasts were displayed, which indicated that, while the weather would be suitable for VFR flight at first, it would deteriorate below VMC towards Adelaide. The TAF for Adelaide required 30 minutes holding fuel because of periods of reduced visibility in heavy showers and low cloud. The pilot checked the ARFORs but apparently did not check the TAF. He submitted a plan utilising the same time intervals which he had planned and submitted at Albury the previous morning.

In planning the flight, the pilot had used the RNC and RTC, and had omitted the 28 nautical mile segment between Morgan and Stonefield through misinterpretation of the information on the charts. This omission, and the use of winds of lesser strength than indicated on the ARFORs, resulted in a total planned time interval about 15 minutes less than it should have been.

The flight departed carrying only four minutes fuel margin over the erroneous flight time interval plus 45 minutes fixed reserve. The Departmental officer accepting the plan misread the total endurance figure and did not recognise the fact that the aircraft was not carrying the 30 minutes holding required by the Adelaide forecast, nor the alternate or 30 minutes holding required for a VFR flight planned to enter a capital city primary control zone.

As the flight progressed, the pilot deduced that the wind was different from that used for the plan. This was because the aircraft was about 11 minutes late at Stonefield, which he concluded was because of much stronger winds than forecast. By this time the weather had deteriorated as predicted. The pilot entered cloud at 3500 feet after passing Stonefield, and then advised Adelaide Flight Service that he had insufficient fuel to retain his reserves intact. He did not really consider diversion to suitable VFR alternatives such as Waikerie or Renmark because of the difficulty with fuel supplies there, and also because he wanted to get to Adelaide. Approach Control initially refused a clearance request from Flight Service because VMC did not exist on the planned track, however, after being advised of the aircraft's low fuel situation, a clearance was passed to enter controlled airspace and to expect radar vectoring.

Shortly after establishing contact with Adelaide Approach Control, the pilot indicated that he was having trouble avoiding cloud. The aircraft was radar vectored and descended north of the field until it became visual at about 1700 feet. It was unknown to the Adelaide controllers that during the descent the aircraft was operating in cloud with the autopilot engaged.

The pilot realised just how far he had gone into his reserves when the right engine stopped through fuel exhaustion just after the aircraft had vacated the landing runway. At that time the right fuel gauge indicated approximately 10 litres and the left gauge approximately 30 litres.

During the investigation of this incident, it became apparent that the pilot gave very little attention to the forecast weather and his flight planning. Even with the marginal fuel for the flight as he planned it, he did not ascertain the actual amount of fuel on board. He displayed a lack of knowledge concerning fuel requirements and the rules of the air affecting aircraft on VFR flights. The pilot also revealed that he had made a similar descent through cloud some months earlier. With a total instrument flight time of five hours gained during his licence training, and no instrument rating, it is probably very fortunate that the pilot had a serviceable autopilot to use, otherwise the results may have been different.

The investigation also revealed that Departmental personnel did not recognise the inadequate fuel figures indicated by the pilot on his flight plan.

Flight safety is the responsibility of everybody within the industry. Conscientious attention to his direct area of responsibility by each person should ensure complete safety, however, when individual errors occur and are not picked up by the monitoring system, they compound to the extent where safety is quickly compromised ●

IMPORTANT!

Review of free distribution list

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Comments:

Boeing 767 - 200 cover illustration (reversed for the purpose of layout.)

Basic aircraft specification

Power plant: Two Pratt and Whitney JT9D-7R4D turbofans rated at 21 656 kgp (47 700 lbs).
Fuel capacity: 58 895 l (medium range option 42 846 l) in integral wing tanks.
Performance: Max operating speed 0.86 mach; max cruising speed 506 kts at 30 000 ft; long range cruise 459 kts at 39 000 ft. Range with 211 passengers, 2740 nm at 0.8 mach
Weights: Operating weight 81 856 kg; max payload 30 708 kg; max zero fuel weight 112 592 kg; max take-off weight 136 200 kg; max landing weight 122 580 kg
Dimensions: Wingspan 47.65 m; overall length 48.5 m; overall height 15.85 m; aspect ratio 8.7 to 1; sweepback 31.5 deg.; undercarriage track 9.29 m
Accommodation: Two pilots plus optional third crew; typical mixed passenger accommodation 18 six-abreast first class plus 193 seven-abreast economy; max one-class 255 seven-abreast. Underfloor cargo hold 22 containers and 12.18m^3 bulk cargo.

Cutaway drawing key

1 Radome
2 Radar scanner dish
3 VOR/Localiser aerial
4 Front pressure bulkhead
5 ILS glidescope aerials
6 Windscreen wipers
7 Windscreen panels
8 Instrument panel shroud
9 Rudder pedals
10 Nosewheel bay
11 Cockpit air conditioning duct
12 Captain's seat
13 Opening cockpit side
14 Centre console
15 First officer's seat
16 Cockpit-roof systems control panels
17 Flight engineer's station
18 Observer's seat
19 Pitot tubes
20 Angle of attack probe
21 Nosewheel steering jacks
22 Twin nosewheels
23 Nosewheel doors
24 Waste system vacuum tank
25 Forward toilet compartment
26 Crew wardrobe
27 Forward galley
28 Starboard overhead sliding door
29 Entry lobby
30 Cabin divider
31 Port entry door
32 Door control handle
33 Escape chute stowage
34 Underfloor electronics racks
35 Electronics cooling air system
36 Skin heat exchanger
37 Fuselage construction
38 Cabin window panel
39 Six-abreast first class seating
40 Overhead stowage bins
41 Curtained cabin divider
42 Sidewall trim panels
43 Negative pressure relief valves
44 Forward freight door
45 Forward underfloor freight hold
46 LD-2 cargo containers, 12 in forward hold
47 Centre electronics rack
48 Anti-collision light
49 Cabin roof frames
50 VHF aerial
51 Seven-abreast tourist class seating
52 Conditioned air riser
53 Air conditioning distribution manifolds
54 Wing spar centre section carry-through
55 Floor beam construction
56 Overhead air conditioning ducting
57 Front spar/fuselage main frame
58 Starboard emergency exit window
59 Starboard wing integral fuel tank
60 Thrust reverser cascade door, open
61 Starboard engine nacelle
62 Nacelle pylon
63 Fixed portion of leading edge
64 Leading edge slat segments, open
65 Slat drive shaft
66 Rotary actuators
67 Fuel system piping
68 Fuel venting channels
69 Vent surge tank
70 Starboard navigation light (green)
71 Anti-collision light (red)
72 Tail navigation strobe light (white)
73 Static dischargers
74 Starboard outer aileron
75 Aileron hydraulic jacks
76 Single slotted outer flap, down
77 Flap hinge fairings
78 Flap hinge control links
79 Outboard spoilers, open
80 Spoiler hydraulic jacks
81 Rotary actuator
82 Flap drive shaft
83 Aileron hydraulic jacks
84 Inboard aileron
85 Inboard double slotted flap, down
86 Flap hinge control linkage
87 Fuselage centre section construction
88 Mid-cabin toilet compartments
89 Cabin attendant's folding seat
90 Port emergency exit window
91 Ventral air conditioning plant
92 Mainwheel doors
93 Door jack
94 Wheel bay pressure bulkhead
95 Starboard wheel bay hydraulic reservoir
96 Rear spar/fuselage main frame
97 Pressure floor above wheel bay
98 Cabin floor panels
99 Seat mounting rails
100 Overhead stowage bins
101 Cabin roof lighting panels
102 Centre stowage bins
103 VOR aerials
104 Fuselage skin plating
105 Negative pressure relief valves
106 Rear freight door
107 Seven-abreast tourist class seating
108 Rear toilet compartments
109 Cabin attendant's folding seat
110 Rear galleys
111 Overhead sliding door counterbalance
112 Rear pressure dome
113 Fin root fillet
114 Tailfin construction
115 Fin 'logo' spotlight
116 Starboard tailplane
117 Leading edge HF aerial
118 HF aerial coupler
119 Television aerial
120 Fin tip aerial fairing
121 Tail VOR aerials
122 Static dischargers
123 Rudder
124 Rudder hydraulic jacks
125 Balance weights
126 Rudder honeycomb construction
127 Tailplane centre section
128 APU intake plenum
129 Gas turbine auxiliary power unit (APU)
130 Tailcone
131 APU exhaust
132 Port elevator
133 Elevator hydraulic jacks
134 Honeycomb control construction
135 Static dischargers
136 Tailplane construction
137 Fin 'logo' spotlight
138 Tailplane sealing plate
139 Fin attachment frames
140 Tailplane trim control jack
141 Rear fuselage construction
142 Port rear galley unit
143 Curtained cabin divider
144 Door operating handle
145 Rear entry door
146 Pressurisation outflow valve
147 Bulk cargo door
148 Rear underfloor freight hold
149 Air turbine driven hydraulic pump
150 Trailing edge wing root fillet
151 Inboard flap rotary actuator
152 Inboard double slotted flap
153 Main landing gear mounting beam
154 Retraction jack
155 Inboard spoilers
156 Flap hinge control link
157 Hinge link fairing
158 Port inner aileron
159 Flap 'down' position
160 Outer single slotted flap
161 Outboard spoilers
162 Flap hinge link fairings
163 Honeycomb control construction
164 Port outer aileron
165 Tail navigation strobe light (white)
166 Anti-collision light (red)
167 Port navigation light
168 Port vent surge tank
169 Rear spar
170 Wing rib construction
171 Front spar
172 Leading edge slat segments
173 Slat guide rails
174 Rotary actuators
175 Slat operating links
176 Pressure refuelling connectors
177 Port wing integral fuel tank
178 Wing stringers
179 Wing skin plating
180 Four-wheel main undercarriage bogie
181 Mainwheel leg
182 Undercarriage leg side struts
183 Port wing dry bay
184 Inboard auxiliary fuel tank
185 Engine bleed air ducting
186 Slat drive motor
187 Landing and taxiing lamps
188 Inboard leading edge slat
189 Slat open position
190 Port engine cowlings
191 Intake de-icing air duct
192 Port engine intake
193 Pratt & Whitney JT9D-7R4 turbofan
194 Engine mounting pylon
195 Oil tank
196 Fan air exhaust duct
197 Hot stream exhaust nozzle