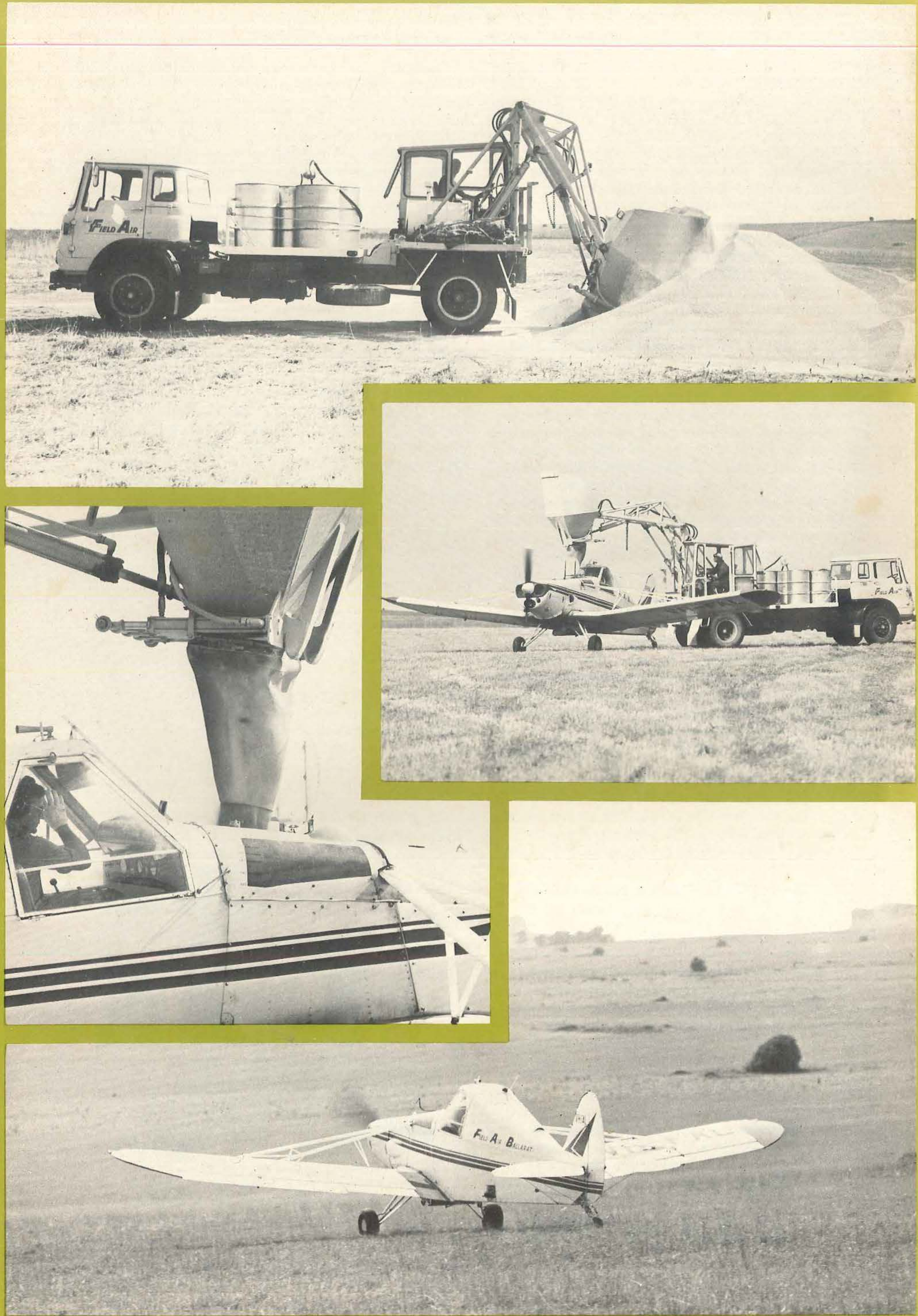

Department of Transport — Australia

108/1979

Aviation Safety Digest

Contents

Covers

Fieldair Pty Ltd is an aerial agricultural company operating from Ballarat aerodrome in Victoria. The cover photographs depict typical scenes of a Piper Pawnee aircraft engaged on superphosphate spreading operations.

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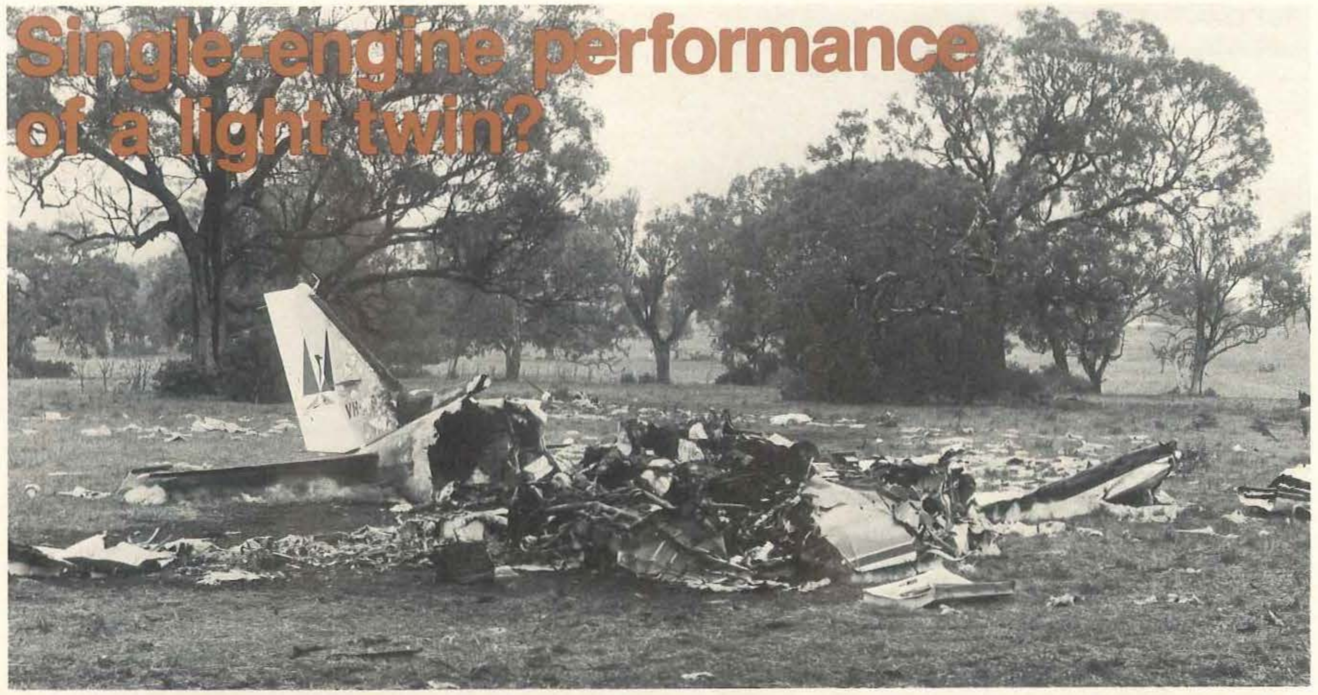
Note: Metric units are used except for airspeed and wind speed which are given in knots; and for elevation, height and altitude where measurements are given in feet.

Single-engine performance of a light twin?



At 0145 hours EST a Piper Navajo Chieftain struck the ground about two kilometres to the north-east of Melbourne Airport while attempting to return for an emergency landing. The aircraft was destroyed by impact and subsequent fire and the pilot, the only person on board, was fatally injured.

The aircraft was based at Moorabbin Airport and, late in the afternoon, it was refuelled and a pre-flight inspection was carried out. The pilot ferried it to Melbourne Airport just after midnight. While he was preparing and submitting a flight plan to Canberra and return, the aircraft was loaded with newspapers and a small quantity of other freight. On returning to the aircraft, the pilot checked the loading documents and the freight and made a walk-around inspection of the exterior of the aircraft.

The pilot started the engines and established radio communication with Air Traffic Control at 0139 hours. He was given a taxi clearance and an airways clearance for departure from runway 34. Upon request, he was granted approval to commence take-off from the taxiway 'J' intersection, some 800 metres from the southern end of the runway. He reported 'ready' at 0143 hours and was immediately given a clearance to take-off. The aircraft took off and, when it was at a height of 100 to 200 feet above the intersection of the departure runway and runway 09/27, the pilot advised '. . . got a fire — fire in the — ah — starboard engine and — ah — doing a low circuit request two seven'. ATC immediately replied '. . . make visual approach runway two seven clear to land'. Acknowledgement of this clearance was the last communication received from the aircraft.

As it passed over the northern end of runway 34 the aircraft commenced a turn to the right and gradually descended. It struck the ground in a right wing down attitude on a track of 070 degrees magnetic and an intense fire broke out. The accident site was 1.8 km to the north-east of runway 34 and 88 feet above the elevation of the northern end of that runway.

At the time of the accident the surface wind was 330 degrees at nine knots, the visibility was 25 km in passing showers, there were three oktas of stratus cloud, base 1800 feet, and six oktas of cumulus cloud, base 3500 feet. It is probable that below 1000 feet there was some wind shear, downdraughts from passing showers and intermittent moderate turbulence.

It has been calculated that the gross weight of the aircraft was 65 kilograms in excess of the maximum take-off weight and the centre of gravity was within limits.

A detailed examination of the wreckage of the aircraft revealed that the landing gear and flaps were fully retracted, the cowl flaps of both engines were midway between the open and closed positions, a considerable degree of nose-left rudder trim was selected, the right engine was closed down and the propeller feathered.

It was established that, as a result of excessively lean mixture operation, there was a hole burned through the piston rings and into the side of the no. 2 piston of the right engine. There was no evidence of fire within the engine compartment but it was apparent that the hole in the piston had resulted in pressurisation of the crankcase cavity, ejection of the oil dipstick, and the consequent venting of oil from the dipstick orifice and the engine breather pipe on to the exterior of the exhaust pipes. The engine had the capacity to continue to produce a substantial amount of power for a limited period.

The turbo-charger density controller of the left engine was found to be incorrectly adjusted to the extent that the engine could develop only about 330 BHP instead of 350 BHP which was its normal capability.

The probable cause of the accident was that, believing there was a fire in the right engine compartment, the pilot closed the engine down in circumstances where the single-engine performance capability of the aircraft proved to be insufficient to sustain continued flight.

This accident involved a modern, relatively sophisticated light twin which was unable to continue flying following an engine shutdown shortly after take-off. Why?

The article 'One down and one to go' in *Aviation Safety Digest 105* dealt in detail with the requirements for light twins and the factors which affect their single-engine performance. Let us now consider those factors in relation to this accident.

At the outset it is important to remind ourselves that the performance requirements for light twins call for demonstration of engine-out performance only in the **en route** configuration. **Take-off, approach and landing are not considered.**

The Australian one-engine-inoperative climb requirement for light twins engaged in IFR operations is the achievement of a single-engine climb gradient of 0.5 per cent under the following conditions:

- Altitude 5000 feet AMSL
- Temperature +15 degrees Celsius (ISA +10)
- Propeller of inoperative engine feathered
- Landing gear and flaps retracted
- Maximum continuous power from the operating engine
- Maximum take-off weight.

In establishing the required certification performance it is permissible to fly with up to five degrees of bank towards the operating engine.

For the Piper Navajo Chieftain the 0.5 per cent climb gradient at best rate of climb speed under the above conditions is equivalent to a rate of climb of about 55 feet per minute.

In the performance section of the pilot's operating handbook for the Chieftain there is a chart which gives single-engine rates of climb for varying conditions of temperature, aircraft weight and pressure altitude. The chart indicates that on the night of the accident, with the temperature at 16 degrees Celsius and at an altitude of 500 feet, the aircraft should have been capable of a single-engine climb rate of 220 feet per minute, i.e. a two per cent gradient, at maximum take-off weight. With this anticipated rate of climb the aircraft should have been able to complete a safe return to the aerodrome on one engine.

In the event, the aircraft was unable to achieve anything like this climb performance. It is probable that the same could be said about many similar light twins of comparable age being flown under the same conditions. The reasons for not achieving the expected rate of climb could include the following:

- The pilot's reaction and performance in the emergency situation
- The age and condition of the airframe
- The power available from the operative engine
- The aircraft's flight attitude
- The aircraft's gross weight.

We will now discuss these factors in detail.

Pilot reaction and performance

The figures given in the performance charts published by the manufacturer are based on the results of test flights conducted by a professional test pilot under controlled conditions, being pre-planned exercises specifically flown to determine single-engine performance in the en route configuration. Under such conditions the test pilot is readily able to set up and maintain the aircraft in the required configuration for the duration of the test. The result is, of course, the achievement of optimum performance for the aircraft and the objective is simply to demonstrate that the aircraft meets the required level of performance.

On the other hand we have a pilot faced with a dire emergency in a slightly overweight aircraft, very close to the ground on a dark night. He has probably had little practice in asymmetric flight at high gross weights and more than likely has never been faced with a situation such as this, which requires him to rapidly set up the aircraft in the appropriate single-engine configuration and to keep it flying at its optimum performance level.

It is quite obvious that the pilot in the emergency situation is unlikely to rapidly achieve and then maintain an aircraft performance equivalent to that obtained by the test pilot during the test program.

Age and condition of the airframe

Apart from the conditions mentioned in the last section as being necessary to achieve the performance chart results, the tests would also have been flown in a new aircraft or one in excellent condition. Condition of the airframe can deteriorate in service and all the small dents, chipped and flaked paint, and misfitting doors and hatches will tend to reduce the aircraft performance.

This particular Chieftain had flown about 3400 hours since new. An estimated degradation of performance for this aircraft is a reduction of the single-engine climb gradient by about 100 feet per minute, which means that almost half the anticipated single-engine climb performance has been lost for this factor alone.

Power available from the live engine

As mentioned earlier the operative engine on the aircraft was not delivering its maximum rated power. The pilot's operating handbook for the Chieftain contains a power setting chart which shows the manifold air pressure (MAP) which should be expected for maximum rated power under varying conditions of temperature and altitude. The engine turbo-chargers are fitted with density controllers and the maximum MAP obtained will vary with ambient conditions. There may even be small differences between individual engines. It is important for pilots to know what MAP values should be expected for maximum rated power under various ambient conditions.

The estimated effect of the lower-than-normal power on the left engine in this case was a loss of approximately 75 feet per minute rate of climb.

Aircraft attitude

The single-engine climb performance charts in the pilot's operating handbook for the Chieftain are based on the aircraft being in a five degree bank towards the operative engine and tracking along a straight line. The reason for this is to reduce the total drag of the aircraft. The turn performed by this aircraft, after the engine was shut down and assuming that the pilot maintained the best single-engine rate of climb speed, requires a bank angle of 15 degrees away from the live engine.

The estimated effect of this factor was a further loss of about 40 feet per minute rate of climb.

Aircraft gross weight

The calculated take-off weight of the aircraft was 65 kilograms above the maximum permissible; this further reduced the single-engine rate of climb by about 25 feet per minute.

Net effect on performance

Without evaluating the effect of the pilot's performance on the climb capability of the aircraft, the net effect of the other four factors mentioned resulted in a probable reduction of the single-engine rate of climb by about 240 feet per minute; in other words the aircraft could not be expected to maintain height, let alone climb.

What could have been done to overcome the degrading effect of the above factors on the aircraft's single-engine climb performance?

Regular and thorough maintenance of the airframe will help to limit the potentially critical performance loss resulting from airframe condition.

Power availability is also dependent upon maintenance, and servicing organisations must ensure they use the correct procedures when adjusting engines for maximum power output. Pilots can confirm these settings by ensuring they know the cockpit indications to expect in the ambient conditions prevailing.

It is essential that pilots of all aircraft be familiar with the performance capability of the aircraft they are flying, especially when operating at or near the maximum permissible weight. Do not be lulled into a false sense of security by the en route climb certification requirements. Following an engine failure just after take-off, a light twin with the aircraft weight close to the maximum permissible will probably not maintain height, because of the factors mentioned earlier.

Learn to better appreciate the limitations of the aircraft by practising engine failures at a safe height, but with the aircraft at a high gross weight and in the take-off configuration. Reduce power to the zero thrust setting and you may be surprised, indeed disappointed, but at least you will be more aware of the capabilities of the aircraft and yourself.

The question of aircraft attitude in connection with this particular accident can only be answered with considerable conjecture regarding the pilot's reaction to the apparent engine fire and his knowledge of the aircraft's single-engine climb capability.

The piston failure that occurred in the right engine allowed the crankcase to pressurise and forced oil out of the engine breather pipe and the oil filler access. The oil evidently ignited when it came in contact with the hot exhaust and this obviously gave the pilot the impression of an engine fire. Examination of the cowls from the right engine showed that there had been no engine fire prior to impact, but the fire referred to by the pilot may have been local flaring of oil droplets as they contacted the hot exhaust pipes.

There have been numerous piston failures in light twins but most have occurred during daylight hours. When such failures have occurred pilots have seen oil streaming on to the cowls and/or smoke. Had it been night-time they might well have noticed an indication of fire. The pilot's operating handbook emergency procedures require that, in the event of an engine fire in flight, the engine is shut down and secured and the aircraft is landed at the nearest suitable aerodrome. The pilot of this aircraft was obviously following that procedure. To land at the nearest suitable airport required only a gradual turn to reach runway 27 at Melbourne and this was the pilot's declared intention.

It could not be established if the pilot knew the single-engine performance he could expect from his aircraft. If he believed that the figures given in the pilot's operating handbook were applicable, his decision to shut down the engine and turn towards the aerodrome is understandable. If he was aware of the likely single-engine performance capability in the prevailing circumstances, it must be concluded that his concern about the apparent engine fire overrode that knowledge and for this reason he chose to turn the aircraft towards the aerodrome, thereby sacrificing some of the rate of climb.

It becomes quite obvious that the one factor which is most readily controllable to improve the single-engine performance is the aircraft's gross weight. Any reduction in gross weight will achieve a corresponding increase in single-engine climb rate, and for most light twins the benefit to be gained is about 15 to 20 feet per minute for each one per cent decrease in weight. It is clearly important for all pilots of light twins to recognise not only the serious consequences of overloading their aircraft but also the ready means which exist for enhancing the single-engine performance by a reduction in aircraft weight.

The Australian design standards have been developed on the basis of achieving a satisfactory record over the complete spectrum of operations, but it is vital to remember that the requirements for single-engine performance in light twins relate only to the en route phase of flight with the aircraft in its lowest-drag configuration. Pilots must also remain aware of their own performance limitations in respect of their ability to react quickly and effectively in the case of an unexpected engine failure in a more critical phase of flight. If you have any doubts as to your own or your aircraft's ability to cope with an engine failure in flight you should carefully consider the desirability of keeping the aircraft weight to a level which will provide additional single-engine climb capability.

From the investigation findings we know that the pilot did not need to shut down the engine immediately. If he had reduced power on the suspect engine, the rate of oil spillage would have reduced and so too would the symptoms of the apparent fire. He could have then gained sufficient altitude and positioned the aircraft for a safe landing before shutting down the engine.

With the benefit of hindsight we can say that the accident became inevitable when the pilot shut down the engine; however, he probably did not know the reasons for the apparent fire. It must be concluded that his concern about the engine fire was apparently far greater than any concern about single-engine performance. Perhaps if he had fully understood this aspect, his course of action would have been different ●

Child restraints in general aviation aircraft

For some time now child restraint devices have been used in motor vehicles and have proved to be capable of protecting children in motor collisions from what otherwise would have been more serious injury. The use of such devices in general aviation aircraft is fully supported by the Department of Transport as long as the means of installation is in accordance with manufacturers' recommendations and the items used are of the required standard.

A recent letter from an interested pilot suggested that an article on this subject in the *Aviation Safety Digest* would be of use to general aviation pilots. The following extract illustrates his concern.

'For some time I have been wanting to take my 15-month-old daughter flying, however, I am concerned about her safety if she is just held by my wife. I have been considering the use of my automotive child seat which uses the existing lap/sash seat belt. Of course, this could only be used if the aircraft is fitted with a similar lap/sash harness.

'I feel that there must be many other pilots concerned over this matter and that you may be able to investigate the position more thoroughly, followed by an article in the *Digest*'.

The use of child restraints in general aviation is not presently covered by any mandatory requirements. Children constitute a small proportion of those who fly in general aviation aircraft, and only small children need special restraints; older ones can be adequately protected by the use of an adult restraint system, if necessary combined with the use of an approved child seat.

Nevertheless, adequate child restraints in general aviation aircraft would improve the safety of all occupants. They would optimise the child's protection and the protection of other occupants who might, in an accident, be injured by a child thrown about in the cabin.

A child restraint approved for automotive use is acceptable for use in general aviation aircraft if it is manufactured to comply with Australian Standard AS1754 and secured to the aircraft seat or structure in a manner capable of resisting the emergency-landing inertia forces of 3*g* upward, 9*g* forward and 1.5*g* sideward.

Child restraints include child seats and harnesses made for children. The following table shows the type of restraint most suitable for your child:

Type of restraint	*Approx. age of child*	*Weight of child*
Child seat	6 months-4½ years	9 kg (20 lb)-19 kg (40 lb)
Harness	12 months-11½ years	9 kg (20 lb)-38 kg (80 lb)

Restraint devices approved for automobile use and complying with AS1754 carry a label displaying the

Child seat

Child harness

Standards Association of Australia (SAA) symbol and are therefore readily identifiable. A list of currently approved child restraints is available from the SAA Office in the capital city of your state.

At present there is no SAA-approved child restraint for an infant under six months or nine kilograms. If no special child restraint is available, an adult seat belt is suitable for a child of 12 months or older. Researchers now agree that it is safe for even a very young child to wear a properly adjusted adult seat belt.

Notes on installation

—It is essential that the child restraint be connected exactly as shown in the manufacturer's instructions for the type of device. Buckles and adjusters should not be located on corners.

—Child restraint systems designed to AS1754 for use on a car seat in combination with an adult three-point *static* harness (i.e. not fitted with an inertia reel retractor) can be used directly in light aircraft in combination with a three-point harness *not* fitted with an inertia reel. In such installations the sash of the safety harness is used to anchor the top of the child restraint.

—In locations where the car safety harness *is* fitted with an inertia reel retractor a converter buckle is supplied with the child restraint to convert the lap-sash harness into a lap belt, and the upper attachment is provided by an additional strap connected to the rear parcel shelf. Similar provision must be made in the case of a light aircraft harness fitted with an inertia reel, particularly in view of the fact that the aircraft reel has a locking threshold approximately three times greater than that of the car retractor. Therefore, when the child restraint is intended for a light aircraft seat equipped with a harness fitted with an inertia reel, and where it is physically possible to make use of the provisions available for the same car situation, approval should be sought from the Department to carry out a small modification to the aircraft structure for connection of the child restraint upper strap. The child restraint can then be fitted to the aircraft seat in the same way as it is fitted to the car seat.

—Other child restraints requiring direct attachment to the aircraft structure could also be installed provided a suitable scheme has been submitted to and approved by the Department.

Use of restraints

—Child restraints are designed to restrain the skeletal structure of the trunk. Compression of the abdominal area must be avoided. A harness should be worn across the lap and the chest.

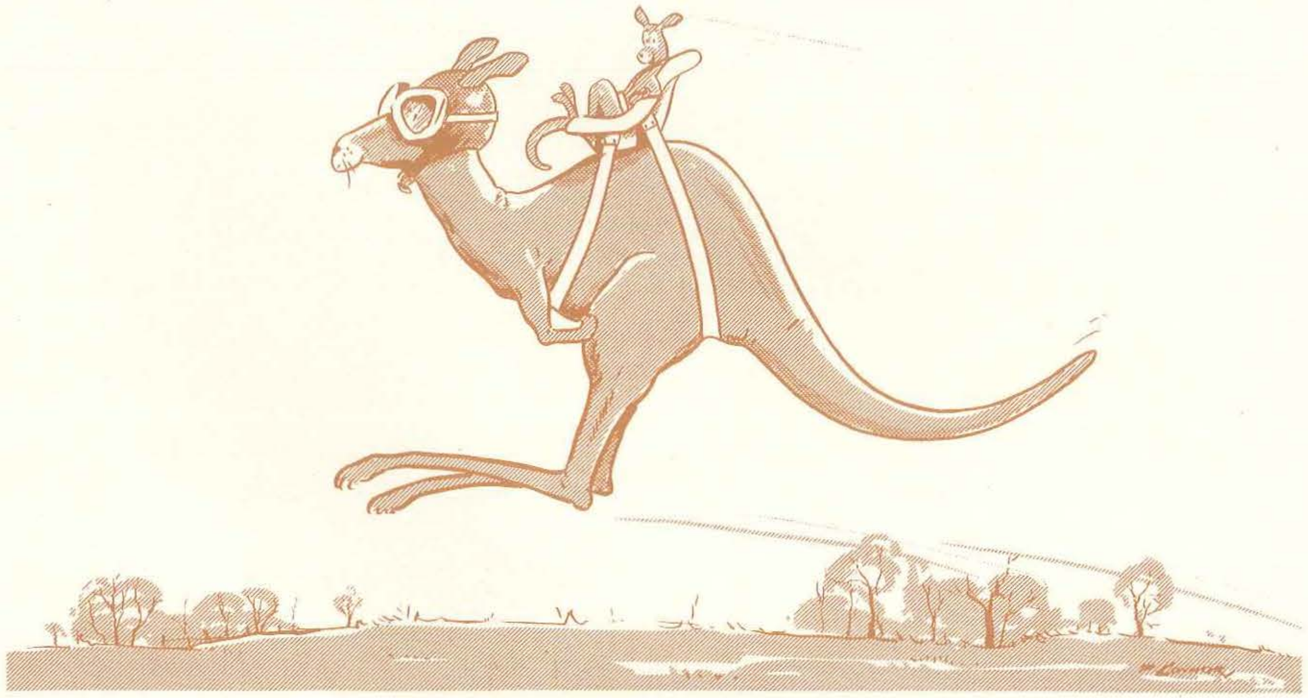
—Harnesses should be adjusted to fit as firmly as possible, consistent with comfort, to provide the protection for which they have been designed. Undue slack in a harness will greatly reduce the protection afforded the wearer. Individual straps of a harness should not be left undone.

—If it is necessary to nurse a child because there is no child restraint fitted to the aircraft, never place the seat belt around both yourself and the child. This could result in injury to the child as a result of your weight acting upon him in an accident or even under turbulence.

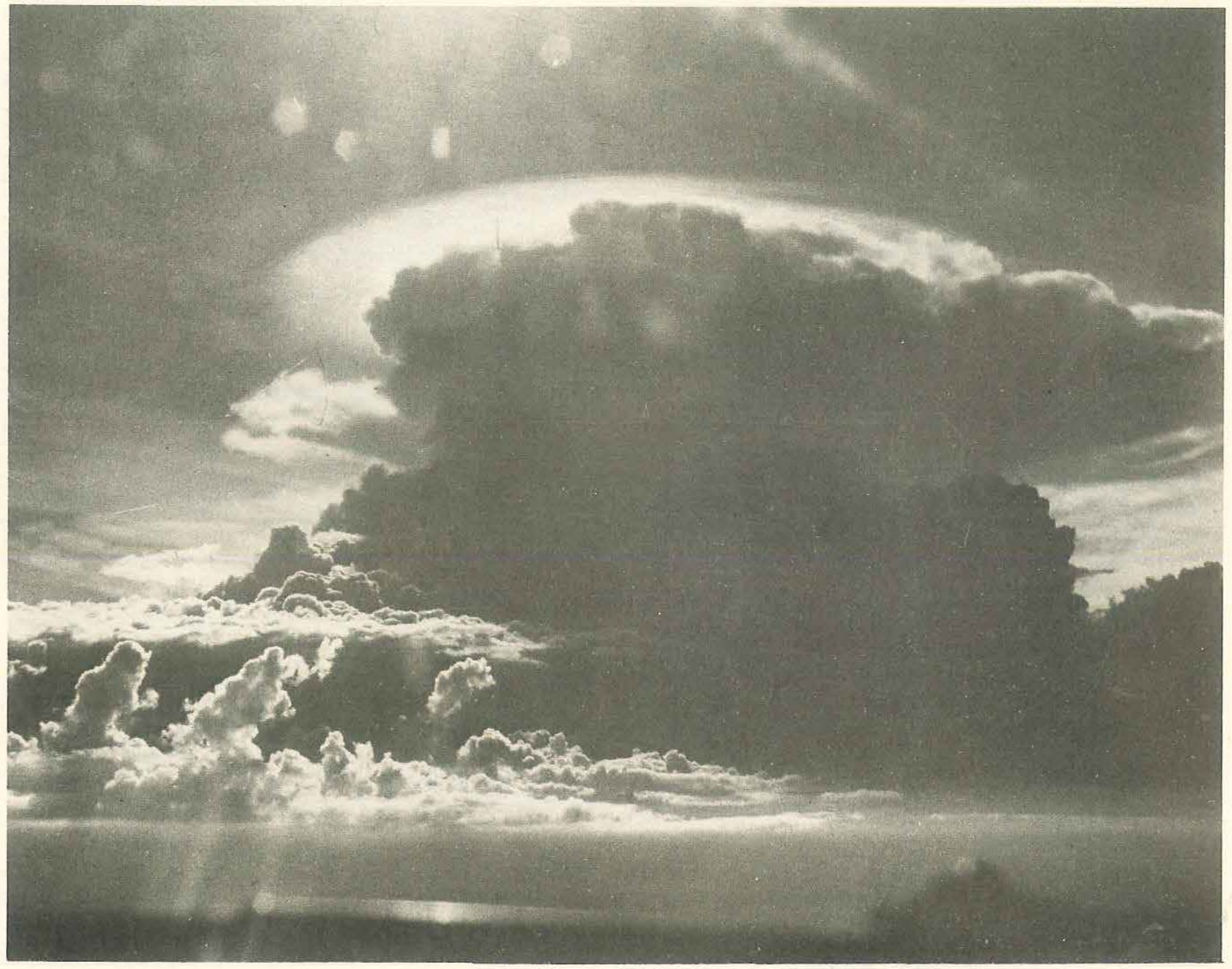
—If the webbing becomes frayed, contaminated or damaged, replacement should be carried out by the manufacturer or his agent. It is essential to scrap the entire child restraint after it has been used in a severe impact even if damage to the assembly is not obvious.

—Care should be taken to avoid contamination of the webbing and padding with polishes, oils and chemicals, particularly battery acid. Cleaning may be carried out using mild soap and water.

The problem of child restraints in general aviation aircraft is under constant review. Investigations carried out for automotive use continually provide new data applicable to most aviation situations. New products and corresponding standards are also being developed. Any significant developments in these areas will be brought to your attention in the *Digest* ●



Meteorology and the pilot
Part 1 — thunderstorms



This is the first in a series of articles which has been prepared to help you better understand the weather and how it will affect your operations. The series is not intended to be a basic course in meteorology, nor is it directed specifically to any section of the industry. Basic knowledge will be gained by studying the Manual of Meteorology Part 2, formerly the Aviation Supplement, and whatever other publications you need to pass the necessary examinations at various licence levels. This series *is* intended to supplement your basic knowledge and provide some techniques to minimise the potential hazards of natural phenomena.

We all know what thunderstorms look like and the hazards they pose to aircraft: severe turbulence, hail, icing and very heavy rain, to name just a few. A thunderstorm packs into one vicious bundle just about every weather hazard known to aviation. Much has been written about the mechanics and life cycle of thunderstorms as they have been studied for many years; but while much has been learned the studies continue because there is still a lot more to learn.

Knowledge and weather radar have modified our attitudes towards thunderstorms, but one rule continues to be true — any thunderstorm should be considered extremely hazardous. Almost any thunderstorm can spell disaster for the wrong combination of aircraft and pilot.

To refresh your memory, let us recall the necessary ingredients for the formation of a thunderstorm, and its life cycle.

Ingredients

- Unstable air through a considerable depth of the troposphere.
- A lifting mechanism to trigger the instability.
- Abundant moisture through a considerable depth of the troposphere.

Life cycle

Mix the ingredients well and in no time at all cumulus clouds will begin to form. All thunderstorms start life as a cumulus cloud but only a few cumulus clouds develop into thunderstorms. As the cloud grows so does the updraught which may reach 3000 feet per minute. Active growth of the cell towards the cumulo-nimbus (thunderstorm) stage is indicated by vigorous, clearly defined boiling at the top of the cloud.

When the cloud has grown fully, quite often beyond 35 000 feet in mid-latitudes and over 60 000 feet in the tropics, it develops its characteristic flattened top. Raindrops and ice crystals in the cloud have grown to such a size that they are no longer supported by the updraught and they commence falling, evaporating into the clean air drawn into the cloud and thus cooling it, forming strong downdraughts in parts of the cloud. Large wind shears and severe turbulence occur because of the updraughts and downdraughts. Precipitation, possibly in the form of hail, reaches the ground at this stage.

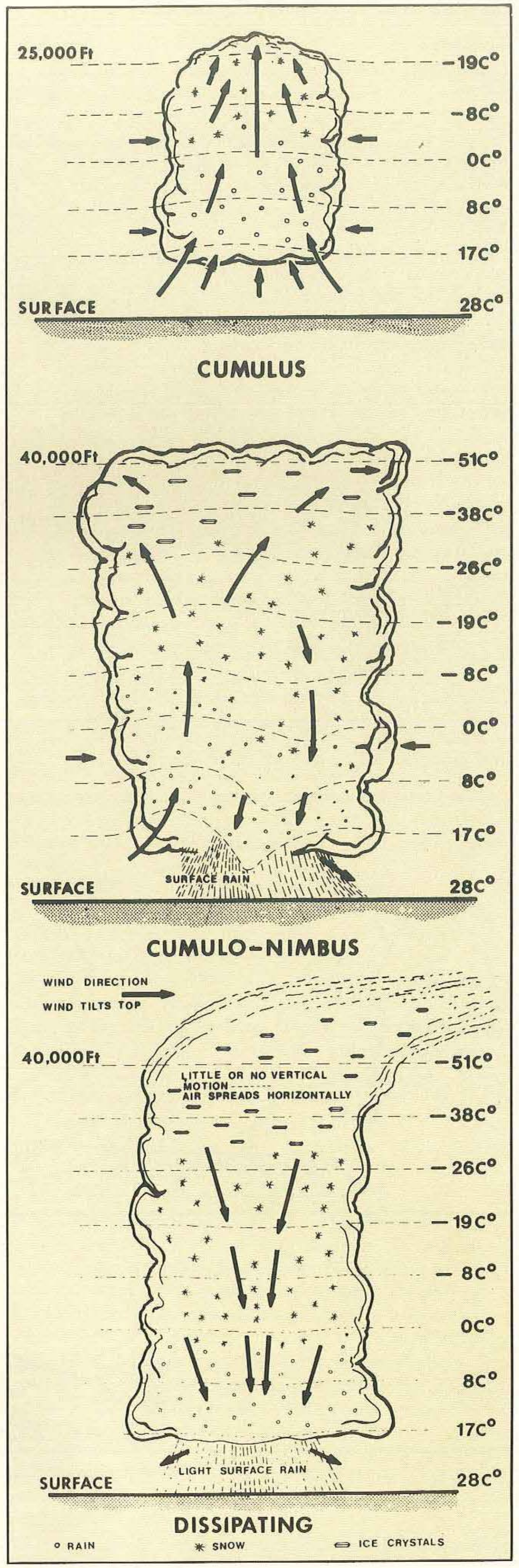
As the downdraught grows vertically and horizontally, it eventually extends through most of the cloud. Rain gradually decreases as no new condensation is taking place. The top of the cloud becomes more fibrous in appearance and the feathered anvil continues to extend in area. Within a short time after the cessation of rain, the cloud itself breaks up. The typical life cycle is about 60 minutes, though some storms may last several hours.

Scientists estimate that 44 000 thunderstorms lash the earth's surface every day. At any given moment 1800 of them are in action. Thunderstorms come in many sizes and shapes and are often called 'weather factories' because of the great variety of extreme weather conditions they can produce. They occur individually as separate, widely-spaced storms, or in long squall lines along or roughly parallel to a front.

The most violent thunderstorms draw air into their cloud bases with great vigour. The incoming air acquires a rotational component and it often forms an extremely concentrated vortex from the surface well into the cloud. Meteorologists have estimated that wind in such a vortex can exceed 200 knots; pressure inside the vortex is quite low. The strong winds gather dust and debris, and the low pressure generates a funnel-shaped cloud extending downward from the cumulo-nimbus base. If the cloud does not reach the surface, it is a 'funnel cloud'; if it touches a land surface, it is a 'tornado'.

Tornadoes occur with both isolated and squall line thunderstorms. Reports or forecasts of tornadoes indicate that atmospheric conditions are favourable for violent turbulence. An aircraft entering a tornado vortex is almost certain to suffer structural damage. Since the vortex extends well into the cloud, any aircraft flying in a severe thunderstorm could encounter a hidden vortex.

Summed up, thunderstorms are meteorological monsters and a fundamental flying rule is: stay out of them.



Hazards associated with thunderstorms

Turbulence

Potentially hazardous turbulence is present in all thunderstorms and can destroy an aircraft. The most frequent and severe turbulence effects occur near adjacent updraughts and downdraughts in the mature storm and result from rapid encounters with alternately ascending and descending air and/or air ascending or descending at markedly different rates.

While the main problem with the draughts is the large vertical displacements of the aircraft, turbulence has a twofold effect: severe loadings on the aircraft structure and violent changes in attitude which may result in overloading during recovery.

Outside the cloud, shear turbulence has been encountered up to several thousand feet above ground as far as 30 km laterally from a severe storm. A low level turbulent area is the shear zone associated with the gust front. Often, a 'roll cloud' on the leading edge of a storm marks the top of the eddies in this shear and it signifies an extremely turbulent zone. Gust fronts often move up to 25 km ahead of associated precipitation. The gust front causes a rapid and sometimes drastic change in surface wind ahead of an approaching storm.

It is almost impossible to hold a constant altitude in a thunderstorm, and manoeuvring in an attempt to do so produces greatly increased stress on the aircraft. It is understandable that the speed of the aircraft determines the rate of the turbulence encounters. Stresses are least if the aircraft is held in a constant attitude and allowed to 'ride the waves'. To date, we have no guaranteed way to pick 'soft spots' in a thunderstorm.

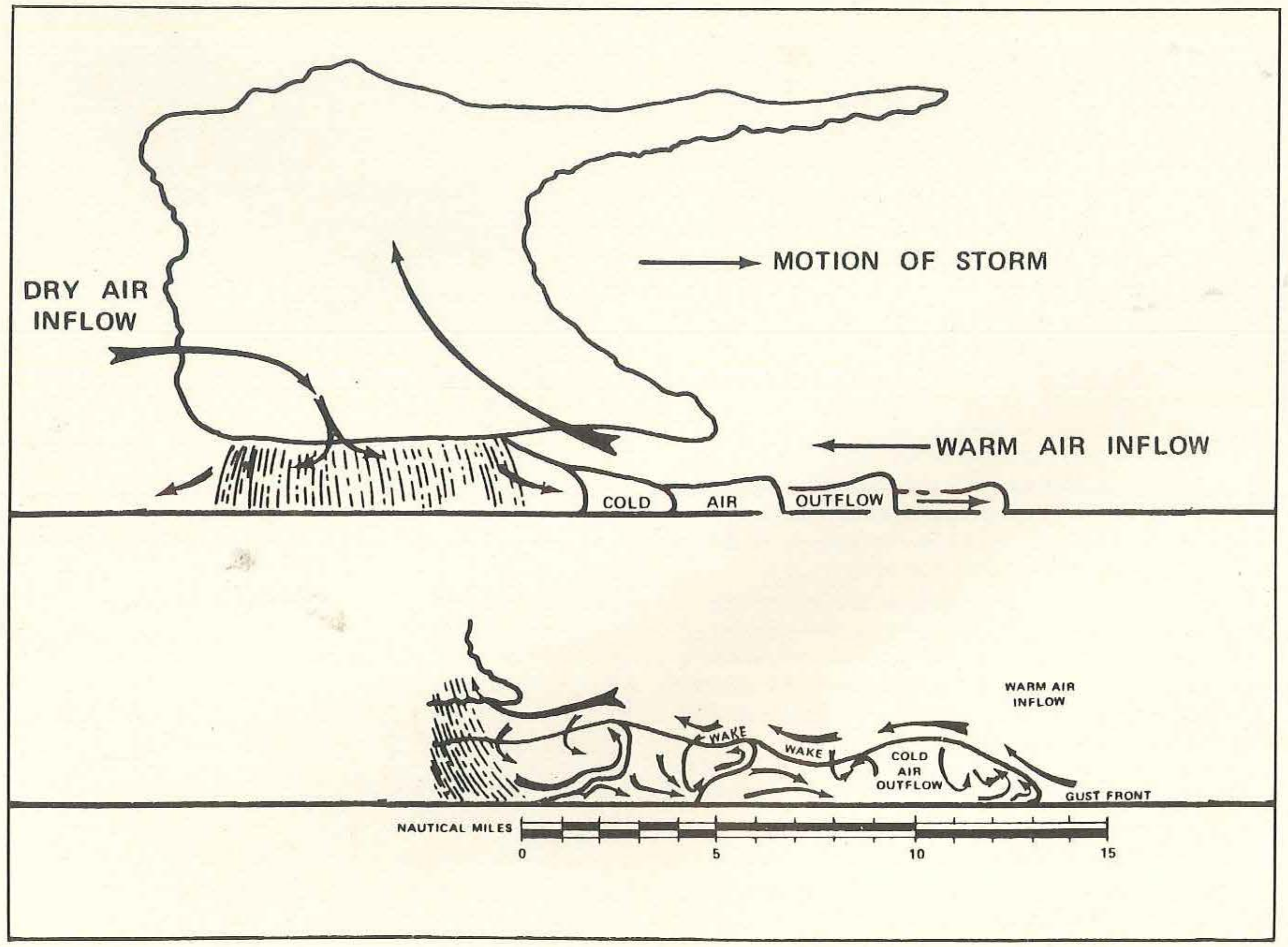
Hail

Hail competes with turbulence as the greatest thunderstorm hazard to aircraft. Supercooled drops above the freezing level begin to freeze. Once a drop has frozen, it can grow rapidly by impact with other drops which freeze on it, so the hailstone grows — sometimes into a huge iceball. Large hail occurs with severe thunderstorms that have built to great heights. Eventually the hailstones fall to the ground, possibly some distance from the storm core. Hail may be encountered in clear air several kilometres from dark thunderstorm clouds.

As hailstones fall through air with a temperature above zero degrees Celsius, they begin to melt and precipitation may reach the ground as either hail or rain. Rain at the surface does not mean the absence of hail aloft. You should expect hail with any thunderstorm, especially near the updraught or core of the cumulo-nimbus. Hailstones larger than one centimetre in diameter can significantly damage an aircraft in a few seconds.

Icing

Updraughts in a thunderstorm support abundant liquid water and, when carried above the freezing level, the water becomes supercooled. When temperature in the upward current cools to about minus 15 degrees Celsius, much of the remaining water vapour sublimates as ice crystals, and above this level, at lower temperatures, the amount of supercooled water decreases.



Supercooled water freezes on impact with an aircraft. Clear icing can occur at any altitude above the freezing level; but at high levels, icing may be rime or mixed rime and clear. The abundance of supercooled water makes clear icing very rapid between zero degrees Celsius and minus 15 degrees Celsius, and encounters can be frequent in a cluster of cells. Thunderstorm icing can be extremely hazardous.

Airframe icing is not always a problem with individual thunderstorms, particularly if the lateral extent of the storm is not great resulting in a small exposure time to icing conditions. However, the potential for heavy icing is present in each storm and for this reason a cluster or line of thunderstorms may present serious airframe icing problems.

For piston engine aircraft the possibility of induction icing is ever present in certain combinations of temperature, relative humidity and visible moisture. Engine intake icing and the ingestion of hail and water are constant problems for turbine-powered aircraft.

The best remedy for all icing is prevention. Use of anti-icing equipment before entering an area of possible icing conditions should ensure a safe passage. If the aircraft is not fitted with anti-icing equipment, or if it was not used in time, the correct use of de-icing equipment, in accordance with the pilot's operating handbook, should reduce the effects of this hazard.

Low ceiling and visibility

Obviously, visibility is near zero within a thunderstorm cloud. Ceiling and visibility also may be restricted in precipitation and dust between the cloud base and the ground. The restrictions create the same problem as all ceiling and visibility restrictions, but such hazards are greatly increased when associated with the other thunderstorm hazards of turbulence, hail and lightning which make precision instrument flying virtually impossible.

Effect on altimeters

Surface pressure usually falls rapidly with the approach of a thunderstorm, then rises sharply with the onset of the first gust and arrival of the cold downdraught and heavy rain showers, falling back to normal as the storm moves on. This cycle of pressure change may occur in 15 minutes. If the pilot does not receive a corrected altimeter setting, his altimeter indication may be more than 100 feet in error.

Lightning

A lightning strike can puncture the skin of an aircraft and can damage communications and electronic navigational equipment. Lightning has been suspected of igniting fuel vapours causing explosion; however, serious accidents caused by lightning strikes are extremely rare. Lightning can momentarily blind the pilot, rendering him temporarily unable to navigate either by instruments or by visual reference, and lightning can also induce permanent errors in the magnetic compass. Lightning discharges, even distant ones, can disrupt radio communications on low and medium frequencies. Though lightning intensity and frequency have no simple relationship to other storm parameters, severe storms, as a rule, have a high frequency of lightning.

Weather radar

Weather radar detects droplets of precipitation size. Strength of the radar return (echo) depends on drop size and number. The greater the number of drops, the stronger the echo; and the larger the drops, the stronger the echo. Drop size determines echo intensity to a much greater extent than does drop number. Hailstones are usually covered with a film of water and, therefore, act as huge water droplets giving the strongest of all echoes.

Individual thunderstorm cells build and dissipate rapidly. Therefore, do not attempt to plan a course between cell echoes. The best use of ground radar information is to isolate general areas and coverage of echoes. You must avoid individual storms from in-flight observations either by visual sighting or by airborne radar. It is better to avoid the whole thunderstorm area than to detour around individual storms unless they are scattered.

Airborne weather avoidance radar is, as its name implies, for avoiding severe weather — not for penetrating it. Whether or not you fly into an area of radar echoes depends on echo intensity, spacing between the echoes and the capabilities of you and your aircraft. **Remember that weather radar detects only precipitation drops; it does not detect turbulence.** Therefore, the radar scope provides no assurance of avoiding turbulence. The radar scope also does not provide assurance of avoiding instrument weather from clouds and fog. Your scope may be clear between intense echoes; this clear area does not necessarily mean you can fly between the storms and maintain visual sighting of them.

The most intense echoes are extreme thunderstorms. Remember that while hail always gives a radar echo, it may fall several kilometres from the nearest visible cloud and hazardous turbulence may extend to as much as 30 km from the echo edge. Avoid the most intense echoes by at least 30 km: that is, echoes should be separated by at least 60 km before you fly between them.

Airborne radar is a valuable tool. However, it is principally an indicator of storm locations for avoidance purposes.

Do's and don'ts of thunderstorm flying

Above all, remember this: never regard any thunderstorm lightly even when radar observers report the echoes are of light intensity. Avoiding thunderstorms is the best policy. Following are some do's and don'ts of thunderstorm avoidance:

- **Do** plan an alternative route, before becoming airborne, if thunderstorms are forecast. Planning will be far more rational in the calm of the briefing office than in flight when confronted by the problem. Be prepared to divert before the thunderstorms become unavoidable.
- **Don't** land or take off in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.
- **Don't** attempt to fly under a thunderstorm even if you can see through to the other side.

Turbulence and wind shear under the storm could be disastrous.
- **Don't** fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms not embedded usually can be visually circumnavigated.
- **Don't** trust the visual appearance as a reliable indicator of turbulence inside a thunderstorm.
- **Do** avoid by at least 30 km any thunderstorm identified as severe or giving an intense radar echo.
- **Do** circumnavigate the entire area if the area has five oktas or more thunderstorm coverage.
- **Do** remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.
- **Do** regard as extremely hazardous any thunderstorm with tops 35 000 feet or higher whether the top is visually sighted or determined by radar.

If you cannot avoid penetrating a thunderstorm, following are some do's **before** entering the storm:
- Tighten your seat belt, put on your shoulder harness if you have one, and secure all loose objects.
- Plan and hold your heading to take you through the storm in a minimum time.
- To avoid the most critical icing, establish a penetration altitude below the freezing level or above the level of minus 15 degrees Celsius.
- Verify that pitot heat is on and select carburettor heat or turbine-engine anti-ice. Icing can be rapid at any altitude and cause almost instantaneous power failure and/or loss of airspeed indication.
- Configure your aircraft for turbulence penetration using power settings and airspeed recommended in your aircraft manual.
- Turn up cockpit lights to highest intensity to lessen temporary blindness from lightning.
- If using automatic pilot, disengage altitude-hold mode and speed-hold mode. The automatic altitude and speed controls will increase manoeuvres of the aircraft thus increasing the likelihood of structural stress.
- If using airborne radar, tilt the antenna up and down occasionally. This will permit you to detect other thunderstorm activity at altitudes other than the one being flown.

Following are some do's and don'ts **during** the thunderstorm penetration:
- **Do** keep your eyes on your instruments. Looking outside the cockpit can increase danger of temporary blindness from lightning.
- **Don't** change power settings; maintain settings for the recommended turbulence penetration airspeed.
- **Do** maintain a constant attitude; let the aircraft 'ride the waves'. Manoeuvres in trying to maintain constant altitude increase stress on the aircraft.
- **Don't** turn back once you are in the thunderstorm. A straight course through the storm most likely will get you out of the hazards in the shortest time. In addition, turning manoeuvres increase stress on the aircraft.

This article applies to all aircraft operations. The main difference between VFR and IFR is that the non-rated pilot on a VFR flight must avoid thunderstorms at all costs. A properly rated pilot of an IFR-equipped aircraft should only consider penetrating thunderstorms when alternative action is not available, and then only with extreme caution and adequate preparation ●

Pilot contribution

Aviation Safety Digest 102 contained an article entitled 'Programmed Mind' which reminded me of an error I once made as a result of similar programming. Although the incident occurred some time ago while I was a military pilot, the lesson learnt applies just as readily to civil aviation.

I was to carry out an instrument training flight in a Douglas Skyhawk from my home base at Nowra to Williamtown RAAF Base. I had planned to cruise at Flight Level 210 and carry out a TACAN approach at Williamtown followed by several touch-and-go landings prior to returning to Nowra.

At Nowra, the wind was blowing quite strongly from the west, as it is wont to do the greater part of the year, and the duty runway was 26. I departed Nowra, climbed to FL210 and proceeded to Williamtown. On first contact with Williamtown Approach, the controller gave me the landing information, then radar vectored me to the Initial Approach Fix. The Initial Approach Fix for a TACAN approach to either runway 12 or 30 at Williamtown was at the same position to the south-west of the field, and the pilot simply turned left or right as appropriate and followed a DME arc until intercepting final approach to either runway. Consequently I turned right then followed the arc to the left until aligned on final for runway 30.

The approach controller, who had said nothing, handed me off to the tower, and on contact with the tower I was initially bewildered when I was instructed to break right and join downwind for the duty runway 12. You can imagine my acute embarrassment when I realized I had made an approach to the reciprocal runway, as I had programmed myself to thinking that the wind would be blowing from the west at Williamtown. In fact it was blowing from the south-east, and in what had been a relatively short trip of about 20 minutes, my mind did not register the fact that the wind might be blowing from another direction, and I obviously did not pay much attention to the landing information.

I offered profuse apologies to the RAAF controllers, whom I am sure were smirking behind their microphones, cancelled any thought of touch-and-go landings and high-tailed it for Nowra. I now listen attentively to the ATIS ●

Fuel contamination

After landing at a mining airstrip in Western Australia, the pilot of a Mitsubishi MU-2 arranged for the refueller to add three 200 litre drums of Jet A-1 fuel to the aircraft's tanks

The refueller rolled three fuel drums out to the aircraft and stood one at each wing tip and the other near the nose. He then unsealed the two drums at the wing tips and pumped their contents into each tip tank. Meanwhile, the pilot had been unloading the aircraft and when he had finished, he broke the seal and removed the bung on the third drum and, using a portable hand-operated rotary pump carried in the aircraft, pumped the contents into the centre tank. About 20 minutes after the refuelling operation had been completed, the pilot took an opaque plastic coffee cup and drained from each wing tip fuel tank a small sample of liquid which he visually inspected, smelled, identified as the correct fuel and then threw on the ground. The fuel drums were re-bunged and rolled away to the side of the parking bay.

A short time later, with seven passengers on board, the aircraft took off and while on climb through about 8000 feet the pilot began transferring fuel from the tip tanks to the centre tank. As the aircraft approached 12 000 feet, the pilot noticed a drop in torque and EGT for the left engine and, as he tried to identify the malfunction, he noticed a similar power drop in the right engine. A trouble check and routine corrective action had no effect so the pilot decided to land at another aerodrome and establish the cause of the problem. He had just begun to divert however, when both engines rapidly lost power and finally flamed out. The pilot attempted a relight but was unsuccessful.

The aircraft was over flat, spinifex-covered desert country about 128 km from the departure airstrip. The pilot briefed the passengers to prepare for a forced landing, transmitted a Mayday call and successfully put the aircraft down between two long, parallel six metre high sand dunes. Apart from slight buckling of the nose wheel doors, the aircraft was undamaged and none of the occupants was injured.

Subsequent checks of the aircraft's fuel system at the forced landing site and the drums from which the aircraft was refuelled showed that the fuel was heavily contaminated with water. A visual check of the contents of the left tip tank revealed about 160 to 180 litres of clear water with a layer of fuel about 10 mm deep lying on top. Samples of liquid from the right tip tank appeared to be a 50/50 mixture of water and fuel, while the centre tank contained about 35 per cent water and 65 per cent fuel. The fuel lines to the engines contained mostly water with some fuel globules.

Samples of the liquid remaining in the three drums used to refuel the aircraft showed varying mixtures of water and fuel. The liquid in one drum consisted of clean, fresh water lightly contaminated with fuel, another contained approximately 50 per cent water and 50 per cent fuel and the third drum, which was probably used to refuel the centre tank, contained only Jet A-1. Other sealed 200 litre drums from the same stock were opened and also found to be contaminated with water in various amounts.

Samples of the water obtained from the aircraft and the fuel drums were subjected to laboratory analysis and after comparison with several other samples, it was determined that the water in the drums had come from a ground water bore a short distance from the town served by the airstrip. Fuel company documentation showed that the contents of the drums met all the prescribed quality control requirements prior to their delivery to this location.

All the drums in which water was found appeared to contain a total quantity of liquid close to the 200 litres which was supposed to be in them. They were neither over nor under filled and, before they were opened to refuel the aircraft, all drums apparently had the seals intact. The water could not have been in the drums accidentally because, in one case at least, some fuel must have been removed, a similar quantity of water placed in the drum and the drum then resealed.

It was not possible to determine how, why and by whom the water was placed in the 'sealed' drums of Jet A-1. Certainly, the pilot was not expecting to find water in either the drums or the aircraft's tanks, but his quality control checks were cursory in the extreme. Jet A-1 is colourless and the presence of water may be difficult to detect unless the proper refuelling procedure is followed and water-detecting aids are used. But no checks for contaminants were carried out before refuelling commenced, no filtration equipment or water-detecting aids were used at any stage, and the checks the pilot made after refuelling had been completed were totally inadequate to detect the presence of water in the fuel.

The circumstances of this accident are unusual in that no pilot, maintenance engineer, or refueller would normally expect to find water in such large quantities as were present on this occasion. Nevertheless, the precautions to be taken during refuelling, especially when using drum stocks, are described in detail in Air Navigation Order 20.9 and their adoption in this instance would have ensured that contaminated fuel was not pumped into the aircraft's tanks ●

Carburettor icing

(Refer to lift-out probability chart in centre section)

To assist readers to better understand the nature of carburettor icing, the *Aviation Safety Digest* recently published two articles on this subject. Included in no. 103 was a diagram which enabled pilots to anticipate ice formation but required them to obtain a dewpoint figure. This figure is readily available to pilots at briefing offices with a meteorological officer on duty, but not elsewhere. To overcome this difficulty another chart, using the wet and dry bulb temperatures of a given air mass to predict the probability of carburettor icing, has been prepared and is enclosed as a lift-out centre section in this issue.

To obtain the temperatures the correct equipment is necessary and may be purchased from any scientific instrument company. The cheapest fixed installation may be obtained for less than 20 dollars and a portable type costs under 40 dollars. While this expense may be unwarranted for individual pilots or aircraft owners, aero clubs and flying schools may find the equipment a valuable teaching aid when used in conjunction with the enclosed lift-out chart. Also, conscientious pilots will be able to anticipate carburettor ice formation by using the equipment and consulting the chart prior to flight.

The major cause of carburettor ice is the temperature drop of up to 40 degrees Celsius resulting from the evaporation of fuel, particularly from metal surfaces. A second cause is the temperature drop resulting from the expansion of the air/fuel mixture at the throttle butterfly; this effect is small at high power but can be up to 10 degrees Celsius at approach and idle power settings.

Reference to the lift-out chart shows the wide range of ambient conditions conducive to the formation of carburettor ice in a typical light aircraft engine. Note particularly the extent of the risk of serious icing under descent power, which includes summer temperatures under humid conditions.

Why then are there not more cases of carburettor icing?

The answer is that engine manufacturers have long recognised the problem and modern reciprocating aero-engines are designed to minimise their susceptibility to icing. Features such as intake manifolds cast integrally with the engine sump and the bolting of carburettors direct to the sump normally provide substantial protection. However, this is effective only while the engine is hot. Adding the fuel to the air just before the inlet valve as in fuel injection engines provides practically full protection, although still with some susceptibility to throttle icing at reduced power.

Remember that low power operations are most conducive to icing because of the double effect of fuel evaporation and airflow throttling; extended low power/low temperature operations at cruise altitudes may lower engine temperatures into the vulnerable range. A factor often forgotten is that cruise just below cloud will also be in very moist air, close to the saturation level ●

Carburettor icing — probability chart

To use the chart

- Obtain the wet and dry bulb temperatures
- Enter the chart with the wet and dry bulb temperatures
- Refer to the shading legend appropriate to the intersection of the temperature lines
- From the intersection of the temperature lines, obtain the relative humidity on the curved scale, and the humidity ratio from the right hand scale

Example shown on chart

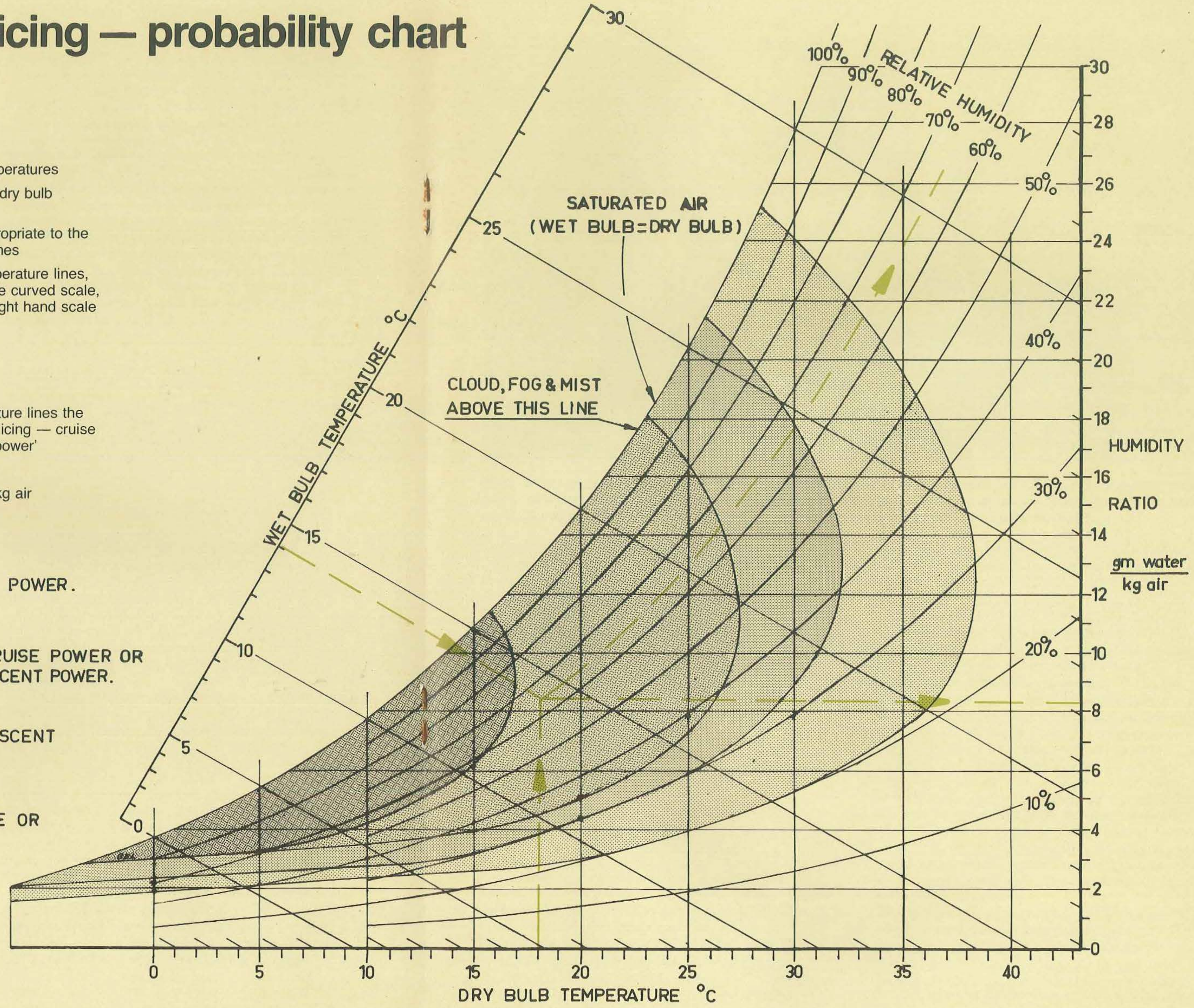
- Wet bulb temperature 14°C
- Dry bulb temperature 18°C
- From intersection of the temperature lines the shading legend gives, 'moderate icing — cruise power, serious icing — descent power'
- Relative humidity 65 per cent
- Humidity ratio 8.5 gm water per kg air

SERIOUS ICING-ANY POWER.

MODERATE ICING-CRUISE POWER OR SERIOUS ICING-DESCENT POWER.

SERIOUS ICING- DESCENT POWER.

LIGHT ICING-CRUISE OR DESCENT POWER.



Wire strikes

Many pilots associate accidents involving overhead wires with agricultural flying, not realising how many of these occur in other general aviation operations. The following article provides advice for the agricultural pilot and all other general aviation pilots on the problem of wire strikes.

Collisions with overhead wires, or wire strikes, continue to account for a significant proportion of accidents involving general aviation aircraft. Table 1 shows that for the last five years an average of 10 per cent of general aviation accidents involved wire strikes. Surprisingly, the majority no longer occur in agricultural operations. The total number of wire strikes is increasing, and so is the number suffered by aircraft on other than agricultural operations.

Year	*Total general aviation accidents*	*Wire strikes*	
		Agricultural	*Other*
1974	256	13	6
1975	208	11	8
1976	243	11	14
1977	221	11	13
1978	250	17	17

Table 1

In May 1979, approximately 90 delegates, representing 70 per cent of agricultural operators in Australia, attended the Aerial Agricultural Association of Australia Convention in Perth. Among the speakers was Mr C. J. Freeman from the General Aviation Branch, Department of Transport. Mr Freeman presented the following paper on the problem of locating and avoiding power lines.

While the paper is directed towards pilots engaged in agricultural operations, the comments about locating power lines would also apply to any general aviation pilot conducting a precautionary search prior to landing away from an established aerodrome.

'Call them what you will but without doubt wires, high tension lines, cables and Single Wire Earth Return lines are probably the greatest hazard facing the agricultural pilot today, whether he is inexperienced or highly experienced.

'During the period 1974–78, wire strikes accounted for 20 per cent of agricultural aircraft accidents in which the aircraft was substantially damaged or destroyed. They also accounted for 40 per cent of all fatalities and 36 per cent of all serious injuries in agricultural operations, so it can be seen that the chance of surviving a wire strike accident is considerably lower than for any other type of agricultural accident. Indeed, as 17 per cent of all wire strikes result in fatal injury and 22 per cent in serious injury, a pilot involved in a wire strike has more than one chance in three of being killed or seriously injured.

'These facts are quite obvious to the pilot involved in agricultural operations and particularly in spraying operations, but wire strikes continue. Why?

'In a representative ten wire strikes, two involved wires of which the pilot was unaware, one involved misjudgement of wire clearance and seven — that is 70 per cent of all wire strikes — happened when the pilot forgot about a wire he had previously located.

'What can be done to reduce the occurrence of wire strikes?

Wire location
'During the training of an agricultural pilot greater emphasis must be placed on working around wires, after locating them from indications given by poles, insulators, cross trees, buildings and *common sense*. The pilot must realise that the indications on their own are not good enough; he must locate the actual wire. If in doubt he must fly over the pole to locate the wire; he is unlikely to fly into the indication.

'The importance of treatment area inspections must be strongly emphasised. Ground inspections are of doubtful value in determining pole runs and wire dispersal, and are often impossible. Aerial inspections are much better, as the perspective is correct and the chance of a pole being hidden from sight is less because it is possible to see other poles in the run. One problem with an aerial inspection is that, having carried it out, the pilot usually begins treatment immediately and has little time to digest all the information gathered during the inspection.

'The problem of transferring an inspection in plan to a treatment in elevation is not great, in fact the inspection is a combination of plan and elevation.

'The aerial inspection must be conducted with great thoroughness, starting as the aircraft approaches the treatment area and continuing on into the area. Nothing must be left on the basis of, "I think that is where it goes". The pilot must be 100 per cent certain and if he is not, then he must look again. However he must not fly around the area excessively as this could disorientate him in relation to obstacles. It is also time wasting and time wasting will eventually apply pressure which could result in mental overload.

'The pilot must make proper use of all visual clues. The most obvious are the pole runs associated with the wire run. It is often possible to locate the main feed line (particularly with Single Wire Earth Return lines) and this, combined with the knowledge that dwellings in the area all have power connected, will give an indication of the possible pole and wire runs. The type, number and attitude of insulators indicate the wire disposal on the pole, and if interpreted properly will yield a wealth of information on wire direction, height, tension and so on. Cross trees on the poles indicate supplementary wire runs and the angle of the cross tree, in relation to the main run, will indicate the angle of the supplementary or spur wire.

'Finally, it can be said that, as a general rule, in an area where domestic power supply is available, all dwellings and most other buildings have power connected. No attempt should be made to begin a treatment until the wires supplying all buildings in the treatment area have been located.

'Always remember, visual clues are only *indications* of wire runs; the wire itself *must* be located.

Misjudgment of wire clearance
'This usually results from one of two factors. The first is that the pilot takes avoiding action too late to clear a wire. This may occur at the end of a run or during a run when there is insufficient clearance to fly under the wire.

'To overcome this problem it is essential that the pilot select some reference point at which avoiding action must be commenced in order to provide adequate clearance of the wire. Two situations where use of this technique is advisable are approaching a wide span of wire and when approaching a wire that is at an angle to the flight path. It can also apply when approaching wires which are at different heights, because the highest wire always looks farthest away.

'The second factor arises when the pilot finds that the wire he intended to fly under is either lower than he thought or has an obstruction underneath it. In respect of the former, it should be obvious during the inspection that a wire has either adequate clearance or suspect clearance. These parameters will vary as a pilot gains experience.

'When the clearance is suspect the aircraft should be flown at spraying height, parallel to the wire, and the clearance physically checked. The pilot can then decide whether he will fly over or under the wire during the treatment.

'Obstructions beneath the wire should be located during inspection. During training strong emphasis should be placed on inspecting the surface below the lower levels of the wire run for obstructions and undulations. The fences alongside the spraying run are other areas where the pilot is likely to encounter extraneous bits and pieces of equipment encroaching upon his flight path. When an obstruction is located under a wire during a spraying run, it is usually a small one, otherwise it would have been seen during the inspection.

To avoid it, yaw the aircraft and flat turn slightly. As a last resort hit it (unless it is a human marker). This is infinitely better than striking the wire. There is little other than wires, large trees or new fences that will stop an aircraft, and staying airborne with a wheel, undercarriage leg or spray pump removed is preferable to hitting the ground hard with the aircraft in one piece.

Strikes on 'forgotten' wires
'This problem involves the highest proportion of strikes, deaths and serious injuries, yet is the hardest to solve. During training the future agricultural pilot must be made aware that one fatality in four involves striking a wire that had already been located. While it is essential to locate wires, it is even more important to remember them. The only way to remember a wire is to dismiss all extraneous matter from your mind while engaged in treating an area and concentrate on the job in hand. Easily said but hard to practise, particularly when the chemical or avgas that you expected in half an hour will not be available for another four hours. But it is extremely important, and new minds can be trained to do it. The budding agricultural pilot can also be trained to carry out an extra "wires" or "obstructions" check before carrying out clean-up runs. This is the main area of wire strikes and results from relaxation or mental overload, and these two factors can go hand-in-hand with orientation of the treatment area and obstructions changing through 90 degrees. The RAAF carry out an extra "wheels" check on final approach. Maybe a verbal "wires" check would be a professional approach to this problem.

'We are losing experienced pilots as well as new men. Most industry pilots would be aware of a number of highly experienced pilots, with many years in the industry, who have lost their lives through wire strikes over the past few years. The industry cannot afford to lose men of such calibre and experience. Some have struck wires and survived; many others have come perilously close to wires they had forgotten about. Remember, it can happen to you even though you have many years and thousands of hours of experience.

'The problem of mental overload is uppermost in the case of the experienced pilot. Individuals vary as to the mental load they can tolerate but all must reach saturation at some time and the addition of one more factor will drop some items out of their memory. These items will not necessarily be unimportant ones. To avoid this possibility, pilots must be encouraged to relegate items that do not require their full attention. They must also train themselves to dismiss from their heads all extraneous matters that do not relate to the actual job in hand. They can reduce their mental load by better planning; a properly planned operation reduces the need to carry a heavy mental load. A note pad in the cockpit to jot down items that need to be acted upon at the next landing could reduce this load and accordingly the chance of overlooking a wire.

'In addition, loader drivers could be trained to accept more responsibility, thus reducing the pilot's mental load and ensuring that his approach to the job is a little more relaxed. The solution is therefore twofold: reduction of extraneous loading on the pilot by better planning, and training of auxiliary staff.

'Pilots must realise that their biggest hazard is distraction. It is imperative that they dismiss from their minds all items not associated with the actual treatment. The bullet can't kill you unless someone pulls the trigger: in this case the wire is the bullet, and the distraction is the pull on the trigger.

'The causes of distraction are all too well known — chemical not available, avgas not turned up, more work coming in, leaking nozzles, tonight's accommodation, last night's row with your wife or girlfriend, et cetera. The owner/pilot is at the greatest risk for he has business pressures to contend with as well. It is essential that you dismiss these problems until you have landed, when they can be handled without the distraction of having to fly an aircraft as well.

Familiarity
'One last factor is familiarity. No pilot of sound mind feels contempt for wires, but it is possible for him to become too familiar with them and feel less concern than is healthy. Unfortunately, after the battle with the wires in and around the treatment area has been won, they do not fall down or disappear. They stay there and wait — and the war goes on.

To sum up, I am advocating:
- More emphasis on training new pilots in location of wires.
- More thorough inspections of areas under, and close to, wires, particularly where the wire is low.
- The use of supplementary reference points where it is difficult to pinpoint the position of the wire.
- Extra checks before clean-up runs.
- Above all, awareness that distraction from the job in hand resulting from mental overload causes wire strikes with more than one chance in three of death or serious injury.
- Delegation of more responsibility to loader drivers.

'Do not let familiarity make you casual in your approach to wire location and avoidance. Maintain high standards and always have a healthy respect for the potential death-trap of wires.

'In conclusion, it is worth noting that if you hit a wire and you are wearing a crash helmet your chances of survival are doubled!'

The non-agricultural pilot and wire strikes

While collisions with overhead wires are a hazard associated with the very nature of agricultural flying, the case is different for other kinds of flying. There are two basic situations which result in wire strikes by aircraft not engaged in agricultural operations.

The first is the complete disregard of Air Navigation Regulation 133 by the pilot who engages in unauthorised low flying. These illegal and often spur-of-the-moment operations have been responsible for innumerable accidents since the earliest days of aviation. The dangers involved have not changed over the years: if anything, the likelihood of flying into a power line has increased.

Overhead wires are now found all over the country, and are not confined to areas of habitation. They criss-cross the landscape, and vary in size and shape from large multi-cable transmission lines on steel towers to innocuous single-cable power lines on wooden poles. Transmission lines often span valleys from hilltop to hilltop and may be up to 400 feet above the valley floor. Single wire lines, though usually only about 30 feet above the ground, often have extremely long spans, up to 300 metres between poles. In these days of environmental awareness, the authorities usually position poles to be as inconspicuous as possible, quite often hidden amongst trees.

The net result is that overhead wires are extremely hard to see, especially for the pilot of a low flying aircraft who is not on the look-out for them.

Before descending below 500 feet AGL consider the risk to your aircraft and passengers of engaging in this unauthorised activity. There is only one solution — don't do it!

The second situation which results in collisions with overhead wires involves aircraft landing and taking off. Government and licensed aerodromes are listed in AIP AGA which includes the obstruction-clear gradient of the take-off climb surface from the end of each flight strip.

These gradients take account of obstructions inside the standard splays. Quite often these gradients are less than one in 50 but only rarely as steep as one in 20. A pilot knows that if he maintains at least the listed gradient he will not encounter any obstructions, including wires, during take-off or landing. However, a long, flat approach below the listed gradient, or a loss of engine power after take-off could result in a wire strike.

Authorised Landing Areas (ALAs) present a major problem for aircraft during take-off and landing. In this situation the pilot must ensure that the physical dimensions and characteristics of the area meet the requirements specified in the AIP and the VFG. The maximum permitted obstruction-free landing and take-off gradients are one in 20 for day operations and one in 30 for night operations. If a pilot normally operates from a government or licensed aerodrome, the one in 20 gradient at an ALA is steeper than he is accustomed to. Therefore, although an obstruction may not penetrate this gradient it could still constitute a hazard to a pilot making a flat approach.

A pilot intending to use an ALA cannot afford to assume that there are no hidden obstructions such as power lines in the approach and take-off area simply because no one has mentioned them. He must make every endeavour to ascertain the existence of wires or other obstructions. This can be done visually during a ground inspection of the area, or verbally when discussing the use of the area with the owner, occupier or controlling authority.

Having taken the necessary actions pre-flight, the pilot's next opportunity for safeguarding against a possible wire strike will be during his precautionary search prior to landing. If there are no major transmission lines in the area it will be safe to descend below 500 feet AGL. Using the techniques mentioned earlier in this article, the pilot can locate any indications of wire runs and then locate the wire itself. In consideration of the average height of power lines, there is no need for this inspection to be conducted at less than 150 feet AGL. Once the pilot is assured that he has located any wires, and he is completely satisfied they do not comprise a hazard to his intended operation, he can descend further for the landing.

If, prior to take-off, a pilot considers that an overhead wire may present a problem in the event of a loss of engine power he should consider the use of an alternative take-off direction that will overcome the hazard.

The use of fixed-wing and rotary-wing amphibious aircraft is increasing in popularity. Associated with the increasing popularity is an increasing rate of wire strike accidents. There are numerous lakes, reservoirs and waterways in Australia that would be suitable for these operations except that power lines are strung across them with the poles hidden above the shoreline. With a background of water these lines are extremely hard to see. Pilots intending to use a waterway, for the first time particularly, should be extremely vigilant. Do not be misled into believing that a power line stops at the shore because you cannot see the wires across the waterway. Make the extra effort needed to be positive that there are no wires above the waterway.

The likelihood that an aircraft flying close to the ground will encounter overhead wires is growing consistently; the only safe course is to expect that wires will be a hazard in any operation involving low flight. Be sure to take the necessary precautions to avoid them. In the words of Mr Freeman: 'I believe the wire strike problem is now extreme. If an average pilot set out to fly for one hour, in a straight line, over a rural area, at 25 feet AGL, he would fly into a wire before the hour was up, no matter how vigilant his look-out. For this pilot the only safe place, in an aircraft below 500 feet in such an area, is stationary on the ground! ●

Passenger evacuation briefing in general aviation

Two unrelated and quite different accidents in the United States a few years ago promote a common flight safety lesson. In the first accident, a DC10 aborted a take-off following a bird-strike which caused an engine to explode. The landing gear collapsed and the aircraft caught fire. All of the 128 occupants escaped quickly without serious injury: the passengers were airline employees and most of them were familiar with evacuation procedures. In the second accident, exactly 12 months later, nine passengers involved in the crash of a Falcon 20 experienced 'severe difficulties' evacuating the aircraft because they had not been briefed on the relevant procedures before departure. Furthermore, there were no placarded instructions for opening the main cabin door or the two overwing exits. Fortunately, there was no resultant fire and all passengers eventually escaped.

Both these accidents indicate the importance of a conscientious passenger evacuation briefing and the lesson is just as important to the general aviation pilot as it is to the airline captain, particularly with the increasing passenger-carrying capacity and complexity of modern general aviation aircraft. But rather than attach a complacency tag to the general aviation operator who fails to brief his passengers adequately, further consideration of the matter is warranted for there may perhaps be other subconscious factors involved.

Firstly, in this technological age, it is all too easy to assume that passengers will automatically know how to open cabin doors and emergency exits. After all, one might say, they have only to read the placards. But how often have passengers required assistance to even unlock their seat belts after a normal flight? In the added shock and confusion of an emergency evacuation, even the simplest task can become difficult. Pressurised cabins have added weight to doors and hatches and complexity to their locking mechanisms, and placards may not be readily seen in an emergency night landing.

Secondly, in most general aviation commercial operations, the pilot generally identifies himself closely with the passengers. He may have assisted with the luggage handling, he probably closed the cabin door and almost certainly brushed past them on the way to his seat. He senses that in the event of a crash landing, he will immediately be on hand to direct the evacuation. But there is no guarantee that the pilot, particularly in single pilot operations, may not be fully occupied in securing the aircraft or making radio transmissions. He may be incapacitated and relying on his passengers to not only fend for themselves but also to assist him to leave the aircraft.

Thirdly, there is often the thought that a comprehensive emergency brief may put unpleasant doubts into the passengers' minds, particularly when given by the pilot rather than a glamorous cabin attendant making the evacuation brief a slightly easier pill to swallow. However, a short but appropriate explanation of evacuation procedures will not only play a major role in the success of any evacuation but can also assist in removing any feelings of underconfidence amongst passengers perhaps travelling in a light aircraft for the first time.

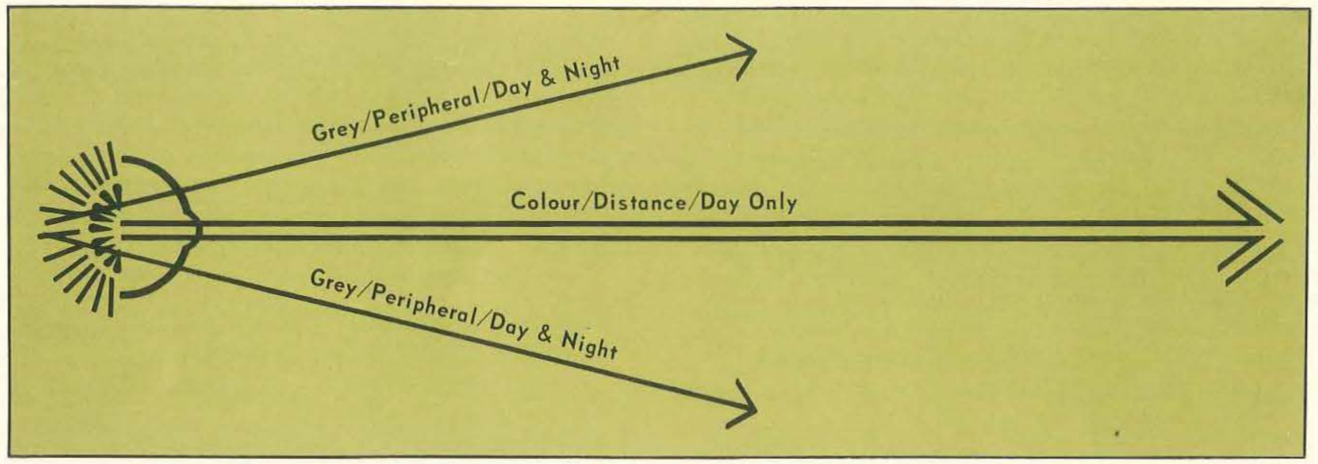
The length of the brief and the manner in which it is presented are naturally as important as the information given. Prior to a departure, coverage of the evacuation procedure in the pilot's brief need include little more than an indication of the position and operation of the normal and emergency exits, and attention drawn to passenger briefing cards if required to be carried on the aircraft.

Conversely, a passenger brief prior to a planned emergency landing with a jammed undercarriage or a forced landing without power can be much more specific and directly related to the circumstances and passengers on board. Additional consideration can be given to the particular requirements of individuals, particularly children or handicapped people. Specific instructions on the location of first aid kits and how and when emergency exits are to be opened can be given if time permits, and passengers can be briefed against the subconscious human reaction to leave through the door they used on entering even when this exit is blocked by fire or debris or is jammed. Advice may be given on other important factors such as the need to remain seated until the aircraft comes to rest and then to move quickly without panic until well clear of the aircraft.

An accurate and confident emergency brief can only be given if the general aviation pilot has been properly trained and remains thoroughly conversant with evacuation procedures as required by ANO 20.11. In the unfortunate event that an actual evacuation becomes necessary, both the crew and passengers will then be better prepared mentally and physically to cope with what otherwise could be a confusing, stressful and potentially dangerous situation ●

Vision 3 — night vision

A veteran pilot once remarked that night flying is no different from day flying — it is just that at night you cannot see anything. Although there is a lot of truth in his statement, you can usually see *something*. To compensate for what you cannot see, you need proper instrumentation. To make the most of your vision at night you need to understand how the eye operates in darkness.



Cones and rods

There are two kinds of light-sensitive nerve endings at the back of your eye; a dual structure of cones and rods. Cones provide precise vision and colour differentiation; they are much less sensitive to light than rods. Rods are much more light sensitive than cones, but are incapable of precise vision.

The cones, because they need greater intensity of light to function, are used in day vision. In fact, the cones stop working altogether in semi-darkness. Millions of these tiny structures are clustered at the back of the eyeball, directly behind the pupil. They not only distinguish colours but pick up distant objects as well.

The rods are concentrated in a ring around the cones. Being colour-blind, they see only in greys and are used in peripheral vision during the day — that is, they perceive objects in motion out of the corner of the eye. Because the rods can still function in light of 1/5000, the intensity at which the cones cease to function, they are used for night vision. These structures are 100 000 times as sensitive in the dark as they are in sunlight. However, they do need more time to adjust to darkness than the cones do to bright light. Your eyes become adapted to sunlight in 10 seconds, whereas they need 30 minutes to fully adjust to a dark night. Bright lights (such as landing lights) knock out night vision, requiring you to 'night adapt' all over again to regain maximum night vision.

The fact that the rods are distributed in a band around the cones and, therefore, do not lie directly behind the pupils, makes 'off centre' viewing important to the pilot during night flight. That is, night flying requires a different visual technique to day flying. You can see an object best during daylight by looking directly at it. At night, however, a scanning procedure is more effective — you will find after some practice that you can see things more clearly and definitely at night by looking slightly to one side of them, rather than straight at them. If, during your attempts to practise the scanning procedure, you find that your eyes have a tendency to swing directly towards the target, force them to swing past it so that the rods on the opposite side of the eyeball pick up the object.

Rhodopsin

The underlying factor governing dark adaptation sensitivity is the quantity of rhodopsin available in the back of the eye. Rhodopsin is the light-capturing substance carried in the rod receptors of the retina. When light strikes the retina, the rhodopsin is bleached and must regenerate.

It has been estimated that a pilot can experience a 30–50 per cent reduction in his night vision as a result of several hours exposure to bright sunlight, especially in a light-covered environment such as sand, sea or snow. The effect is cumulative, and repeated exposure may leave you with poor night vision for as long as a week.

Recovery normally follows simply as a result of resting the eyes or protecting them from bright light, but restoration of visual powers is a gradual process. Don't expect good night vision after a day on the beach or the ski slopes.

In any event, if you are a pilot who flies at night occasionally, you will do well to form the habit of carrying sunglasses at all times and wearing them whenever the sunlight is strong.

The selection of sunglass lenses is important. The wearing of neutral density anti-glare glasses with an average transmission of 15 per cent is recommended. Only with a true neutral filter is colour vision entirely normal and it has been determined that a lens with 15 per cent transmission is most suitable for the level of brightness encountered in flying.

Hypoxia

Hypoxia occurring during flight has a deleterious effect on night vision and for this reason pilots are advised to use supplementary oxygen during night flights. Some sources state that the decrease in night vision is five per cent for every 2000 feet, between 4000 feet and 12 000 feet above sea level. It has been shown that a 25 per cent improvement in night vision occurs at a height of 5000 feet above sea level with the administration of oxygen.

Carbon monoxide (smoking)

Excessive carbon monoxide produces the same decreased night visual capability and increased time for dark adaptation as hypoxia from increased altitude.

For example, a five per cent blood saturation with carbon monoxide gives an effect on the visual threshold equal to 8000–10 000 feet of altitude. Smoking three cigarettes can cause a CO saturation of approximately four per cent. Pilots should therefore observe the 'No smoking within 60 metres of the aircraft' sign at all times.

Tinted windscreens

Another precaution is to avoid the use of aircraft with tinted windscreens when flying at night, particularly on Night VMC operations. This kind of flight, which is usually carried out in small general aviation aircraft, is the most critical visual task of a pilot. In visual flight by day a pilot can see what he needs to under conditions of relatively high illumination. In instrument flight by day or night he does not have to depend upon external vision at all, except in the take-off and landing phases when he is not usually required to depend on seeing low contrast objects, because the key items of information are presented in high contrast by self-illuminated devices, for example patterns of light. However, in Night VMC, by definition, the pilot has to be able to navigate by visual reference to the ground. He must keep clear of cloud or obstructions by visual reference and it is a great advantage to be able to make use of the natural horizon whenever possible.

Except in fairly bright moonlight, the ground-referenced navigation is based largely on recognizable collections of ground lights which are seen in high contrast. However, keeping clear of obstructions or cloud requires that the object to be avoided must be seen in low contrast under conditions of very low illumination. The natural horizon may, and usually does, present a similar viewing situation.

Since, in these circumstances, the pilot's ability to see is being pushed to its limit, any factor which tends to impair this performance is highly undesirable. One such factor is lowered light transmission in the windscreen, deliberately introduced by tinting.

If you have a choice of aircraft available for your Night VMC flight, increase your odds and select the one with the clear windscreen. It may just make the difference ●

Pilot contribution

In response to your request for pilots to relate experiences which may help to remind others of essential features in maintaining safe flying, I send you the following cautionary tale.

While recently flying from Perth to a country centre with a single airstrip, I gave an inbound call on the area VHF frequency at 20 nm from destination, specifying destination, distance and altitude. A few minutes later I intercepted a call from another aircraft operating in the circuit at my destination and called him up to repeat my inbound call, receiving acknowledgement from him.

As my course for the aerodrome was approximately on the base direction for the strip, I descended to circuit height and joined base leg, giving a radio call on base leg, specifying the runway.

After turning on to final approach, my passenger drew my attention to another aircraft flying on a parallel course at the same altitude, about 200 feet to starboard. He had obviously been on final approach to the same runway. I knew that the aircraft previously operating in the circuit was on the ground at this stage. I continued my approach and landed.

The pilot of the aircraft with which I had a relatively narrow escape from collision made a tight low level circuit and was already on final approach as I taxied back along the strip.

After he had landed and shut down, I approached him and, in order to bring up the subject as tactfully as possible, I apologised for unwittingly baulking his landing approach. He said that he had been surprised to see me and that he had not heard my calls as he had had his radio turned down. I said no more, but mentioned the incident to the organisation from whom he had hired the aircraft, when I returned to Perth. They replied that he was a charter pilot who had seemed to be very experienced. Certainly his handling of his aircraft appeared to me to be most competent, skilful and expert — much better than my own flying skills could hope to be.

There appear to be two major lessons to be learned from this incident.

Firstly, if I had been keeping a proper look-out on base leg before turning on to finals, I should have seen this aircraft approaching on a collision course from starboard and I must have given way to him.

Secondly, no matter how skilful and experienced a pilot is, he must still observe the precaution of broadcasting his intentions and listening out for other aircraft when landing anywhere, even at relatively remote country strips.

Though these lessons have been stressed in the *Aviation Safety Digest* repeatedly in the past, you may feel that a further repetition is well worth-while ●

Boeing 727 descends into the sea

While making a non-precision instrument approach at night to Pensacola Regional Airport, Florida, USA, a Boeing 727-235 descended into the sea about three nautical miles short of the runway threshold. Three of the 52 passengers were drowned when the aircraft sank in about 12 feet of water, but the remaining passengers and the six crew members were rescued by the crew of a tugboat which happened to be in the vicinity at the time of the accident.

The aircraft departed Mobile on an IFR flight plan to Pensacola, cruising at 7000 feet. The captain was flying the aircraft. On contacting the Pensacola radar controller the aircraft was told that it would be vectored for an airport surveillance radar (ASR) approach to runway 25. ASR provides range and azimuth information to the controller but not altitude data. At the crew's request, the controller restated the type of approach and added, 'Pensacola weather, measured ceiling four hundred overcast, visibility four (miles), fog, haze'. The crew acknowledged and shortly afterwards asked the controller if the ILS for runway 16 was in use. They were told it had been out of service for several months because of construction on the runway.

At this point, the 727 was being vectored for the approach behind another jet airliner and the controller transmitted to both aircraft, '. . . published minimum descent altitude (MDA) four eight zero (480 feet), missed approach point (is the) runway threshold'. The message was acknowledged only by the other aircraft. The cockpit voice recorder (CVR) transcript from the 727 subsequently showed that when the message was broadcast, the crew was reviewing the ASR approach to runway 25. The first officer (FO) briefed the captain correctly on the approach minima and the missed approach procedure, and the captain acknowledged the briefing.

At 11 miles north-west of the airport, the flight was cleared to descend and maintain 1700 feet and was advised that a 'Twin Beech' on an ASR approach 'broke out at four hundred and fifty feet indicated'. The FO remarked that 480 feet was the MDA, and that 450 feet was 'illegal for that runway'.

Shortly afterwards, the FO reported descending through 2600 feet 'for seventeen hundred (feet)'. The flight was vectored to a heading of 110 degrees and the captain began the approach checks. The descent and in-range check lists had been completed and the before-landing initial check list was begun.

Two minutes later the controller told the flight it was six miles north-east of the airport, and the aircraft was successively turned on to 160 degrees and 220 degrees. The captain called for 15 degrees of flap and, five seconds later, the flight engineer reported that the before-landing initial check list was complete.

Half a minute later, the crew received and acknowledged clearance to descend to 1500 feet. The controller told the flight it was 'five and one-half miles from the runway — continue to your minimum descent altitude'. The crew acknowledged the clearance and the flaps were extended to 25 degrees. Shortly afterwards, the controller instructed the flight to turn on to 250 degrees and the transmission was acknowledged.

When the aircraft was four miles from the runway the controller reported that the preceding jet aircraft had carried out a missed approach. The crew replied, 'Thank you'. Almost immediately, the landing gear warning horn sounded and four seconds later, as the aircraft rolled out on the final approach heading, the captain called for the landing gear and the landing final check list.

In response to the flight engineer's check list challenge 'Landing gear and lever', the FO responded, 'Down, three greens'. The flight engineer stated, 'Standing by on the final flaps'. These remarks coincided with a transmission from the controller that the aircraft was on course and three and a half miles from the runway.

Four seconds later, the ground proximity warning system (GPWS) whooper sounded and the 'pull up, pull up' voice warning began. The GPWS warning continued for nine seconds and during this time only two remarks appeared on the CVR transcript — the captain said, 'Did you (get) your thing?', and the FO commented, 'Descent rate's keeping it up'.

The flight engineer activated the inhibit switch of the GPWS in response to what he believed was the captain's command to turn the system off. Several seconds after the warning ceased, the FO called, '. . . we're down to fifty feet' and two seconds later the aircraft hit the water.

Investigation

Aircraft performance

A flight data recorder (FDR) readout was made of the final seven minutes 22 seconds of the flight. The last 10 minutes of the CVR tape were transcribed.

Examination of this information revealed that the descent rate was less than 1000 feet per minute until passing through 1300 feet, when it increased to about 1500 feet per minute. At 500 feet the rate increased to 2000 feet per minute and at 300 feet began to decrease again to about 1250 feet per minute. It remained at that value over the last 100 feet of the descent. The GPWS activated at about 500 feet — almost coincident with the maximum descent rate — and ceased at about 250 feet.

During the descent from 1700 feet, the indicated airspeed was between 150 and 160 knots IAS until the aircraft reached 600 feet, when it started to decrease. The last recorded airspeed was 138 knots IAS.

The final descent from 1700 feet was begun with the landing gear retracted and the flaps extended to 15 degrees and with a thrust reduction to 25 per cent of take-off rated thrust. This was maintained until about 1400 feet when the flaps were extended to 25 degrees. Over the next 21 seconds the thrust was reduced, reaching 12.5 per cent at 1250 feet. Thrust stayed at 12.5 per cent for about nine seconds then reduced to flight idle. At 940 feet, when the landing gear was extended, the thrust had reached flight idle and it remained there during the final 35 seconds of flight.

The pitch attitude trace showed that the aircraft descended from 1700 feet to 1500 feet at an attitude of about three degrees nose up. Shortly after leaving 1500 feet the flaps were extended to 25 degrees, and from that point down to 1300 feet the attitude decreased to about zero degrees. At about 1250 feet the nose of the aircraft was lowered to three degrees nose down, and this attitude was maintained down to 500 feet. At 500 feet, almost simultaneous with the GPWS warning, the pitch attitude lowered to four degrees nose down and remained there until about two seconds before the GPWS warning stopped. At this time the nose of the aircraft was raised, and over the last 10 seconds the pitch attitude increased to about 0.5 degrees nose up at impact.

ATC procedures

The prescribed ASR procedures for this airport state that the final approach fixes are five miles from the thresholds of all runways, the minimum altitude at the fixes is 1500 feet, and descent to the MDA begins at the final approach fix (FAF).

The approach gate is defined as 'the point on the final approach course which is one mile from the final approach fix on the side away from the airport or five miles from the landing threshold, whichever is farther from the landing threshold. . .'. The approach gate for runway 25 was six miles from its threshold.

The controller is required to vector arriving aircraft to intercept the final approach course at least two miles outside the approach gate and at an altitude which will allow descent in accordance with the published procedure for a non-precision approach. Based on these requirements, the *intercept point* on the final approach course to runway 25 is eight miles from the threshold. The controller is also required to give 'advance notice of where descent will begin and issue the straight-in MDA prior to issuing final descent for the approaches'.

The aircraft was about five miles from the runway before the controller issued the turn on to the final approach heading. The controller said he knew the turn on to final was less than eight miles from the runway and that it was not as far out as he would have liked, but that he never doubted the safety of the approach.

The controller also furnished the flight with six position reports; the first two based on the distance of the aircraft from the airport, and the last four on its distance from the runway.

The controller knew he was required to give the pilot advance notice of the descent point, but as the aircraft was already descending, and as he had cleared it to descend to the MDA before it reached the descent point, he 'felt that would not apply; he was already in a descent'.

The FO testified that the entire crew was busy after they descended from 1700 feet, 'but not to the point where it was of great concern to me'. He also noted however, that 'the check list was delayed because we were not aware that we were at the final approach fix until we received clearance down to our minimum descent altitude'; and further, 'we were definitely not in the configuration over the final approach fix that we had desired'.

The captain expected to be vectored to intercept the final approach course and be given warning of the FAF so that he '. . . could have the aircraft in the landing configuration at the time (he) arrived over the final fix'. He did not receive the information he needed, particularly the distance to the FAF, although he knew that it was five miles from the runway. If he had received this distance information the aircraft would have been stabilised, there would have been 'much less to do after passing the final approach fix', and 'more attention (would have been) directed to flying and less at accomplishing other functions'. The captain testified that he felt a little rushed, but '. . . didn't feel rushed enough to execute a go-around at that point'. In response to the question 'At any time did you think the approach should be abandoned or refused?' he answered, 'If I had thought so, I would have gone around'.

The flight engineer testified that after they were cleared to the MDA he had 'a slight feeling of rush'. He said that the controller gave them a turn about the same time they were cleared to the MDA, and he '. . . felt like we were a little bit rushed due to where we were at in the check list and everything, but I didn't think it was that serious'.

Ground proximity warning system

When the GPWS system operates, large undimmable red 'pull up' lights located on the lower right hand corner of the captain's and FO's instrument panels provide a visual warning; aural warning is provided by a speaker located in the cockpit ceiling. The GPWS inhibit switch, which de-activates the system, is located on the flight engineer's lower panel and is safety wired in the armed position. If the system is inhibited and the switch is then returned to the armed position there is a four second delay before it resumes normal operation.

The GPWS has five warning modes, but only two are pertinent to this accident:

Mode 1 – Excessive descent rate below 2500 feet above ground

Mode 1 does not depend on aircraft configuration and functions all the time. It is triggered by a descent rate of 1700 feet per minute at 700 feet AGL, decreasing linearly to about 1400 feet per minute at ground level.

Mode 4 – Non-landing configuration below 500 feet AGL.

With the gear down and flaps set at 25 degrees, a Mode 4 warning is triggered at 500 feet AGL at a sink rate of about 1420 feet per minute.

Modes 1 and 4 activate visual and aural alerts followed by a verbal command 'pull up, pull up'. The warnings are continuous until the condition is corrected.

If a GPWS warning is sounded on descent, company instructions provide the following guidance to the flight crew:

'It is not intended that a missed approach be conducted in each case involving a GPWS warning. The GPWS alert is a warning that the crew must immediately focus their attention on terrain proximity and make a determination as to whether the warning is valid. If there is any doubt as to the validity of the warnings, positive action to alter the flight path to stop the warning should be initiated immediately. This action is particularly appropriate under the following conditions:

(a) While manoeuvring for an approach at night or in instrument conditions.
(b) When established on an approach where vertical guidance is unreliable . . .'

When the GPWS warning sounded, the captain looked at his altimeter and instantaneous vertical speed indicator (IVSI) and '. . . misread the altimeter. I had 1500 instead of five (500 feet), and my rate of descent was in the vicinity of 2000 (feet per minute)'.

The FO thought the aircraft was still above 1000 feet when the GPWS activated. He said that he 'noticed an excessive descent rate', identified that as the cause of the alarm, and brought it to the captain's attention. He thought that the captain had acknowledged the information; he saw the captain initiate back pressure on the yoke, he felt the aircraft respond, and at that point the ground proximity warning system ceased'.

The captain believed that since he was at 1500 feet when the GPWS warning began, he did not make any drastic corrections, because he '. . . wanted to make it as smooth as possible'. He just 'eased the yoke back and I think I used a little cruise trim . . .' but did not add power. 'When I started shallowing the descent, the warning went off and I thought the problem had been solved'. He also checked on terrain proximity. 'I looked for terrain. There was none to see. I could have used the radio altimeter but did not do so because I was mentally above a thousand (feet) and I don't normally use it on this type of approach until after I have passed a thousand'.

The loudness of the aural warning made verbal communications between crew members difficult. Although the remark, 'Did you (get) your thing?', was recorded on the CVR, the captain did not recall making the remark and the FO did not recall hearing it. A similar GPWS on another company Boeing 727 was measured for loudness; it produced a level of about 100 dB. According to acoustics experts, this noise level would impede normal verbal communication.

The flight engineer thought he saw 700 feet on the altimeter when the GPWS activated. He heard the remark, 'Did you (get) your thing?', and believed it was the captain talking; however, because of the noise of the GPWS warning, he was not positive of the exact words or whom the captain was addressing. He said he asked if the captain wanted the GPWS shut off but the CVR transcript does not corroborate this statement; he then heard the FO say that the descent rate was 'keeping it up' and replied, 'I am disconnecting this. Okay, just a second'. The flight engineer broke the safety wire and turned off the GPWS. Later he returned the switch to the armed position. He thought that the system would reactivate if the aircraft was still being operated 'within the alarm parameters of any mode of the system'. The GPWS alarm did not sound again.

Altimetry

The captain's and the FO's instrument panels were equipped with drum-pointer type barometric altimeters, in which hundreds of feet are indicated by a radial pointer and thousands of feet are indicated on a rotating drum.

The captain said that he misread his altimeter at 500 feet and believed he saw 1500 feet. 'When that figure got on my mind as I ran my scan after that, I was seeing 400 and 300 and they were 14 and 13 in my mind. I was looking at the needle instead of looking at the 1000 foot marker in it. I didn't actually look at the 1000 foot pointer at the time. I just glanced down at the 100 foot pointer'.

After being cleared to the MDA the FO reset the altitude alert system and shifted his vision outside the cockpit to seek ground cues. He saw a red light which he was unable to identify and his attention remained outside the aircraft until the GPWS alert began. After the alert was silenced, he 'referenced (his) altimeter — in preparation for . . . one thousand foot call. That was when (he) noticed 1100 feet.' He said his procedure for reading the altimeter is to read the pointer first. 'That is the most obvious, because the hand is pointing to a number'. Next his eyes go to the window, and he notes the thousand that is associated with the previously observed hundred feet, and in his mind computes the altitude.

He stated that 'Each pilot has a built-in time clock, so to speak, where you are in a habit of doing certain things — selecting flaps, whatever, and looking back at your instruments'. In this case the aircraft had attained a higher descent rate than normal, which he was 'not aware of at the time'. 'When I looked back referencing my instruments expecting to see 1000 feet, in my own internal time clock, that was where I expected that we would be, approximately 1000 feet. That was confirmed when I saw the "1". I initially read that as 1100 feet because that is what I expected to see'. He added that he failed to make the required altitude callouts because he was never aware of the fact that the aircraft was below 1000 feet until just before impact. According to the CVR, the only altitude callout he made was at 50 feet.

The captain alluded to a similar sensing of time passage during the descent, '. . . normally when you start to descend, you don't expect to go through this great an altitude this quickly, and at the completion of these things you just normally expect to be at a higher altitude than we were . . .'

The captain's and FO's radio altimeters, located near their attitude indicators, provide absolute altitude data below 2500 feet AGL. Both were set to the proper MDA for the approach, and therefore the MDA warning lights on the flight directors and above the radio altimeters should have illuminated when the aircraft descended below the MDA.

The captain and FO could not state whether the MDA lights were illuminated, but they could not recall seeing them, and did not recall ever looking at their radio altimeters. They added that the radio altimeter is a backup instrument until the aircraft is below 1000 feet and that there is no need to include it in their monitoring scan until then. Since, in their minds they never reached 1000 feet, they did not expand their scan pattern to include the instrument.

Operating procedures

According to the company's B-727 Flight Manual, the pilot not flying is required to call out the following:

'1000 feet — (SPEED) and (SINK RATE),
200 feet above (MDA),
100 feet above (MDA),
MDA,
Runway in sight or Missed Approach Point'.

He is also required to call out any excessive deviations from the desired sink rate and target indicated airspeeds.

The flight manual also advises the pilots: 'IF AT ANY TIME during the approach the aircraft alignment, altitude, speed, sink rate, or any other factor gets out of bounds to the point that excessive manoeuvring is necessary to achieve the proper re-alignment, a MISSED APPROACH shall be commenced'.

It states that the use of the flight director on an MDA-type approach is optional but recommends that the flight director not be used for the descent portion of ADF or ASR approaches because of the workload added by manual control and the confusion that results.

Analysis

The evidence showed that the radar controller did not adhere to established procedures designed to aid the flight crew in the proper pacing of their cockpit duties during the ASR approach. He was required to position the aircraft on the final approach course at least eight miles from the runway, but gave the aircraft its vector to the final approach course about five miles from the runway, and the crew completed the turn about six seconds after they were told they were four miles from the runway.

Since the ASR approach is not based on a navigation aid which provides a portrayal of position data on the aircraft's navigation instruments, the pilot must depend on the controller for information as to his aircraft's position relative to the airport at all times, particularly information concerning distance from the final approach descent point, so that he can configure his aircraft for the approach in a timely manner. Although the controller did provide the flight with position information several times, he did not give the required 'advance notice of where descent will begin'. He contended that this notice was no longer required, since he had cleared the aircraft to descend to the MDA before it reached the FAF. However, the standard procedures are intended to ensure that the controller affords the pilot preparation time to configure his aircraft for the impending final descent, and the clearance to descend to the MDA half a mile before the descent point did not comply with either the intent or recommended phraseology of these procedures.

The controller said he had misjudged the aircraft's distance and turned it on to final inside the recommended distance. However, he knew that the aircraft was in a 'descent configuration', that he had cleared it to the initial approach altitude about six miles from the runway, and that it was intercepting the final approach course about 4.5 miles from the runway. Since the controller had received no information from the pilot to indicate he was having difficulties, there was no reason for him to terminate the approach.

Because the controller did not position the aircraft on the final approach course outside the approach gate, he created a situation that made it impossible for the captain to configure the aircraft in the manner specified in the flight manual in that he would have had to lower the flaps to 25 degrees and extend the landing gear either as he was approaching the fix or on the intercept turns to the final approach course.

While on a 110 degree heading, which was within 40 degrees of what would constitute a downwind leg to runway 25, the captain was told that his aircraft was six miles north-east of the field; 34 seconds later he was turned to a heading of 160 degrees. He should have recognised that this heading approximated a base leg to runway 25, and that it would keep his aircraft within six to eight miles of the field until he was turned to the final approach course and fix. Since the captain knew that the FAF and the 'start descent' point were five miles from the runway, he should have recognised that the intercept turn or turns from the 160 degree heading would place him on the final approach course at, or possibly inside, the FAF. Thus, he should have known that he would need to extend the flaps to 25 degrees and lower the landing gear either on this leg or on the turn to intercept the final approach course. The evidence showed that either he did not recognise what was happening, or he was unable to make these adjustments to the recommended procedures.

The captain did nothing to further configure his aircraft until about one minute after it was turned on to the intercept heading to the final approach course, when he requested 'twenty five flaps'. The landing gear was not extended until half a minute later, when the aircraft was completing its turn on to the final approach course and was descending through about 940 feet.

These delays resulted in landing flap never being extended, and increased the captain's workload during the descent, thus contributing to the major causal area of the accident — a lack of altitude awareness. The delay in beginning the 'before landing' final check list also contributed in part to the FO's failure to provide the captain with some of his required altitude callouts.

The evidence disclosed that the FO either did not look at his altimeter or he did not perceive what he saw until the aircraft was at 100 feet, when it was descending at 20 feet per second.

The FO's duties also required him to seek ground cues during the descent. The origin of the red light which he saw was never determined but his preoccupation with it caused him to omit several required callouts. He did not call out a descent rate and an airspeed which exceeded the recommended parameters, and he did not make the required altitude callout at 1000 feet; his explanation for the latter omission was the upset of his 'inner time clock' which was based on a normal descent rate.

The first positive indications that the FO had returned his attention inside the cockpit were his extension of the landing gear and his response to the relevant check list challenge. He did not recall any altimeter or IVSI readings during this period and had either redirected his attention outside the aircraft or was monitoring the landing gear warning and position lights. During this time the aircraft descended through 680 feet and he did not provide the captain with the required '200 feet above MDA' call.

The GPWS warning began shortly after this, and the ensuing cockpit conversation disclosed that the captain's and FO's attention was directed immediately to their IVSIs and the 2000 feet per minute descent rate, not to their altimeters. Neither noted that the MDA had been passed.

While the FO's failure to provide the captain with altitude callouts during the upper part of the approach can be attributed to his distraction by outside visual cues, another source of distraction from about 1000 feet down to the activation of the GPWS was his workload during landing gear extension and the associated monitoring tasks. Under normal circumstances these tasks should have been completed before the start of the descent to MDA, not upon leaving 1000 feet.

A review of the captain's activities from 1700 feet to the activation of the GPWS disclosed that from 1700 feet to about 1300 feet he had established a stable approach path — the average rate of descent was about 600-800 feet per minute; there was a slight increase in airspeed from 154 to 160 knots IAS; the thrust was stabilised at 25 per cent of take-off rated thrust; and, except for a momentary pitch down as the flaps were extended to 25 degrees, the pitch attitude decreased slowly from three degrees nose up at 1700 feet to two degrees nose up at about 1300 feet. Had the landing gear been extended and the flaps lowered to 30 degrees, the aircraft would probably have achieved the desired parameters for the approach. However, because the landing gear was not extended for another 25-30 seconds and the flaps remained at 25 degrees, the captain experienced added difficulties in his attempts to attain the desired descent rate and airspeed.

Contrary to the flight manual's recommendations, the captain continued to use his flight director during the approach, but only for heading guidance. An FAA report on pilot eye-scanning techniques notes that during a flight director approach, 74 per cent of the pilot's scan time is devoted to the flight director attitude indicator. In this instance, the manner in which the captain was using his flight director attitude indicator probably caused him to devote a higher percentage of his eye scan time to the flight director indicator and less to the other flight instruments.

At 1300 feet, when the turn to 250 degrees was commenced, the captain increased the rate of descent to 1000 feet per minute, decreasing thrust and lowering the nose to a pitch attitude of about three degrees nose down. The pitch attitude thereafter remained constant until the GPWS warning began, but the descent rate increased as a result of further thrust reduction and the extension of the landing gear. The captain had established an attitude which initially produced the desired rate of descent; however, he still kept retarding thrust until it reached 12.5 per cent of take-off rated thrust. At this point, the airspeed was about 10-15 knots IAS over target speed and it appears that the thrust reduction was an attempt to reduce airspeed while maintaining the pitch attitude. Since the captain did not alter the pitch attitude, the lower thrust settings reduced the airspeed and increased the descent rate. Further thrust reduction resulted in the aircraft approaching the MDA with thrust at flight idle and with a descent rate at or above 1600 feet per minute.

The evidence concerning this phase of the flight disclosed that the demands of trying to establish a stablilised approach and ensuring that the MDA was reached in sufficient time at a safe airspeed might have contributed to a breakdown in the captain's instrument scan pattern. He evidently fixed his attention on the flight director indicator and either excluded the altimeter and IVSI from his scan, or placed them at the outer perimeter of his attention span where he did not perceive their readings. Of paramount importance to this phase of the flight were the required altitude callouts, which the FO failed to make.

The captain experienced the same sense of pace that misled the FO and, since he was not aware of any rate of descent in excess of 1000 feet per minute, he did not expect to go through 'this great an altitude this quickly'. Thus, when the GPWS activated and he saw 500 feet on his altimeter he believed it read 1500 feet. The evidence showed that the captain was well aware of his altitude at 1700 feet, he knew he was cleared to descend to 1500 feet, he knew he was cleared to the MDA, and he set up a 1000 feet per minute descent rate some time after receiving this clearance. The Board could not determine how, under these circumstances, the captain could have read 500 feet and interpreted it to be 1500 feet, an altitude he knew he had left almost one minute earlier.

The captain also said he misread his altimeter twice more after he made the first error. Since he knew he was descending towards the MDA and he could hear the ground proximity warning, the Board did not believe it reasonable that he would repeat the first error twice more. While the warning was sounding, however, the captain recalled the IVSI reading correctly. He recalled his control inputs, the manner in which they were made, and the results these inputs had on the descent rate. Based on the foregoing, the Board concluded that the captain focused his attention on the IVSI and either did not look at his altimeter or did not perceive its reading.

The Board believed that the GPWS warning might have prevented the pilots seeing the MDA lights. Although the evidence disclosed that the MDA warning light system was operational and that the proper MDA value had been inserted into the radio altimeter, neither pilot saw these lights illuminate. The activation of the GPWS warning directed the attention of both pilots to their IVSIs and the GPWS pull-up lights, which are much brighter than the MDA lights. As a result neither pilot saw the last automatic warning that might have alerted him to the altitude.

The flight engineer believed he had been instructed to turn the GPWS off and the CVR transcript substantiates his belief. After the system was turned off the flight engineer reset the switch. He must have reset it within four seconds of impact however, since the system did not have time to recycle.

Once the GPWS had sounded, the captain concurred with the FO's analysis that it was the excessive descent rate which caused the warning. He eased back on the control column, saw the descent rate lessen and heard the alarm cease. But the alarm ceased because the system had been inhibited, not because of the change in the descent rate. The captain erroneously concluded that the problem was solved. The rate of descent had decreased to 1600 feet per minute when the warning was silenced and the captain continued to descend without checking his altimeter. In this case, his failure to check his altimeter was vital to the safety of the flight, since the performance analysis disclosed that at this time the captain could have arrested the descent and avoided the crash.

Because the sky was dark and the aircraft was being flown in instrument meteorological conditions on an approach which afforded the pilot no vertical guidance, a prudent captain would have initiated a missed approach at the onset of the warning rather than try to determine its validity. The procedures in the company flight manual stated that under these conditions positive action to alter the flight path would be 'particularly appropriate'. Merely easing the nose of the aircraft up to reduce the descent rate without adding thrust cannot be classified as such positive action. The fact that the aircraft entered the warning regime in a three degree nose down attitude, at a descent rate of 2000 feet per minute and with all engines at or near flight idle should have constituted added grounds for the captain to positively alter the flight path.

The GPWS procedures also required that the pilots 'focus their attention on terrain proximity' to determine the validity of the warning. The beginning of the GPWS alert constituted, if not an emergency, certainly an abnormal situation and should have made them check every available altimeter system to fix the position of the aircraft relative to the terrain. The pilots knew they were at an altitude where the radio altimeters were operative, they knew that the approach was being made over water, and they knew that there were no terrain features present that would have made the radio altimeter readout suspect. Under the circumstances, the Board concluded that an experienced flight crew should have checked their radio altimeters, since these would have provided them with an immediate readout of absolute altitude.

In summary, the Board believed that the ATC procedures affected the conduct of the approach and, therefore, contributed to the chain of events which led to the accident. Although the controller had placed the aircraft in a position from which the approach could have been completed safely, he also had placed it in a position where the captain had to alter the timing of his check list procedures in order to configure his aircraft more rapidly than usual. While the controller's handling of the flight did not place the aircraft in a dangerous position, his non-standard procedures made the approach more difficult for the crew to accomplish.

The accident would have been averted, however, had the pilots performed to the established standards expected of airline flight crews. It was apparent that a lack of professionalism on the crew's part contributed to their inability to recover from a procedural error on the part of the controller.

Probable cause

The Board determined that the probable cause of the accident was the flight crew's unprofessionally conducted non-precision instrument approach, in that the captain and the crew failed to monitor the descent rate and altitude, and the first officer failed to provide the captain with required altitude and approach performance callouts. The crew failed to check and utilise all instruments available for altitude awareness, turned off the ground proximity warning system, and failed to configure the aircraft properly and in a timely manner for approach.

Contributing to the accident was the radar controller's failure to provide advance notice of the 'start descent' point which accelerated the pace of the crew's cockpit activities after the passage of the final approach fix ●

(Condensed from a report published by the National Transportation Safety Board, USA)

From the Reports . . .

QFI commenting on a student pilot: 'When this student starts the engine, he starts a chain of events over which he has no further control'.