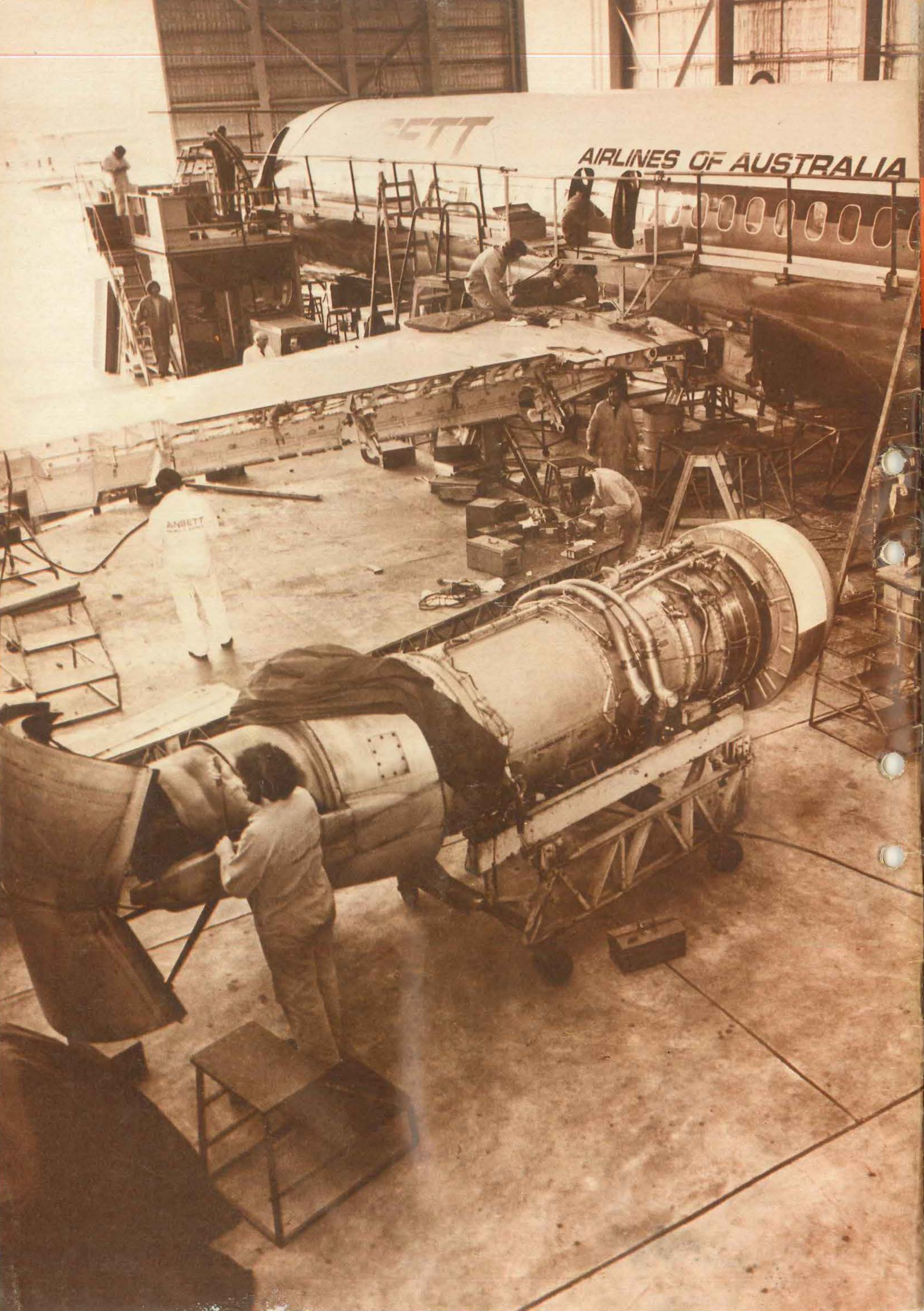
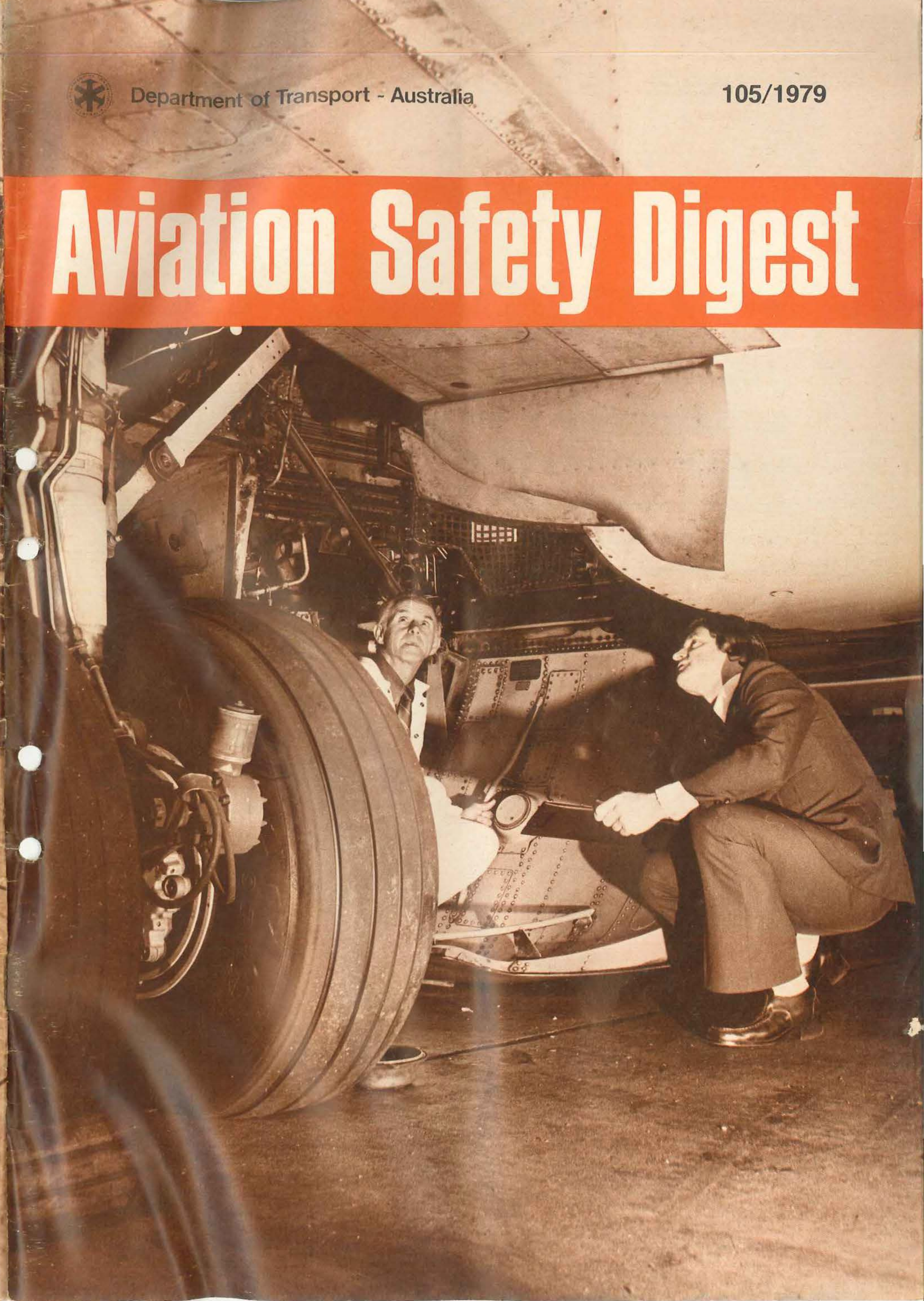


Department of Transport - Australia

105/1979

Aviation Safety Digest



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Oxygen and the pilot

More and more light aircraft these days are coming equipped with turbochargers, pressurization and the performance to fly up where the angels sing. As general aviation develops, more pilots are being trained to operate machines capable of high altitude flight. There is a lot to learn about this kind of flying and a good starting point is the reaction of the human body to flight above 10 000 feet.

Air pressure

About 175 years ago scientists first discovered that the prime purpose of breathing was to obtain oxygen needed by the body and to get rid of excess carbon dioxide, a waste product.

The human body is a heat engine which, like any engine, consumes fuel (the carbohydrates, fats and proteins derived from food). This fuel is converted into the energy we need to live by a burning process called oxidation. As in any other burning process, a certain amount of oxygen is necessary. When the body is resting, it consumes approximately 0.3 litres of oxygen per minute. When given an added workload such as walking or running, the body, like any other machine, will generate more heat and use more oxygen, perhaps as much as five litres per minute.

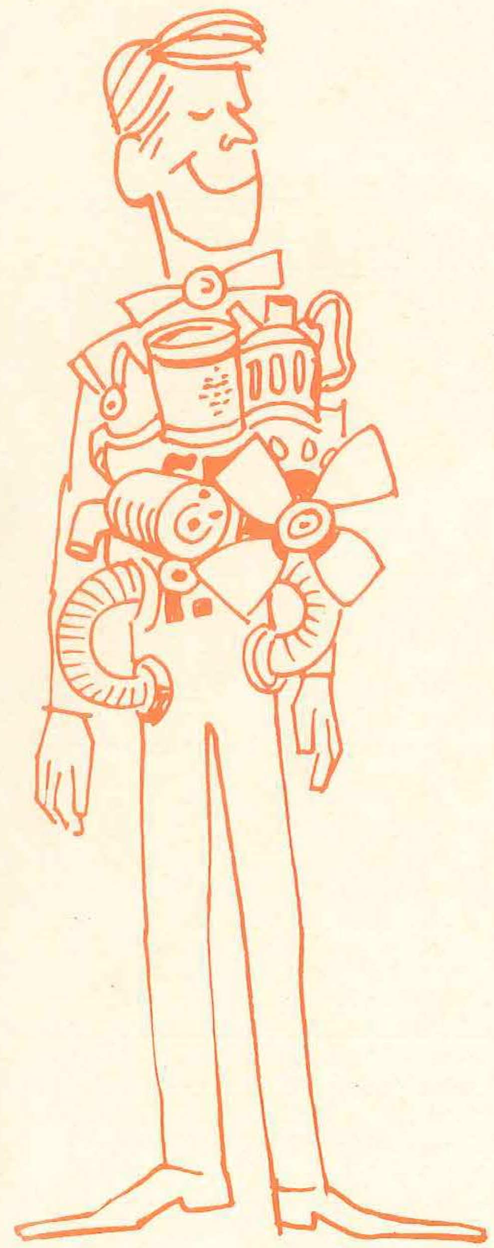
To extract this oxygen from the air, the body is equipped with a respiratory system (lungs). The oxygen is then distributed through the body by a circulatory system (heart, arteries and capillaries).

Air contains about 20 per cent oxygen and about 80 per cent nitrogen. At sea level, a healthy man can extract enough oxygen from the air to maintain his system and continue his normal activities. About 8000 or 9000 feet, however, problems of oxygen shortage begin to appear. Because the air is less dense, it offers less actual oxygen per breath of air inhaled — even though oxygen and nitrogen are still mixed in the 20:80 ratio. The density of air is measured by barometric pressure, and it is on this principle that your altimeter is built.

Oxygen is carried in the blood as a simple physical solution, and in loose chemical combination with the haemoglobin of the red cells in the form of oxyhaemoglobin. As the result of inhalation of air into the lungs, blood is oxygenated and this oxygen is carried to all the tissues of the body. Carbon dioxide produced in the tissues is carried in the blood, in chemical combination and in simple physical solution to the lungs where it is exhaled.

Blood can be compared to a conveyor belt, constantly hauling oxygen in and carbon dioxide out. The amount of oxygen that can be carried in the blood depends, to a large extent, upon the pressure that the oxygen gas in the air exerts on the blood as it passes through the lungs. (Manufacturers of carbonated drinks take advantage of this pressure principle to dissolve large amounts of carbon dioxide gas in their beverages).

At 10 000 feet, the blood of a man who is exposed to outside air can still carry oxygen at 90 per cent of its capacity. At this altitude, the flight performance of a healthy pilot is impaired only after some time, when he may find himself a little less dexterous than usual at tuning radios, slower at working navigational problems, and less able to sustain close concentration. At 14 000 feet, he may become appreciably handicapped — forgetting to switch tanks, flying off course, or disregarding hazardous situations. At 18 000 feet and beyond, exposure to environmental air will quickly cause total collapse and inability to control the aircraft.



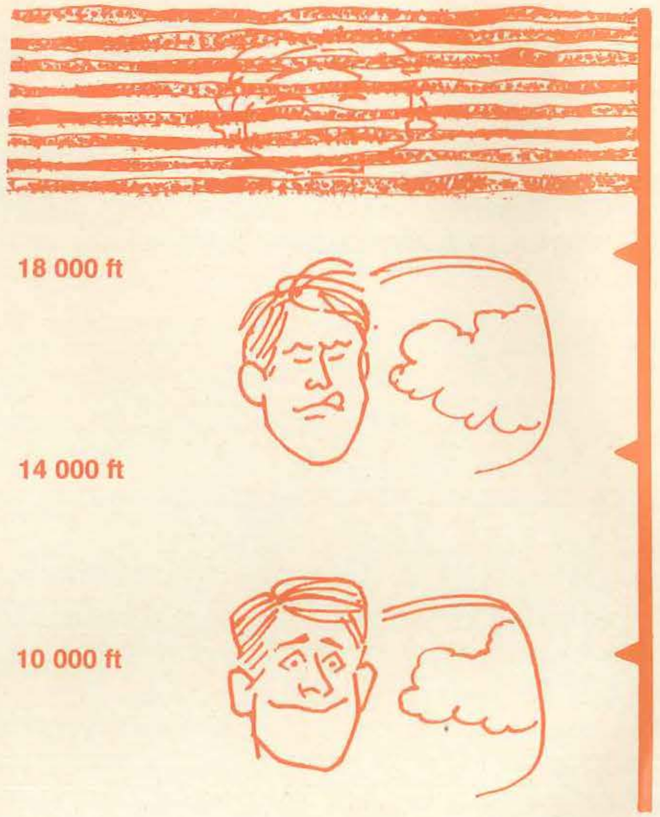
This means that if you choose to fly at high altitudes, you must take along either oxygen or pressure. You have a choice, then, between pressurizing the cabin of the aircraft or breathing a mixture with more oxygen in it.

Hypoxia

Lack of oxygen is the greatest single danger to man at high altitudes, despite the importance of pressure and temperatures. The shortage of oxygen in the human body results in a condition called hypoxia, which simply means failure of the tissues to receive a sufficient supply of oxygen. When a pilot inhales air at high altitudes, there is not enough oxygen pressure to force adequate amounts of this vital gas through the membranes of the lungs into the blood stream, so that it can be carried to the tissues of the body. The function of various organs, including the brain, is then impaired.

Unfortunately, the nature of hypoxia makes you, the pilot, the poorest judge of when you are its victim. The first symptoms of oxygen deficiency are misleadingly pleasant, resembling mild intoxication from alcohol. Because oxygen starvation strikes first at the brain, your higher faculties are dulled. Your normal self-critical ability is out of order. Your mind no longer functions properly; your hands and feet become clumsy without you being aware of it; you may feel drowsy, languid, and nonchalant; you have a false sense of security; and, the last thing in the world you think you need is oxygen.

As the hypoxia gets worse, you may become dizzy or feel a tingling of the skin. You might have a dull headache, but you are only half aware of it. Oxygen starvation gets worse the longer you remain at a given altitude, or if you climb higher, your heart races, your lips, ears and the skin under your fingernails begin to turn blue, your field of vision narrows and the instruments start to look fuzzy. But hypoxia — by its nature a grim deceiver — makes you feel confident that you are doing a better job of flying than you have ever done before. You are in about the same condition as the fellow who insists on driving his car home from a New Year's Eve party when he can hardly walk. Regardless of his acclimatization, endurance, or other attributes, every pilot will suffer the consequences of hypoxia when he is exposed to inadequate oxygen pressure.



What do you do about it? There is one general rule: Do not let hypoxia get a foot in the door. Carry oxygen and use it before you start to become hypoxic. Do not gauge your 'oxygen hunger' by how you feel. Gauge it by the altimeter.

Here are some general suggestions which apply to young, healthy flyers.

1. Carry oxygen in your aircraft or do not fly above 10 000 feet. If bad weather lies ahead, go around it if you cannot get over it.
2. Use oxygen on every flight above 10 000 feet. You will probably need it, and when you do, you might not realise it.
3. Use oxygen on protracted flights near 10 000 feet. It will not hurt you and you will be a lot sharper pilot.
4. As the retina of the eye is the most sensitive tissue in the body to lack of oxygen, use oxygen on all night flights above 4000 feet. If you want to give your night vision the best protection, use oxygen from the ground up.
5. Breathe normally when using oxygen. Rapid or extra-deep breathing can cause loss of consciousness also.

Flying above 10 000 feet without using oxygen is like playing Russian roulette — the odds are that you may not get hurt, but it is a deadly game! Above 18 000 feet your vision rapidly deteriorates to the point that seeing is almost impossible. The engine sounds become imperceptible, breathing is labored, and the heart beats rapidly. You have not the vaguest idea what is wrong, or whether anything is wrong. At 25 000 feet you *will* collapse and death is imminent unless oxygen is restored.

Individual response to hypoxia is so varied that no one can predict the extent of oxygen depletion needed to bring on the onset of symptoms — or which symptoms will predominate with any given individual. One person will suffer from headaches, another from dizziness, and another from euphoria under exactly the same conditions.

Breathing problems? Recognise and cope

Condition	Common symptoms	Cabin altitude	Exposure time	Conditions	Corrective action
Hypoxia	Visual disturbances Lightheadedness, dizziness Confused thinking Cyanosis Apprehension Sense of well being Muscular inco-ordination and tingling	Rare below 10 000 feet	Indefinite	Oxygen generally not used	100% OXYGEN and EMERGENCY REGULATOR SETTING Descend to safer altitude
		Expected between 10-15 000 feet	About 30 minutes	No oxygen used, or significant leak in system	
		Causes collapse above 18 000 feet	Five minutes to 12-15 seconds	Leak in oxygen system or loss of mask after decompression	
		Always above 50 000 feet without pressure suit.	Less than one minute	With pressure breathing equipment only	
Fear or anxiety (recognised fear) followed by	Uneasy sensation Tenseness Lightheadedness, dizziness Visual disturbances Fatigue Tremors	Any altitude	Constant or precipitated by unusual situations within seconds	Under any condition	Recognition of problem, then **Breathing Control** If in doubt, take one deep breath of 100% oxygen, hold breath for 10 seconds, and breathe slower.
Hyperventilation	Lightheadedness, dizziness Tingling Visual disturbances Tremors Confused thinking, faintness Numbness	Any altitude	Within seconds	Under any condition, but most likely when pressure breathing.	

Pilots who are older, fatter, out of condition or heavy smokers should limit themselves to a ceiling of 8000 to 10 000 feet unless oxygen is available. Smoking reduces tolerance to altitude because carbon monoxide from tobacco smoke combines with haemoglobin in preference to oxygen. Thus less haemoglobin is available for oxygen and a combination of carbon monoxide and increase in altitude can result in hypoxia at lower altitudes.

Remember no one is exempt from the effects of hypoxia. Everyone needs an adequate supply of oxygen. Some pilots may be able to tolerate a few thousand feet more altitude than others, but no one is really very far from average.

Hyperventilation

Some people believe that breathing faster and deeper at high altitudes can compensate for oxygen lack. This is only partially true. Such abnormal breathing, known as hyperventilation, also causes you to flush from your lungs much of the carbon dioxide your system needs to maintain the proper degree of blood acidity. The chemical imbalance in the body then produces dizziness, tingling of the fingers and toes, sensation of body heat, rapid heart rate, blurring of vision, muscle spasm and, finally, unconsciousness. The symptoms resemble the effects of hypoxia and the brain becomes equally impaired.

You are most likely to hyperventilate while flying under stress or at high altitude. For example, the stressful feeling of unexpectedly entering instrument conditions, noting both fuel gauges bouncing on empty, or developing a rough-running engine over water or mountainous terrain may make you unconsciously breathe more rapidly or more deeply than necessary.

A pilot who suffers an unexpected attack of hyperventilation, and has no knowledge of what it is or what causes it, may become terrified thinking that he is experiencing a heart attack, carbon monoxide poisoning or something equally ominous. In the resulting panic and confusion, he may lose control of the aircraft, exceed its structural limits and crash.

A little knowledge is all you need to avoid hyperventilation problems. Since the word itself means excessive ventilation of the lungs, the solution lies in restoring respiration to normal. First, however, be sure that hyperventilation, and not hypoxia, is at the root of your symptoms. If oxygen is in use, check the equipment and flow rate. Then, if everything appears normal, make a strong conscious effort to slow down the rate and decrease the depth of your breathing. Talking, singing or counting aloud often helps. Normally paced conversation tends to slow down a rapid respiratory rate. If you have no one with you talk to yourself. Nobody will ever know.

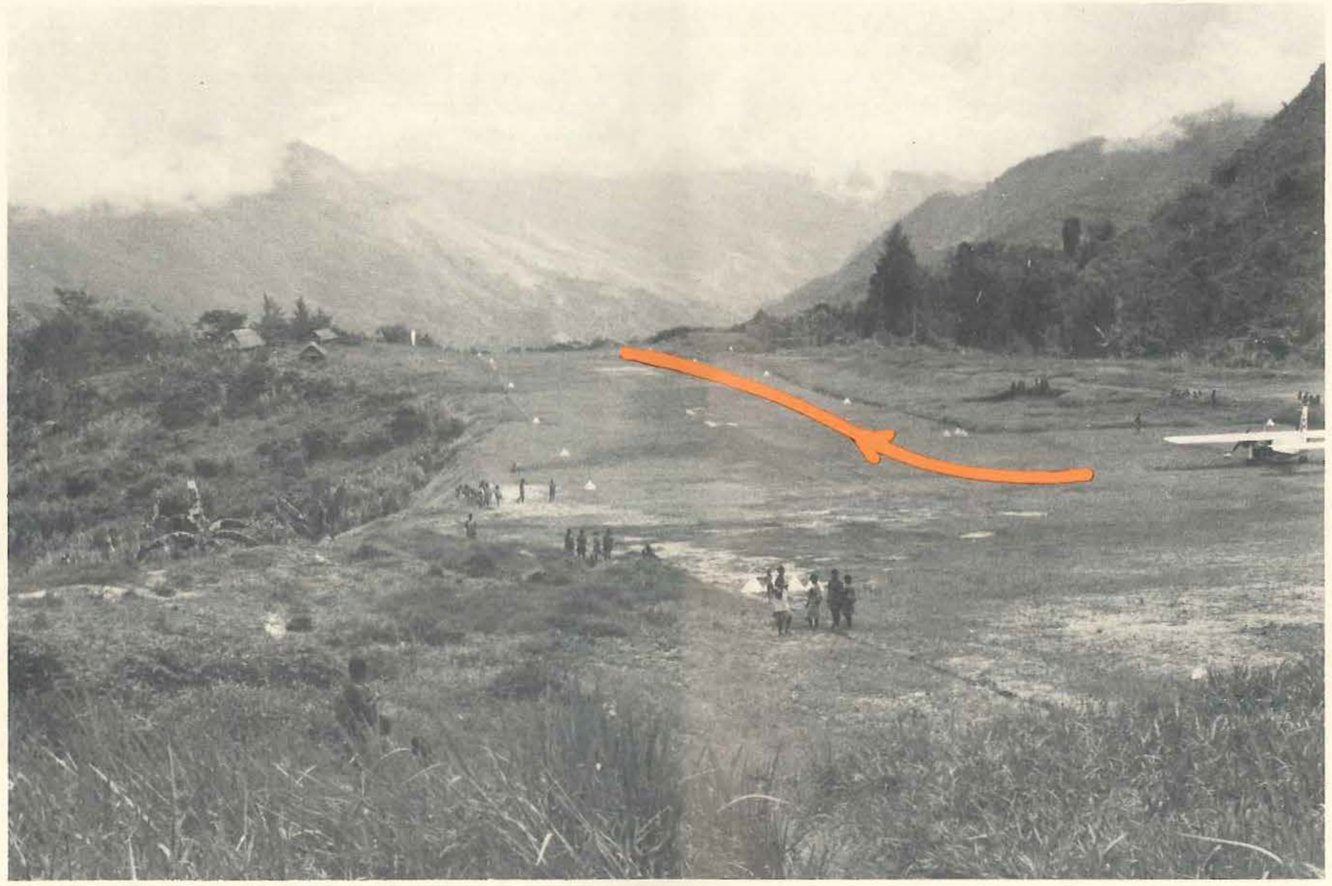
Normal breathing is the cure for hyperventilation. The body must be allowed to restore the proper carbon dioxide level, after which recovery is rapid. Better yet, take preventative measures. *Know* and *believe* that overbreathing can cause you to become disabled by hyperventilation.

The best way to recognise the symptoms and understand the effects of hypoxia is to experience it under controlled conditions. This is possible in a decompression chamber and the Royal Australian Air Force has four such chambers located at Amberley, Qld.; Richmond, NSW; Point Cook, Vic; and Pearce, WA. At present arrangements exist for interested organisations to undergo one day training courses in hypoxia and disorientation, in groups of 15-20 people. Enquiries concerning the courses should be directed in writing to the Director of Aviation Medicine, Department of Transport, P.O. Box 1839Q, Melbourne.

A future article in the Digest will deal with oxygen equipment in use and discuss its proper care and correct operation ●

Use all the strip length — and keep to the centre

A Britten Norman Islander, operating a regular public transport service departing from and terminating at Lae, Papua New Guinea, was scheduled to land at several highland airstrips en route. Outbound from Lae, the flight progressed normally and after landing at the second of the strips, the pilot taxied the aircraft to the parking bay 50 metres from the south eastern end and shut down the engines.



This particular airstrip is on a wide sloping shelf on the side of a mountain and heads directly up the slope. The approach to the strip is clear of obstructions. The average gradient along the strip is seven per cent, consequently only one-way operations are possible. The central 10 metres of the strip width consists of crushed coral and limestone and has a hard, sparsely grassed surface, but over the 10 metres either side of this central area the grass is tough and dense. From the north western threshold the ground falls away steeply to the valley floor 3000 feet below.

With three passengers on board, the pilot started the engines for departure. He did not taxi out to the centre line of the strip, nor did he take advantage of the extra 50 metres of usable strip above the parking bay. Instead, he carried out his pre-take-off checks in the parking bay and then taxied as far as the right hand side of the strip. Without stopping, he began the take-off run through thick grass near the right hand edge of the marked area.

About a third of the way along the strip, the down grade increases markedly and, upon reaching this point, the pilot momentarily considered abandoning the take-off. Up to this stage acceleration had been poor but the airspeed was increasing so he decided to continue. Acceleration remained poor however and, even though the pilot felt that the wheel brakes were dragging, he was now committed to take-off. The aircraft was rotated and the nose wheel left the ground about 20 metres from the end of the strip. The main wheels remained firmly on the ground and, as the aircraft over-ran the strip, the wheels struck a shallow ditch and a 40 cm high earth embankment across the end. The impact forced the right main landing gear leg rearwards to an angle of about 45 degrees and catapulted the aircraft into the air.

Barely maintaining flying speed, the aircraft flew through the tops of trees level with, and 60 metres beyond, the end of the strip. Impact with the tree tops dented the leading edge of the right wing but the aircraft continued in flight and, as the ground sloped away steeply from this point, the pilot was able to safely lower the nose and accelerate to normal flying speed.

(continued on page 14)

A chance in a million — a pilot contribution

In telling this story I have no intention of castigating myself for what happened but I will endeavour to criticise my decisions in order that others may learn from my experience.

The aircraft involved was a 1966 model Cessna 182 which I had flown for 45 hours in the last six months. It was one May morning when I filed a flight plan from Archerfield to Barcaldine tracking over the Taroom NDB. There was no significant weather indicated in the forecast and I planned to fly at 6500 feet. I departed Archerfield at approximately 1150 hours local time. My track was direct Archerfield–Taroom and with an airways clearance I climbed to 6500 feet. This put me on top of four oktas of scattered cumulus but the flight to Taroom was uneventful. I heard a number of weather reports on the radio indicating poor weather east of my track, but a report from a pilot who had departed Barcaldine indicated the weather there to be clear. Just after my Taroom position I encountered a build-up of cloud consistent with the previous reports from other pilots. Knowing the weather to be clear, I advised Flight Service that I was climbing to 8500 feet and this put me on top of eight oktas of stratus. I am not endorsed on the ADF but nonetheless I use the instrument and had it tuned to the Taroom NDB.

Approximately 120 miles north west of Taroom a break in the cloud confirmed my position as over the Carnarvon Ranges. Some ten or fifteeen minutes after verifying my position I first noticed shiny spots on the right hand side of the windscreen. It wasn't very long after this that there was a secondary effect on the windscreen of a smudginess and then ripples running from the bottom to the top. My position was about 30 miles north west of Consuelo Peak, flying at an altitude of 8500 feet on top of eight oktas of stratus and I realised that the engine was losing oil. A quick glance at my maps showed Springsure 50-60 miles away and rugged country all the way; Barcaldine still 180 miles; Charleville about 140 miles and Tambo over 100. It was at that stage I realised that as a flight planner I was worth about five per cent.

My first real need was a break in the cloud so that I could verify my position. It had to come soon — or so I hoped — Barcaldine weather was okay but that was 180 miles away. I figured I would hang off calling Charleville and telling them of my problem until I could give them a more accurate idea of my position — could not be real sure above eight oktas of stratus. Suddenly, to my left a huge valley in the clouds and at the end Mother Earth below, so I turned left and down I went. By this stage the right hand side of the windscreen was almost completely covered with oil and I knew I had a real problem. The cloud base turned out to be 3500 feet and a glance at the map showed the elevation in this area at between 2000 and 2500 feet. So that put me at 1000 feet above what I found to be rugged sandstone cliffs and deep gorges covered with heavy scrub as far as the eye could see in all directions.

At this stage I called Charleville Flight Service and told them of my situation which I now realised was pretty desperate. I would like to thank the operator at Charleville, who had declared an alert phase on the flight, for not harrassing me at this time for a position report as this might have added to my problems. I have flown this area a number of times and I knew that the nearest flat country that I could land on was in the direction of Augathella or Tambo and that the road running Augathella–Blackall, if I made it before the oil pressure dropped, was suitable to land on. I tried to tune the Blackall NDB but could not get a whisper out of it. Still too far away.

So I changed to a heading that I hoped would put me in this area. I was flying for about ten minutes after my descent hoping to see the black soil plains in the distance — the windscreen was almost completely covered with oil — when suddenly in the middle of my last remaining area of visibility out the windscreen, among this dense scrub, the most welcome sight I have ever seen in my life — an airstrip lying straight in front of me.

My first temptation was to fly a straight-in approach but I resisted and decided to fly a proper circuit. There was no wind direction indicator — but that was the least of my worries. I had only recently completed three hours of night circuits and I felt this helped me to land the aeroplane incident free. I feel I used good sense in flying a proper circuit and getting a look at the strip. Even though there was nothing that represented a hazard on the strip at the time, within two hours it was covered with grazing horses. A straight-in approach then could have been rather risky. As it transpired I had landed on a cattle property of some half million hectares of which I had used approximately two, the only two on the property clear of trees.

I leave myself open to constructive criticism but in the future, where possible, I know I will flight plan shorter legs between points that can be positively recognised and I will certainly think twice before flying over any large area of eight oktas of cloud ●

Editorial

***Aviation Safety Digest 102* contained an article titled 'Acrobatics and structural limitations'. The aim of that article was to clarify any doubts that readers might have had concerning the manoeuvres permitted in normal and utility certificated aircraft. The following letter was received from a well-known aerobatic pilot in response to publication of the article.**

'I read with interest the article, "Acrobatics and structural limitations" in Digest 102. Perhaps my experience causes me to review articles such as yours too critically, but I do react this way because of several factors.

'Firstly, those who wish to learn the art of flying usually read avidly. Secondly, because of their lack of experience, they are unable to discriminate and this can cause problems. For example, they may give irrelevant detail undue importance or they may misinterpret the writer's meaning. Finally, in an effort to discriminate between different articles, they are apt to give more importance to articles in official magazines compared to the information which may be available from other sources. Therefore, I believe one segment of your article deserves comment.

'A Cessna Aerobat was used in all your diagrams. This is a good aircraft on which to learn basic aerobatic manoeuvres. The aircraft is light on the controls, reasonably responsive and it has the added advantage that it is familiar to many students who have already learnt to fly in the Cessna 150. However, as the aircraft has a clean design, even a 20 degree dive will produce a rapid acceleration. What then is the connection between the aircraft performance, my previous observations and your diagrams?

'Your final diagram illustrates a Cessna Aerobat performing a vertical eight; therefore, a novice aerobatic pilot may be excused for believing that the Aerobat can easily perform this manoeuvre. He has seen the manoeuvre performed by that aircraft in an official magazine, therefore it has "official approval". This manoeuvre is not simple in any aircraft, and if performed in the Aerobat the aircraft could very well exceed:

- the VNE at the bottom of the second loop,
- the maximum permissible engine RPM, and
- the 'G' limit of the airframe.

'I realise that the "rules" state that the instructor should be rated on the manoeuvre, but few instructors would be so rated. Unfortunately, I believe, the inclusion of this manoeuvre and the Aerobat in your article may stimulate the more inexperienced instructors and students to attempt it.

'I commend you on the general content of the article. With the increased interest in this type of flying, I hope we may expect many more articles in the Digest to keep aerobatics as safe as possible. However, in future articles, I hope that a more cautious approach will be evident.'

The above comments are considered to be valid and we commend the writer on his observations. The use of the same aircraft for all diagrams arose from editorial expediency.

With the exception of inverted flight and flick manoeuvres, aircraft in the acrobatic category do not normally have flight manual limitations with respect to particular manoeuvres. The onus is therefore on the pilot and the operator to determine what activities a particular pilot/aircraft combination may engage in safely.

Our enquiries suggest that it is, in fact, difficult to perform a 'vertical eight' in a Cessna Aerobat and not exceed the aircraft limitations. It would appear that pilots of the Cessna Aerobat prefer to approximate the 'vertical eight' and complete the top loop with the aircraft nose above the horizon, then perform the half roll still climbing slightly, and commence the lower loop with the airspeed not above 60 knots. This procedure reduces the possibility of inadvertently exceeding the aircraft limitations.

Ensure that you know the aircraft limitations when you put your own to the test ●

Unorthodox but effective

Problem

The safety officer at a large airport was concerned about a certain flying school's habit of leaving wheel chocks lying about the tarmac. He correctly believed that, as the area was often used by other taxi-ing aircraft, the chocks presented an unnecessary hazard. Repeated attempts to have the school take appropriate action had no result.

Solution

Removal of the chocks by the safety officer. Faced with the prospect of either continually tripping to the safety office to retrieve the chocks every time it happened, or replacing them at a cost of $16 per pair, the flying school quickly realised it was far more practical to remove the chocks from the tarmac themselves. Perhaps not the most orthodox way to impart a safety message but effective, nevertheless ●

One down and one to go — the facts about engine failure in a light twin

This article is about pilots who fly light twin-engine aircraft (below 5700 kg maximum weight). More importantly it explains how those pilots can save the lives of their passengers and themselves by understanding the implications of an engine failure at a critical phase of flight.

Bob was obviously proud of his new aeroplane. Brightly painted, the light twin was visual proof of a very successful business. Although he would never admit to it being other than a means of transport, the amount of care and attention Bob lavished on the aircraft suggested a relationship not often seen between man and machine.

'Better than the old single; gets there quicker and two engines are better than one.' Bob never seemed to tire of extolling the virtues of his aeroplane, and his listeners usually responded in a gratifying, if perhaps predictable, manner. It was generally agreed he had done the right thing; the previous aircraft was old, and instrument flying in a single did not appeal. Hence the twin, complete with the very latest navigation aids and multi-engine safety. Bob quickly mastered the art of twin-engine flying and rapidly began to accumulate hours.

The day was fine, with a hint of possible late afternoon thunderstorms as Bob taxied the aircraft. At the holding point, he carried out his usual, meticulous, pre-take-off check and reviewed the engine failure emergency drills. Lined up and rolling for a flapless take-off, with the minimum control speed of 81 knots and best single-engine rate of climb speed of 108 knots firmly in his mind, Bob should have been conditioned to the possibility of an engine failure. Nevertheless when it did happen, at about 90 knots and with the landing gear still down, he was taken by surprise. The change of engine noise and sudden yaw momentarily froze him in his seat before he reacted.

'Stop the yaw — wings level — check maximum power — get the gear up — flaps are up — nose down to get 108 knots — can't, too low — which engine — dead leg-dead engine — check the throttle — yes, that's it — feather — hell, the speed's down to 85 knots! . . . .'

Still under control but with a slowly decreasing airspeed, the aeroplane descended into trees about a kilometre beyond the end of the runway.

Why?The day was warm, but not hot. 'Shirt sleeve conditions', the investigator had said. The fuel tanks had been full and even with some cartons of freight on board, the aircraft was certainly heavy but still about 50 kilos below maximum take-off weight. A detailed examination of the wreckage had shown that the operating engine was capable of developing full power at impact.

What went wrong? Was it the pilot, the aircraft, or something else? The pilot had performed his normal checks faultlessly and, after the initial shock of the engine failure, he did what he thought was correct. Other than the failed engine, the aeroplane was in first class order. What then went wrong? Another unexplained accident? Not a bit of it! Bob was simply unfortunate to experience an engine failure in his light twin at its most critical phase of flight — just after lift off. The warm day and heaviness of the aircraft did not help matters.

Why did the aircraft fail to climb? Isn't it a basic design concept of multi-engine aeroplanes that failure of an engine will not compromise its safety? Surprisingly the aircraft designer could consult his graphs and charts and show that, for the conditions existing at the time of the accident, with the gear down, the propeller on the failed engine windmilling and a lower than optimum airspeed, the aeroplane would descend at 130 feet per minute.

Is this unique to Bob's aircraft or a performance characteristic shared with other light twins? If the latter, how can multi-engine aircraft be built, certificated and sold if incapable of maintaining altitude or climbing following an engine failure at a critical phase? To answer these questions it is necessary to consider some basic airworthiness design philosophies. As a starting point, a comparison will be made between light twins and large transport category aircraft.

The fail-safe concept

In formal terms, light aircraft are those having a maximum take-off weight of 5700 kilogrammes or less. This quite arbitrary barrier separates the large transport category aeroplanes from the normal, utility or acrobatic category aircraft.

Designed in accordance with the 'fail-safe' concept, the large transport category aeroplane can be said to represent the epitome of aerial safety. Simply speaking 'fail-safe' implies that flight safety will not be unduly jeopardised should there be a failure of any one element (or in some cases multiple elements) within any of the various systems comprising the complete aeroplane. For example, wing structures have multiple load paths and essential items of equipment are duplicated; similarly there are usually at least two qualified pilots. To sustain this concept in terms of flight performance automatically requires at least two engines and consequently all large transport category aeroplanes are multi-engined. Should an engine fail at any point, from the beginning of take-off to the completion of landing, the flight can be safely terminated or continued.

Take-off performance information is given to the pilot in the form of accelerate-stop and engine failure-continued take-off distances, together with the appropriate decision and take-off safety speeds; commonly known as V_1 and V_2. The aeroplane must be capable of making both an accelerate-stop and a continued take-off within the runway length available. Take-off and en route flight paths are established assuming engine failure at the most critical point, and the approach and landing segments are similarly treated. The weight of the aeroplane must be adjusted before take-off to accommodate the most critical of the above flight phases. The end result is, of course, the achievement of a very high level of safety, so much so that airline travel ranks significantly better in this regard than the more traditional forms of transport.

The light aeroplane, on the other hand, is designed and certificated against a much simpler set of design rules. In Australia, these rules are given in Air Navigation Order 101.22. This document in turn specifies a definitive set of light aeroplane design standards, the American Federal Aviation Regulations Part 23.

The fail-safe philosophy as such does not form the foundation of this code, a fact easily demonstrated by the obvious presence of a great many single-engine aeroplanes. Just as power plants need not be duplicated, neither do many other components of the design; and of course single-pilot operation is common. The light aeroplane design standards have evolved over the years to the point where modern aircraft have a safety record which, from an engineering point of view at least, is very good indeed; but these standards do not, nor are they meant to, provide as high a level of safety as the transport category rules.

Why not design a multi-engine light aeroplane to the transport rules and take full advantage of the extra safety? It can be done and has been done, but like everything else it must be paid for. The price is high, not only in terms of the initial purchase and subsequent maintenance costs but also in relation to the operating economics. To realise the engine-failed performance of the large aeroplane, the average light twin would be so payload-limited it would be virtually unusable. If light aircraft are to be operated in a realistic manner, a level of safety lower than that present in large transport aircraft, must be tolerated.

Performance standards

The most immediately apparent differences between the transport category and the light aircraft design codes are those relating to flight performance. Every pilot who has flown a single-engine aeroplane is well aware of the consequences of engine failure; at best a damage-free forced landing, at worst a fatal accident.

The light twin, however, would seem to greatly improve on this situation. With the failure of one engine the available power has only been halved, but the question is, can the remaining fifty per cent be used to sustain flight? The only real answer is that it depends upon which phase of flight the aircraft is in when the engine fails.

Unlike transport aircraft, where positive one-engine-inoperative climb performance is always available, the light twin is required to demonstrate engine-out performance only in the en route configuration. *Take-off, approach and landing are not considered.* In official language, light twins are 'aeroplanes with a performance such that a forced landing should not be necessary if an engine fails *after* take-off and initial climb'.

The take-off and initial climb are thus considered to be all-engines-operating manoeuvres and the flight manual take-off distances and take-off climb data are scheduled on this basis. Do not expect to find V_1 or V_2 speeds for a light twin; in the context of an all-engines-operating performance, they have no meaning. The Australian flight manual take-off distance is the all-engines distance from a standing start to clear a 50 foot obstacle, multiplied by an appropriate safety factor (normally between 1.15 and 1.25). After take-off the aircraft must be able to achieve at least a six per cent gradient of climb, once again with all engines going.

Not until the aeroplane is cleaned up, at a reasonable height above obstructions and has reached an airspeed at least equal to the best single-engine rate of climb speed can any reasonable assurances be made as to the one-engine-inoperative performance. There can be a period of up to 15 seconds after lift-off where, should an engine fail, an accident may very well occur. That is the type of risk the light twin pilot has to face during take-off and initial climb. The actual risk period can vary greatly of course, depending as it does on aeroplane type and weight, and on atmospheric pressure and temperature; under favourable circumstances it may well be as low as a few seconds. But exist it does and so provides a graphic illustration of the difference in safety levels between large and small aircraft.

En route climb requirement

As already mentioned, the one-engine-inoperative climb standard is concerned with the en route phase only. The Australian requirement is to maintain height for VFR operation and a 0.5 per cent gradient of climb for IFR operation. These performance levels must be demonstrated at maximum take-off weight, a pressure altitude of 5000 feet and an outside air temperature of 15°C. The aeroplane must be in the normal en route configuration with the inoperative engine stopped and its propeller feathered. The operating engine is set for maximum continuous power. Climb speed will be appropriate to the best gradient of climb which, for all practical purposes, will be approximately equivalent to that for best rate of climb. In absolute terms the above performance levels are not high; for example a 0.5 per cent gradient represents a rate of climb for the average light twin of between 40 and 60 feet per minute. Even so there are quite a number of modern aeroplanes that need to be weight limited to achieve even this performance.

Manufacturers must produce aeroplanes that comply with the applicable design requirements. When carrying out his certification trials a manufacturer uses a new, or near new, aeroplane with the engines and airframe in better than average condition. All aeroplanes, however, deteriorate to some extent after they have been in service for a time; engines may no longer deliver full power, and doors and panels might not fit as well as they did. Combined with an indifferent exterior finish it should come as no surprise that the single-engine climb rate of an older aircraft could be as much as 150 feet per minute less than the certificated performance.

The effect of changes in configuration and conditions

As well as being familiar with basic performance limitations in asymmetric flight, pilots of light twins must also be aware of the manner in which performance will change if any parameter affecting it changes. Consider a typical piston-engine twin with an engine failed and its propeller feathered. The operating engine is set for maximum continuous power, the speed is that for the best single-engine rate of climb and the aeroplane is banked five degrees towards the live engine. With this state of equilibrium established, let us make some changes and observe what happens.

Speed. Any increase or decrease in speed from the optimum will have the same result — the rate of climb will be reduced. An approximation for a typical piston-engine light twin would be for a climb reduction of some 30-40 feet per minute for a speed variation of 10 knots either side of the best rate of climb speed. Reduce the speed more than 10 knots and the reduction in rate of climb will be very much greater.

Flaps. Extension of the flaps to the take-off or landing position will increase drag and reduce the rate of climb. It is difficult to be precise because of the different flap systems, but extension of the flaps to the normal landing position could reduce the rate of climb by more than 200 feet per minute. On the other hand very small flap extensions (two to four degrees) may be beneficial. Any such gains are small however, and experimentation should be left to the manufacturer's test crews.

Landing gear. Extension of the gear could also reduce the rate of climb up to 200 feet per minute. It is worth remembering that some types of landing gear, in the process of retraction, might have more drag than when down and locked. This can be expected if the aircraft has wheel well covers which are closed when the gear is down, but open during retraction.

Propeller. Energy is extracted from the airstream by a windmilling propeller and the result, as expected, is increased drag which reduces the rate of climb between 100 and 200 feet per minute.

Flight attitude. Certification rules permit five degrees of bank towards the live engine for compliance with the one-engine-inoperative climb requirements. Most manufacturers take advantage of this. In wings-level asymmetric flight an aircraft will sideslip while maintaining heading, thus increasing drag. Banking towards the operating engine reduces drag by reducing the sideslip as well as the amount of rudder required, and the rate of climb can increase by 10 to 20 feet per minute.

Power. One-engine-inoperative climb performance is achieved with the live engine producing maximum continuous power which for many engines is take-off power. Obviously, any reduction in power will cause a reduction in the rate of climb.

Factors affecting single-engine performance in a light twin

In your favour	Against you
• Power available from the live engine	• Extended landing gear and flaps
	• Windmilling propeller
	• Any loss of power from the live engine due to age, maintenance, etc.
	• Variations from best rate of climb speed
	• High aerodrome altitude
	• High ambient temperature
	• High aircraft weight
	• Lack of pilot skill

If you act to reduce the effect of those factors working against you, the aircraft may maintain height or even climb. Assess each take-off before you go and plan your actions should an engine failure eventuate.

The result of varying most parameters from the certification condition is obviously detrimental. Can anything be done by the pilot to improve the situation? Fortunately at least three positive actions can be taken.

Compliance with the performance standards requires demonstration at maximum take-off weight, at an altitude of 5000 feet and a temperature of 15°C, i.e. ISA plus 10°C. By reducing the weight, altitude or temperature, the climb performance can be improved. A reduction in weight will result in an increase in rate of climb. This is a most important factor as the pilot can readily change the aircraft weight by adjusting fuel and payload. The rate of climb on one engine can vary by approximately 15 to 20 feet per minute for each one per cent change in weight. If you have loaded your aircraft to its flight manual limit and not considered the implications of an engine failure, you are living in a dream world.

For most aeroplanes the lower the altitude, the better the climb performance. For the typical light twin (with one engine stopped) the rate of climb will decrease approximately 30 feet per minute for each 1000 feet increase in altitude if the aeroplane is equipped with normally aspirated engines. If the aeroplane has turbo-charged engines the rate of climb can be expected to decrease by up to 10 feet per minute for each 1000 feet increase in altitude. How can you offset this effect? By adjusting the aircraft weight. For instance, if taking off from an aerodrome at 3000 feet above mean sea level a reduction of five per cent in the take-off weight will offset the reduced rate of climb due to the altitude (for the typical light twin).

As with altitude and weight, so it is with temperature. Reduce the temperature and the rate of climb will increase; about 20 to 30 feet per minute for each 10°C change. By adjusting departure times, the pilot can take advantage of lower ambient temperatures. Try leaving earlier in the day. Weight adjustment can also be used to offset the effect of temperature.

Obviously there are a lot of light twins flying, and they have their share of engine failures. Accidents as a result of these failures are fortunately rare. The reason, of course, is that not all engine failures happen during the take-off phase, at high aerodrome altitudes or in high ambient temperatures.

The Australian standards have been designed to provide the required level of safety on the basis of achieving a satisfactory record over the complete spectrum of operations. But there is no room for complacency; during take-off, the one-engine-inoperative climb capability of light twin-engine aeroplanes is not guaranteed, and is in marked contrast to the generally sprightly performance with both engines operating.

It is vitally important to remember that the requirements for single-engine performance relate *only* to the en route phase of flight with the aircraft in its lowest drag configuration. Aircraft are usually designed to meet the minimum requirements and any additional single engine performance is fortuitous. It is a pilot's responsibility to take whatever steps he can to enhance this performance in the event of an engine failure.

Pre-take-off emergency considerations

Aircraft weight.	Adjust to counter the effects of high altitude and high temperature.
Safety speed.	Check the flight manual — do not let the aircraft speed fall below this in flight.
Runway length.	Use the longest suitable runway. If an engine fails shortly after lift-off, excess runway and over-run areas can be used for an immediate landing.
Single-engine climb speeds.	If an engine fails with gear and flaps extended before the speed for best single-engine *angle of climb* is reached consider a forced landing immediately. If continued flight is elected, achieve and maintain the speed for best single-engine *rate of climb*.
Terrain.	Will terrain affect your actions in the event of an engine failure? Will best single-engine angle or rate of climb be adequate to clear obstacles or gradient of the terrain?

Many light twins committed to single-engine flight soon after take-off in adverse conditions are only capable of a controllable rate of descent.

In the event of an engine failure during take-off or initial climb:

- Ensure that the maximum power available is set — *maintain best single-engine rate of climb speed.*
- Check the gear and flaps are retracted — *maintain best single-engine rate of climb speed.*
- Identify the failed engine (dead leg–dead engine and the instruments) and confirm by slowly closing its throttle — *maintain best single-engine rate of climb speed.*
- Feather the propeller on the dead engine and check for fire. If time permits complete the engine failure drills. — *maintain best single-engine rate of climb speed.*
- If the aircraft can maintain a safe manoeuvring height, position for a landing — if not select the most suitable forced landing area.

Although Bob is a figment of our imagination, his type of accident is not. Too many pilots could point to our opening story and say, 'You have it all wrong, my name isn't Bob!' ●

(continued from page 7)

The pilot advised Lae Flight Service that the aircraft had been damaged and that he would be returning to Lae. Reaching the circuit area, he feathered the starboard propeller and landed the aircraft on a cleared grass area alongside the sealed runway. As the fuselage contacted the ground, the aircraft slewed to the right through 90 degrees and came to rest on the edge of the runway. Neither the pilot nor any of the passengers was injured.

The aircraft was extensively damaged by its impact with the embankment. The right main landing gear was torn from its housing in the wing, buckling the surrounding structure and the right hand flap. The landing gear assembly remained attached to the wing only by torn and buckled sheet metal that had formed the rear box of the right hand nacelle. Although the wheels and brake units were found to be serviceable, the right hand brake was choked with mud and grass.

Obviously, the surface over the full width of the departure strip did not comply with the relevant take-off and landing area standards; however, the central 10 metres of the strip was quite satisfactory for take-off and landing. At the time of the accident the grass on either side of this central area was dense and tangled, and between 15 and 20 cm deep. Clearly, the rolling resistance of this thick grass and the inadvertent wheel braking caused by the grass-choked right brake seriously degraded the aircraft's take-off performance. It is not surprising therefore, that the aircraft failed to accelerate to take-off speed in the available strip length. As it happened, had it not been for the shallow embankment at the end of the strip, which literally threw the aircraft into the air, and the deep valley beyond, the aircraft may well have crashed into the trees rather than just managing to scrape through the tops and remain airborne.

The pilot had operated into the strip about 100 times without incident and was familiar with its characteristics. It is certain that had he taxied from the parking bay to the top of the strip and used the full length of the firm, central portion for take-off, the aircraft could have become safely airborne in less than two-thirds of the available distance, and thus completed the flight without incident ●

From one of our readers — a valid message from the past

Although I am not a licensed pilot and fly only occasionally with a friend, I still have an enthusiasm for aeroplanes and read the *Aviation Safety Digest* with great interest. The regular occurrence of accidents caused by pilots pressing on in marginal weather seems as prevalent today as when I was a pilot in the RAAF from 1942 to 1946. Perhaps an account of my own lack of caution in 1944 may give you an opportunity to repeat the lesson once again with a different slant — even if it is 35 years after the event.

On the morning of 11 December 1944 I flew an RAAF Vengeance from East Sale to Tocumwal. It is about 290 km and the track lies across the rugged Southern Alps, with Mount Buller reaching up to about 5500 feet. The weather was fine and the flight took about an hour.

At that time I had logged about 500 hours in single-engine aircraft, with over half those hours on Vengeances which I had been flying continuously for more than a year, including a spell in a dive bomber squadron. I mention this only to indicate that I felt quite comfortable in the aeroplane.

I took off on the return flight from Tocumwal at 1700 hours *without getting a route weather forecast.* It had been fine all the way that morning, it was clear now at Tocumwal, so why waste time when I could be on my way and looking forward to downing an ale in the mess at East Sale by 1820 hours.

I climbed to the planned cruising altitude of 8000 feet, adjusted revs, boost and mixture, and settled down for a pleasant late afternoon view of the Alps.

Just past Benalla clouds loomed ahead, so I began climbing with the aim of either flying over them or through the 'canyons' between the tops. At 14 000 feet over Mansfield it was obvious that this plan would not work. The cloud tops seemed to be over 20 000 feet and the choice was to return to Tocumwal or proceed into cloud on instruments.

I chose the latter course. Lining up my gyro compass with the magnetic compass and checking all the blind flying instruments, I entered cloud. My plan was to continue on course, let down to 10 000 feet, fly five minutes past ETA, then if still in cloud, to let down straight ahead over Bass Strait. It would then be a simple matter to turn and fly north to the coast, which I knew very well in that area.

Not long after entering cloud, severe turbulence and freezing conditions were encountered. This in itself was not particularly alarming, since the Vengeance was a very stable and robust machine, with wings built to withstand about 12*g*. Perhaps in a spartan sort of way I was even enjoying the experience.

Suddenly the situation changed. The airspeed and rate of climb needles flickered and assumed meaningless positions, and I became decidedly uneasy. The altimeter began to unwind and the familiar hiss of air passing the canopy indicated high speed. The aircraft must be in a spiral dive but what the hell should I do? Glancing quickly outside, the penny dropped. The wings were covered with clear ice and the pitot head was encased in it too. I switched on the pitot heat and prayed it was not too late.

Just as suddenly as they had gone unserviceable, the instruments registered again. The pitot heat had worked mercifully fast. The airspeed was over 350 knots and the rate of descent was 'off the clock'. First, get the wings level on the artificial horizon, then pull out of the dive. When this was achieved the altimeter read well under 7000 feet and Mount Buller was probably not all that far away.

Stabilized again on course at 8000 feet in continuing turbulence, I waited for ETA plus five minutes and began to let down. At this time I had been on instruments for about 30 minutes, and with 1000 feet showing on the altimeter, was still in cloud and looking anxiously for the ocean. At 800 feet I broke out in heavy rain and smartly turned to the north.

After 10 minutes, when no coastline appeared, my confidence was evaporating. Was the compass astray? Maybe I was heading out to sea. I asked my rear seat passenger what his compass read — same as mine. Okay, but what had happened to Australia?

Five minutes later we emerged from the rain into reasonably clear skies and ahead lay what looked like Lakes Entrance. Making a positive identification, I turned west for Sale. We landed there just before last light, having taken almost two hours for the trip. The aircraft still had a coating of ice when I parked it on the tarmac. The control tower was unmanned, as flying at the base had terminated by mid-afternoon. Because no departure signal had got through from Tocumwal, they were not even expecting us.

It was a very chastened young man who sat in his room that night and pondered the extent of his folly. Firstly, no check on the weather. Then, pressing on because it was more desirable to spend the night at home base than to endure the minor hassles of bunking down elsewhere. And finally, failing to switch on the pitot heat in icing conditions.

Pressing on was the major sin because, as it turned out, we had flown blind through a line of thunderstorms with all their related hazards. Full marks to the Vultee Aircraft Corporation for building such a stout aeroplane which survived the tremendous buffeting of several cumulo-nimbus clouds.

One small afterthought. Despite my folly, I survived probably because of regular sessions on the ground in the Link Trainer. If you must fly IFR, it pays to keep in practice. But if you want to be an old pilot, it is better to treat the weather with the respect it deserves ●

Recurring fault leads to fatal ditching

When, in a single-engine aircraft, any problem is experienced with the engine or its associated controls, the pilot should plan to land as soon as possible to correct the problem and not get caught out with a total and irreversible loss of power. Because the pilot of a Piper PA28 in the circuit area at Bankstown did not do this, he found himself unable to reach the runway. He ditched the aircraft in a river but died a week after the accident without regaining consciousness.

The aircraft was owned by the pilot and kept on the line of a flying training organisation. It had recently undergone a major overhaul and had been test flown satisfactorily by the chief pilot of the company co-ordinating the overhaul. Before accepting the aircraft, however, the owner requested that it be checked by the Chief Flying Instructor from the training school.

The owner was to fly the aircraft from the left hand seat for the 'acceptance' flight which was to initially consist of a circuit and landing. The CFI was in the right hand front seat. All was normal until final approach when traffic conditions required a go-around. The owner tried to push the throttle control forward from its halfway position but could not do so. The CFI also tried without success so he took over control of the aircraft and completed a circuit and landing with the power available. No emergency was declared.

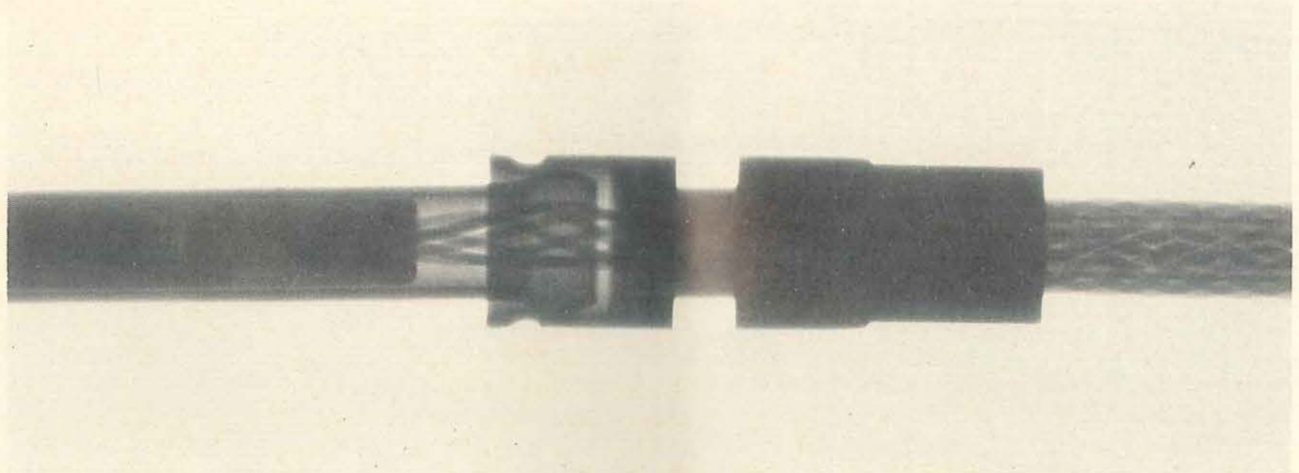
After landing the condition was reported to the servicing organisation. An engineer inspected the throttle system and decided to remove the carburettor which appeared to be a little stiff in operation. No positive fault was discovered in the carburettor but the throttle shaft was overhauled. No fault was found in the throttle control linkage. A few days later, when the aircraft was ready for another acceptance flight, the owner again arranged to conduct this with the CFI. A test flight of 48 minutes duration including circuits and upper air work with emphasis on the throttle operation revealed no faults. The aircraft returned to the airport without incident.

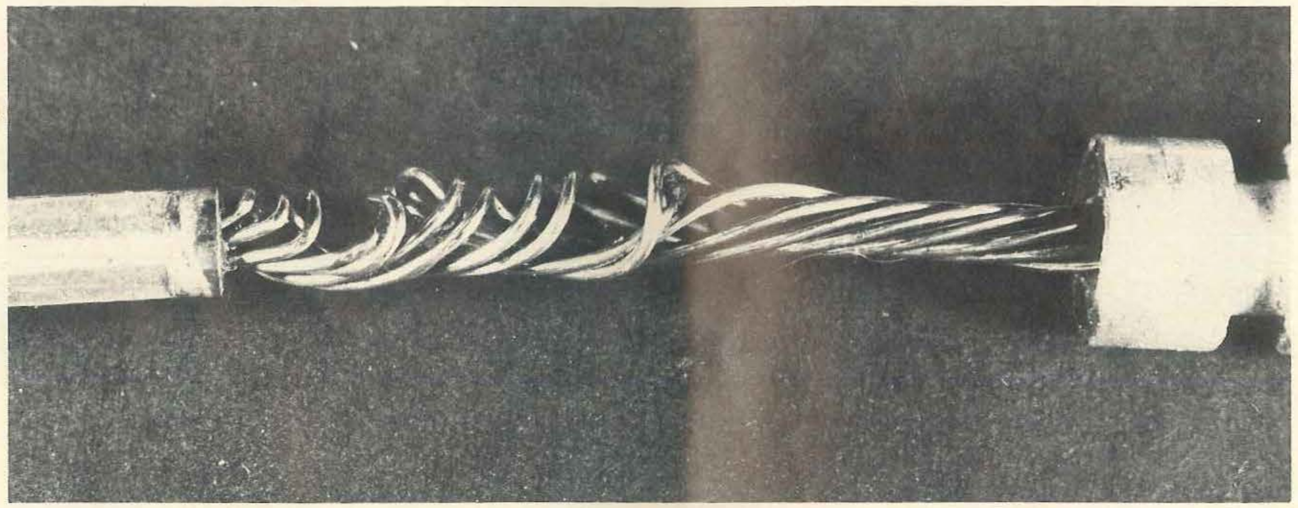
On completion of the landing and shutdown the two pilots were met by a friend of the owner who had been invited along for a short flight. The owner accepted the aircraft as serviceable and decided to take his friend for a couple of circuits. Start-up and take-off were normal and the aircraft levelled-off at 1000 feet on downwind. Because of preceding traffic, the pilot reduced power to maintain separation. When he went to open the throttle again it appeared to catch momentarily before moving forward. The two men looked at each other and the throttle, but nothing was said.

The aircraft ahead was making a wide, long circuit, so the pilot of the Cherokee delayed his base turn and extended the downwind leg. After turning base and making the appropriate radio call he closed the throttle, lowered flap and commenced descent. It became obvious on base leg that power would be needed to have 500 feet height for the final turn. The pilot pushed on the throttle but it would not move from the closed position.

Despite his desperate attempts to move it, the throttle would not budge. The pilot hit it and shook it without success. The aircraft was turned on to final approach in line with the runway but was obviously undershooting. When at a height of about 300 feet, still searching for a place to land, the pilot gave a Mayday call and continued trying to open the throttle.

It appeared to the passenger that the aircraft may not clear a busy road next to the aerodrome boundary, and it was at this time the pilot turned the aircraft to the right for a ditching in the river.





Top: A radiograph of the throttle cable from another PA-28 which was damaged during a forced landing following engine failure. Note the initial buckling of the inner cable.
Bottom: The buckled inner throttle cable from the aircraft that ditched in the river. Wear marks on the wires revealed it had been buckled for some time.

The passenger braced himself for impact just before entry. The aircraft overturned and sank. The passenger managed to exit the cabin through the windscreen but the pilot was trapped underwater until rescue services arrived. The aircraft had to be pulled into shallow water and turned upright before the pilot could be released.

Subsequent detailed examination of the wreckage revealed a compression failure of the inner throttle cable at the carburettor end (see photograph). Microscopic examination of the buckled wires revealed two stages of wear and the buckling reduced the cable length by 16 mm. Bench tests conducted to measure the loading effect of the buckling indicated that a force of 10-15 kg was required to move the cable towards the throttle-open position.

The type of cable used on this throttle control is common to other aircraft types and compression failure leading to restricted throttle movement is not unknown. The cable cannot be readily examined for internal damage and, except for sophisticated and expensive laboratory techniques, it must be destroyed to be examined. It is obvious therefore that if any difficulties are experienced with a throttle control and no positive fault can be established, consideration should be given to replacement of the cable.

The real reason for this tragic and unnecessary accident was not the problem with the throttle control — it was the pilot's failure to treat a recurring but intermittent fault with the seriousness it deserved. A declaration of a 'Pan' situation as soon as the fault was noticed would have given the pilot priority in the circuit and he could have planned and flown a pattern which would have required the minimum amount of throttle adjustment. Possibly the previous incident, when the instructor took over control and did not declare an emergency, might have affected the pilot's assessment of the severity of the situation.

There is no penalty for seeking assistance — if there is ever the slightest doubt about the safety of your aircraft and its occupants try to 'stack the odds' on your side. Alert ATC or Flight Service and the appropriate safety actions will be taken. If you have any special requirements, make them known. Read the emergency section of the En Route Supplement and familiarise yourself with the procedures. Apart from preventing damage to an aircraft you may someday save a life — perhaps your own ●

Lack of knowledge can cause accidents

After landing at his destination and shutting down the engine, the pilot of a Cessna 210 forgot to turn off the anti-collision beacon and the master switch. Some time later, one of the five passengers who had been on board the aircraft noticed the beacon was still operating and switched it off, but he did not turn off the master switch as well.

Towards the end of the day, the pilot and his passengers returned to the aircraft and boarded it for the return flight. The pilot tried to start the engine but found the battery was flat. He then swung the propeller and the engine fired and ran for a short time, but cut out. Realising the engine would have to be primed before it would re-start, and that electrical power would be needed to operate the auxiliary fuel pump, the pilot obtained a set of jumper leads to connect the batteries of two cars to the aircraft's 24 volt system.

The leads were connected by spring clips to the main pins in the ground servicing receptacle and the pump began to operate, but the leads momentarily short-circuited and the pump stopped. After a brief search a blown fuse was located alongside the receptacle. As there was no spare the pilot, in order to restore power to the system, bridged the terminals with silver paper. He then primed the engine with the electric fuel pump, removed the silver paper and, with another pilot at the controls, successfully started the engine by swinging the propeller.

The passengers boarded the aircraft again and the pilot carried out his pre-take-off cockpit checks. The alternator did not excite and consequently, there was no electrical power available at all from either the aircraft battery or the alternator. Concerned that the landing gear may not remain locked down without electrical power, the pilot decided to pump up the pressure in the hydraulic system and, after ensuring the landing gear selector was in the 'down' position, he operated the emergency extension hand pump. Unknown to the pilot however, the only effect this had was to cause the landing gear doors to open and remain open. Unable to lower flap without electrical power, the pilot taxied the aircraft on to a stretch of gravel road he was using as an airstrip and began a flapless take-off with the landing gear doors open.

The available length of road was 804 metres and, after travelling about 450 metres, the aircraft was lifted off in a nose high attitude at very low speed. It reached a height of about 30 or 40 feet but would neither climb nor accelerate further. Seeing power lines directly ahead at the same height, the pilot realised he would be unable to clear them, so he lowered the nose to try to gain speed and fly under the wires. Immediately, the aircraft lost height and the rear of the fuselage and the tail plane began striking low scrub. The aircraft lost speed quickly and, with the pilot still holding back-pressure on the controls, the aircraft sank on to the ground. It came to rest, extensively damaged, 600 metres beyond the end of the strip and 1404 metres from the point at which the take-off was commenced.

The cause of the accident was that the pilot made a premature lift off and then failed to obtain sufficient airspeed to allow the aircraft to climb. His lack of knowledge of the various aircraft systems was revealed in a whole series of ill-considered actions and decisions which culminated in an attempted take-off, without electrical services of any kind, from an area of marginal length.

As the pilot was not using the correct NATO adapter for the ground power receptacle, his efforts to supply power to the aircraft's electrical system with jumper leads meant that no connection was made to the small, polarity-sensing pin in the receptacle. As a result, the aircraft ground power relay failed to energise and no electrical power was available through the heavy duty circuit. Thus, while the pilot was able to prime the engine with the auxiliary fuel pump through a parallel circuit, he was unable to start the engine using the electric starter. When the engine was eventually hand started, the alternator would not produce any output because there was no battery supply to excite it. Thus there was no electrical power at all available to operate the systems associated with normal flight.

When the pilot tried to pump-up pressure in the hydraulic system, he did not realise that, with the landing gear selected 'down' and electrical power off, the landing gear door control valve moves to the 'doors open' position and remains there. With the door control valve open therefore, the landing gear doors opened and remained open when the pilot operated the emergency extension hand pump. The open doors further degraded the take-off and climb performance of the aircraft ●

When the owner-pilot of a Beech 35 was starting the engine to move his aircraft to the refuelling point, the starter turned the engine very slowly in a 'series of jerks'. The engine started however and the aircraft was taxied into place.

On completion of refuelling, the pilot again tried to start the engine but this time it turned over to compression and stopped. Assessing the problem as a flat battery, he connected jumper leads from a car battery to the aircraft and the engine started normally. The pilot noticed the ammeter was showing neither charge nor discharge but as 'this was its normal position' he was not unduly concerned. With one passenger on board, he taxied the aircraft to the runway holding point and carried out his pre-take-off checks.

After take-off, the pilot selected the landing gear 'up' and set the engine to climb power. He believed that the landing gear retracted at the normal rate and, though he did not see the position lights change, he assumed the landing gear was up. At 700 feet he began a turn but then noticed that the single fuel gauge, which moments before had indicated nearly full, was now showing only half capacity. He selected other tanks but the needle continued to fall until the gauge read 'empty' for all tank selections. As the auxiliary tanks had been full on take-off, and the mains at least half full, it was clear to the pilot that the aircraft had developed an electrical fault. He attempted to cycle the landing gear and lower the flaps, but when there was no reaction or any lights, he concluded the aircraft had suffered a total electrical failure.

Deciding to land again at his departure point, the pilot realised the landing gear would have to be extended manually. He asked the passenger to move into the back seat to manually lower the landing gear. The pilot pulled the appropriate circuit breaker and then turned the manual extension handle once himself to demonstrate to the passenger how to wind the gear down. He advised his passenger that 50 turns of the handle would be required to fully extend the gear.

The passenger found the handle stiff to operate and after 25 revolutions it locked solid, though he noticed it could be wound back in the opposite direction. The pilot saw that the nose gear mechanical indicator showed 'up' and after attracting the attention of another aircraft returning to the circuit, it was confirmed by using hand signals that the landing gear was retracted. The pilot decided there was nothing more he could do so he landed the aircraft with the gear up.

Subsequent investigation revealed that the battery was flat, the generator was unserviceable and the gear had been wound *up* not *down*.

In this accident the landing gear was wound 'up' inadvertently. The *Airplane Flight Manual* specifically states 'engage handcrank and turn counterclockwise as far as possible (approximately 50 turns)' and 'do not retract the landing gear manually' ●

Systems knowledge — the electrical system

The preceding accident reports illustrate a factor often revealed during air safety investigations — insufficient knowledge of aircraft systems operation, in both normal and emergency conditions. The aircraft electrical system and the emergency landing gear extension system are those most often involved in accidents and incidents. In this article we will look at a simple electrical system and discuss its normal operation, and the recognition and correction of faults which may develop. Later articles will expand upon this and also discuss other aircraft systems.

Without reference to any manuals, can you answer the following questions about the aircraft you usually fly:

- Is it fitted with an alternator or a generator?
- What is the difference?
- With all electrical power turned off, does the ammeter pointer rest in the centre of the scale or on one side?
- How do you check that the alternator or generator is charging?
- What fault protection indicators are fitted and what actions are required if they operate?
- What electrical system controls are operable from the cockpit?

If you were able to answer all the questions then you probably have a reasonable knowledge of the electrical system. Even so, we suggest you keep reading as revision rarely goes astray.

You will know that there are two main sources of electrical system power in the aircraft — the alternator or generator and the battery. It is important to understand that both must be functioning if the system is to operate correctly. The correct system operation is readily achievable if you understand the function and control of the electrical system components. It is not intended to try and explain basic electrical theory in this article. If you require a more detailed explanation than provided here then consult your servicing organisation or other qualified persons for guidance.

To begin with we will consider a simple schematic diagram of the electrical system; a schematic diagram shows the various components in the system and their interconnection but does not include actual wiring connections. In presenting a schematic diagram a variety of symbols are used for simplicity.

By studying the schematic diagram in conjunction with the contents of the table following it, you will be able to see the interconnection of the various components in the electrical system. The arrows on the diagram represent the conventional direction of current flow, which is one way, from positive (+) to negative (−), in a direct current (DC) system.

The table lists the components in a basic electrical system and describes various aspects of their operation. We will now explain particular points of interest about some of these components.

Voltage regulator

Everyone who flies should know there is a voltage regulator in the aircraft electrical system which regulates the output of the alternator or generator and also controls the recharging of the battery. The pilot has no control over the operation of the voltage regulator.

Alternator or generator?

What is the difference? Any rotating producer of electricity initially develops alternating current (AC) which flows in alternate directions. As the electrical power we require in the aircraft system is direct current (DC) we must rectify the alternating current.

In a generator this is done mechanically by fitting a commutator, made from copper segments, to the rotating component known as the armature.

In an alternator the rectification is obtained electronically by the use of diodes, or electrical rectifiers, which are normally fitted to the end plate of the alternator.

The important difference between alternators and generators is in their operation. An alternator requires an input of electricity from the battery before it will produce electrical energy. Once operating, however, it will produce a high output at low r.p.m. and requires less mechanical energy to operate. A generator does not require an input from the battery to produce electrical energy but it will not produce sufficient output at low r.p.m. to supply the required electrical loads. Some aircraft need to be idled at 1000-1200 r.p.m. to ensure that electrical loads are met by the generator and not the battery. For simplicity, the rest of this article will refer only to the alternators; the information, however, will be equally applicable to generators.

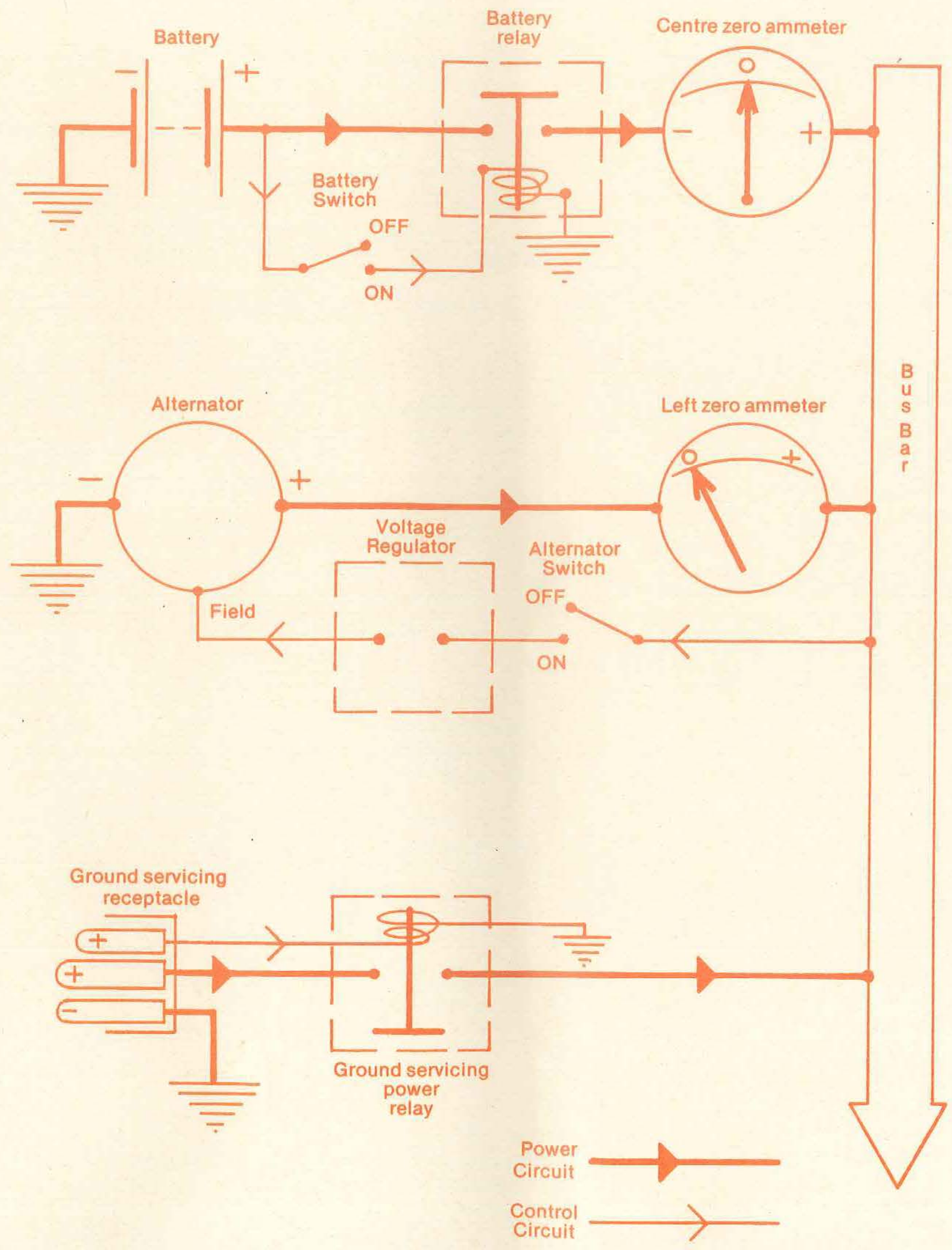
Voltmeter

Some single-engine aircraft are equipped with a voltmeter which can be used to verify ammeter indications. Its main purpose, however, is in twin engine aircraft to check load sharing.

Ammeter

That all-important gauge in the cockpit that is so often misunderstood. There are two distinctly different methods of connecting the ammeter into the electrical system. It is necessary to understand this difference in order to appreciate the ammeter indications. We will use very simple schematic diagrams to explain the difference.

(continued on page 24)

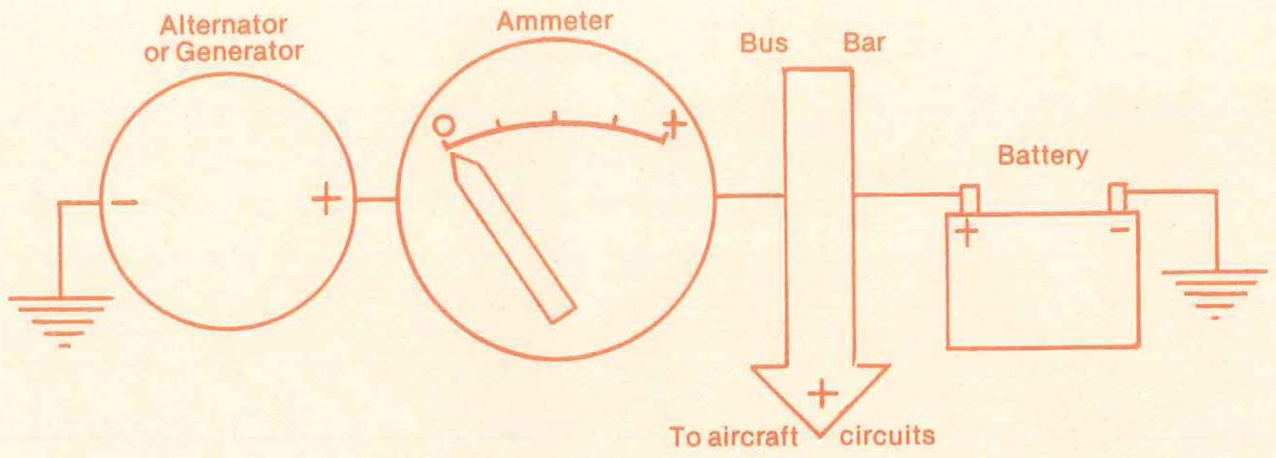


Schematic diagram Simplified Electrical System

Component	Location	Function	Operation	Control	Preflight check	Faults	Recognition	Reason	Correction
Battery	Engine compartment or fuselage	To provide electrical power for starting, ground and emergency operation of the electrical system.	Chemical production of electricity	Battery switch operates battery relay and connects battery to busbar.	Ensure security, no loose connections, no leaks, fluid level correct.	Cracked case Discharged	Leaking fluid No electrical power when battery switch turned on. Starter will not turn engine	Old age Dropped during servicing Alternator not charging, old age, electrical system left on	Replace Recharge or replace battery
Alternator (or generator)	On engine	To provide electrical power in flight	Engine driven by Vee belt or gears	Alternator switch connects battery to alternator field; similar for generator	Belt tight, not broken, no loose connections.	Not charging	Ammeter indication, gradual loss of power, radios, navaids and electrical instruments, alternator failure warning light.	Broken or loose drive belt. Internal failure	Replace or tighten belt Replace alternator
Voltage regulator	In engine compartment or electrical compartment	To control alternator output voltage	Electrical	Nil	Connections	Not operating	As for the alternator	Internal failure	Replace
Battery switch	Instrument panel	To operate battery relay	Manual	Nil	Switch operates	Not operating	Physical condition	Internal failure	Replace
Alternator switch	Instrument panel	To energise alternator field	Manual	Nil	Switch operates	Not operating	Alternator not charging	Internal failure	Replace
Ammeter	Instrument panel	To indicate alternator output *or* battery charge and discharge	Electrical	Nil	General condition	No indications	Pointer does not move when electrical system operated	Internal failure	Replace
Starter relay (or contactor)	Near starter motor	To connect the starter motor to the battery	Electrical	Starter button or 'start' position on the ignition switch	Starter motor operates	Not closing	Starter motor does not work	Internal failure	Replace
Starter motor	On engine	To rotate the engine for starting	Electrical	Starter button or 'start' position on the ignition switch	Starter motor operates	Not operating	Starter motor does not work	Internal failure No electrical power. Battery discharged	Replace Check circuit breakers and fuses. Replace or recharge battery
Ground servicing receptacle and relay	Near battery	To connect ground power to the aircraft for servicing	Manual	Nil or a ground power switch on panel	General condition	Auxiliary pin not powered	No power to busbar with external power connected	Incorrect connection to ground servicing plug	Connect correctly
Overvoltage warning protection	Warning light on instrument panel	To indicate an overvoltage condition has occurred	Electrical	Overvoltage sensor	Nil	Excessive alternator voltage	Overvoltage warning light illuminated	Alternator/ regulator fault	In accordance with aircraft manual

Note: Always check for loose connections and broken wires; if any are found have them repaired.

System 1 left-zero ammeter

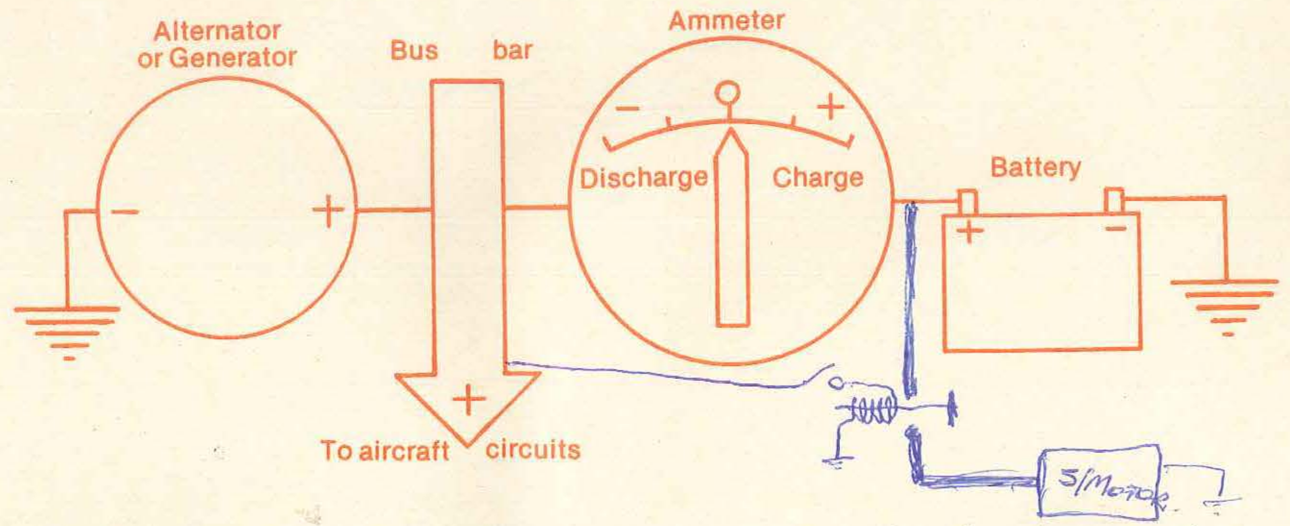


In this circuit the ammeter is measuring only the output of the alternator. The ammeter is graduated with zero amperes at the left hand end of the scale and increasing in amperes to the right. With the battery switch 'on' and the engine not running, or with the engine running and the alternator switch 'off', the ammeter will show zero. If the engine is started and the alternator is turned 'on', the ammeter will then show the alternator output.

The battery discharges during starting, therefore ammeter indication will be quite high during initial battery recharging just after the engine has been started. When the battery is fully charged, and the alternator is operating, the ammeter should show a reading slightly above the zero graduation if all other electrical circuits are off. As the electrical load is increased by turning on lights, radios, etc, the reading will increase.

If the ammeter pointer drops to zero in flight, it probably means an alternator failure. If action in accordance with the pilots' handbook fails to restore an ammeter indication above zero, then reduce the electrical load to a minimum, as only the battery is supplying electricity. Land as soon as possible to have the problem corrected.

System 2 centre-zero ammeter



In this circuit the ammeter is measuring the flow of current to the battery (charge) or from the battery (discharge). The ammeter pointer shows zero in the centre of the scale, with increasing charge to the right and increasing discharge to the left.

With the battery switch 'on' and no alternator output, the ammeter will indicate a discharge, i.e. the flow of current from the battery to whatever electrical circuits are energised. With the alternator producing power, if the electrical load is less than the capability of the alternator, the ammeter will indicate a charge, i.e. a flow of current to the battery. If the electrical load exceeds the output of the alternator, the battery must also supply electrical power and the ammeter will indicate a discharge. If this occurs reduce the load where possible until the ammeter indicates a charge; if unloading the system does not result in a 'charge' indication, the alternator has probably failed. The appropriate action should be taken in accordance with the pilots' handbook.

Battery switch/alternator or generator switch

These two switches appear in various configurations in different aircraft. Sometimes they are separate and are operated independently. Other times they are 'ganged' and operated together. This combined switch is often called the Master Switch. In either case, two functions are performed by the switches. The battery switch operates the battery contactor (or relay) and connects battery power to the bus bar. The alternator switch connects the alternator field to the bus bar, thus providing the alternator with battery power for 'field excitation'. If the aircraft is fitted with a generator, the generator switch connects the generator field to the voltage regulator to control the generator output.

Regardless of the type of aircraft or the style of switches fitted, both switches must be 'on' if the electrical system is to operate normally. If it becomes necessary to turn either switch 'off' in flight, the aircraft is in an emergency condition and consideration should be given to termination of the flight as soon as possible.

Ground servicing receptacle

This is a socket where external power may be connected to the aircraft electrical system. Note carefully the name — ground *servicing* receptacle. The main purpose of this item is to allow servicing personnel to power the electrical system for maintenance. However, if a pilot is concerned about conserving the aircraft battery during cold weather starts, an external power source can be connected for engine starting. It is not intended to be used as a connecting point for jumper leads from a car battery if the aircraft battery is flat.

To connect external power to the aircraft all three pins in the socket must be correctly powered and this is best done with a standard NATO plug on the external power source. If the small pin is not powered the ground power relay will not operate and the external power will be unusable for engine starting.

Overvoltage protection

This safeguard is not fitted to all aircraft. For those aircraft which are equipped with this device there are different actions required if an overvoltage condition develops. Because these actions vary considerably, it would be unwise to try and specify them here. Refer to your pilots' handbook to ascertain if overvoltage protection is fitted and the correct action to take if the condition arises.

Fuses and circuit breakers

There are many of these protective devices fitted to a modern aircraft and it is in the pilot's best interest to know their location. If they require replacement the aircraft could be stranded for the want of a little more knowledge by the pilot. All protective devices are rated at a current which will prevent the particular circuit cable from overheating and so prevent smoke emission and subsequent fire. This protection will only be retained if a correctly rated fuse or circuit breaker is used as a replacement.

Points to remember

Use of silver paper, nails, fencing wire and materials other than correctly rated fuses to replace a blown fuse is very dangerous. Without the protection of the correct value fuse, an electrical fire could result. Always ensure there are spare fuses in the aircraft and learn how and where to replace them.

If a particular fuse is continually blowing, there is a fault in the circuit. Continual replacement of the fuse only increases the danger of an electrical fire. Report the problem on the maintenance release and ensure it is corrected. Starting a flight with a 'flat' battery could result in being without any electrical system power. If the battery is flat replace it or have it recharged before flight.

Check the battery regularly for leaks, water level, connections and security. Remember it is the 'heart' of the electrical system.

If you start the engine with radios and other unnecessary electrical equipment turned on you may damage them. Large voltage fluctuations occur when the starter is engaged and these can create havoc in sensitive electronic circuits. Turn on ancillary equipment after the engine is started and after you have checked that the alternator or generator is charging. For the same reasons turn off the equipment before shutting down the engine.

Be alert for broken wires and loose connections during your preflight inspection and ensure that you turn off all electrical systems and the battery switch after the engine shutdown.

Read the pilots' handbook and ensure you are thoroughly conversant with the correct procedures for both normal and emergency operations. If there is anything about which you are unsure, consult your engineering workshop or other qualified organisations or persons for guidance ●

From the incident files

The captain of an RPT aircraft has reported that on several occasions at major capital city airports he has taxied his jet, at night, behind general aviation aircraft not displaying their anti-collision lights. When the smaller aircraft is stopped, or moving behind another large aircraft it is extremely difficult to see. The possible results are obvious.

Pilots are reminded that aircraft, in flight or operating on the manoeuvring area of an aerodrome at night or in conditions of poor visibility, are required to display anti-collision lighting in addition to navigation lights. Unserviceable equipment is no excuse, except when it fails in flight. Failure to display anti-collision lighting may result in an unnecessary and costly accident ●

Low cloud and rain — why 'have a go'?

After a delay of about two hours because of poor weather, a PA-28 aircraft departed from Jandakot on a VFR flight to Kalgoorlie. Only eight minutes after departure the pilot and his two passengers were killed when the aircraft crashed into high ground, out of control. The general accident area was covered by low cloud and thick fog, with rain falling at the time.

The pilot and his passengers had first attended the briefing office at about 0730 hours Western Standard Time and obtained the relevant meteorological forecasts. Not holding an instrument rating, the pilot was restricted to flight under the Visual Flight Rules and consequently filed a VFR flight plan for the business trip to Kalgoorlie.

During the briefing, the duty Flight Service Officer had explained the area and terminal forecasts, indicating that a VFR flight would probably be unsuccessful. There was a band of frontal activity about 160 km wide across the proposed flight path with a cloud coverage of five to seven oktas, from 1000 feet base up to 30 000 feet tops. The visibility was forecast to reduce to 4000 metres in heavy rain. This discussion on the weather lasted about 15 minutes.

Not dissuaded in filing a flight plan, despite the forecast weather, the pilot left the briefing office with his two companions and went to the offices of the aircraft operator. Again attempts were made to try and dissuade the pilot from proceeding with the flight. The operator suggested that the pilot should postpone his departure by a day. Apparently the pilot believed that because the weather was better along the track, the flight could be completed.

During the next half hour the three men had coffee, loaded the aircraft and were seen moving around the tarmac photographing other aircraft. When it rained heavily, they sat in the cabin of their aircraft.

At 0844 hours the pilot advised the tower by radio, that the aircraft was taxi-ing. He was informed that weather conditions were non-VMC towards the foot-hills and it was suggested that he call again in 10 minutes. This was done and ATC advised the pilot that the cloud base had lowered and, from the tower, it appeared doubtful that VMC existed over the foot-hills.

The aerodrome was closed to VFR operations at 0907 hours and to all operations at 0919 hours. The passage of the front occurred at 0945 hours and a short while later weather conditions began to improve. At 0959 hours the aerodrome was opened to sector VFR, however, the sector to the south east remained closed. The tower received another taxi-ing call from the aircraft at 1009 hours and again the pilot was informed that conditions appeared to be unsuitable for VFR flight across the hills.

The pilot returned to the briefing office about 1015 hours and amended the Sartime on his flight plan. He had a short discussion with the FSO about the weather and left the office with the intention of 'going and having a look'.

The next contact with the pilot was at 1028 hours when he called the tower again about the weather and was advised that visibility towards the hills had improved to about eight kilometres. The pilot reported that the aircraft was taxi-ing for Kalgoorlie.

Because the flight had been planned through controlled airspace, Jandakot Tower contacted ATC at Perth Airport to co-ordinate an airways clearance, but a clearance was unavailable as the Perth control zone was non-VMC. When the pilot was informed of this, he elected to proceed outside controlled airspace via Mt Dale, elevation 1798 feet, which is 41 kilometres east of Jandakot.

At 1038 hours the aircraft was ready for take-off but owing to preceding traffic did not receive take-off clearance until six minutes later. The pilot reported departure at 1047 hours. The tower controller observed the aircraft make a left turn after taking off from runway 30 and head towards Armadale and Mt. Dale. At that time the tops of the hills were visible from the tower.

At approximately 1055 hours an aircraft was heard in the vicinity of the hills; the engine sound was rising and falling giving the impression of high aircraft speed. The sound of impact followed shortly afterwards.

Subsequent examination of the wreckage, located at 900 feet above mean sea level, revealed that the aircraft had struck the ground at high speed in a steep nose down, right wing down attitude. The aircraft had burst apart and the majority of the wreckage came to rest nearly 100 metres from the initial impact point. Detailed examination did not reveal any evidence of mechanical malfunction which could have contributed to the accident.

The impression gained by those people who came in contact with the pilot and his passengers during the morning was that there was no apparent pressure on the pilot to complete the flight on that day. The trip had been delayed several times and the business commitment in Kalgoorlie was not limited by time. The investigation did not reveal any personal problems, either psychological or physiological, that would have affected the judgement of the pilot. He had used aircraft for business travel a number of times in the past.

Since commencing his training in 1972 the pilot had accumulated 239 hours experience. He completed 5.5 hours practice instrument flying during his initial training but had recorded no other instrument flying since then. He had flown two hours in the 90 days preceding the accident.

The position where the aircraft actually encountered IMC was not established; however, in consideration of the events leading up to the accident; the pilot was obviously aware that the probability of completing the flight in VMC was marginal.

Did he believe that he could fly through the adverse weather to the expected clear area a long way ahead? Did he consider the front which had just passed over the airport and which was moving in a general easterly direction? Did he have a change of heart after the aircraft had proceeded a few kilometres and was he attempting to get clear, when he lost control of the aircraft? These questions cannot be answered; however, on this occasion there was no excuse for being 'caught out'. The conditions were clearly evident before departure and a delay of even a few more hours could have prevented this unnecessary loss of life.

Ask yourself, what would I have done under the circumstances? Or more importantly, what will I do if confronted with the same situation? ●

Search and rescue, part 5

This is the final article in the series on the organisation of search and rescue operations in Australia. Part 4 explained the planning of a search to ensure adequate coverage of the area, and also described the search operation from the initial briefing of search crews through to the location of survivors. Once their position has been established, the next step is to rescue them. This article will describe the processes of rescue planning, rescue operations and supply dropping from aircraft.

In those cases where survivors are located by surface search parties, their rescue is automatic if one of the on-scene SAR units can carry out this task. On the other hand, if survivors have been located by searching aircraft, the rescue operation can be very complex and may require diversion or despatch of helicopters, ships or fixed-wing aircraft capable of dropping flotation and survival equipment. The rescue procedures can become further complicated if the search operation must continue until all survivors have been located. When large numbers of persons are involved some of the survivors may not be immediately located so a systematic search is continued while the rescue operation is in progress.

Planning the rescue

A number of important factors need to be considered in determining the method of rescue to be employed and the type of facilities to be used. The first consideration is whether or not the search unit from which the survivors have been sighted, or any other facility at the scene, has been able to take any effective action. The next consideration is the location of the survivors in relation to the available rescue facilities and the environment in which they are situated. Are they on land or in the water and what is the type of terrain or the distance to shore? Associated with these facts is the distance of the survivors from operating bases and medical facilities. If the SAR operation has been well planned, potential rescue facilities will have been strategically located in or around the search area and will be ready to be despatched as soon as survivors are located.

During rescue operations and until it can be positively proven otherwise, it is assumed that survivors are in need of immediate medical aid. When they are suspected or known to be injured, the delivery of first aid equipment and medical supplies is of paramount importance.

A further consideration in planning a rescue is the magnitude of the situation. The extent of the rescue effort and the facilities required is directly related to the expected number of survivors, or, in other words the total number of persons on board. A lot of resources would be required to rescue survivors if a wide body jet, carrying two or three hundred persons, ditched at sea hundreds of kilometres from the coastline. Other factors which influence the amount of aid necessary are terrain, existing and forecast weather, access routes, distance to travel and the amount and type of survival equipment available on scene.

Selecting rescue methods and facilities

Basically it can be said that the environment of the distress scene, the urgency of the operation and the magnitude of the rescue effort required will dictate both the methods and facilities selected. The environment surrounding the survivors will usually be the paramount influencing factor.

Some of the rescue methods available are:

- helicopter landing
- helicopter hoist pick-up
- land party rescue
- ship rescue
- fixed-wing aircraft landing, and
- air dropping survival equipment from fixed-wing aircraft.

The availability of facilities capable of using specific rescue methods, and their proximity to the rescue site, are prime considerations in the selection of rescue facilities.

The crews of rescue craft will not be directed to execute a particular manoeuvre, technique or method that is hazardous to the crew or craft unless a thorough evaluation of the circumstances indicates that acceptance of the risk is warranted. In all cases the captain has the ultimate authority and responsibility for determining whether or not to proceed with the operation.

Let us now consider the various functions of different rescue facilities and the manner in which they can be deployed.

Helicopters

The ability of the helicopter to hover and land in restricted spaces makes it a very important facility for rescue operations. The addition of flotation equipment also allows it to land near survivors in the sea. Some of the limitations of helicopters, however, are not readily apparent. For example, because a helicopter cannot hover at high altitude it will generally have to land during a mountain rescue. In fact, landings are preferred for all helicopter rescues because heli-lifting can present hazards to both the aircraft and crew as well as the survivors.

Fixed-wing aircraft

The most useful role of fixed-wing aircraft in rescue operations is in providing immediate assistance by directing surface rescue units to the scene. Orbiting the position, dropping survival equipment including a portable radio transceiver, confirming the position, showing lights or using other visual signals all serve to lift the morale of survivors. In this way their immediate needs are provided for, and their position fixed.

Ships

When survivors are a considerable distance from shore, rescue will normally be carried out by long-range merchant or military ships. Because of ships' relatively slow speeds, helicopters may sometimes be used for evacuating survivors in need of medical attention from the ship to a hospital or emergency care centre. Rendezvous between the ship and helicopter can be made at appreciable distances off-shore for this purpose but once again there are several limitations in this procedure. Unless the ship has a helipad or is of sufficient size to cope with a landing on its deck, the survivors would probably have to be winched off. Some helicopters, particularly military machines, have special equipment for this purpose.

Supply dropping

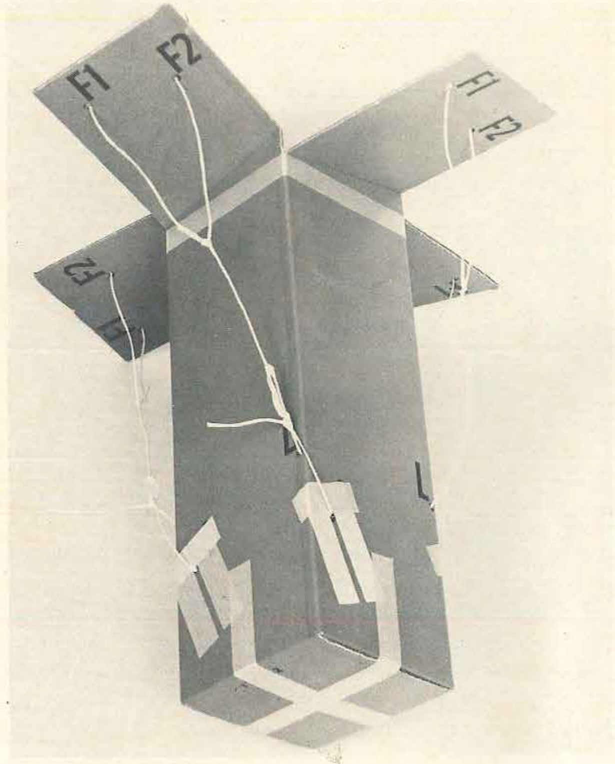
The decision as to whether or not to drop supplies to survivors is dependent on the time delay expected before their rescue can be effected. If they are in danger due to exposure, drowning, medical or survival reasons such as the need for water, then it is necessary to air drop equipment to them.

Supplies may also have to be dropped to augment those carried by approaching rescue units.

Mobility of survivors on land generally makes possible the recovery of equipment dropped a short distance away, but air drops to survivors at sea require a high degree of accuracy.

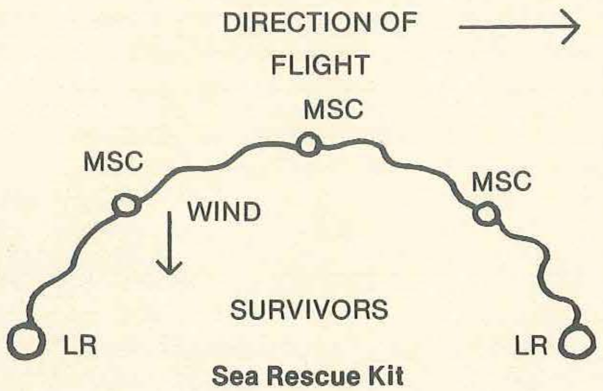
In order to provide flotation and other sustenance equipment to survivors and to ensure their rescue, the Department of Transport maintains marine rescue facilities at 26 locations throughout Australia. Major holdings of liferafts and marine supply containers are located at Darwin, Perth, Sydney and Townsville with smaller holdings at several other points around the coast.

When survivors are on the ground, a land party can usually get into the area fairly quickly either by helicopter, four wheel drive vehicle or horseback. Until a land party can get into the area, survivors and indeed the ground party itself can be supported by dropping food, water, medical supplies in a container called a Helibox. This is simply a cardboard box 230 mm square and 650 mm in length. The top flaps are extended and when rigged for use are folded outwards at an angle. When ejected from the aircraft this causes the helibox to auto-rotate and the rate of descent is reduced. In this way five to seven kg of food, medical equipment, water or radios can be delivered.



A marine rescue is effected by carrying out what is known as a multi-unit drop of a sea rescue kit (SRK). This kit consists of two 10 or 30-man liferafts and three marine supply containers (MSC) which are each linked together by 100 m of buoyant rope so that on deployment from the aircraft a spread of 550 m is achieved. The rafts are attached at each end of the kit with the MSCs which contain approximately 14 kg of rations, water, medical supplies, signalling equipment and morale boosters such as playing cards, in between them.

When the SRK is delivered to survivors in the water, it is dropped across and upwind of the survivors' position. As the wind effect on the inflated liferafts is greater than on the MSC, the SRK will drift down on the water and form a large 'U' around the survivors.



Sea Rescue Kit

Survivors can grasp one of the float ropes and pull themselves along and into a liferaft. By this means survivors can be supported and sustained until such time as a ship can pick them up.

Aerial delivery of supplies is a difficult and exacting operation, therefore the Department provides air traffic controllers trained as dropmasters at all locations where marine rescue equipment is held. Marine multi-unit drops are carried out under the direct supervision and control of a qualified dropmaster who is responsible for pre-flight briefing of aircrews, and safety and security within the aircraft cabin during flight. In addition, two despatchers are required for multi-unit drops while only one despatcher is required for helibox or single-unit static line operated drops.

Dropmasters undergo comprehensive training in theoretical and practical aspects of supply dropping as well as acquiring an intimate knowledge of SAR equipment. Having successfully completed the theory, they must demonstrate proficiency to a SAR supervisor during an actual multi-unit drop to 'survivors' in the ocean. In order to maintain this qualification, a dropmaster is required to satisfactorily complete at least one multi-unit supply drop every twelve months.

Air traffic controllers are selected for training as dropmasters because the type of duty performed in their day-to-day functions requires an extensive knowledge of flight patterns and procedures. This expertise is also required in the role of a dropmaster, while their continuous availability at all locations at which marine equipment is held, ensures coverage throughout Australia's area of responsibility.

In presenting this series of articles we aimed to provide our readers with a broad insight into the philosophy and conduct of search and rescue operations in Australia. It is possible that any member of the aviation community could be called upon to assist in the search or rescue phases and we hope that, having read these articles, you will be more aware of the importance of your task in relation to the success of the overall operation ●