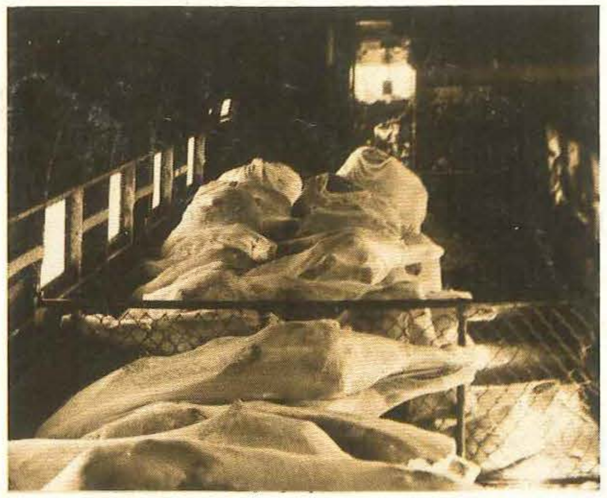
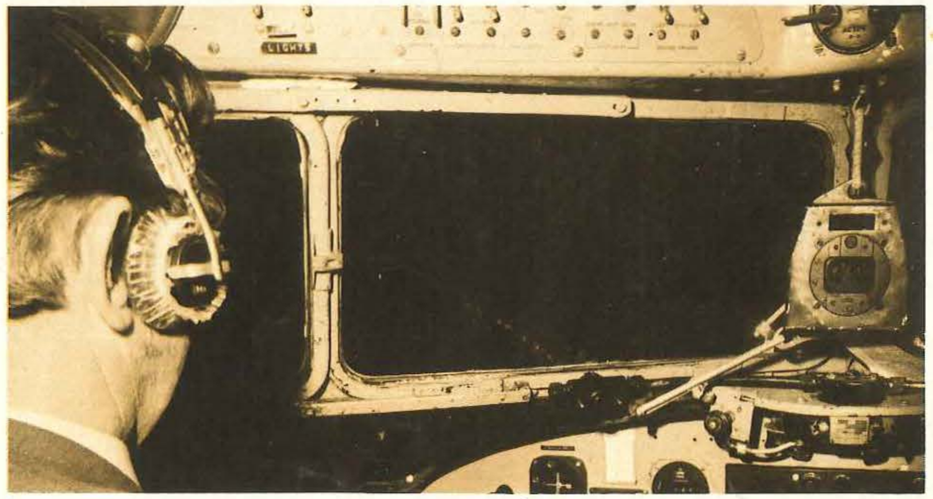
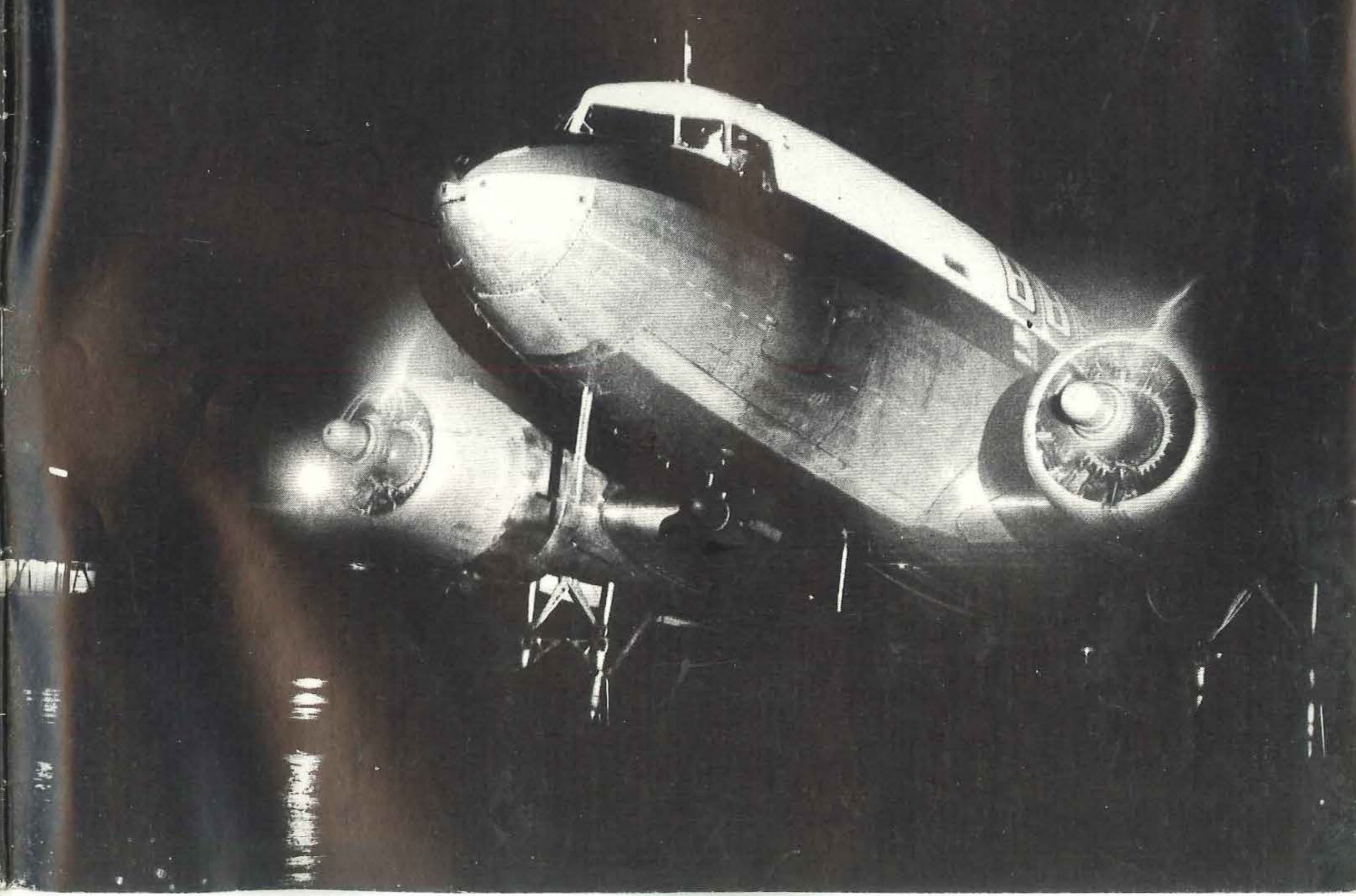
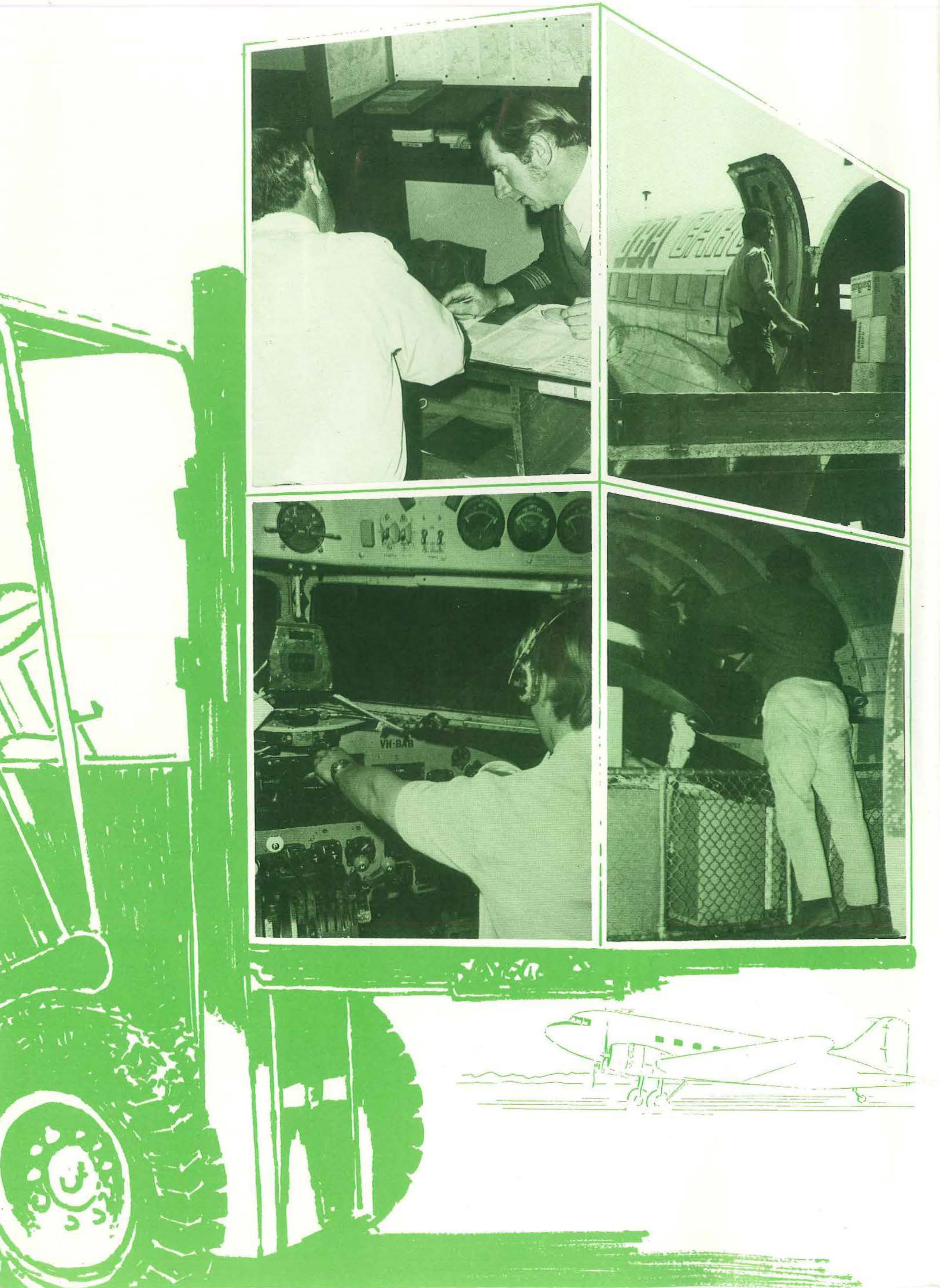




Number 88 1974 AUSTRALIAN DEPARTMENT OF TRANSPORT

AVIATION SAFETY DIGEST





COVER STORY:

Workhorses: Today while the attention of the aviation world tends to be directed towards the exciting possibilities of supersonic transports, wide-bodied 400 passenger domestic aircraft, and exotic business jets, it is sobering to reflect that much solid, if unspectacular work, is still being done by the 'old faithfuls' of aviation. The DC3s operating the well-established Bass Strait airfreight service of BBA Cargo Pty Ltd are a case in point. With frequent services between Essendon, Launceston, and King Island, the hardworking DC3s are in effect the 'heavy transports' of what is today, a fully-integrated, interstate haulage system, complete with facilities such as airport warehouses, mechanical loading systems, and specially designed conveyor equipment.

All manner of general cargo and manufactured goods — engine parts, groceries, plumbers' fittings, softgoods, canned foods, sporting equipment, perishables, to name only a few, are carried to the Tasmanian ports on the flights out of Essendon. More specialised wares, such as carpets, furniture, vegetables, frozen fish, fresh meat, and even mining samples, representing the output of the various Tasmanian ports, make up the aircraft manifests for the return flights.

The company's all-weather operations today are a far cry from those it began with a small fleet of ex-World War II Avro Ansons, 25 years ago this November. The Ansons continued as the mainstay of the work for the first 11 years, an era during which the Bass Strait service grew and developed, despite the limitations of operating VFR on routes renowned for poor weather. But with the acquisition of DC3s in 1960, the company could be said to have come of age. IFR operations became its way of life and disruption of its services by the vagaries of the weather became a thing of the past.

The essence of good business is dispatch, and probably nowhere is this more so today than in interstate freighting. Night operations are an inescapable way of life for all who engage in this business and airfreighting now is no exception. To many Melbournians living in the city's eastern outer suburbs, the subdued drone of the DC3s, returning from their nightly hauls to Launceston, are a familiar sound in the early morning skies. But soon now the familiar beat of the faithful Pratt and Whitney R1830s is to be joined by a new note. With the addition of a four-engined, Dart-powered Argosy to its fleet, the company has not only almost doubled its cargo-handling capacity, but enters an entirely new era in the development of its operations.

Perhaps of all the work it has yet undertaken, the company's greatest contribution has been to the inhabitants of isolated King Island. Throughout the several times that this Island has been without a shipping service, the company has virtually fed the population and taken off its produce. Last year, when the King Island shipping crisis was at its height the company moved more than 4000 metric tons of general cargo to and from the Island within a period of 12 months. Without the availability of the company's aircraft at such a time, the plight of the Island's population would have been serious indeed.

Altogether, in its 25 years of operation, the company's Bass Strait freight service has flown some 70,000 hours. Considering all this has been achieved without a serious accident — even the Anson era produced only two minor mishaps — the company and its staff have a safety record of which they can be rightfully proud.

DEPARTMENT OF TRANSPORT AUSTRALIA

AVIATION SAFETY DIGEST

Number 88 1974

CONTENTS

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TRI-STAR FLIES INTO GROUND

Four minutes after going around from an approach to land at Miami International Airport, Florida, U.S.A. because of an indicated undercarriage malfunction, a Lockheed L-1011 Tri-star descended into the ground and was destroyed. Ninety-nine of the one hundred and seventy-six occupants were killed and the remaining seventy-five sustained varying degrees of injury. The investigation concluded that preoccupation with the apparent malfunction distracted the crew and allowed the aircraft's descent to go unnoticed.

The Tri-star was operating a scheduled passenger flight at night from New York to Miami and had departed at 2120 hours. The flight was uneventful until on final approach to Miami's runway 09 left, when the undercarriage was selected down and the green light which indicates the nose leg is down and locked, failed to illuminate. The captain recycled the undercarriage but still the light failed to come on, so he called Miami tower and advised they would have to circle while they dealt with the problem. The aircraft was cleared to climb straight ahead to 2,000 feet and call Miami Approach Control. At 2335:09 hours, the aircraft contacted Miami Approach Control and reported, 'Approach Control, Eastern four zero one, we're right over the airport and climbing to two thousand feet, in fact, we've just reached two thousand feet and we've got to get a green light on our nose gear'.

At 2335:20, Approach Control acknowledged the flight's transmission and instructed the aircraft to maintain 2,000 feet and turn to a heading of 360 degrees. The new heading was acknowledged by the aircraft at 2335.28.

At 2336.04, the captain instructed the first officer, who was flying the aircraft, to engage the autopilot and the first officer acknowledged the instruction.

At 2336:27, Miami Approach Control requested, 'Eastern four oh one, turn left heading three zero zero'. The aircraft acknowledged the request and complied.

On the flight deck, the first officer succeeded in removing the lens assembly for the nose undercarriage lamp but it jammed when he attempted to replace it.

At 2337:08, the captain instructed the second officer to enter the forward electronics bay, below the flight deck, to check visually the alignment of the nose gear indices. (Proper nose gear extension is indicated by the physical alignment of two rods on the undercarriage linkage. With the nose wheelwell light illuminated, these rods may be viewed by means of an optical sight from the forward electronics bay, which is just forward of the nosewheel well).

At 2337:24, a downward vertical acceleration transient of 0.04 g caused the aircraft to descend 100 feet and the loss in altitude was arrested by a pitch-up input.

At 2337:48, Approach Control requested the flight to turn left to a heading of 270 degrees magnetic. The flight acknowledged the request and turned to the new heading.

Meanwhile, the flight crew continued their attempts to free the lens of the nose undercarriage lamp from its retainer but without success. At 2338:34, the captain again directed the second officer to descend into the forward electronics bay to check the alignment of the nose gear indices.

At 2338:46, the aircraft called Miami Approach Control and requested a clearance to 'go out west just a little further' while they attempted to rectify the fault. Miami Approach Control granted the request.

From 2338:56 until 2341:05, the captain and the first officer discussed the faulty lamp assembly and how it might have been reinserted incorrectly.

At 2340:38, a half-second C-chord, which indicated a deviation of ± 250 feet from the selected altitude, sounded in the cockpit. No crew-

TRI-STAR FLIES INTO GROUND

member commented on the C-chord and no pitch change to correct for the loss of altitude was recorded.

Shortly after 2341, the second officer raised his head into the cockpit and said, 'I can't see it, it's pitch dark and I throw the little light, I get, ah, nothing'.

The flight crew and a company maintenance specialist who was occupying the forward observer seat on the flight deck then discussed the operation of the nose-wheel well light. The specialist then went down into the electronics bay to assist the second officer.

At 2341:40, Miami Approach Control asked, 'Eastern, four oh one, how are things coming along out there?'

This query was made a few seconds after the Miami controller noted an altitude reading of 900 feet in the aircraft's alphanumeric data block on his radar display. (The controller later testified that he contacted the aircraft because the flight was nearing the airspace boundary within his jurisdiction. He further stated that he had no doubt at that moment about the safety of the aircraft. Momentary deviations in altitude information on the radar display, he said, are not uncommon; and more than one scan on the display would be required to verify a deviation requiring controller action.)

At 2341:44, the aircraft replied to the controller's query with, 'Okay, we'd like to turn around and come back in', and at 2341:47, Approach Control granted the request with: 'Eastern four oh one, turn left heading one eight zero'. The aircraft acknowledged and started the turn.

At 2342:05, the first officer said, 'We did something to the altitude'. The captain's reply was, 'What?'

At 2342:07, the first officer asked, 'We're still at two thousand, right?' and the captain immediately exclaimed, 'Hey what's happening here?'

At 2343:10, the first of six radio altimeter warning 'beep' sounds began. They ceased immediately before the sound of the initial impact with the ground at 2343:12.

The site of the crash was 19 miles west northwest of Miami Airport in the flat, low-lying marshland of the Everglades. The aircraft, which was in a 28 degree bank to the left at the time of impact, was fragmented, but only a flash fire occurred as the aircraft broke up; and the wreckage did not burn. The weather at the time was fine and clear but the night was dark and there was no moon.

The aircraft was equipped with a Lockheed expandable digital flight data recorder system (DFDR). This is a new type of recorder which has the capability to record numerous performance parameters. In this case, 62 parameters were retrieved which gave a comprehensive and detailed history of flight, and provided the basis for an analysis of the autopilot and autothrottle systems. The aircraft was also equipped with a Fairchild Cockpit Voice Recorder, the tape of which was recovered intact. A transcription was made of the voices and sounds commencing from the time of the crew's initial call to Miami Tower.

The nature of the break-up precluded determination, by physical means, of the integrity of the primary flight control system before impact. The primary flight control positions were recorded, however, by the DFDR, and showed that the control columns were in an aircraft nose-up position when the crash occurred. The DFDR indicated that there was a power reduction in the Nos. 2 and 3 engines 160 seconds before impact. A second power reduction in the No. 1 engine was matched with the power on the Nos. 2 and 3 engines. Finally the power in the No. 1 engine was retarded more than 10 seconds before power was reduced on the two other engines.

The flap lever in the cockpit was set at 18 degrees and the extension of the inboard jackscrew on the starboard wing flap corresponded with that setting. The leading edge slats on the intact portion of the starboard wing were fully extended. The flap and leading edge slat positions agreed with the DFDR record.

The undercarriage lever was in the down position and the starboard main undercarriage, which remained in place, was down and locked. Both the nose and port main undercarriage were separated from the aircraft and were extensively damaged. The nose undercarriage warning lamp assembly was jammed in a position 90 degrees clockwise to, and protruding a quarter of an inch, from its normal position. Both its bulbs were burned out.

Performance tests were conducted at Miami, using a Lockheed L-1011 simulator, and an L-1011 test aircraft. In addition, an Aircraft Performance Group analysed the aerodynamic characteristics of the aircraft type, in relation to the performance characteristics of the accident aircraft. The group also conducted a study of the aircraft's autopilot and autothrottle systems, to determine if they were operational during the final moments of the flight. This investigation disclosed the following:

- The accident flight path was consistent with the established aerodynamic characteristics of the aircraft type.
- The autopilot was engaged at various times during the flight, and was in the control wheel steering (CWS) pitch mode during the last 288 seconds of the flight.
- The autothrottle system was not in use during the final descent.

The Lockheed L-1011 Avionic Flight Control System (AFCS) is composed of four major sub-systems: the autopilot flight director system, the yaw stability augmentation system, the speed control system, and the flight control electronics system.

The aircraft's autopilot flight director system (APFDS), which provides autopilot and flight director pitch and steering commands, has two roll and two pitch computers. The 'A' system relates to autopilot 'A' and to the flight director on the captain's side; the 'B' system relates to autopilot 'B' and to the flight director on the first officer's side. The two autopilots cannot be operated simultaneously, except in the autoland mode. The function and operation of the autopilot are displayed on the captain's and the first officer's panels through AFCS warning and AFCS mode annunciators. The APFDS engage panel, the Nos. 1 and 2 VHF navigation panels, the autothrottle system panel, the heading and pitch mode panel, a navigation mode panel, and the altitude select panel are all located on the glare shield; they are the means by which the various functions of the AFCS are selected.

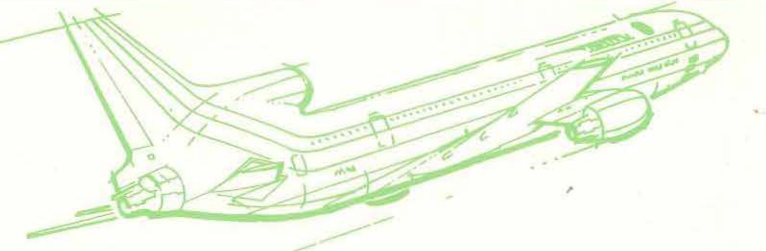
The basic mode of autopilot system operation is control wheel steering (CWS) and in this mode, provides attitude stabilization, with attitude changes effected by the application of light forces to the control wheel by the crew. When engaged in a command mode the autopilot will provide total control of the aircraft in accordance with selected heading, pitch or navigational system inputs.

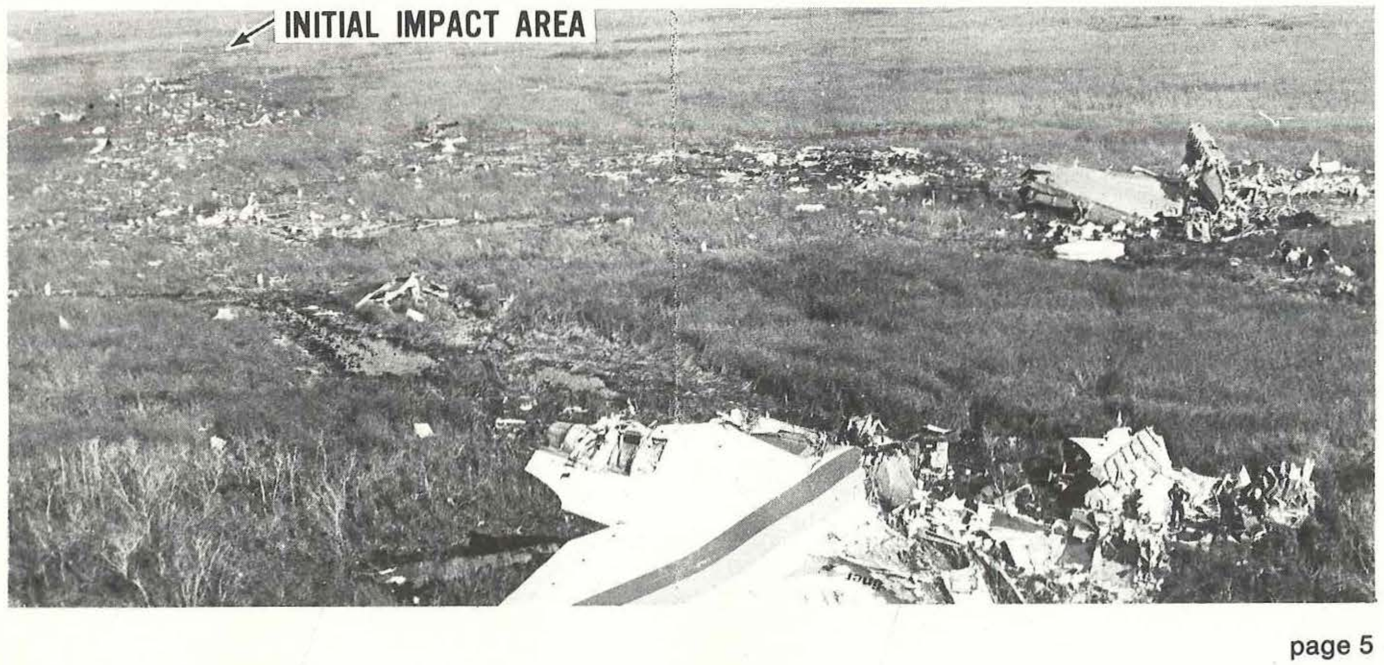
When operating in any mode, the selected heading or pitch command function may be disengaged by an overriding 15 lb force applied to the respective control system through the control wheel. If the force is applied to the pitch control system, only the pitch axis control will be affected and will revert to the basic attitude stabilization mode of operation. If the force is applied to the roll control system, the autopilot engage lever will revert to the CWS position.

The altitude hold mode is unique in that, although it is a command function, it may be engaged when the autopilot is selected to provide either basic CWS or command operation. When altitude hold is selected, the autopilot provides pitch signals to maintain the altitude existing at the time of engagement. As already mentioned, pilot-applied pitch forces on the control wheel will cause disengagement of the altitude hold function, reverting the pitch channel to attitude stabilization which is sensitive to control wheel inputs. In this case however the autopilot engagement lever will remain in the previously selected position, i.e., either CWS or Command. In this way it is possible to disengage the altitude hold without an accompanying 'CMD DISC' warning appearing on the captain's or first officer's annunciator panels. Such an occurrence would be indicated only by the extinguishing of the altitude mode select light on the glare shield, and the disappearance of 'ALT' on both annunciator panels.

It was found that the two pitch computers in the aircraft were not matched. The pitch override force required to disengage the altitude hold function in computer 'A' was 15 pounds, whereas in computer 'B' it was 20 pounds. As a result of the mismatch, it would be possible, with the 'A' autopilot system engaged, to disengage the 'A' AFCS computer, but not the 'B' AFCS computer. In this situation, the altitude mode select light would remain on, the 'ALT' indication on the captain's annunciator panel would go out, and the same indication on the first officer's annunciator panel would remain on, which would give the first officer the erroneous indication that the autopilot was engaged in the altitude hold mode.

It was concluded from the investigation that the aircraft's powerplants, airframe, electrical and pitot static instruments, flight controls, and hydraulic and electrical systems were not factors contributing to this accident and the thrust of the investi-





Low level aerial photograph showing the wreckage trail. The tail section is in the foreground. Some idea of scale can be gained from the man standing at the extreme right of the tail-section wreckage.

TRI-STAR FLIES INTO GROUND

gation was focused on ascertaining the reasons for the unexpected descent. The areas considered were:

- Subtle incapacitation of the pilot.
- The autopilot system of operation.
- Flight crew training.
- Flight crew distractions.

Subtle incapacitation had to be considered in view of the finding of a tumor in the cranial cavity of the captain and which would have affected his peripheral vision. If the captain's peripheral vision was severely impaired, he might not have detected movements in the altimeter and vertical speed indicators while he watched the first officer remove and replace the undercarriage lamp assembly. However, the captain's family, close friends and fellow pilots advised that he showed no sign of visual difficulty in the performance of his duties and in other activities requiring peripheral vision. In the absence of any indications to the contrary, the Board believed that the tumor was not a causal factor in this accident.

In considering the use of the autoflight system, it was noted that the go-around was flown manually by the first officer until 2336:04 when the captain ordered engagement of the autopilot. The affirmative reply by the first officer implies that the autopilot was engaged at this time. Verification of such action was provided by the analysis of the DFDR readout, which showed pitch control surface motions indicative of autopilot control in either altitude hold or pitch CWS. An altitude of 2000 feet was found selected in the altitude select window.

Which of the autopilots was engaged, i.e., system 'A' or system 'B', could not be determined, but it was considered that the first officer would have probably engaged system 'B' to the command position, with the altitude hold and heading select functions selected, in accordance with general practices. At the same time, the first officer probably selected 2,000 feet into the altitude select/alert panel.

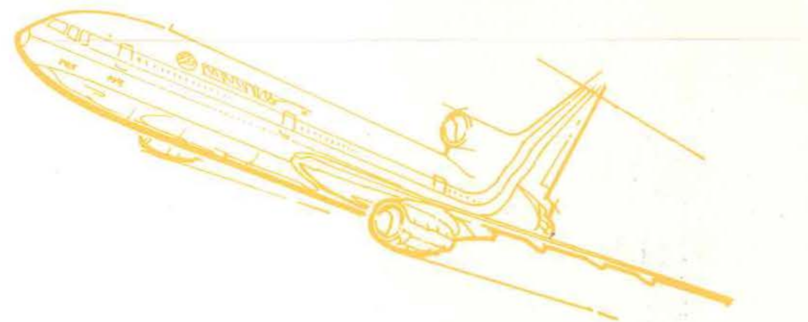
At approximately 2337, some 288 seconds prior to impact, the DFDR readout indicates a vertical acceleration transient of 0.04 g causing a 200 fpm rate of descent For a pilot to induce such a transient, he would have to disengage, either intentionally or unintentionally the altitude hold function. It is conceivable that such a transient could have been produced by an inadvertent action on the part of one of the pilots applying a force to the control column. Such a force would have been sufficient to disengage the altitude hold mode.

It was noted that the pitch transient occurred at the same time as the captain told the second officer to 'Get down there and see if the nose wheel's down'. If the captain had applied a force to the control wheel while turning to talk to the second officer, the altitude hold function might have been accidentally disengaged. Such an occurrence could have been evident to both the captain and first officer by the change on the annunciator panel and the extinguishing of the altitude mode select light. If autopilot system 'A' were engaged, however, the discrepancy in the disengage force comparators, i.e., the mismatch between computers 'A' and 'B', would become a significant factor in this analysis. Because of this mismatch and the system design, a force exerted on the captain's control wheel in excess of 15 pounds, but less than 20 pounds, could result in disengagement of the altitude hold function without the occurrence of a corresponding indication on the first officer's annunciator panel. This would lead to a situation in which the first officer, unaware that altitude hold had been disengaged, would not be alerted to the aircraft altitude deviation. If the autopilot system 'B' was engaged, as is believed to have happened, such a situation could not have occurred since a force in excess of 20 pounds would have been required to disengage the altitude hold function and both annunciator panels would have indicated correctly. For this reason, the Board concluded that the mismatched pitch computers in the autoflight system were not a critical factor in the accident.

It is significant that recognition of the 100 foot loss in height took place 30 seconds after the 0.04 g pitch transient occurred, and after a heading change was requested by approach control. The DFDR readout indicates a 0.9 degree pitchup manoeuvre coincident with a change of heading. The DFDR analysis of lateral control system motions indicates that the heading select mode was used for the last 255 seconds of flight to control the aircraft to a heading of 270 degrees. Selection of the new heading would have required action by the first officer, and it is reasonable to assume that the autopilot was set up to provide pitch attitude stabilization sensitive to control wheel inputs and heading select, to achieve and maintain the 270 degrees heading.

In the pitch attitude stabilization mode, the aircraft will respond to intentional or unintentional movements of the control wheel. Furthermore, while the aircraft is operating in this mode, the effect of aircraft thrust changes, without compensating pitch attitude control inputs, will be directly related to changes in vertical speed.

Three-dimensional diagram showing aircraft's initial approach path to runway 09L, subsequent go around and inadvertent descent to point of impact.



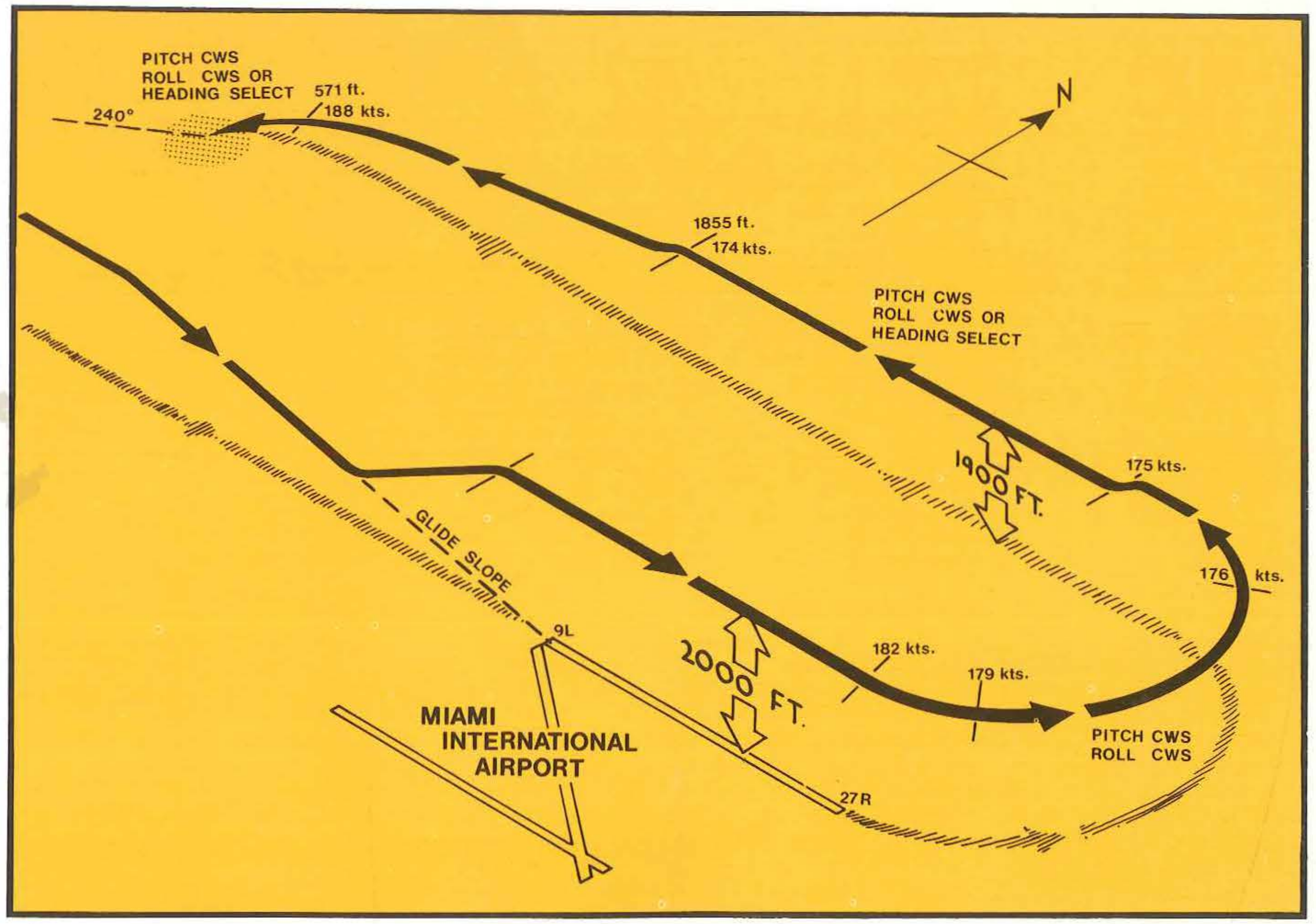
An indication that the throttles were not retarded by a properly operating autothrottle system was provided by the sequence in which the power was reduced. The throttles are clutched together and driven simultaneously by one servo, and as the autothrottle system of the aircraft was found to have been functional, the Board did not believe that this system was involved in the reduction of thrust. Accordingly, after examination of the possibilities, the Board believed that the throttles were intentionally retarded by one or both of the pilots.

Regardless of the way in which the status of the autoflight system was indicated to the flight crew, or the manner in which the thrust reductions occurred, the fact that the aircraft was descending would have been evident from the flight instruments. Together with the altitude-alerting and the C-chord signal, their indications should have alerted the crew to the undesired descent.

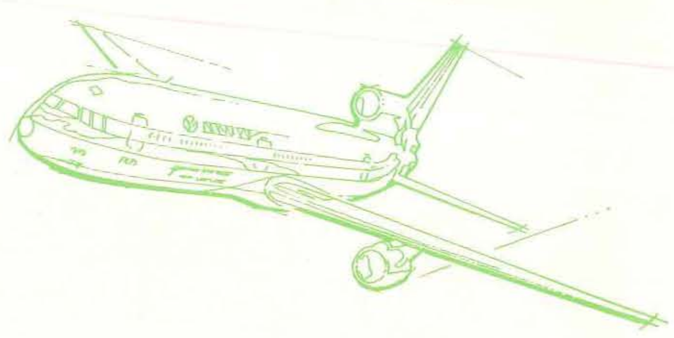
The throttle reductions and control column force inputs made by the crew, suggest that the crew members were not aware of the low force gradient input required to effect a change in aircraft attitude while in CWS. The Board learned that lack of knowledge about the capabilities of the new autopilot was not limited to the flight crew of the aircraft involved in the accident.

Although formal training provided adequate opportunity to become familiar with this new concept of aircraft control, operational experience with the autopilot was limited by company policy. Company operational procedures did not permit operation of the aircraft in CWS; but required all operations to be conducted in the command modes. This restriction might have compromised the ability of pilots to use and understand the unique CWS feature of the new autopilot.

The Board believed that the present airline training programme was adequate, but in need of more frequent quality control progress checks of the student during the ground school phase of the training, as well as an early operational proficiency follow-up check in the flight simulator after



TRI-STAR FLIES INTO GROUND



the pilot had flown the Tri-Star in scheduled passenger service.

Another problem concerns the new automatic systems which are coming into service with newer aircraft, and being added to older aircraft. Flight crews become more reliant upon the functioning of sophisticated avionics systems, and their associated automation, to fly the aircraft. This is becoming increasingly so as the reliability of such equipment improves. The evidence of pilots indicated that dependence on the autopilot is actually greater than anticipated in its early design and its certification. This is particularly true in the cruise phase of flight. Good pilot practices and company training dictate however that one pilot should monitor the progress of the aircraft at all times and under all circumstances.

It was evident from the investigation that the flight engineer, after climbing down into the forward electronics bay below the flight deck, was unable to see if the nose undercarriage was locked down because the nose-wheel well light was not turned on. If the linkage rods indicating that the undercarriage is down are to be viewed at night, the nose-wheel well light must first be turned on from a switch on the captain's 'eyebrow' panel. The person viewing the rods must then pull a knob above the optical sight, which removes a lens cover at its far end. In this case the flight engineer twice said that he could see nothing, and that it was 'pitch dark'. It is not known whether:

- the captain ever attempted to turn on the light (the crew seemed to think that the light should be on whenever the landing gear was extended);
- the light was inoperative; or
- the flight engineer properly operated the knob which removes the optical tube cover.

In any event, the Board believed that this unsuccessful attempt to ascertain whether the nose undercarriage was locked down contributed to the distraction of the crew. For this reason, the Board believed that the system should be operable by one man and that the switch for the light should be located near the optical sight. Furthermore, a placard outlining the proper use of the system should be installed nearby.

The Board is aware of the distractions that can interrupt the routine of flight. Such distractions usually do not affect other flight requirements because of their short duration or their integration into the flying task but in this accident the following took place:

- The approach and landing routine was interrupted by an abnormal gear indication.
- The aircraft was flown to a safe altitude and the autopilot was engaged to reduce workload, but positive delegation of aircraft control was not accomplished.
- The nose undercarriage lamp assembly was removed and incorrectly reinstalled.
- The first officer became preoccupied with his attempts to remove the jammed lamp assembly.
- The captain divided his attention between attempts to help the first officer and orders to other crew members to try other approaches to the problem.
- The flight crew devoted approximately four minutes to the distraction, with minimal regard for other flight requirements.

It is obvious that this accident, as well as others, was not the final consequence of a single error, but was the cumulative result of several minor deviations from normal operating procedures which triggered a sequence of events with disastrous results.

Investigation of the Air Traffic Control responsibilities in this accident revealed another instance where the Automated Radar Terminal Service system as is in use at Miami conceivably could have aided the approach controller in his ability to detect an altitude deviation of a transponder-equipped aircraft, analyze the situation, and take timely action to assist the flightcrew. In this accident, the controller, after noticing on his radar that the alphanumeric block representing the flight indicated an altitude of 900 feet, immediately queried the flight as to its progress. An immediate positive response from the flightcrew, and the knowledge that the radar equipment, at times, indicates incorrect information for up to three scans, led the controller to believe that the flight was in no immediate danger. The controller continued with his responsibilities to the five other flights within his jurisdiction.

The Board recognized that the Automated Radar Terminal Service system was not designed to provide terrain clearance information and that the FAA has no procedures which require the controller to provide such a service. However, it would appear that everyone in the overall aircraft control system has an inherent responsibility to positively alert others to apparent hazardous situations, even though it is not his primary duty to effect the corrective action. Accordingly the Board recommended that considerations be given to the possible development of procedures to aid flight crews when marked deviations in altitude are noticed by an air traffic controller.

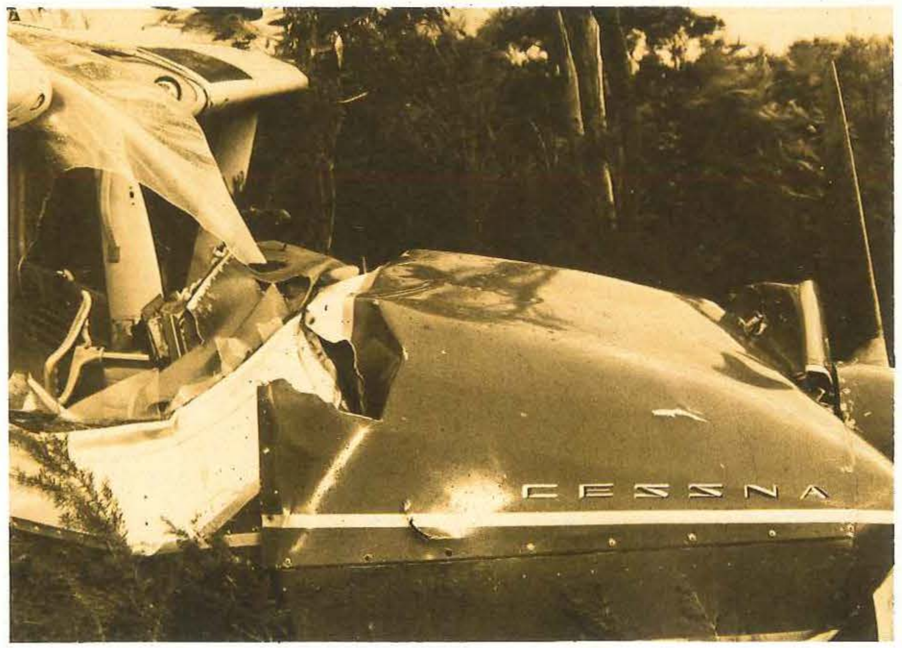
* * * * *

Probable Cause

The National Transportation Safety Board determined that the probable cause of this accident was the failure of the flight crew to monitor the flight instruments during the final four minutes of flight and to detect an unexpected descent soon enough to prevent impact with the ground. Preoccupation with the malfunction of the nose landing gear position indicating system distracted the crew's attention from the instruments and allowed the descent to go unnoticed.

STALL AFTER TAKE-OFF

Shortly after taking off from an island in Bass Strait, in gusty cross-wind conditions, the port wing of a Cessna 172 dropped and the aircraft descended steeply in a turn to the left, striking scrub-covered ground beyond the end of the strip in a steep nose-down attitude. The pilot was seriously injured, the front seat passenger received minor injuries, but the two back seat occupants escaped unhurt.



TOP: View of landing area. Wreckage is in scrub at right of picture.

CENTRE: The badly damaged Cessna after the accident.

BOTTOM: The nose-down attitude at impact is evident from the degree of telescoping in the forward section of the fuselage.

The aircraft was based in Northern Tasmania and, at the time of the accident, was operating a charter flight to Smithton from Three Hummocks Island off the northwestern tip of Tasmania. The aircraft had arrived on the island from Smithton a short time before the accident carrying the pilot and one passenger. About fifteen minutes later, the pilot and three passengers for the return flight boarded the aircraft. After the engine was started, the aircraft taxied to the western end of the landing area where the pilot carried out an engine run-up and, after completing his take-off checks, lined up for take-off on a heading of 090 degrees. The wind at the time was blowing from the north-east and gusting to about 25 knots.

The engine was heard to increase in power then the brakes were released and the take-off began. The aircraft gained speed, lifted off normally and climbed quite quickly to about 70 feet. At this height the aircraft suddenly appeared to be more affected by the cross-wind, and the nose was seen to yaw into wind as though the pilot were compensating for this effect. Still climbing quite steeply, and buffeting in the turbulence of the gusting wind, the aircraft momentarily lost height. Then the port wing dropped quite sharply and the aircraft nosed down into a steep spiral dive to the left, disappearing behind a hill. Moments later there was a sound of an impact. The witnesses immediately jumped into their car and drove as quickly as possible to the scene of the accident, where they found the badly damaged Cessna lying in scrub, and the occupants in a dazed condition extricating themselves from the wreckage.

The landing area on Three Hummocks Island is a dome-shaped area of cleared scrubland on the western side of the island. As a landing area it could possibly be described best as an 'all over field' because the strips are not defined, and the progressively increasing slope towards its extremities, makes it difficult to define the exact lengths available in the various directions. During the investigation however, it was estimated, as accurately as circumstances permitted, that the usable length in the direction of take-off was 1,450 feet. In this direction the length of the area from fence to fence would be close to 1,600 feet.

Examination of the wreckage showed that the aircraft had plunged into the scrub-covered terrain beyond the eastern boundary of the landing area in a 30 degree nose-down attitude while banked about 30 degrees to port. The manually operated flaps were selected to the second stage or 20 degree position. There was nothing in the wreckage to suggest that there had been any fault or malfunction in the aircraft which could have contributed to the accident. The all up weight of the aircraft at the time of the accident was 2,070 lbs., comfortably below the maximum permissible take-off weight of 2,300 lbs. It was calculated that in the conditions existing at the time of the accident, the take-off distance required, with 10 degrees of flap, was 1,400 feet.

The pilot held a commercial licence with almost 1,800 hours experience, much of it having been gained during operations from bush-type strips of the sort where the accident occurred. The pilot said that after completing his pre-take-off checks, he selected two stages of flap, lined up into the east and applied power smoothly. The aircraft accelerated normally but he remembered the stall warning operating. At a height of about 50 feet, the aircraft swung to the left and the next thing he remembered was walking around outside the aircraft.

The passenger who was occupying the right hand front seat said that the take-off seemed normal except that the stall warning was operating continuously from the time the aircraft lifted off. Soon afterwards the port wing dropped and the pilot exclaimed, but he didn't hear what he said. The next thing he remembered was lying under the wing of the aircraft on the ground with an injury to his head.

It was evident from the investigation that the length of the strip and the loading of the aircraft were not factors contributing to the accident. The cross-wind component on the strip at the time of take-off was probably close to, if not a little above, the maximum permissible cross-wind component for the aircraft type. The pilot said the wind was blowing from about 050 degrees at 20 to 25 knots and the two witnesses who watched the take-off from the strip estimated it was from a north to north-easterly direction, gusting up to 25 knots. From all the information available, including a post-accident analysis of the weather made by the Meteorological Bureau, the investigation concluded that the average head wind component was about seven knots and the cross-wind component slightly above the aircraft type maximum of 15 knots.

The aircraft's performance chart, which showed the length required for take-off in the prevailing conditions as 1400 feet, specified a flap setting of 10 degrees to achieve this figure. Also, according to the company's operations manual, the flap setting for a minimum ground-roll take-off is 10 degrees. The setting for a cross-wind take-off is specified as flaps up, or 10 degrees as appropriate. Nowhere is a setting of more than 10 degrees advocated for take-off. The aircraft's flight manual also stipulates that for such a take-off, the aircraft be held on, or close to the ground until take-off safety speed is attained.

The pilot could not recall the speed at which he lifted off, nor was the investigation able to uncover any other evidence concerning the indicated airspeed during the aircraft's initial climb. It is evident however, from the flap setting actually used, together with the evidence that the stall warning was sounding, that the pilot did not comply with the recommended take-off technique. Rather, the evidence suggests that the aircraft climbed away steeply and it is likely the speed would have been significantly less than the take-off safety speed. When the aircraft had climbed to about 50 feet, and became exposed to the full effect of the strong, gusting wind, the speed was evidently still dangerously low and a fluctuation in wind velocity sufficient to cause the aircraft to stall, was apparently encountered.

It is a well known fact that the stalling characteristics of most aircraft are more positive with flap and power applied, and in this case, with at least climbing power applied, and 20 degrees of flap lowered, the stall could be expected to be quite pronounced. In this configuration also, torque reaction would be high and would tend to roll the aircraft to the left at the point of stall, as happened in this case.

There is no reason to believe the accident was in any way attributable to the fact that the landing area and wind conditions were marginal. Rather the situation simply called for a degree of professional skill and adherence to the correct operating technique. This required technique was obviously not followed and it can only be concluded that, following a take-off in strong, gusty wind conditions, the pilot failed to maintain an airspeed, which provided an adequate margin of safety to compensate for the effect of gusts.

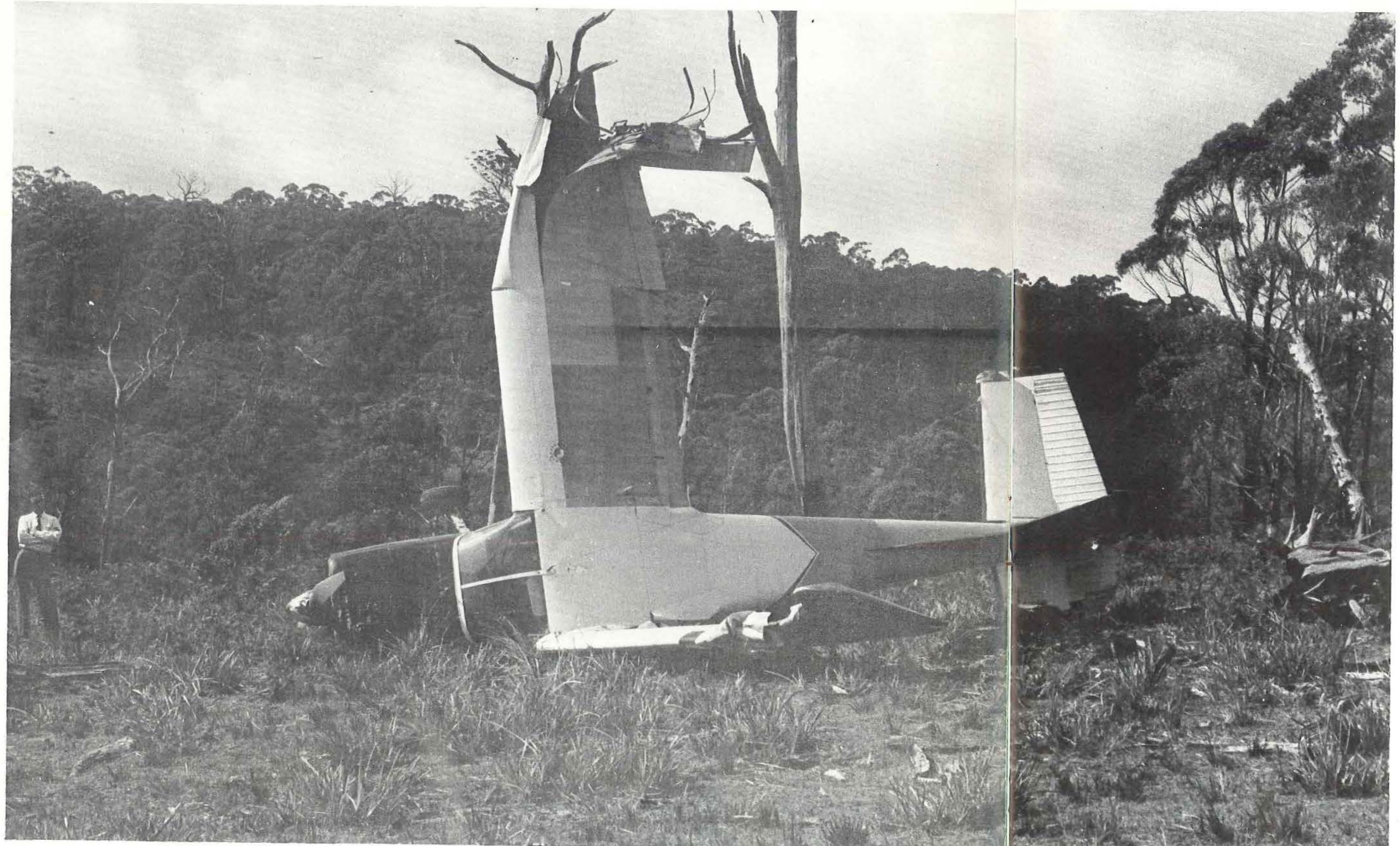
Comment

To obtain the maximum advantage in terms of take-off distance, close attention must be paid to achieving and maintaining the correct take-off safety speed. Generally speaking, at a given take-off safety speed, the more flap that is extended, the longer will be the total distance to a height of 50 feet. The gain from the use of flap for take-off comes from the reduction in stalling speed that occurs as flap deflection is increased, thus permitting the use of lower take-off safety speeds. As the take-off distance is very dependent on the take-off safety speed, any reduction in this parameter, all other factors being equal, will reduce the take-off distance. As the flaps are progressively extended however, the total drag of the aircraft also increases, thus producing a tendency to increase the take-off distance again. At a certain flap deflection, a point could be reached where any further increase in flap deflection will increase the distance to 50 feet, despite the further reduction in take-off safety speed, resulting from the use of flap.

AFTER THE FALL

Energy conversion and all that!

With acknowledgement to
Air Progress U.S.A.



A good example of 'how to crash without hurting yourself'. The occupants of this Cessna 180 escaped almost unscathed.

A recent National Transportation Safety Board Study on light aircraft emergency landings, underscore an important fact that's too often ignored: in off-field landings, speed kills. An 85 mph crash is twice as severe as one at 60 mph — which means that you're twice as likely to get killed. A pilot may be faced with a choice of approaches to a marginal emergency field — a clear approach with the wind or a difficult, obstructed one into the wind. And while it's far better to roll into the trees than drop into them, it may still be better to put highest priority on low groundspeed and make the more difficult approach into the wind.

All other things being equal, the severity of a crash depends mainly upon the energy that must be dissipated to stop the aeroplane. As you learned in High School, kinetic energy is proportional to the mass and the square of the speed — the formula is $E = \frac{1}{2} M V^2$. Double the speed and you quadruple the kinetic energy, and hence quadruple the violence of the crash. Remember that energy is not momentum, which is directly proportional to speed. There's an old joke about a canopy manufacturer who proudly tells a potential customer that his canopy can withstand the impact of a 10 pound chicken at 600 mph. To which the customer of course replies. 'Yeah, that's great, but what about a 600 pound chicken at 10 mph?' The two chickens have the same momentum, but the small, speedy pullet has 60 times the energy and is therefore 60 times as likely to break the canopy. So the customer needn't have worried!

There are numerous ways to transfer an aircraft's kinetic energy into other forms of energy, thereby bringing it to a stop. In a crash, the primary kinetic energy outlet is the crumpling, bashing and ripping of all that sheet metal, with miniscule amounts of energy dissipated through heat and sound. (Theoretically, it's possible to convert most of the aircraft's kinetic energy to sound energy, bringing the plane to a halt without a scratch. But that would also deafen people for miles). Kinetic energy can also be dissipated by imparting motion to other objects, like dirt or trees or water. Back in the 1950's, Colonel John Stapp's famous rocket sled was slowed from 600 mph to about 30 mph in seconds, by a water brake that scooped up tons of water and sent colossal fusillades of spray into the air. Stapp pulled 40g's, but he survived because the energy was converted at a fairly constant rate. In theory, a Cherokee could stop in its own length from 70 mph and never subject itself or its passengers to more than 8g's of deceleration. It wouldn't be comfortable, but if you were wearing a shoulder harness you'd certainly survive. Does that mean you could fly into a haystack and walk away from it? Probably. And a good healthy stand of hay or corn will stop you almost as quickly and smoothly as an arresting cable.

So students, it's a simple matter of energy conversion, $E = \frac{1}{2} M V^2$. Land slowly and run into something soft. Keep it into the wind, overshoot, and head for those amber waves of grain, and above all, don't be afraid to crumple your aeroplane instead of yourself!

Comment

Though not quite in our 'style', the case made out in this article has a great deal to be said for it. The philosophy it expresses has certainly been borne out in practice in some Australian accidents, which at first sight might be judged 'non-survivable'.

Many years ago, the pilot of an Auster flying from Bankstown, N.S.W., to a destination west of the Great Dividing Range, became caught in cloud a few miles south of Katoomba. He became disorientated and lost control but, more by good fortune than good management, succeeded in reducing the diving aircraft's speed from almost 140 knots to 60 knots. At this point the aircraft emerged from cloud, but too late to avoid flying into heavy timber, which covered the floor of the valley into which the aircraft had descended while in cloud. Indeed, so thick were the trees where the aircraft crashed that the pilot, who was the only occupant and had escaped unhurt, was unable to find the aircraft again. It took him four days to 'walk out' to civilization! Some of our older readers may recall that this accident was recorded in *Aviation Safety Digest* No. 6 in January 1956.

Other more recent instances have been the Cessna 205 which crashed in the Weddin Range near Grenfell N.S.W. ('Anatomy of an Accident', *Digest* No. 65) and the Cessna 172 which was deliberately 'ditched' into tall timber in a valley near Moss Vale, ('I had no Fears about Flying in Cloud!', *Digest* No. 75). In both these cases too, the several occupants escaped, seemingly miraculously, with comparatively quite minor injuries.

There was another instance several years ago, also in N.S.W., in which a Cessna 180 lost power while flying over heavily timbered hilly country near Mittagong. The only area remotely resembling a forced landing ground was a small, extremely rough paddock on a hillside, surrounded by high trees. The aircraft was only about 1500 feet above the ground when the engine lost power and there was little time for manoeuvring, but the pilot planned the approach so that, just before the aircraft touched down at about 40 knots, he could deliberately fly the starboard wing into the trunk of a tree on the approach path. A moment before this initial impact, he applied starboard rudder to skid the aircraft. The result was that the aircraft pivoted 90 degrees to the right around the tree, and struck the ground skidding sideways. The port undercarriage collapsed during the rapid deceleration and though the aircraft fell on its port side before it came to a stop, the four occupants escaped virtually unscathed.

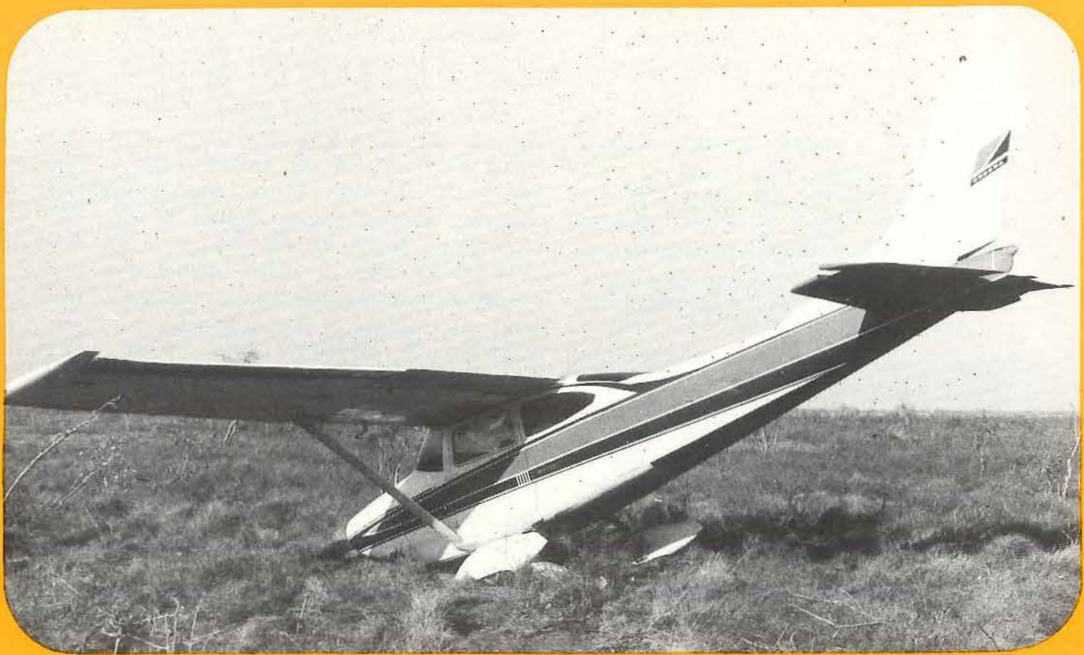
It is significant that in all these cases the airspeed at the time of impact had been reduced almost to the point of stall, and the 'appendages' of the aircraft's structure — wings, undercarriage, tail surfaces etc., absorbed most of the remaining kinetic energy.

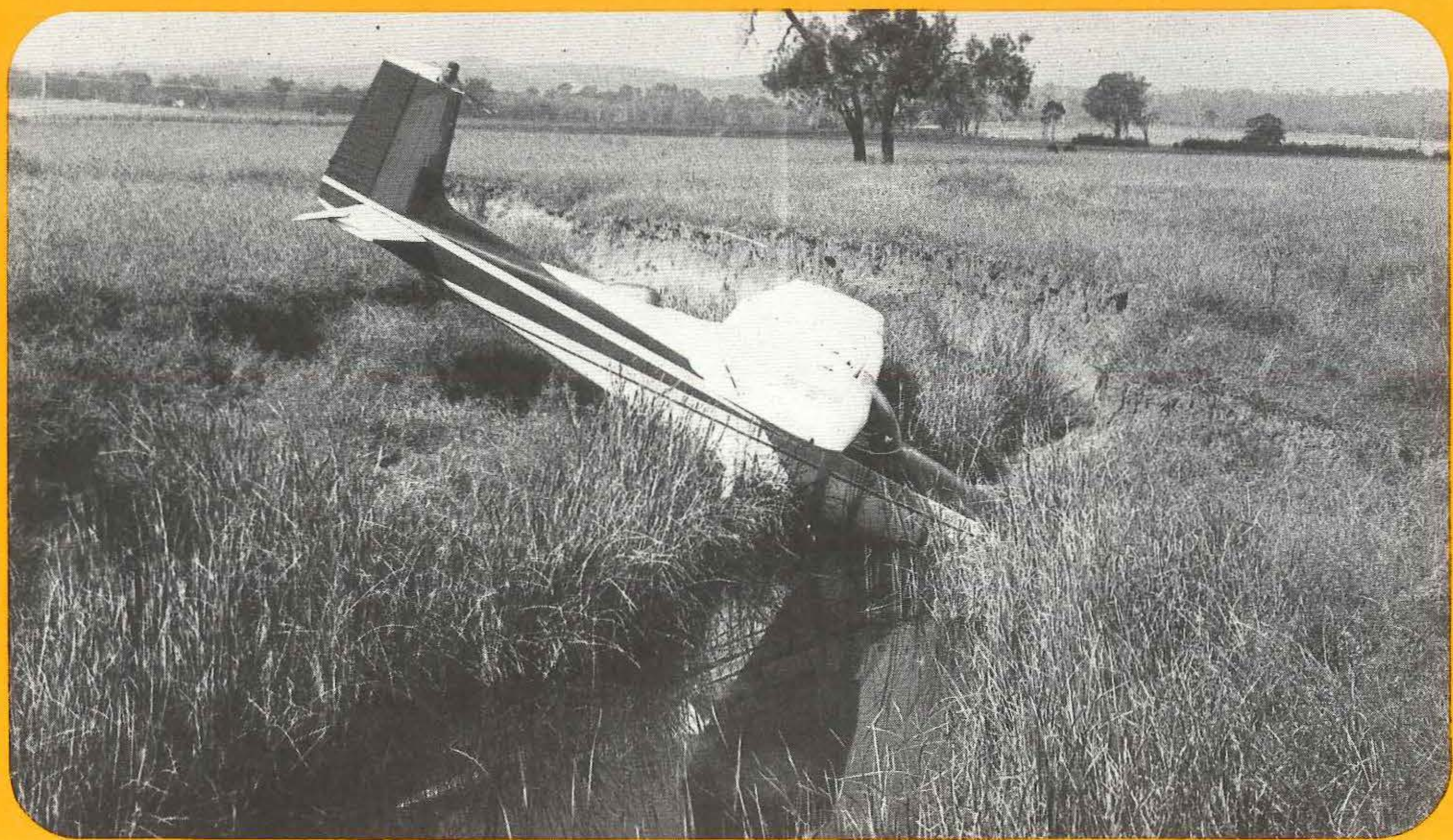
PREVENTION IS BETTER THAN CURE

These expensive embarrassments could have been prevented.........

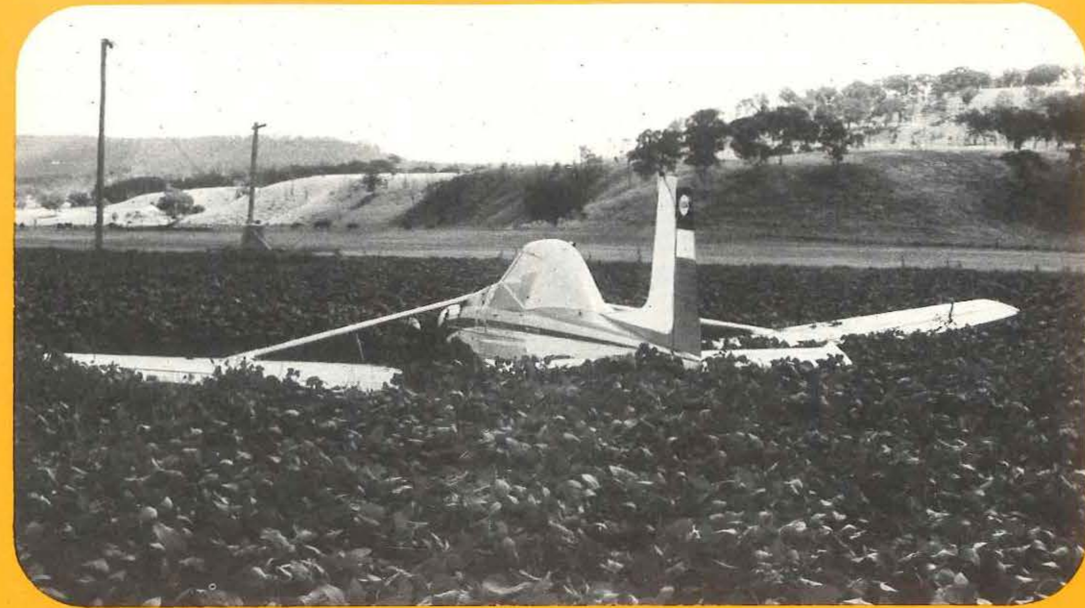
. . . if the pilot had adequately chocked the wheels before attempting to start the engine by hand.

. . . if the pilot had not allowed the aircraft to run out of fuel. (As might be expected he had not visually checked the tanks before departing!)





. . . if the pilot had been properly briefed on the position of a hard-to-see power line before commencing spraying operations.

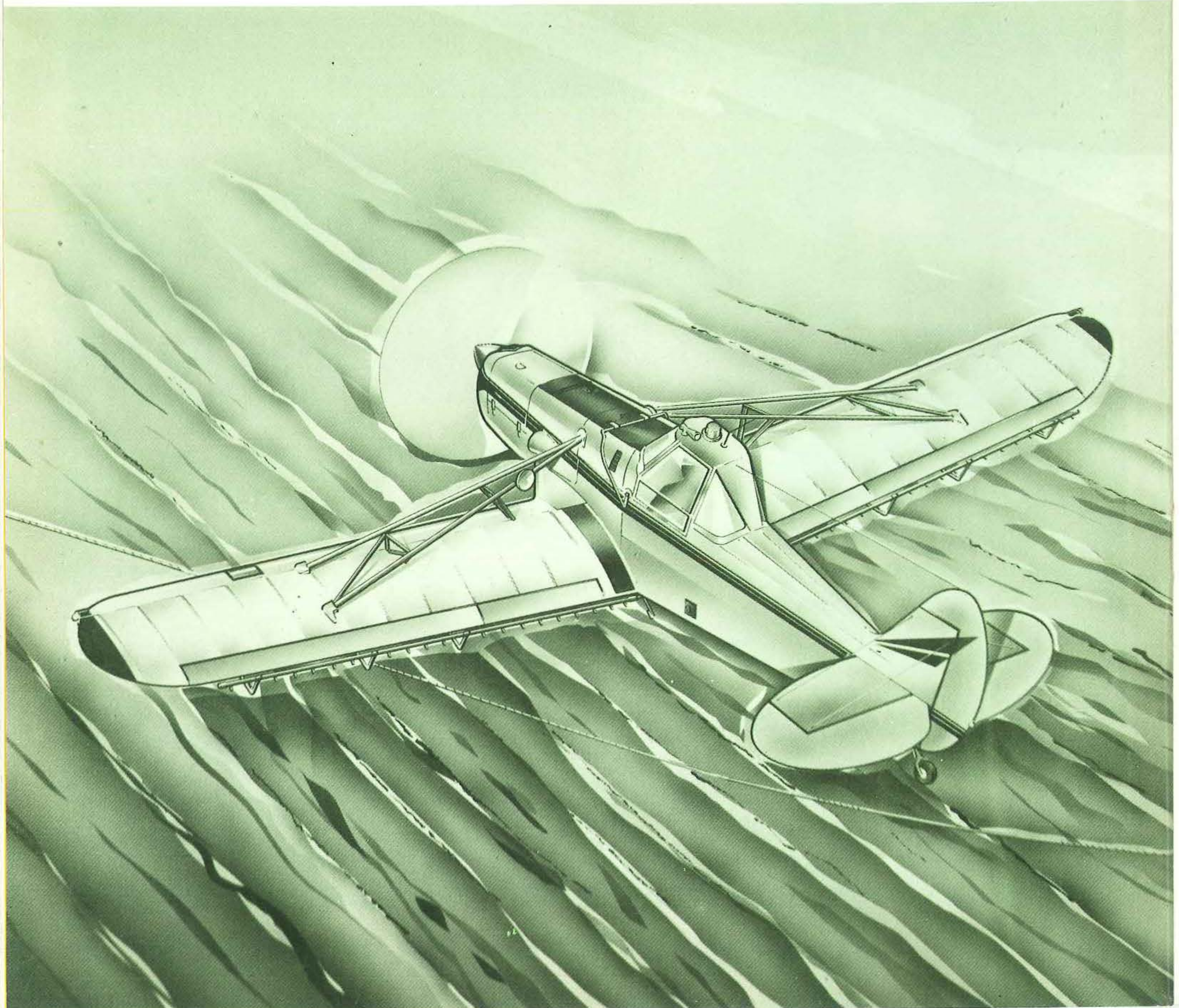


. . . if the pilot had detected a dragging main wheel brake when he experienced directional control difficulties opposite to those to be expected during a cross-wind take-off.

. . . if the pilot had not attempted to land on an air strip of inadequate length.

LAPSE IN CONCENTRATION

On a farming property in south-eastern Queensland, the owner discovered that portion of his sorghum crop urgently needed spraying to control a quickly-spreading insect pest. Learning that the aerial agricultural firm he usually engaged would be unable to treat the crop for at least two days, the farmer telephoned another local operator who agreed to do the work the same day if possible with his Pawnee aircraft. He was unable to make more definite arrangements at the time however, as the pilot concerned was away spraying cotton and was not expected to return until later in the day. During his conversation with the operator, the farmer described the location of the property, the acreage and the type of pest, and indicated that the field was contoured into alternative strips of two stages of crop growth. Only the strips of new sorghum growth, about 70 acres in all, were to be sprayed. He did not mention any hazards in the area to be treated but said he would call again and give more detailed information directly to the pilot.



When the farmer telephoned later however, the pilot still had not returned and he confined his discussion with the operator to describing the layout of the contour strips. The operator indicated that the pilot would probably ring the farmer, before flying to the property, to obtain full details of the work.

The field to be treated was approximately rectangular and aligned north-east, south-west. For his discussion of the details with the pilot, the farmer had prepared a sketch of the field and on it, had shown the run of a power line outside and parallel to the boundary fence on the north-eastern side. The power line, 80 feet from the fence, consisted of a single-wire supported on poles about 890 feet apart. The height of the wire above the ground varied between 34 feet at the pole adjacent to the northern corner of the field and about 24 feet at the centre of the span. Apart from clumps of low trees along two boundary fences and four large, isolated trees in the field, there were no other significant hazards to the operation.

The farmer waited some time for the telephone call from the pilot but eventually had to leave his house to attend to other matters on the property. Only a few minutes afterwards however, the pilot rang and, in the farmer's absence, a carpenter who was working in the house answered the telephone. But, as he knew nothing of the details of the operation, the conversation was limited to a very brief assessment of the local weather. The call was terminated by the pilot indicating that he would be arriving over the property in about 20 minutes.

When this message was passed on to the farmer, who was to act as a marker, he realised he had no information as to the swath widths and returned to his house to ring the operator yet again. By this time the aircraft had already taken off so, after speaking briefly on the telephone with the pilot's loader-driver about the swath widths, the farmer hurried off to pick up a neighbour who was to help him with the marking, and drove to the field.

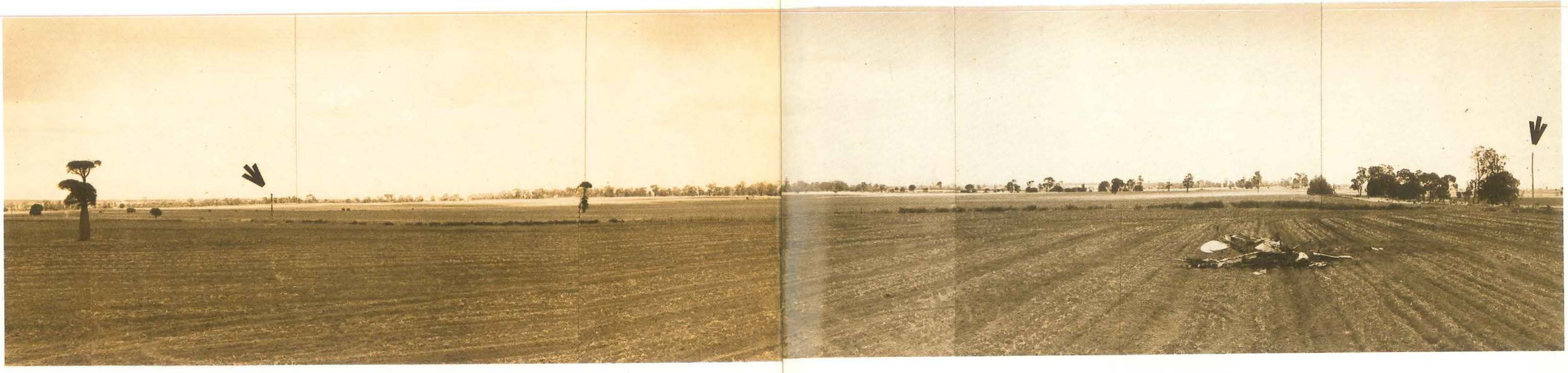
Thus it eventuated that, although four telephone conversations had been carried on between the farmer and the operating company, the pilot and the farmer had not conversed directly and at no time were the hazards in the field discussed.

As he was dropping his neighbour near one corner of the crop, the two men saw the aircraft in the distance and, by the time the farmer had taken up his own position on the north-eastern boundary of the field near the power line, the aircraft had arrived overhead. After making a partial circuit of the field it descended and began its first spraying run into the north-east towards the power line.

In this direction, the aircraft was crossing the contoured strips of crop approximately at right angles and it was necessary for the pilot to switch the spray on and off four times over a distance of slightly less than 3,000 feet. Watching the aircraft heading across the field towards him, the farmer could see the spray starting and stopping as the aircraft passed over the strips. At the end of the run, the aircraft continued in level flight past the farmer, over the boundary fence, and under the power line, before making a normal procedure turn. Lining up for the return run, the aircraft was positioned low and well back over the adjacent field before passing beneath the power line once again and continuing on over the crop.

Three runs in each direction were completed in this manner, with the aircraft passing under the wire on each occasion. With each run, the aircraft was progressively approaching the centre of the span where the clearance of the wire above the ground was reduced to about 24 feet. As well, the aircraft had to pass over the four foot high boundary fence, eighty feet before reaching the wire. On the

The burnt-out wreckage of the Pawnee as it came to rest inverted. One of the poles of the power line which the aircraft struck can be seen in the background.



seventh run, as the aircraft passed above and behind the farmer and he began getting up from where he was crouched to take up a new position, he sensed it was higher than it had been on previous runs. Looking up, he saw the aircraft in a nose-up, port wing down attitude, heading directly at the power line. As he watched, the aircraft struck the wire a few feet in from the port wing tip, and it caught on the support bracket for a floodlight installed beneath the wing for night spraying. Rolling to the left, the aircraft continued upwards until, at a height of about 50 feet, the nose dropped and the aircraft, now fully inverted, dived steeply into the ground. Almost immediately an intense fire broke out and the aircraft quickly burned to destruction. When rescuers reached the wreckage, they found that the pilot had been killed.

Apart from the damage caused by the wire strike and impact forces, examination of the wreckage did not disclose any pre-existing airframe or engine defect. The floodlight and a section of the wing structure were found on the ground directly beneath the power line.

The pilot was very experienced in agricultural operations and had accumulated a total of over 8,200 flying hours. Of these, 7,700 hours had been flown in Pawnee aircraft. There was no evidence that he had suffered any physical disability or that he had been overcome by any toxic effect from the chemicals.

Despite the absence of a detailed briefing from the farmer on the hazards to aerial spraying in the field, the circumstances of the pilot's first six runs suggest he was aware of the presence of the power line. Although he had not treated this particular field before, he had sprayed neighbouring properties on previous occasions and the power line continued almost in a straight line through the adjoining field before branching in two different directions. The pilot had made a partial circuit when he arrived over the field and, being familiar with the features of the adjacent properties, it is unlikely he would have overlooked the wire. Indeed, located only 80 feet outside the boundary of the crop, the wire was in such a position that an aircraft almost certainly would have collided with it if the pilot had not known it was there. From the evidence of the farmer and the other witness who was acting as a marker, the aircraft had remained close to the ground until well out beyond the wire on the outward runs and had descended early on the inward ones.

For operations in this direction, the pilot was faced with the choice of flying under the wire throughout, over the wire throughout, or adopting a compromise technique of flying under the wire near the poles and over the wire near the centre of the spans. Near the poles, the aircraft would have been able to operate under the wire quite comfortably but midway between the poles, the lower ground clearance together with the need to clear the boundary fence, would have reduced the margin for error and might have prompted the pilot to consider changing to over-the-wire operation as the aircraft neared these sections. Operating over-the-wire would have dictated an early pull-up in order to avoid it, but samples taken of the crop during the investigation confirmed that the spray had still been operating beyond the point where a planned pull-up would have been necessary to clear the wire.

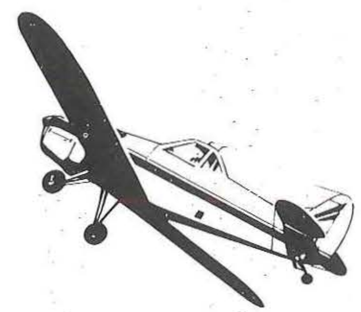
From the evidence available, it was not possible to determine the exact reason why the aircraft struck the wire. With the benefit of hindsight however, it is clear that the field was at best only marginally suitable for aerial spraying and undoubtedly great concentration would have been required. The changes in the contour curves of the crop were so great that continuous spraying along the strips, though not impossible, would have been difficult. By making his runs across the strips from one side of the field to the other and intercepting the contour boundaries squarely rather than at more acute angles, the pilot was in a position to judge his reference points for switching the spray on and off. Nevertheless, operating the spray pump several times each run was a demanding procedure and could easily have distracted the pilot from concentrating on the other problems. Altogether it is evident that the combination of strip patterns, trees and power line all rendered the spraying of this crop a formidable operational task, and the accident provides a tragic example of the consequences of even the slightest lapse in concentration when hazards are present which leave no margin for error.

Aerial spraying is a task that requires high standards of skill and concentration. This type of flying, when carried out for several hours a day continually over months and years, can impose a great strain on a pilot's physical and mental resources. As well, there is the ever-present danger that, as difficult but similar tasks of this sort are successfully completed time after time, increasing levels of pilot skill and judgement may be surreptitiously accompanied by a relaxation in concentration and vigilance. There is also a possibility that, as a pilot gains this kind of experience, he could well be led into accepting tasks which in reality are not suitable for aerial spraying because the demands, even for a competent and experienced pilot, create a workload in excess of that which a pilot can be expected to regularly perform without error.

Although the investigation of this accident could not establish whether any of these factors were actually present in its development, it nevertheless demonstrates that pilots engaged in such operations, need to be constantly on the alert that they are not compromised by these factors into undertaking a task that cannot be performed with an acceptable level of safety.

Panoramic view of area in which accident occurred. The crop being treated is in the background. The single wire power line spanned the distance between the two indicated poles.

Aerial view of field showing final flight path and accident site. The contoured strips of the crop are clearly visible.



ARE WE DOING OUR JOB?

Just how effective is the *Digest* in preventing the types of accidents it reviews time after time, issue after issue? Readers who have been receiving the *Digest* for a number of years perhaps share our growing feeling that 'this is where we came in', that it has all been said before, probably several times over, that what is going to be said in the next issue is quite predictable, that there is nothing new in it — that it is all such a familiar pattern.

This is so true! The same types of accidents seem to be occurring over and over again, pilots generally seem to go on making the same old mistakes, and there is the impression that the industry as a whole is learning nothing from the mistakes of its less fortunate individuals. Even though for a while there might be some improvement after one particular air safety problem has been 'hit hard', the message is soon forgotten and all too soon the same old familiar accident patterns repeat themselves.

But why should this be so? It is almost certain that individual pilots remain 'once bitten, twice shy'. Unfortunately of course, many of those who make the *Digest's* headlines don't get a second chance. And surely those who are close to these accidents, or upon whom they make a deep impression, don't forget these so-tragic object lessons either.

But obviously many pilots, for one reason or another, are simply not getting the message. Perhaps they've gained their licences since our last attack on that particular problem; perhaps they read about it at the time but then forgot the message under the pressure of more every-day concerns. Perhaps they have moved on to a different type of flying, or to different types of aircraft.

Whatever the reason, it seems that our present safety education system of publicising accidents issue by issue in the *Digest* does not always achieve a lasting impression in the places where the need is greatest. One reader, pointing out the repetitive nature of many of our accidents and the clear accident 'trends' they define, has come up with an idea that may help: From these trends and the accidents that have made them up, develop a master list of the 'does' and don'ts' for operating a light aeroplane — so that pilots can benefit from *all* the object lessons, whether or not they have seen the *Digest* concerned. 'Potted accident experience' you might call it!

This is exactly what we have tried to do on the next pages. Some of the items mentioned might seem superfluous or obvious, but it is aimed primarily at the pilot who doesn't fly often enough for these things to become second nature — as they should be with pilots who earn their living flying aeroplanes!

We offer no apologies if it seems elementary in places — on one point we are on very firm ground: every item mentioned can be supported by a substantial history of accidents that developed simply because that particular item was overlooked.

Are we doing our job?

REMINDERS FOR SAFE FLYING

(N.B. This is *not* a substitute for Departmental and other documents specifying operational requirements for safe flight. Rather it is an *aid-memoire* for all the so-easily overlooked 'little things' which, experience has shown, can become the ingredients for an accident or incident.)

Aircraft Operation

- *Am I in current practice on the type?*
- *Am I completely familiar with its operation?*
- *Have I an adequate knowledge of:*
- *The fuel system, fuel pump and mixture control operation?*
- *Power settings?*
- *Operation of the cowl flaps?*
- *Operating ranges of oil temperature and pressure, fuel pressure, and cylinder head temperature?*
- *How to use the carburettor heat control to best advantage?*
- *The undercarriage emergency extension system?*

Aircraft Serviceability

- *Is it fully serviceable in every respect?*
- *Is the oil level correct?*
- *Are the oil cap and dipstick secure?*
- *Have I ensured that there are no rags, birds' or wasps' nests, or other foreign matter on or in the engine compartment, air intakes, static and fuel tank vents, or pitot heads?*
- *Are the cowlings and inspection hatches secure?*
- *Have the external control locks and pitot covers been removed?*
- *Is there a need to carry tie-down equipment on the trip?*
- *Is the windscreen clean?*

Radio

- *Have I the correct frequencies for the proposed route?*
- *Have I a serviceable HF radio or a VSB if flying in a remote area?*

Emergency Equipment

- *Is there an adequate quantity of water on board?*
- *Are emergency rations warranted for the flight?*
- *Is the aircraft's first-aid kit well-stocked and in good condition?*
- *What about other survival gear? (See the pink pages of the VFG.)*
- *If portion of the flight is to be over water, is there an approved-type life-jacket for each person on board?*

Load

- *Is the load properly secured?*
- *Is it within the maximum permissible weight?*
- *Is the centre of gravity within allowable limits?*
- *Have any ferrous metal or magnetic articles been stowed where they could affect the compass reading?*

Fuel

- *Have I personally checked the fuel contents?*
- *Is it really sufficient for the flight including possible diversions and reserves?*
- *Are the tank caps properly secured?*
- *Have I allowed sufficiently for variations in fuel consumption with altitude flown and power used?*
- *Have the tanks and filter bowls been checked for water?*

Weather

- *Does the forecast I have obtained cover the period in which the flight will take place?*
- *Will there be adequate cloud clearance above the enroute terrain to maintain flight in VMC?*
- *Will I be able to remain clear of cloud or sub-standard visibility at all times?*
- *What is the likelihood of carburettor icing?*
- *Is an 'escape' route available if I should encounter conditions worse than forecast?*

Navigation

- *Have I an adequate knowledge of the route to be flown, and the airways procedures to be followed — Enroute? In controlled airspace? At primary airports? Secondary airports? Aerodromes with a Flight Service Unit? Other non-controlled aerodromes?*
- *Have I the latest VECs, VTCs and AICs applicable to the route?*
- *What Restricted and Danger Areas are there on or close to the proposed route?*
- *Are my WAC charts current editions?*
- *Have I checked the NOTAMS relevant to the route?*
- *Is my flight plan accurate and sufficiently detailed for me to know my position at all times?*
- *Have I a safe alternative plan in case things don't 'work out'?*
- *Have I sufficient daylight for the whole operation — including the alternative plan?*
- *Is my SARTIME realistic?*

Destination

- *Have I checked the current aerodrome NOTAMS?*
- *Am I familiar with the local procedures?*
- *Do I know the location of the landing area in relation to a town or some other prominent landmark?*
- *Is the landing area adequate for the aircraft type?*
- *Are there hard-to-see obstructions on the approach — such as power lines?*
- *Is the likely cross-wind component within the limit specified for the aircraft?*
- *What is the surface like — is it likely to be affected by rain?*
- *Is the correct grade of fuel available there?*
- *What about a telephone, transport and accommodation?*

WATCH YOUR WING TIPS!

This may not be as funny as it sounds. In June last year, when flying a Cessna 402 on an airline service in Hawaii, the pilot noticed that there was an excessive amount of flexing in the starboard wing, by comparison with that of the port wing. After landing at the next port-of-call, he checked the wing externally, but when he could find nothing untoward, he decided to continue with the final leg of the flight. This leg was scheduled to terminate at Honolulu International Airport, where the aircraft was based.

Figure 1:
View from underside of wing looking forward, showing cracked main spar web and failed lower spar cap. The rear section of the lower nacelle structure and most of the wing skin has been removed. Note also the fracture in the wing skin panel which had been hidden by the nacelle fairing.

Once again during flight, the pilot saw that the starboard wing seemed to be flexing excessively and, after landing at Honolulu, he discussed the problem with the company's maintenance staff before writing up the unserviceability. The maintenance chief then took the aeroplane and after taxiing it around the apron at different speeds and over various surface irregularities, confirmed that the wing was flexing to an abnormal extent.

A careful visual inspection of the wing structure through the available access panels, revealed that the web of the main spar was cracked through, close to the inboard side of the engine nacelle. To gain further access to the area of failure, the lower rear engine nacelle skin was removed, and the access panel in the firewall was cut open. It was then discovered that, as well as the cracked spar web, the lower cap of the main spar was cracked completely through, just inboard of the inner support beam for the starboard engine, as was an adjacent wing skin panel previously hidden by the engine nacelle. There were signs of earlier fire damage in the area of the spar failure inside the nacelle. Conductivity tests revealed that the metal of the spar web, the wing skin, and the lower nacelle fairing, was reduced in strength within a radius of three to four inches from the broken spar cap. In this same area the primer paint had been scorched and, in some places, burned away completely.

The aircraft, which had been bought new by the operators, had been in service for 8,373 flying hours. Five years before, when the aircraft had flown 1,830 hours, a fire had broken out in the starboard wing while the engine was being started. As a result the inboard leading edge area had sustained serious fire damage. At the time of the fire, the engine was being started while hot, with the aircraft facing downwind, and an excessive amount of priming was required. When the engine at last fired, the exhaust emitted a large sheet of flame, which was drawn into the engine air intake port in the leading edge of the wing. Here, it set fire to the oil-saturated filter and went on burning as the engine continued to run. It was not known for how long the fire burned, but it was enough to consume the rear wall of the fibreglass air duct, and ruin the leading edge assembly in which the air filter is mounted. After the fire had been extinguished the damaged area was examined and assessed, and the aircraft was ferried back to Honolulu, where it was repaired.

To determine if the nacelle fire had been the sole cause of the starboard spar failure, the aircraft's port wing was subjected to a similar visual and metallurgical inspection. As well, both wings of another of the operator's 402s, which had flown a similar number of hours and had a history of two fires in its starboard engine nacelle and one in the port nacelle, were opened for inspection, and x-ray, conductivity, and eddy-current examinations were carried out. These three wings were all found to be in good condition and were free of fire damage, cracks of any sort or loss of mechanical properties.

The starboard wing was subsequently returned to the manufacturers for a detailed strip examination and the photograph at Figure 1 shows the underside of this wing, with the cracked piece of skin indicated by arrows. The position of the spar cap failure is beneath the arrow nearer the leading edge. When the inboard portion of this severed wing skin panel was removed, the spar web crack could be clearly seen, as could the crack in the lower spar cap itself. This is shown in Figure 2. The metal in the areas where the paint had been charred or burnt away, had been adversely affected by heat.

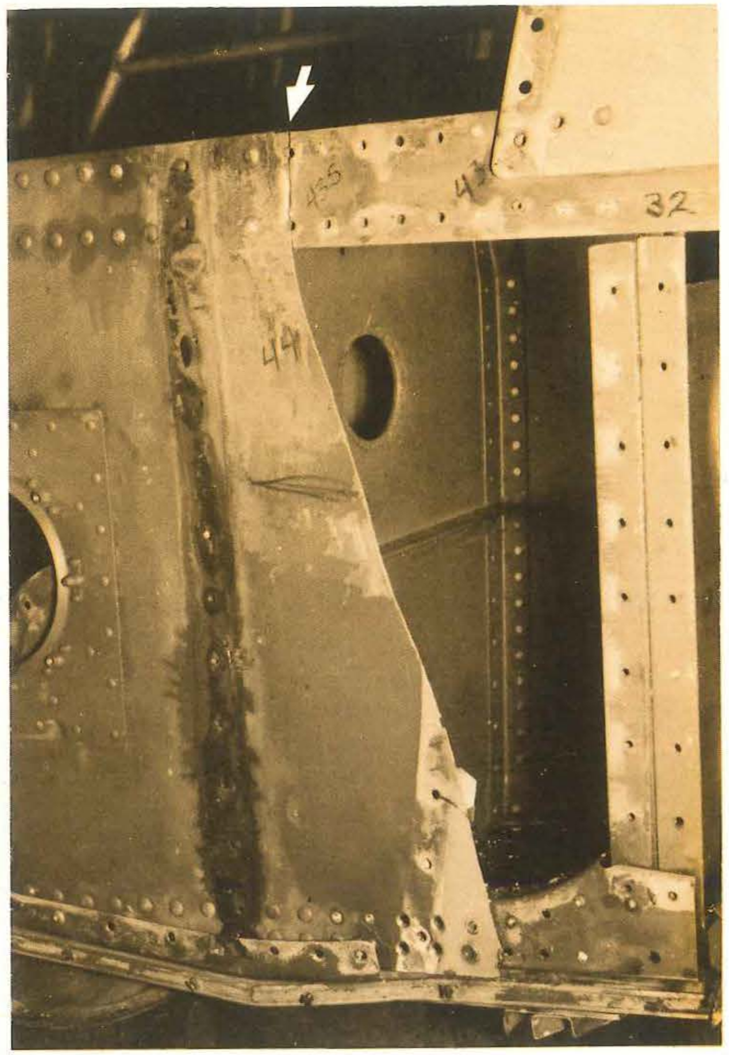


Figure 2 — Left:
Another view from underside of wing showing fractured wing skin panel. Note scorching and charring of skin in vicinity of spar cap failure at top of picture. The engine support beam had been removed before this picture was taken.
Figure 3 — Above:
View of main spar as seen from wing leading edge. The wing is inverted. Note evidence of burning in rectangular wing ducting.

Various other pieces of nacelle and wing skin were removed one by one. The nacelle structure itself had suffered extensive fire damage, especially on the inboard side. The intensity of the fire was particularly evident from the degree of scorching sustained by the stainless steel firewall. Once the nacelle structure had been removed from the wing, the full extent of the fire damage to the wing structure was exposed and charring was evident on the spar web, the spar lower cap, the lower skin of the wing, leading edge ribs, and the fuel lines in the region of the fracture.

A section of the fractured lower main spar cap was removed for metallurgical examination and later, the front and rear spars were removed from the wing and dismantled for inspection. Conductivity tests indicated a weakening of the material in the fire affected areas, and tensile tests of metal cut from either side of the spar cap fracture indicated that the tensile strength had been reduced to less than half the manufacturers guaranteed maximum.

The dismantling of the main spar assembly revealed that the fracture faces of the lower spar cap were severely rubbed, indicating that the crack had been there for some time. Because of the condition of the fracture face, it was not possible to determine when the crack had commenced.

It was also found as the dismantling of the main spar proceeded, that there was a crack in the vertical stem of the 'T-section' upper spar cap. The cracked section was sandwiched between the spar web and a doubler plate, and was therefore not detectable until the spar cap was removed. It was determined that the crack was the result of fatigue and, after being initiated at a rivet hole, had propagated vertically upwards. As a result of the lower cap's failure however, the upper cap was subjected to bending and this had caused the crack to turn and propagate horizontally along the stem. Altogether, the crack was nearly two inches long, and exhibited a number of fatigue striations. Although these in most cases would represent ground-air-ground cycles, it was difficult, without knowing the magnitude of any gusts encountered, to perform a countback to the initiation of the crack.

The investigation as a whole revealed that the aircraft had sustained a fire in the inboard leading edge area, and between the firewall and the main spar, of sufficient intensity to weaken the structure at the lower main spar. The failure of the lower spar cap was determined to be a fatigue failure resulting from the reduced strength of the material. It was evident that the wing loads from two or more flights had been carried with the lower cap of the main spar completely separated. This had caused an excessive amount of load to follow a redundant load path through the forward auxiliary spar and 'the 'sidebrace rib', producing further fatigue cracks in the 'sidebrace rib' web, doubler and upper caps.

In the art of learning from the experience of others, this is a classic example. For how many of us would have been as alert as this pilot? The story would certainly have had a tragic ending had it not been for his vigilance. The need for this sort of attention is necessary whenever we fly and the injunction that forms the title of this article should apply not only in a literal sense, but to every facet of our operations. It's always the unexpected that catches us out!

CAUGHT IN A DOWNDRAUGHT

Early one morning last June, I took off from Bankstown for a flight to Cooma in a Cessna 172. Because the weather was unfavourable in the Canberra-Goulburn area on the direct route, I had planned to go via the coast below 5000 feet as far as Moruya, then on to Cooma at 6000 feet.

The flight to Moruya was uneventful with a visibility of 20 nautical miles and the forecast wind of 25 knots from the west was producing only a slight amount of turbulence. I reported over Moruya at 2200 hours, turned on to heading for Cooma and climbed to 6000 feet, my quadrantal cruising altitude. After about ten minutes however, I began to encounter rain showers and about four OKTAS of cloud at our cruising level. The turbulence over the mountains that the aircraft was now crossing also increased and at times was quite severe. My ETA for Cooma was 2230 hours but on checking the groundspeed on this leg I found it had decreased. At 30 miles north-east of Cooma I reported position and gave a revised ETA of 2247 hours. By this time, the aircraft was flying in light rain and the visibility had decreased to about three miles. Soon afterwards, the turbulence worsened and despite the fact that all instrument indications were normal, the aircraft began losing height.

With mountain tops both to the north and south of my track rising to well over 4000 feet, I immediately applied full power and put the aircraft in a climbing attitude. But there was no noticeable gain in height! I applied carburettor heat to check for any loss of power being caused by carburettor icing, but there was none, so I used the carburettor heat control as little as possible in order that maximum power should be available from the engine. During this time the severity of the turbulence was causing the wings to drop as much as 30 to 35 degrees and, even with full power and the aircraft flown for best angle of climb, it continued to sink.

I suspected that icing, on the pitot or static vents, might have been causing the altimeter to under-read or the airspeed indicator to over-read, but soon it was quite apparent that there was no icing and indeed the forecast had indicated that the freezing level was 9000 feet.

I was still flying in rain and the weather conditions were no better than before when, on my port side, I caught sight of trees at about our own level. Then, as I strained to look ahead through the reduced visibility, I glimpsed more trees in front of the aircraft. I immediately banked to starboard and, still at full power, increased the angle of attack still further. Although in a climbing attitude of 70 knots, the actual rate of climb was very slight and the wheels actually brushed through the tops of the trees before the aircraft could clear them. But, apart from collecting some twigs and leaves in the undercarriage legs no damage was done.

Once over this ridge I managed to climb to 5500 feet and from this point onward I had no trouble maintaining altitude. The aircraft then climbed back to 6000 feet quite readily, and the approach to Cooma and subsequent landing were quite normal. Later in the day, when I submitted my flight plan for the return trip, I learned that a Sigmet had been issued, warning of severe turbulence with westerly winds exceeding 45 knots at 5000 feet. It was only then that I realised I had been flying into wind on the lee side of the mountain ridges approaching Cooma, and had been caught in a downdraught that exceeded the climb capability of the aircraft.

At the time of the incident I had flown 700 hours, including 100 hours night VMC experience, and I was also undergoing instrument training for a higher rating. Although my flight to Cooma was planned under visual flight rules, and it is doubtful that visual meteorological conditions existed at all times, at no stage did I have any difficulty in maintaining control in the reduced visibility. **It was the prevailing downdraught conditions that almost caused the disaster and not any loss of** visual reference, as might have been supposed, had an accident actually occurred. Only the fact that full power was applied and maintained as soon as the aircraft began to lose height, prevented an accident.

If my experience helps other readers to realise that powerful downdraughts are a real possibility when flying in mountainous areas, perhaps it will have been worthwhile. In conditions similar to those I encountered, they obviously have the potential to cause a fatal accident.

Comment

Fatal accidents have certainly occurred in Australia in the past as a result of unexpectedly severe downdraughts in the lee of mountain ridges. The most notable of these was the accident to one of Airlines of Australia's Stinson 'A' Tri-motors which were operating the Brisbane-Sydney service in 1937. Less than half an hour after taking off from Archerfield for Sydney via Lismore, the aircraft crashed on the northern slopes of the Lamington Plateau in the McPherson Ranges. The escarpment lay directly across the aircraft's flight path and, at the time, there were gale force southerly winds in the area. It seems probable that the resulting downdraughts on the lee side of the plateau proved too much even for the Stinson's comparatively good rate of climb.

Another accident for which downdraughts could have been responsible was that to a Cessna 182, which crashed close to the top of a ridge twenty miles south of Katoomba, several years ago, (See 'Cessna Collides with Mountain Ridge', *Digest* No. 60). The cloud base at the time was probably just above the crest of the ridge and to 'squeeze through', the pilot would have been forced very close both to the base of the cloud and to the top of the ridge. It was considered quite possible that, as the aircraft approached the ridge from the north-western side, its performance was affected by the considerable down-draughts which would have existed in the lee of the ridge under the influence of the 35 knot southerly wind blowing at the time. By the time the pilot realised that the aircraft would not clear the ridge, it might have been too late for him to take any avoiding action.

Certainly the experience of another light aircraft pilot would be consistant with this hypothesis. Flying from Cooma to Merimbula in a Champion 7EC in strong westerly wind conditions, the pilot suddenly experienced a descent of 4000 feet per minute as the aircraft crossed the main ridge of the Great Dividing Range, where it falls steeply some 3000 feet to the coastal plain. Clearly if the aircraft had been attempting a flight in the reciprocal direction, there would have been no possibility of outclimbing a downdraught of this magnitude.

These accumulated operational lessons show clearly that our contributor's frightening experience is by no means an isolated case. We entirely agree that conditions similar to those he encountered can expose an aircraft to 'grave and imminent danger', and we commend him for his willingness to share what he has learnt.