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AVIATION SAFETY DIGEST

No. 40, DECEMBER, 1964

DEPARTMENT OF CIVIL AVIATION

AUSTRALIA

AVIATION SAFETY DIGEST

No. 40 DECEMBER, 1964

Prepared in the Air Safety Investigation Branch,
Department of Civil Aviation, Commonwealth of Australia.

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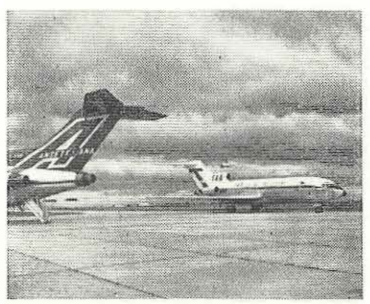

Heralding a new era in Australian Aviation, the first Boeing 727s for domestic airline service arrive at Melbourne Airport at the end of their delivery flights.

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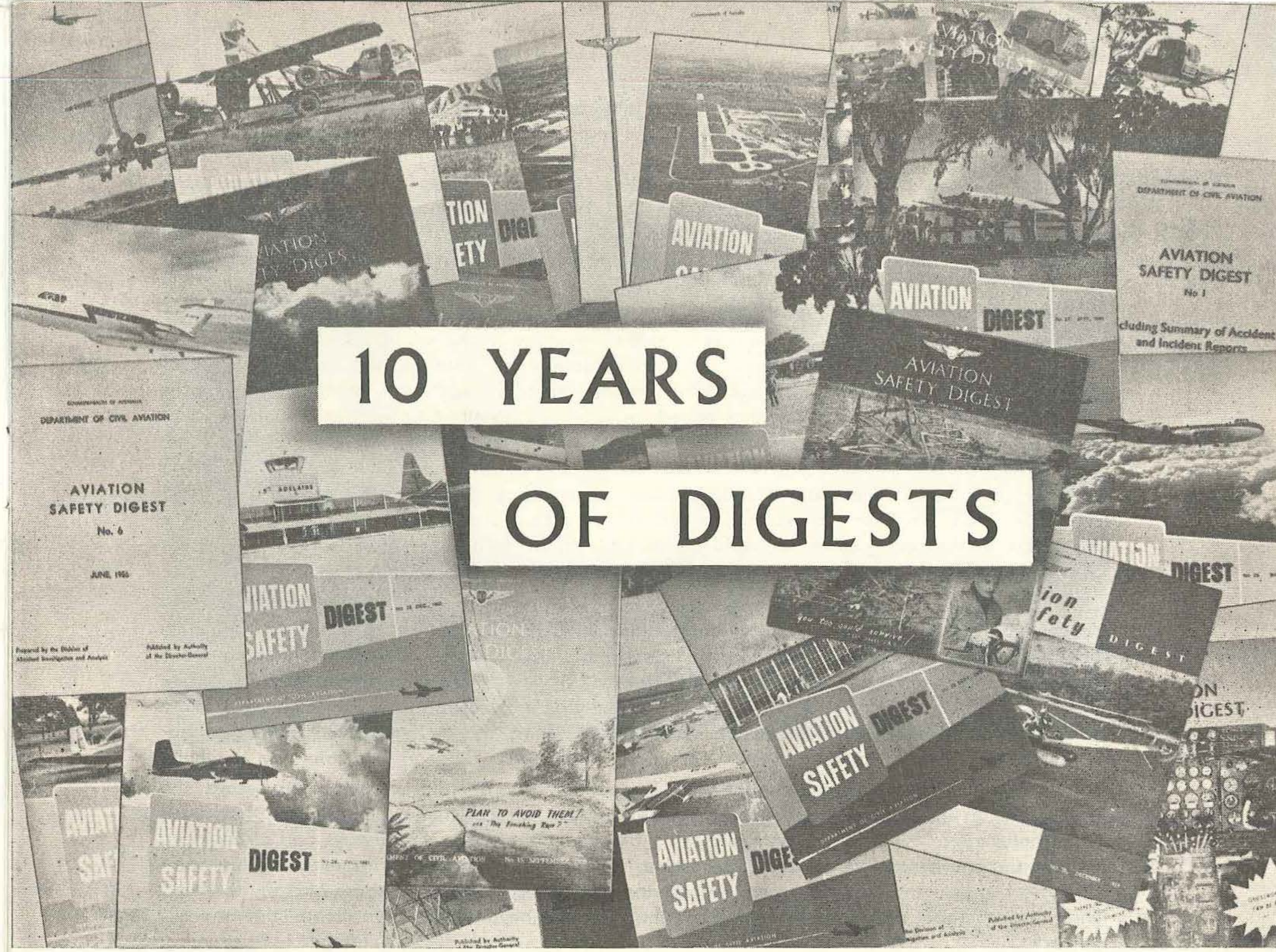


A Word from the Director-General:

This, the fortieth issue of the Aviation Safety Digest, marks the completion of the first ten years of its publication.

Aviation is an ever changing, ever developing pattern and it is almost impossible to isolate any one period as being of greatest significance in its history. Nevertheless these first ten years of the Digest have covered a period which must rank amongst the most interesting in Australian aviation development. It has covered the transition from piston-engined aircraft to turbo-props and on to the era of the pure jet in our domestic public transport field, and in the general aviation field, we have witnessed a mushroom growth having few parallels within industry as a whole. It would therefore seem opportunte for me to comment on the achievements of the past and my hopes for the future as related to air safety, which is the sole objective, and reason for the existence of the Aviation Safety Digest.

The measurement of air safety is complex and extends beyond the simplified consideration of accident rates. Accident rates do however, provide a ready means of comparing levels of achievement and on this basis we have every reason to be proud of the results of the past ten years.

In regular public transport operations our fatal accident rate is so low that comparison of one year with any other has little meaning. The recorded statistics of operations throughout the world have shown a relatively constant trend of improvement leading to an assessed rate of .75 passenger fatalities per 100 million passenger miles flown for the year 1963. This represents a progressive reduction from a rate of the order of 1.35 per 100 million passenger miles during the early stages of the 10 year period. By comparison, in 1963 (the last year of completed statistics) we had a perfect score but recognising the inadequacy of such a short term as related to our operations, it is more significant that the average fatality rate for the entire 10 year period (1954-1963) for Australian operations has been only .23 per 100 million passenger miles.

There is no real basis for comparison of general aviation in the world sphere but within our own operations, we have been able to establish reliable trend data for the various classes of general aviation. Again the result is satisfying and despite occasional small intermediate increases which will inevitably occur in statistics based on relatively small samples, the overall trend in **all** classes of general aviation activity has been towards improvement of the accident rate. Probably the most startling improvement has been evident in aerial agricultural operations where we have seen the accident rate per 10,000 hours flown, drop from its peak of 13.00 in 1955 to 4.08 in 1963. To inject one sour note into such a picture it is necessary to record that, as a percentage of the total number of accidents in agricultural flying, the number involving pilot fatalities is tending to increase and this is one avenue that demands attention.

While this overall picture is very satisfying, its danger is that it may engender a sense of complacency. There is a suggestion for example, that our accident rates are close to the irreducible level and that our necessary further endeavours should be directed only at maintaining these levels. Such thinking is of course, quite fallacious as the only irreducible rate is zero and there is no such thing as an unavoidable accident. Certainly as accident rates become lower, the ability to maintain a given rate of improvement will be diminished, but this should only whet our appetite for seeking ways of improvement rather than lessen our diligence for safety as a whole.

It must also be remembered that while we jointly strive to improve our safety record, the very nature of the industry is tending to work against us and to make the task just that much more challenging. Air traffic is increasing at a tremendous rate and the airways and airports are becoming more congested. Aircraft themselves, as more and more enter the relatively high performance bracket, are becoming more unforgiving. The versatility of the modern aircraft, however, tends to encourage people to try and reach that little bit beyond their own capabilities and experience.

It is my hope therefore, that the second ten years of the Digest will see a continuation of the seeking of safety with all the fervour that has been evidenced over the past several years. Let us remember for example, that even in this year which is just drawing to a close, some 17 aircraft have still managed to collide with wires. Let us remember that as recently as this past winter we had far too many tragic examples of VFR pilots venturing into weather conditions which were beyond their capabilities. Let us remember that throughout the year, each of those incidents involving infringement of a clearance limit was a potential accident. These are just some of the areas where there is evident scope for continued improvement in the safety record and it would be as well for us all to do some soul searching to see what each of us, as individuals, could contribute to the future programme.

As the theme of my remarks was suggested by the ending of an era for the Aviation Safety Digest, it is fitting that I should close by thanking all those people who by their interest, their comments and their contributions have helped to make the Digest the successful publication which we believe it to be. I earnestly hope that we can look forward to the same co-operation in our continuing task of producing the Digest.

D. G. Anderson

Director-General of Civil Aviation

An Expensive Mistake —

Shortly before this picture was taken, that pile of wreckage was a smart Cessna 182. Engaged on a charter flight with only the pilot on board, it had landed at a Queensland cattle station to deliver supplies and was about to depart for another station property. Describing the shattering experience that followed, the pilot told us:

". . . . the battery refused to spin the motor more than two or three compressions. Leaving the throttle set, ignition and handbrake on, I proceeded to hand-start. The motor caught at once and appeared to be turning at approximately 1500 r.p.m.

The cabin window was closed and I was unable to gain entry to the controls and prevent the aircraft's progress.

"The aircraft continued along the ground for approximately 165 yds. on a slightly semi-circular path to the left and was extensively damaged on impact with cattle yards."

The pilot said that before swinging the propeller, he had opened the throttle to the usual setting for a battery start. The handbrake seemed to operate normally and he did not consider it necessary to chock the wheels. In any case he had no chocks with him in the aircraft as this was the first time he had had to resort to hand-starting.

Air Navigation Regulation 223B allows a pilot to hand-start an unoccupied single pilot aircraft on the condition that "adequate provision is made to prevent the aircraft moving forward". To satisfy this requirement, a hand brake system must obviously have design characteristics which will provide restraint over the range of powers that might be developed immediately following a hand-start **and** it must be maintained to a standard which will ensure that the designed degree of restraint will continue to be achieved.

Only a small particle of foreign matter in the system's hydraulic fluid could be sufficient to cause a slight leakage past a master or wheel cylinder valve, and while this would have a negligible effect on the brakes while taxying, brake pressure could gradually be lost while the aircraft is parked.

In the light of this possibility, does YOUR handbrake make "adequate provision"?

This one obviously didn't!

You CAN Loop them, but . . .

In the June issue of the Digest, we published an article which explained in some detail how vital it is for pilots to observe the structural and performance limitations that are placed on aircraft by their manufacturers or by this Department. Although the article was addressed primarily to agricultural pilots and operators, its message was applicable to other aspects of aircraft operations and it was assumed that the warnings it contained would be heeded by pilots generally.

Recently however, "stories" have been reaching us which tell of daring aero club and flying school pilots who, apparently throwing discretion to the winds, set out to impress their more cautious fellows by performing full aerobatic manoeuvers in aircraft certified only for normal category operations. It has given us cause to wonder if these intrepid flyers are as bold as they seem or if they are just abysmally ignorant of the potential dangers lurking in an aircraft structure that is subjected to demands much greater than those for which it was designed. They are apparently unaware of the differences in structural requirements for aerobatic, semi-aerobatic and normal category aircraft. Table 1 sets out the positive and negative limit load factors to which aircraft in these different categories are usually designed. The load factors are expressed in terms of the acceleration due to gravity, familiar to all pilots as 'g'. The design limit load factors are, as their name implies, the limits for structural safety. Loads on the aircraft structure in excess of these design limits can result in damage or even structural failure.

TABLE 1

Load factor	Aircraft Category		
	Normal	Semi Aero-batic	Aero-batic
Max Positive 'g' Max (n_1)	$2.1 + \frac{24000}{W + 10000}$ but n need not be greater than 3.5 and shall not be less than 2.5.	4.5	6.0
Max Negative 'g' (n_2)	—1.0	—1.8	—3.0

Tests have been carried out near Melbourne in one type of aerobatic light aircraft to determine the actual maximum and minimum loadings to which an aircraft structure is subjected during various aerobatic manoeuvres. Some of the results obtained are shown in Table 2.

TABLE 2

Manoeuvre	Max. Load factor measured	Minimum load factor measured
Loop	3.69	.61
Roll off the top	3.97	.03
Spiral Dive	4.36	.30
Spin	3.43	—.15
Hammer Stall	2.84	—.1.35
Stall turn	3.37	—.90
Figure of 8	4.17	—.11

It is important to realize that these results were obtained in a fully aerobatic type of aircraft that is not as aerodynamically clean as some of the more modern single engined types, and that it was flown by a very experienced aerobatic pilot. These figures could therefore be very easily exceeded by an inexperienced pilot flying a clean modern light aircraft in which the airspeed would build up very rapidly.

From the figures in both tables, it can readily be seen that a normal category aircraft made to perform aerobatics will almost inevitably exceed its positive limit load factor of 3.5 g, with the attendant risk not only of structural damage but also of loss of control arising out of structural distortion. Furthermore, as most modern normal category aircraft have a safety factor of only 1.5 between their limit and ultimate loads, the point at which a complete structural failure can occur is only 1.5 times this figure or 5.25 g. In the hands of an inexperienced pilot, it would be only too easy for a modern normal category light aircraft to reach or exceed this ultimate load factor.

It thus cannot be too strongly emphasized that normal category aircraft are simply structurally inadequate for the safe performance of aerobatics. Indeed, while some of these words were actually being written, a report was received from the New Zealand Accidents Investigation Branch describing a fatal accident in which a light aircraft lost a wing during an unauthorized aerobatic manoeuvre.

To those quixotic pilots who know what they can get away with better than the designer, we suggest that even though they are not greatly concerned for their own safety, they could spare a thought for their innocent colleagues who might want to fly the aircraft after they have finished with it.

RADAR MARSHALLING DANGER

In the United States in June this year, a twin-engined aircraft crashed into a mountain while being radar-vectored for an instrument approach to land. All three occupants were killed.

The aircraft was being directed to an approach at Ontario Airport, California, by an F.A.A. controller located at March Field, 20 miles east-south-east of Ontario. After the controller had apparently identified the aircraft on his radarscope by directing it through several turns, he instructed it to descend to 7,200 feet. The wreckage of the aircraft was later found at this level on the side of the 11,000 feet high San Gorgonio mountain.

Although the echo on the radarscope complied with the directions given by the controller, it was later evident that the aircraft to which he had been talking was not the one that had produced the echo on the radarscope which he had been following. The actual identity of the aircraft responsible for the echo seen by the controller was never determined, but there was strong evidence to indicate that its pilot was practising instrument flying techniques by following the instructions intended for the aircraft that crashed.

Since this accident, the F.A.A. has detected several other instances of aircraft deliberately following radar marshalling instructions directed to other aircraft. When interviewed, the pilots concerned have stated that they had been practising instrument flying and that the dangerous and disruptive effect which their action could have had on the control of other air traffic, had not occurred to them.

The F.A.A. have now taken action making it illegal for a pilot to follow a radar vector issued to an aircraft other than the one he is flying.

There is a potential for the same problem to develop in Australia. More ground radar installations are being activated, more aircraft are being fitted with radar frequencies and wider use is being made of radar for aircraft vectoring purposes. At the same time there is evidence of a growing interest in I.F.R. operations by the lighter classes of aircraft and one manifestation of this is an increasing interest in gaining instrument flying practice.

It is to be hoped that the tragic experience in the United States is sufficient in itself to discourage Australian pilots from engaging in this highly dangerous practice of confusing radar indentification procedures—a danger which, incidentally, normally finds its mark in some completely innocent party rather than the offender. Undoubtedly legislation such as that adopted by the F.A.A., will have to be considered but the most important contribution to eliminating the danger would be the full co-operation of pilots. The application of common sense with some concern for the welfare of others should ensure that such a situation will not arise here.

Viscount Loss follows Tailplane Icing

A report which we received a short time ago from the United States Civil Aeronautics Board dealt with the loss of a Viscount 812 as a result of ice accretion on the tailplane. Although this accident is no longer a recent one, and has already received a certain amount of publicity in the aviation press, we believe the following summary of its circumstances and the findings of the investigating authority will be of particular interest because of their relevance to our own airline operations in Australia.

The flight on which the aircraft was engaged was a regular airline operation from Midland, Texas, scheduled to arrive at Kansas City, Missouri, a few minutes before 2300 hours local time.

Normal preparations were made for the flight and the weather forecast issued to the crew stated that moderate to heavy mixed icing could be encountered below 5000 feet in southern Kansas and Oklahoma. The flight proceeded normally at 11,000 feet under Instrument Flight Rules. Approaching Kansas City, the radar approach control gave the flight a series of clearances to descend and several minutes later the flight was cleared to land. The controller advised the crew that they could make a straight-in landing if they wished and gave the wind as 360 degrees at 6 knots. The crew replied that they would land straight-in on runway 18. This was the last transmission received from the aircraft.

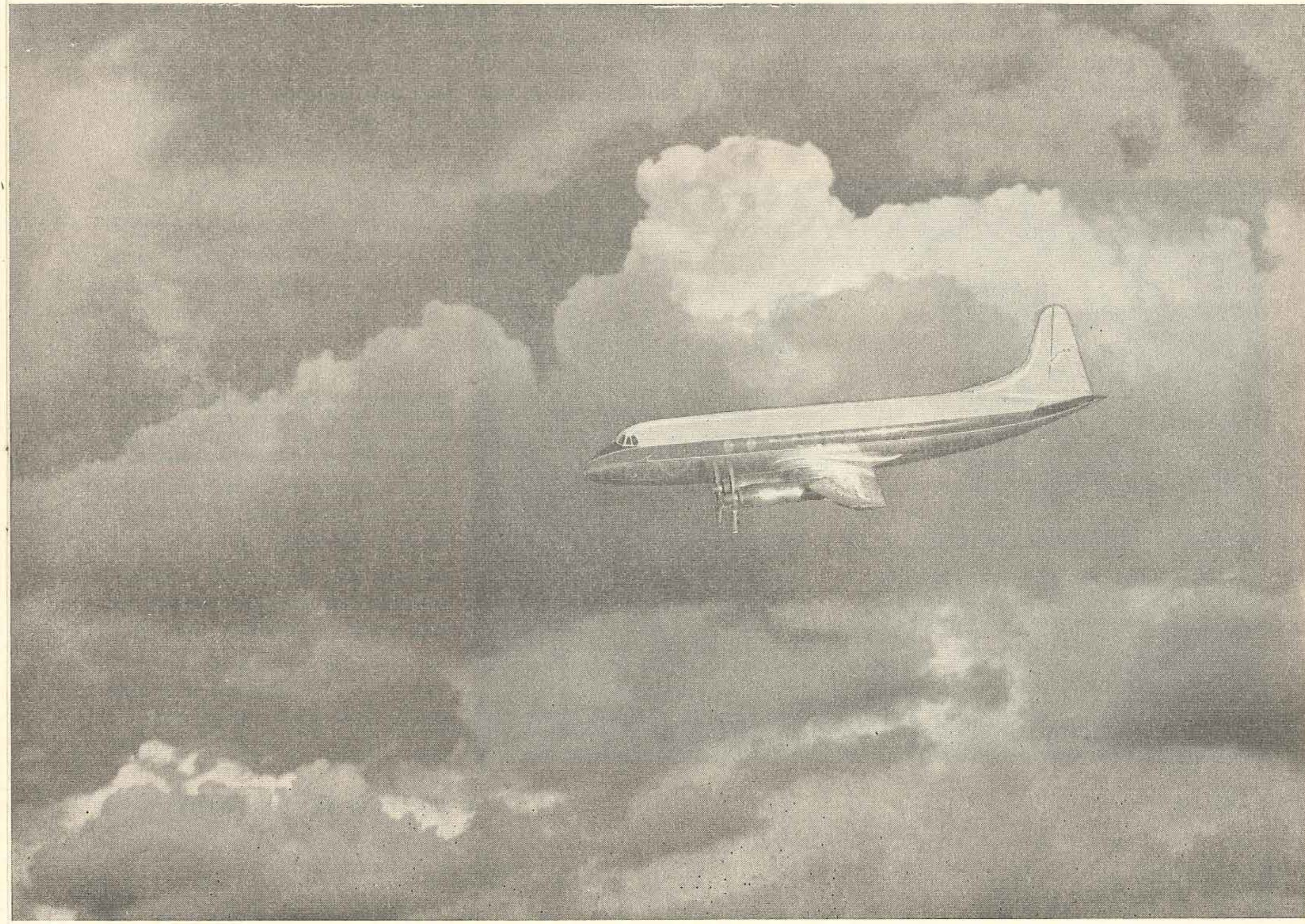
The aircraft was observed making its approach from the ILS outer marker to runway 18. After passing the threshold approximately 80 feet above the ground, the aircraft remained at a nearly constant height until about 3000 feet down the runway, when it descended to about 50 feet. Power was then applied and the aircraft began a missed approach. It climbed to approximately 90 feet but shortly after passing beyond the south end of the runway, nosed down sharply and crashed into an earth mound beside the airport perimeter road. The aircraft bounced over the perimeter road, struck the side of the Missouri River dike, and skidded over the top. The fuselage and major portion of the wing came to rest 680 feet beyond the south end of runway 18 and was engulfed by fire. The three members of the crew and all five passengers were killed and the aircraft was destroyed. A witness approximately 200 yards from the impact area stated that the aircraft had nosed over very sharply into a steep dive but that the nose was rotating upwards just before impact. The attitude of the aircraft at impact was more than 22 degrees below the horizontal.

The investigation showed that the aircraft was airworthy and properly loaded, and there was no evidence of any crew incapacitation. No evidence could be found of a collision with any object either airborne or ground installed, and a very thorough examination of the wreckage failed to reveal evidence of any failure or malfunction in the airframe, engines or the aircraft systems. However, it was found from the position of the jet pipe hot air doors and heat exchanger bypass valve actuators, that aerofoil anti-icing heat was not being used at the time of impact.

A weather observation made at Kansas City Airport three minutes after the accident showed the weather to be: "Ceiling 3,000 overcast; visibility 12 miles, temperature 17°F (—8°C), dewpoint 8°F (—13°C), wind north 6 knots; altimeter setting 30.32". The weather bureau stated that light rime ice was possible in clouds along the route from the last intermediate stop at Tulsa to Kansas City, and that a layer of moderate icing conditions might have existed in the Kansas City area. Heavier icing could have been expected east of the Kansas City area. Statements from pilots who had operated into Kansas City shortly after the accident indicated that an icing layer ranging in temperature from —2° to —12°C., existed in the Kansas City area from the cloud tops at 6,000 feet to their bases at approximately 3,500 feet. The Viscount had been in this icing region for 8 to 10 minutes. Evidence given concerning the operation of the anti-icing system of the Viscount 812 showed that the system is intended to be used before entering icing conditions and that no icing problems had been encountered with anti-icing system turned on.

Previous Viscount accidents and incidents involving flight in icing conditions were also reviewed during the investigation. One incident had occurred when flaps were selected to 40 degrees on the final approach to Willow Run Airport, Michigan. As the flaps extended, the nose of the aircraft went down, and "up" elevator application, instead of arresting the down movement, seemed to accelerate it. The flaps were immediately retracted to 32 degrees and pitch control was regained. The landing was accomplished without further difficulty. Examination of the aircraft showed a concave build-up of ice on the leading edge of the tailplane.

One captain described an incident involving undetected structural icing on another Viscount 812 in the Colorado Springs area on February 20th, 1963. When 40 degrees of landing flap was selected from the 32-degree position at 145 knots with the undercarriage down, the aircraft became extremely nose heavy and the first officer had to assist him to



bring the nose back to the desired angle of descent. The aircraft steadied momentarily, then took up an extremely nose high attitude, again requiring the efforts of both pilots to force it back to the correct approach attitude. Similar oscillations occurred between 135 and 130 knots. As the speed fell, the aircraft began to handle normally and no more control difficulties were encountered during the remainder of the approach and landing. An inspection disclosed light rime ice on the wings and radome and it was found that the leading edges of the tailplane and fin had concave, cup-shaped build-ups of rough rime ice, approximately one-inch thick with horns extending diagonally about one and a half inches upwards and downwards into the stream. The flight had operated in clouds for approximately 10 minutes where the temperature varied from —5°C at the cruising altitude of 10,000 feet to —3°C at 7,000 feet. The propeller, wind-screen, and engine cowling anti-icing equipment was being used but the aerofoil anti-icing had not been turned on.

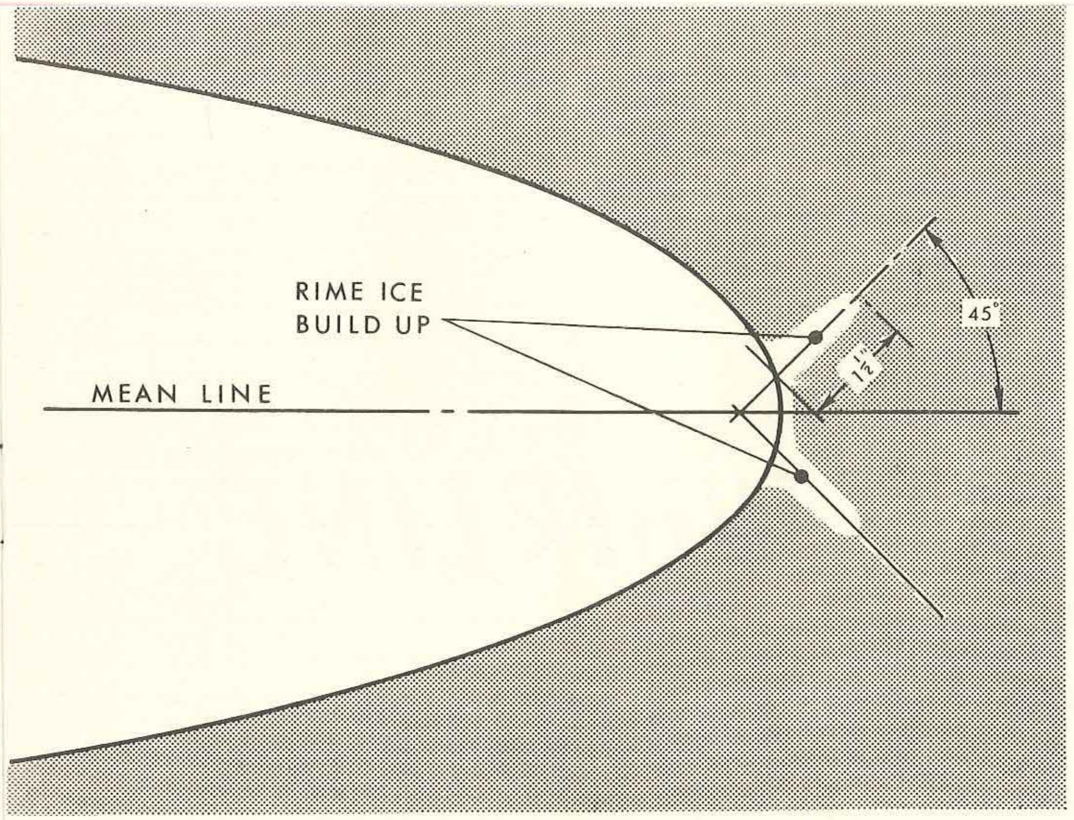
Wind tunnel tests by the manufacturer disclosed that horn type ice formations can be developed on the leading edge of an unheated aerofoil in an ambient temperature range of —5°C to —10°C. In this temperature range, the time required to produce 1½ inch horn formations was about 20 minutes. The aircraft anti-icing system was shown to be capable of preventing the formation of horn type ice or of shedding ice formed before the anti-icing heat was turned on. The tests thus indicated that a horn type of ice formation could only have formed on the tailplane of the ill-fated aircraft if the anti-icing system had failed or was not being used during flight through cloud. No evidence was found during the investigation of the aircraft wreckage to substantiate a failure of the anti-icing system.

For the crew of a Viscount, the first indication that ice is forming on the aircraft is usually the appearance of ice accretions on the windscreen. In this case however, assuming the captain had followed the established company procedure for using the windscreen heat in the low position throughout the flight, it is possible that no ice would have formed on the windscreen, and therefore, in the absence of any indication of ice, the aerofoil anti-icing system would not have been turned on.

The manufacturer's wind tunnel tests also indicated that horn type ice of this magnitude on the leading edge of the tailplane, would have a severe effect on handling characteristics when the tailplane was at a large angle of attack. It was determined that the aircraft could only have pitched down as it did in the altitude available, as a result of either pilot-induced manoeuvre or a sudden loss of down loading on the tailplane. There was nothing to indicate that the manoeuvre had been induced by the pilot but a horn shaped or concave ice formation on the leading edge of the tailplane could have produced a strong nose down pitching moment when the flaps were lowered.

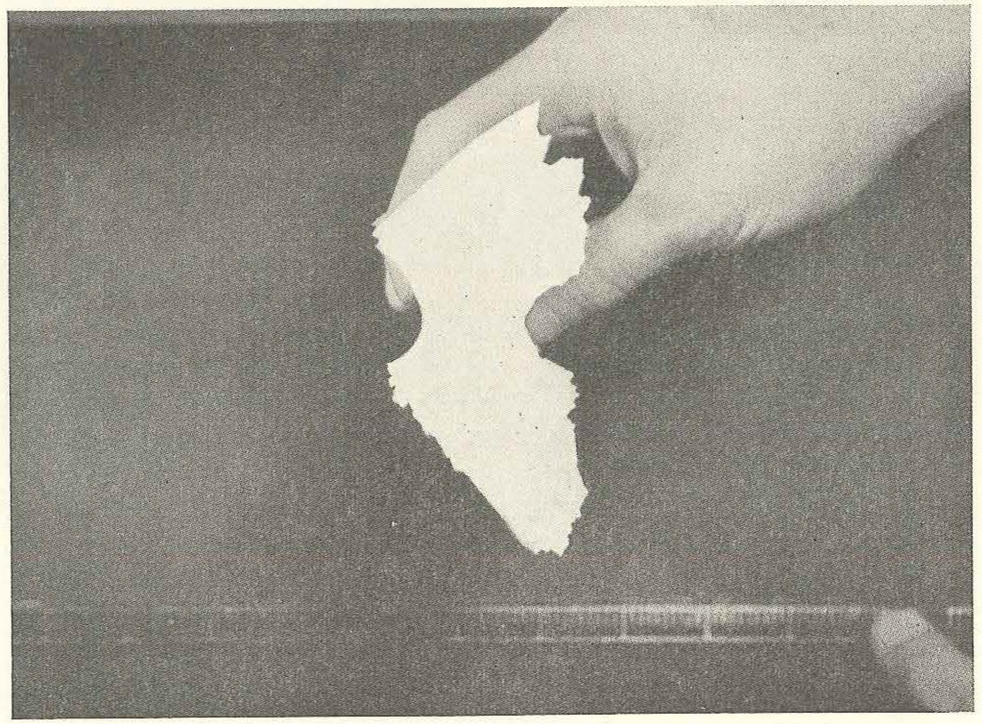
Although the flaps were in the 32-degree position at impact it was found that they had reached this position by being retracted rather than by being extended. It is believed that flaps were lowered to 20 degrees at some point during the approach; most probably at or near the outer marker. The ice shape was such that this amount of flap, at the airspeed involved was not detrimental to the trim of the aircraft. The remainder of the approach was made with 20 degrees of flap until over the runway, when power was reduced and the flaps were extended further, probably to 40 degrees. When the crew realized that a landing could not be made, power was applied for a missed approach and the flaps were raised to 32 degrees. As the airspeed increased to approximately 128 knots the nose-down pitching moment increased to a point where it could no longer be counteracted. This may have been caused either by a progressive loss of negative lift, or by a tailplane stall induced by extreme "up" elevator. At this point the aircraft pitched over and crashed. The evidence indicates that the pilots had attempted to recover from the dive but the altitude was insufficient for their action to be effective.

The probable cause of the accident was an undetected accretion of ice on the tailplane which, in conjunction with a specific airspeed and configuration, caused a loss of pitch control.

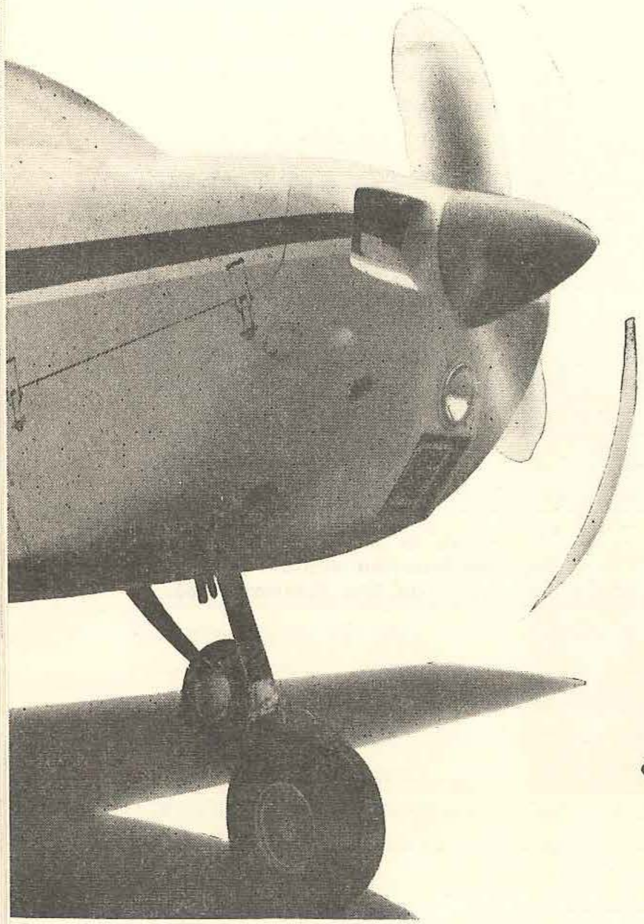


Sketch by pilot illustrating ice formation found on tailplane of Viscount 812 on 20th February, 1963.

LEADING EDGE OF TAILPLANE AT STN.76



Cross section of horn type ice formation produced on the leading edge of an unheated aerofoil section during a wind tunnel test of 15 minutes duration.



WHIRLING SCIMITARS . .

In separate accidents within a period of two days recently, two people were seriously injured when they were struck by the blades of rotating propellers.

On both occasions, the victims were passengers who had just alighted from the aircraft and they were hurt because they were not familiar with the precautions that should be taken to keep clear of propellers. These two accidents followed the general pattern of a number that have taken place in the past, which, as the following summary over the last two years shows, have been responsible all too frequently for very serious injuries to light aircraft passengers.

October 1962: An Auster landed at a country aerodrome in New South Wales at the end of a business flight, and the pilot taxied it up to its hangar. He left his passenger sitting in the aircraft with the engine running while he climbed out to open the hangar doors. The passenger then left the aircraft to assist him and walked around towards the front of the aircraft. As he approached the nose he tripped, putting out his arm to save himself, and was struck by the propeller. The passenger sustained serious injuries and his left arm was later amputated.

December 1963: A private pilot was taking three friends for a pleasure flight in a Cessna 172. Shortly after take-off, the aircraft encountered turbulence and one passenger, a girl of 18 who had never flown before, became airsick, The pilot immediately returned and landed, and after taxying in, parked the aircraft with the engine running. The airsick girl stepped out of the aircraft, stood facing the doorway for a moment, then staggered into the rotating propeller. The impact stopped the engine and she fell to the ground seriously injured.

December 1963: A nineteen year old girl who had flown only once previously, was being taken for a private sight-seeing flight in a Victa Air Tourer. She had entered the aircraft in the normal way by climbing up the trailing edge of the wing, but after the flight was completed she climbed out on to the starboard wing, then jumped to the ground over the leading edge. Her left arm was struck by the propeller, and was injured extensively.

August 1964: An agricultural Beaver had just landed after taking a farmer on an early morning survey flight over his property prior to commencing spreading operations. While the engine was still running, the farmer, who was wearing rubber boots, opened the starboard door and climbed down, placing his right foot on the starboard tyre. The tyre was wet from the morning dew, and his foot slipped as he transferred his weight to it. He tried to avoid the propeller as he fell, but it struck the upper portion of his left arm at least twice, causing severe injuries.

August 1964: A commercial pilot was conducting joy flights in a Cessna 172 from a country airport in South Australia. At the conclusion of a flight, the pilot taxied the aircraft back to the apron to disembark his passengers and left the engine running. A woman passenger who had been sitting in the starboard rear seat, alighted from the starboard door and, seeing her family coming out towards her, walked around the wing strut and across the front of the aircraft to meet them. The propeller struck her left arm fracturing it and gashing it badly in several places. The impact was sufficient to bend the propeller blade.

Although the danger of a rotating propeller may seem obvious to those closely associated with the industry, the danger is not so readily apparent to people unaccustomed to light aircraft and their lack of appreciation of the danger is often accentuated by such factors as excitement and other distractions. The case histories of this type of accident frequently show that they occur simply because the victims either forget or don't realize that the whirling propeller blades are in their way.

At the very minimum, passengers should be reminded of the dangers that exist in the vicinity of an aircraft being operated on the ground, and they should be instructed in the method of entering or alighting that will minimize the dangers. In this regard however, the greatest contribution to safety would be achieved by adopting the principle of always ensuring that the engine is stopped before passengers are permitted to alight, and by having passengers embark before the engine is started. Where this is impracticable, such as when a hand-start is required, an alternative would be to see that passengers are shepherded by a responsible person who is fully aware of the dangers.

The Department is at present considering whether a need exists for mandatory provisions concerning the embarkation and disembarkation of passengers and cargo with engines operating but, irrespective of the outcome of this, there can be little doubt that the implementation of this principle would fall within the category of "good operating practices" and would contribute to safety.

Care needed in Towing

The latest issue of Aviation Mechanics Bulletin published by the Flight Safety Foundation in the United States, mentions that the FAA has reported numerous cases of damage sustained by nose wheel assemblies while aircraft were being moved by power tugs. In most cases the cause was attributed to the turning radius limitations being exceeded. Components affected were towing pins, which on some aircraft are the undercarriage lower hinge pins, shimmy damper rods and attaching brackets, turn stops and steering bungees.

The Bulletin cautions drivers of aircraft tugs against making sharp turns with an aircraft under tow. No doubt some expensive damage to our own aircraft will be avoided if we also heed this warning.

LIGHTNING AND AIRCRAFT

With this issue of the Digest we reproduce with acknowledgment, the second part of an article published by the Lockheed Aircraft Corporation in the March issue of their Field Service Digest. The first part, sub-titled "A Basis for Discussion", was reproduced in our September issue.

Part Two

Further Thoughts and Considerations

When lightning strikes an airplane, a variety of effects can result, but in the vast majority of cases, damage will be slight. Injury to occupants is quite rare, fortunately, and we have seen no reports of an occupant of a metal airplane receiving a fatal shock.

If the aircraft were a perfect, uninterrupted, metal shell with no insulated conductors, such as antennas, leading into the vehicle, it is probable that a dangerous current would never be transmitted internally. Damage would be limited to pitting or occasional puncture of the shell. In many cases, occupants (including flight crews) are not aware that their aircraft has been struck unless a witness reports it, or damage is discovered after landing. Generally, skin damage will be limited to minor pitting or fusing of a few rivet heads, but small punctures do sometimes occur.

Evidence indicates that the path of the lightning in relation to the flight path is apt to determine how severe the damage is. As noted previously, a quick succession of strokes often follows along the trail of ionized air created by the first stroke. If the aircraft is flying along the ionization trail, a sustained flash (consisting possibly of a dozen or more strokes) may contact the skin at one spot and burn a small hole, such as an arc-welder electrode will produce. Such a hole could be an inch or more in diameter, depending on the thickness of the metal. If the stroke path is perpendicular to the direction of flight however, successive strokes will make contact progressively farther aft as the ionization trail "washes" aft in the slipstream; the resulting damage is then more widespread, but of a lesser degree (see Figures 4 and 5). It is also conceivable, depending upon the attitude and flight path of the aircraft in relation to the ionization trail, that an initial stroke to a wing tip for example could be followed by a succession of strokes moving inboard (see the remarks in Part One regarding integral fuel tanks).

Scientists have recorded the wave pattern of many lightning strikes and have found a wide variation in current, duration, and other factors. Despite the wide variation, some authorities classify the lightning as hot or cold according to the type of damage inflicted. In general terms hot lightning involves lesser currents of longer duration and has inflammatory tendencies. On the other hand, cold lightning (high current and short duration) is more apt to inflict damage by the explosive heating of moisture or air in wood and in man-made materials of like composition.

These distinctions are mentioned here as a matter of academic interest only. Obviously, man has no control over the nature of the stroke. We have to assume that aircraft will continue to be struck and do what we can to lessen the possible damage or, assuming a certain amount of damage, ensure that flight safety is maintained at a high level.

One factor which determines the extent of lightning damage — the conducting quality of the exposed target — is controllable, but only insofar as other factors such as function and cost will allow. In modern aircraft structures, cost is usually of secondary importance compared to function but, even so, it is obviously impractical to build the complete airplane of thick enough aluminium or other metal that it would be quite immune to lightning damage. The weight penalties involved would make such a design impractical.

The usual approach to the problem is to determine for each type of aircraft the points of the airplane which are most likely to be struck by lightning. Generally speaking, these points are the extremities of the airplane but, as outlined above, the problem becomes somewhat more involved than this when considering an aircraft's motion through the atmosphere.

THE PROBABLE INTERCEPTION POINTS AND THEIR PROTECTION

To gain some background of information about an airframe in relation to lightning, manufacturers may submit metal scale models of new designs to a specialized laboratory such as the Lightning and Transients Research Institute (LTRI). In this laboratory, the model is subjected to artificial lightning from various points of a spherical perimeter. Once the probable points of interception are known, more detailed studies are often made on actual aircraft components to develop the lightning protection best suited for specific applications. Figure 6 shows just one such series of tests on an aircraft model. In other series of tests on the same model, the airplane attitude was changed to cover as many variations as possible of aircraft position in relation to stroke path.

Unfortunately, as mentioned earlier, aircraft are not, and cannot be, perfect metal shells. The extremities — which most often serve as electrodes for the strike — are commonly fitted with nonmetallic radomes; antennas of various kinds project beyond the shield of the metal shell; and flight control surfaces and propellers offer pointed projections which are vulnerable because of their shape,

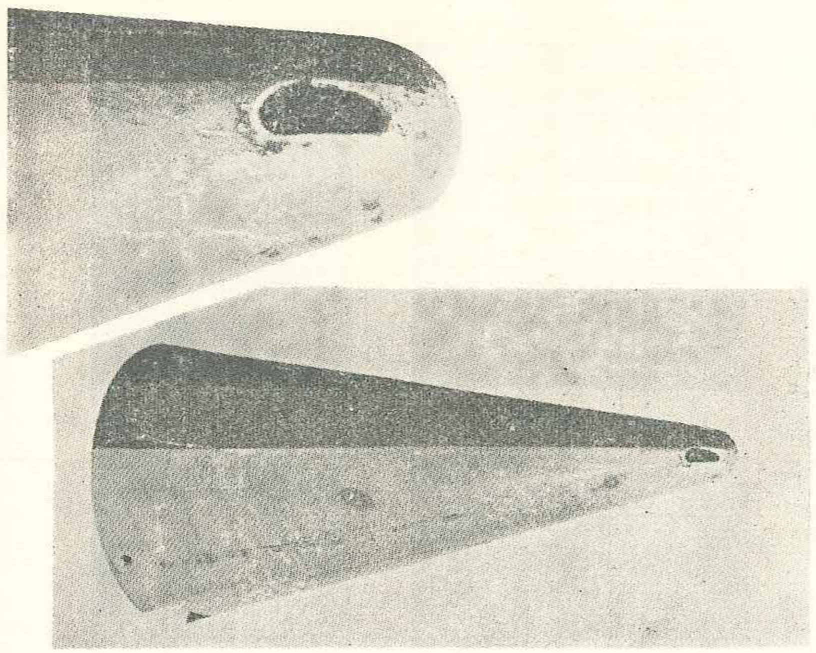
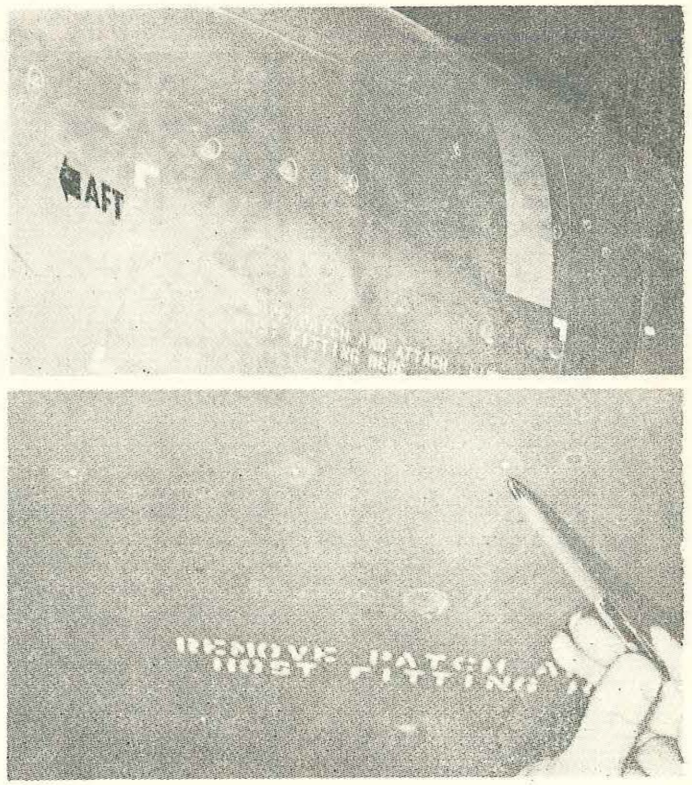


Figure 4
Hole Burned into Non-Structural Fairing.
Typical damage from sustained lightning strike, consisting of several strokes which contact skin at one point.

Figure 5
Pitting of Fuselage Skin Progressing Aft From Flight Station. Typical Damage from multiple-stroke lightning strike where the ionization trail "washes" aft in slipstream



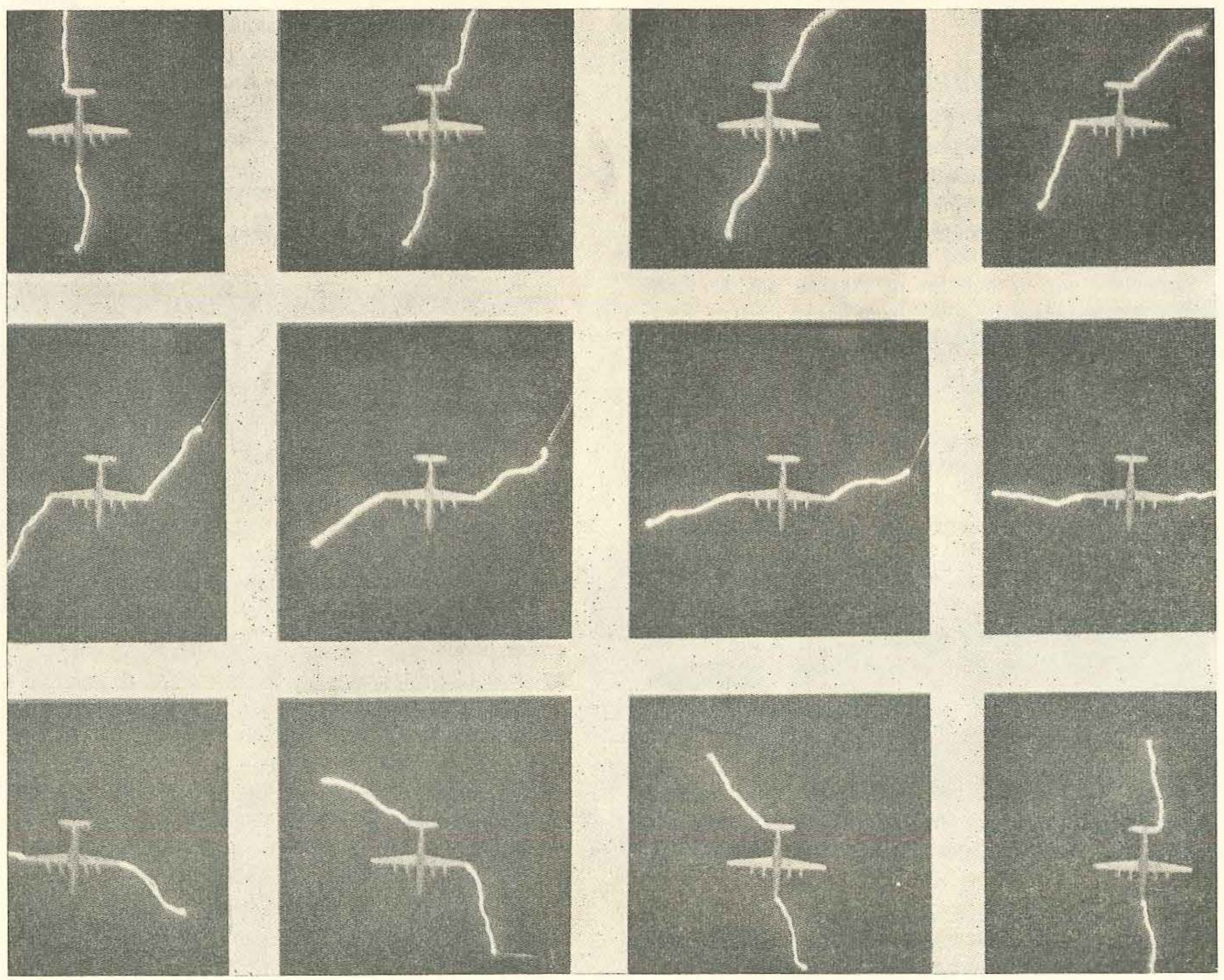
their extreme location, and their bearing attachments to the shell. As might be expected, these are the components most often damaged by lightning strikes (see Figure 7).

RADOMES

Non-conductive shells such as radomes present particularly thorny design problems, and in view of the high incidence of lightning strikes which involve radomes, they warrant some particular attention. Their susceptibility to lightning damage stems principally from their location and their non-conducting qualities. Although they are primarily shields for the antennas, their streamlining is also an important factor to the aircraft's flight characteristics, and if a forward radome is damaged by lightning, debris carried aft by the slip-stream can do additional damage.

One apparent incongruity here is that non-conductive radomes should be struck by lightning at all. The explanation is that the radar dish and metallic parts under the radome send out streamers, which are induced by an approaching stepped leader. Being a dielectric, the radome is heated intensely by the subsequent lightning stroke, and, although damage can be limited to pitting or small

Figure 6
Photographs of One Series of Artificial-Lightning Tests on Airplane Model to Determine Probable Stroke-Interception Points



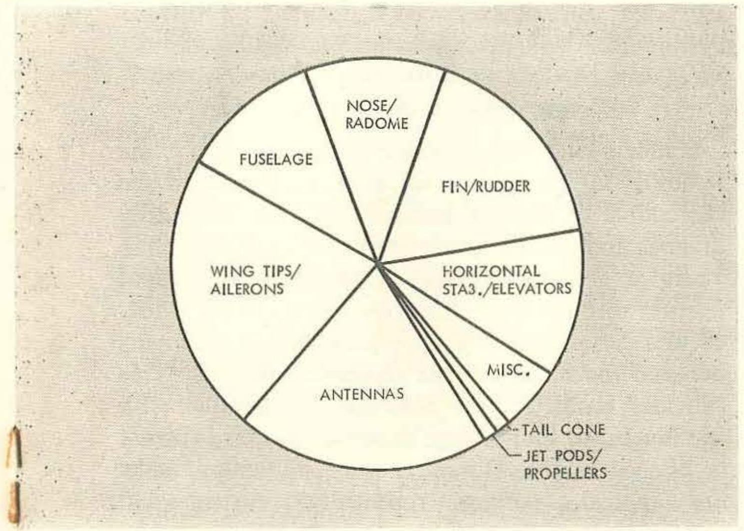


Figure 7
Approximate Distribution of Points on Aircraft Struck by Lightning. Estimated from various military and commercial strike reports

punctures, heating and consequent expansion of the composite material often causes fairly large holes to be exploded into the shell. In other instances, where radomes have been lost completely, it seems likely that explosive heating of the air beneath the radome was a factor. It should perhaps be mentioned that tiny punctures can also be produced by friction charge accumulations on the external radome surface, which puncture through to the interior. In any event, damage or possible loss of a radome is something that has to be considered in the design of an aircraft, mainly from the aerodynamic viewpoint.

It is generally not feasible to alter the location of a radome or its material to provide lightning protection, for the field of surveillance and/or the range of the radar would suffer. The only alternative is to divert the stroke to the skin by a chosen path via a conductor placed so as not to interfere unduly with the operation of the enclosed equipment. Diverters of two general types are in use, the consumable and the permanent.

For most applications, the consumable conductors are in the form of braided wire or narrow thin metallic strips, cemented longitudinally to the radome outer surface, and bonded to the metal skin. The length of the strips, their location, and their cross sectional dimensions are determined by tests to be optimum for the particular application. That is to say, they are planned to provide the best balance between lightning protection and loss of performance from the enclosed equipment.

The wires and the thin strips are not designed to survive a lightning strike, but they can divert a stepped leader to the skin, and even after they vaporize, strikes following in quick succession will find a residual ionized channel to the skin (see Figure 8).

Obviously, if the aircraft should intercept a second strike after the ionized channel has washed aft, a part of the radome protection system will be missing, but the protection zones of the strips are made to overlap, so that the radome is still well protected. In many cases, radomes will remain intact, and the only repair required will be the replacement of the braid or metal strip. The radome should be closely inspected, of course, for the local, intense heat may cause local delaminations of the inner or outer radome skin that are not readily seen. Also, tiny pinholes are sometimes created, and if water enters through such punctures it can interfere with radar operation.

An extensive protection system of the permanent type is shown in Figure 9. This long housing will be recognized by some readers as the MAD boom of the P-3 anti-submarine aircraft. The rods, which

Figure 8
Lightning Protection of P-3A Nose Radome

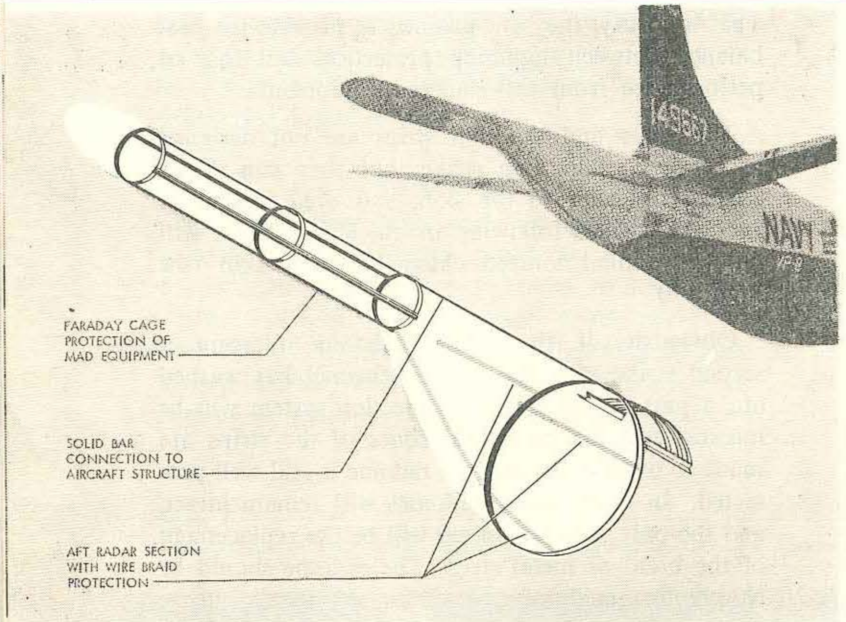


Figure 9
Faraday Cage Type Protection of P-3A MAD Boom

extend almost full length on all four sides, are interconnected at intervals, providing a Faraday cage intended to spread the current so that the tendency of one rod to induce secondary currents in internal components is largely offset by an opposing tendency in the opposite rod.

ANTENNAS

These are often instrumental in leading lightning into the cabin where it damages transmitting-receiving equipment and exposes personnel to hazardous voltage. For this reason, lightning arresters (such as that shown in Figure 10) have been developed. These usually include a special spark gap between antenna and aircraft structure, a dc blocking condenser, and a static leak resistor all encased in metal/glass enclosures. They are located in the antenna lead-in adjacent to the aircraft skin. The arresters are expendable, that is, they must be expected to sustain some damage in diverting the heavy current, and should be frequently inspected to ensure that the correct spark-gap is maintained. Note that they are not intended to protect the external antenna, but are simply intended to provide a calibrated weak point in the antenna system which will break down and carry off the destructive peak voltage through a safe path rather than allowing the lightning to flashover to structure inside the fuselage at a spot of its own choosing. Arresters are not provided for all antennas in all locations. Generally only those which are likely targets because of their shape and location are fitted with lightning arresters.

CONTROL SURFACES

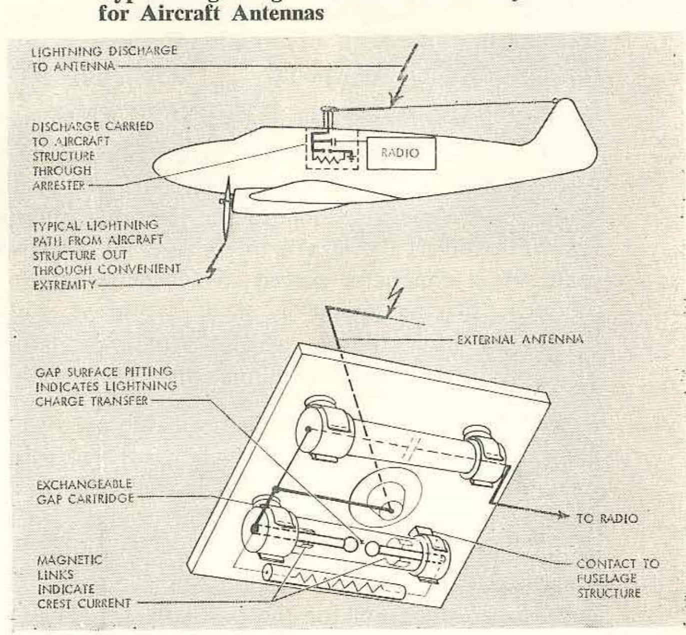
Rudders and elevators, in particular, are prime lightning targets because of their location, and are susceptible to damage because they are necessarily hinged and constructed of light-gauge material. There is no practical way to preclude all current transfer through hinge bearings, but it can be reduced to a certain extent by providing bonding jumpers between the fixed and the movable structure. This provides paths of low resistance in parallel with the hinges, so that a large proportion of the current is bridged safely. However, when millions of volts are applied — perhaps repeatedly — current will inevitably flow through the bearing. Consequently, the bearings should be inspected if a flight control surface is thought to have sustained a strike.

HINTS TO FLIGHT AND MAINTENANCE CREWS

STRIKE EFFECTS AND SOME PRECAUTIONARY MEASURES

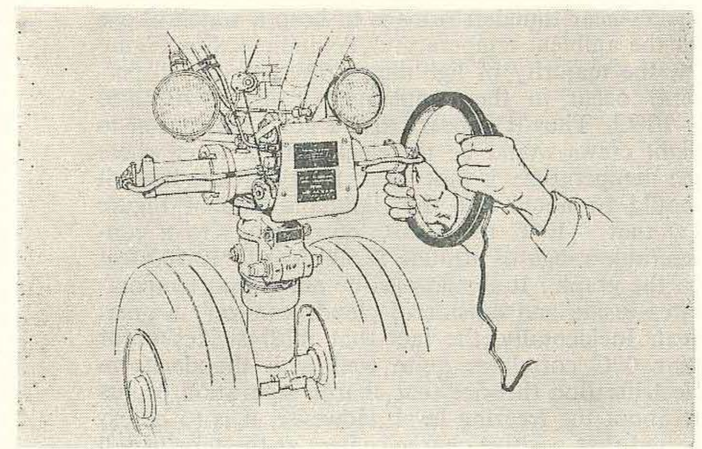
The intense field created by a lightning strike can, on occasion, be quite troublesome to flight crews and maintenance crews alike. Ferrous metals may become magnetized, and indicators which utilize magnets may be disoriented by local steel parts. Magnetic compasses are most vulnerable in this respect, and after a strike has occurred, compass readings are suspect, and should be cross-checked by whatever means are available before trusting them for navigation. In this respect, the pilot can take the precautionary measure of ensuring his gyro-compass accuracy when static build-up and/or St. Elmo's fire gives evidence that the aircraft is in a region of strong potential gradients, often presaging a strike. Gyros are not so prone to malfunction if a strike occurs, and will provide an immediate — although only approximate — check of magnetic compass fidelity.

Figure 10
Typical Lightning Arrester Protection System for Aircraft Antennas



All ferrous metal components in magnetically critical areas should be ground checked after a lightning strike, for it is often necessary to de-magnetize them. Portable de-gaussing devices are available, some of which have proven capable of de-magnetizing even large components such as landing gear and their truss structures without removal from the aircraft (see Figure 11). Following the de-gaussing operation, all compasses should be re-calibrated by compass swinging.

Figure 11
Demagnetizing Ferrous Metal Components with Portable De-gaussing Coil

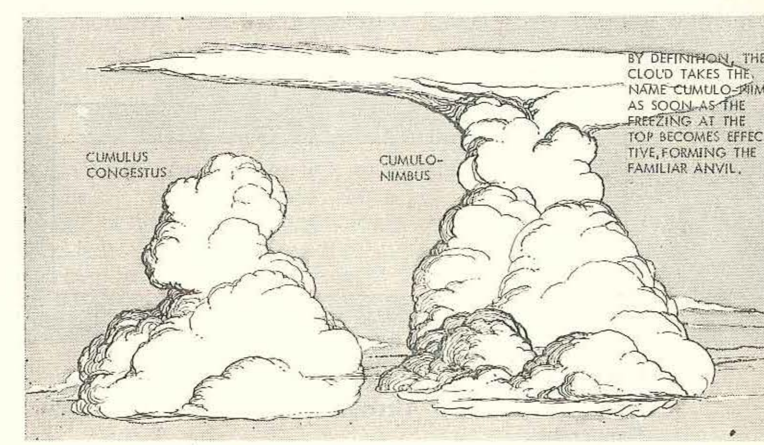


Secondary currents are often induced by the near passage of a lightning bolt, and sometimes there are annoying side effects when induced currents flow in circuits where momentary potential produces actuation. Such incidents are comparatively rare, but cases have been reported in which all the passengers' emergency overhead oxygen masks have dropped out on a high altitude jet transport, bomber tip tanks have been jettisoned, and, by the rarest coincidence, on successive days armament pylons were jettisoned from two fighter aircraft of the same squadron. Most such side effects are spectacular and difficult to overlook when inspecting for strike damage, but it will be well for maintenance personnel to know their aircraft devices — such as electrically discharged fire extinguishers — and check them during the post-strike inspection.

Secondary currents sometimes work through audio circuits to produce a temporarily deafening crash in earphones. Here again, the crew can take heed of static build-up and unseat the earphones by way of self protection.

There have been many instances of crews becoming temporarily blinded by lightning strikes while flying at night, and such blindness has often persisted for several minutes. One precaution which might be taken at the flight crew's discretion is to turn up the cockpit lights to full bright and keep the eyes focussed on the instruments when static, St. Elmo's fire, or other warning signs indicate the likelihood of a lightning strike. This action will have the effect of contracting the pupils of the eyes, making them less susceptible to damage from a subsequent lightning flash. Of course it would never be advisable for the entire flight crew to restrict their vision in this way, but if one member does so, the small loss in observation will be well repaid by the degree of protection gained against an entire flight crew being temporarily disoriented.

Figure 12
Cumuliform Clouds Responsible for Lightning Strokes. Throughout the article we intend the term "thundercloud" or "cumulo-nimbus" to apply also to the cumulus congestus — the most advanced stage of cumuliform cloud before its final evolution as a cumulo-nimbus



AVOIDING LIGHTNING

The golden rule in avoiding lightning is to not fly in, or in the vicinity of, thunderstorms or any of the clouds with high vertical development. These are often called collectively clouds of the cumulo-nimbus type but a meteorologist would also include in the list of various clouds to be avoided others, such as the cumulus congestus, which are simply advanced stages in the development of a cumulus aspiring towards a cumulo-nimbus (see Figure 12). Of course, as far as this golden rule is concerned, the problem of possibly being struck by lightning is not so important as the problems of encountering turbulence, icing, and/or hail — all of which are particularly associated with the thundercloud. However, if we assume that we are forced to fly in the vicinity of a thunderstorm for some reason or another, then it might be helpful to discover some more rules.

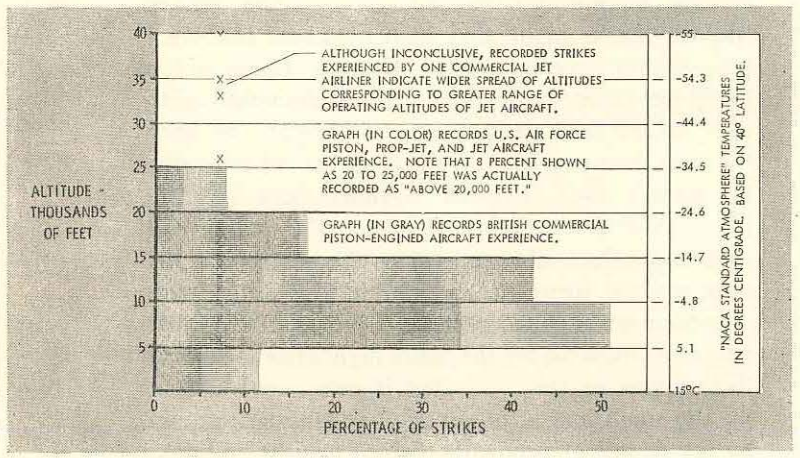


Figure 13
Lightning Strikes to Aircraft as a Function of Altitude — Two Superimposed Graphs

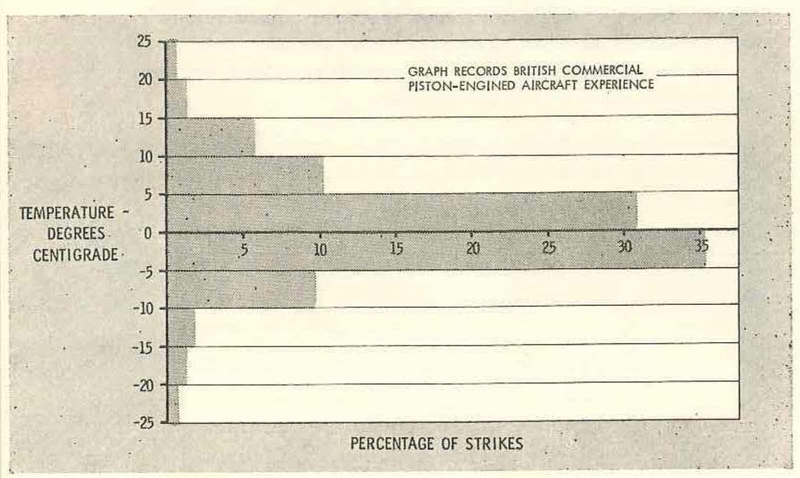


Figure 14
Lightning Strikes to Aircraft as a Function of Ambient Temperature

Statistics on lightning strikes to aircraft seem to show that altitude plays a minor role, in a practical sense, as far as determining the likelihood of being struck. Reports show that most strikes to aircraft occur below 20,000 feet with a certain emphasis on the 5 to 10,000-foot level but these figures also appear to reflect the altitudes where most flying occurs — even jet aircraft spend a large proportion of their average flight time climbing or descending at low operational levels. Figure 13 superimposes two graphs from two entirely different sources and locales. As stated above, about the only conclusion that can be made is that strike probability drops sharply above 20,000 feet. Incidentally, this statement is further supported by Air Force statistics which show that 9 of 11 strikes reported on B-52's were below 20,000 feet, but is somewhat repudiated by another record of 14 jet aircraft strikes (indicated by x's on Figure 13) which shows a wider spread of altitudes corresponding more closely with the greater range of operating altitudes of the pure jet. However, strike probability almost certainly coincides with the altitude range of the cumulo nimbus which, in general terms and depending upon world location, is commonly found between 3 and 30,000 feet, is somewhat less frequent up to 50,000 feet, but can even extend to higher levels than this.

Perhaps a more satisfactory method of avoiding strikes near thunderstorms is to keep a watchful eye on the ambient temperature. As indicated in Figure 14, the majority of lightning strikes (about 80 percent) occur in the temperature range —10°C to +10°C. Thus it appears that a good precaution to flight crews would be to select a flight level where the temperature is not near freezing, although it should be noted (see the righthand side of Figure 13) that —10°C to +10°C corresponds to a considerable range of altitude (2,500 feet to 12,500 feet on the graph.) It should also be noted that temperatures inside and outside of clouds can vary a great deal. Incidentally, the fact that most strikes occur near 0°C correlates quite well with thunderstorm electrification theories that charge separation occurs at about the freezing level. However, it is to be expected that positive charge centers at the tops of tall clouds are at much lower temperatures than this.

RELATED ITEMS AND QUERIES

STATIC DISCHARGERS

These are commonly fixed to the trailing edge of aerodynamic surfaces, especially flight control surfaces, to aid in the dispersion of friction charges which accumulate on the skin of the aircraft. There are a number of designs, the most common type

being a carbon impregnated wick, frayed at the trailing end to provide intimate contact with the slip-stream. After a lightning strike, they should be inspected and replaced as necessary. Except for this reference, any further discussion regarding these devices should hardly be justifiable in an article about lightning. However, one purpose of this article is to dispel popular myth. The purpose of a static discharger is just what the name implies — to discharge static. A widespread misconception that they serve a dual purpose and also, in some way, discourage lightning strikes stems from the equally popular misconception, described in Part One, that an aircraft can become sufficiently charged during flight to originate its own lightning discharge.

Many reputedly authoritative articles on the subject draw definite distinctions between bolts of **natural lightning** and bolts due to **static discharge.** It should be emphasized that aircraft skin friction can at most generate moderately high voltages of about 100,000 volts with charging currents of 0.0005 amperes. These values hardly bear comparison with those of a "natural" lightning discharge, which involve potentials of 10- to 100-million volts and currents sometimes exceeding 100,000 amperes.

However, as indicated earlier, static dischargers do enter the lightning picture to a certain extent. Under certain conditions, they can provide a **local** diverting action to a lightning bolt for a distance approximately equal to the length of the dischargers. It follows that static dischargers should not be installed on an airplane without due regard to this diversion factor. One placed on the outboard end of an aileron for example could well direct a lightning stroke to itself away from the wing tip, and to quote Newman and Robb again, ". . . strikes [which are diverted] to most of the short dischargers in current use jump off the discharger over to the adjacent metal skin resulting in a costly and time-consuming aircraft repair problem, i.e., the repair of skin damage." While on this subject, Newman and Robb also believe that the present dischargers could be mounted with bases which would greatly reduce the damage either adjacent to or at the base of the discharger.

We might at this point answer a question that is relevant and is often asked. High speed fighters frequently do not have and do not **require** static dischargers. The jet engine exhausts are usually sufficiently ionized to carry off most of the accumulated charges of precipitation static. However, this is not true of all jets and, as a general rule, static dischargers are necessary as jet aircraft size and performance increases.

Incidentally, Lightning and Transients Research Institute has developed a graded resistance lightning diverter rod which combines the function of a static discharger with that of a lightning rod. The use of such a device controls, to some extent the specific localized point at which lightning might strike (see Figure 15). The diverter rod base is designed to carry the stroke currents without damage to the skin or airframe at the attachment point.

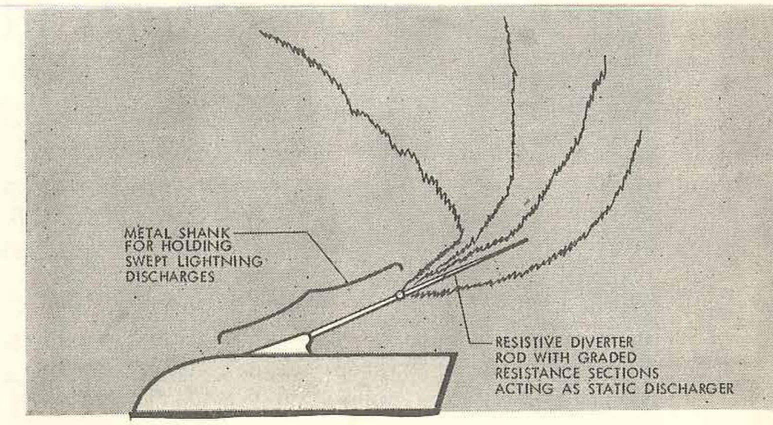


Figure 15
Combined Static-Discharger/Lightning-Diverter Rod for Empennage or Wing Tip Installation

RADAR AS AN ATTRACTOR OF STRIKES

The incidence of lightning strikes to radar devices is inevitably high for reasons which have already been discussed. It is also well known that the energy transmitted via some radar beams is of a high enough order that it can (in some combinations of wave length, range, and power) burn a living organism internally, illuminate incandescent lights, or perform similar feats. Not unnaturally, this has caused some speculation as to whether it is possible for radar to produce ionization of the atmosphere, and thus attract lightning discharges.

Lightning and Transients Research Institute conducted a study on this particular problem of lightning diversion. Selecting an altitude of 40,000 feet as a basis of evaluation (generally speaking, the problem increases with altitude), they arrived at the conclusion that the possibility **might** exist at that altitude if the power flux of the most intense radar beams existing today were increased by a factor of 10.

We recently requested Mr. Robb of LTRI to comment further on this interesting subject. Taken slightly out of context, the reply was: ". . . we do not believe for average radars in present use this is much of a factor as the maximum electric field magnitudes are rather low, well below the ionization levels for medium flight altitudes where most lightning strikes occur. However, it is granted that for very high power radars, high HF antenna voltages, and high altitudes, ionization could be a significant factor in attracting strikes."

Hornet Moth destroyed in Fog

Late in the afternoon of 23rd June, 1964, the overseer of a property near Ballarat, Victoria found the wreckage of a light aircraft and the bodies of its two occupants. The discovery was reported to the police and it was soon established that the wreckage was that of a DH87B Hornet Moth, which had left Moorabbin Airport the day before on a private flight to Ballarat.

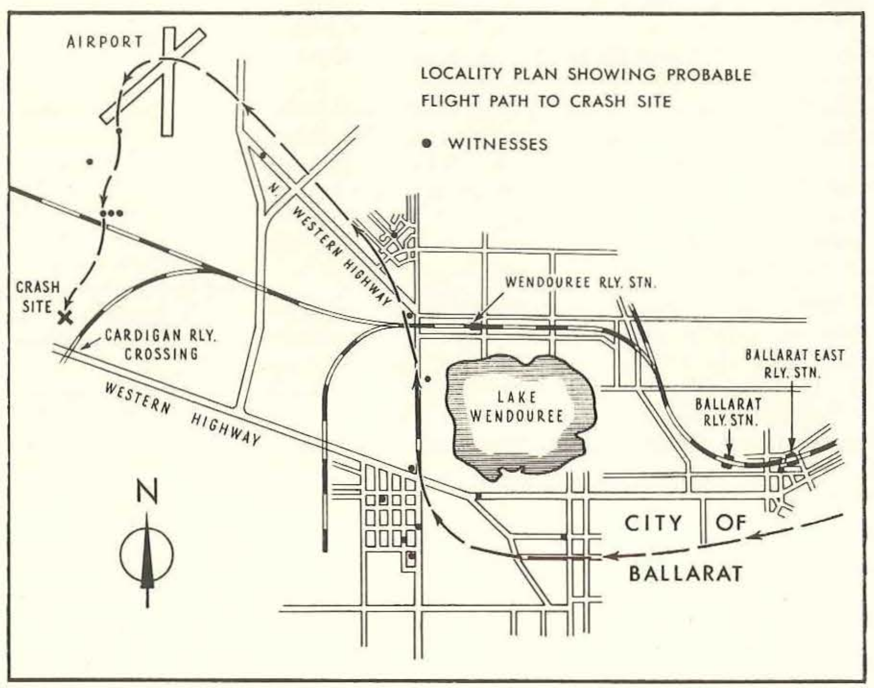
The aircraft was seen at Moorabbin Airport on the day of the accident at about 1100 hours. While it was being refuelled there, the owner, who held a private pilot licence endorsed for the type, carried out a daily inspection. A passenger was seated in the cabin. Soon afterwards, the pilot swung the propeller and the aircraft taxied out. At 1105 hours it called Moorabbin tower and reported "Taxying for Ballarat no details, no SAR". The tower cleared the aircraft for take-off and it departed at 1110 hours. This was the last transmission received from the aircraft.

Although the weather in the vicinity of Melbourne was satisfactory for VFR operations when the aircraft departed, very different conditions existed at its destination. At the time of the flight a post-accident analysis of the weather conditions indicated that a north-westerly stream ahead of a cold front prevailed over the route. There was up to 8/8 of stratus cloud from 500 to 1500 feet above sea level, with 4/8 to 8/8 of strato-cumulus cloud at 2000 feet. Showers and drizzle reduced visibility to one mile, with moderate turbulence.

An hour after it had left Moorabbin, the aircraft was seen flying low over the city of Ballarat in misty conditions. Less than two miles further on in the direction of the aerodrome, it had descended to about 200 feet and was seen dodging patches of scud below the main cloud base. As it continued towards the Ballarat aerodrome, it was noticed flying very low by some 20 witnesses. One said that the aircraft was just above trees 60 to 80 feet high, while another claimed that it was actually evading trees at this height. All agreed that foggy or misty conditions existed and some believed the aircraft was being flown immediately below the cloud base.

The aircraft was next sighted by a private pilot within a mile of the aerodrome, at a height estimated to be less than 60 feet. This pilot had come from the aerodrome only a few minutes before and said that when he left, visibility there was less than 100 yards because of fog. Soon after this, several pilots and aircraft engineers at the aerodrome itself saw or heard the aircraft pass low overhead. A flying instructor inside his home at the aerodrome also heard it and rushed outside, but could not sight it because of stratus cloud at ground level.

The last three persons to see or hear the aircraft were less than a mile from the site of the crash. Two



of them described catching glimpses of it flying low before it "disappeared in the fog." The third heard it fly low overhead but could not see it, and then heard "a burst of power which lasted about three seconds and ceased suddenly." None heard the noise of the crash. The opinion of the witnesses in general was that the aircraft's engine seemed to be running normally but that it was operating at high power during the latter stages of the flight.

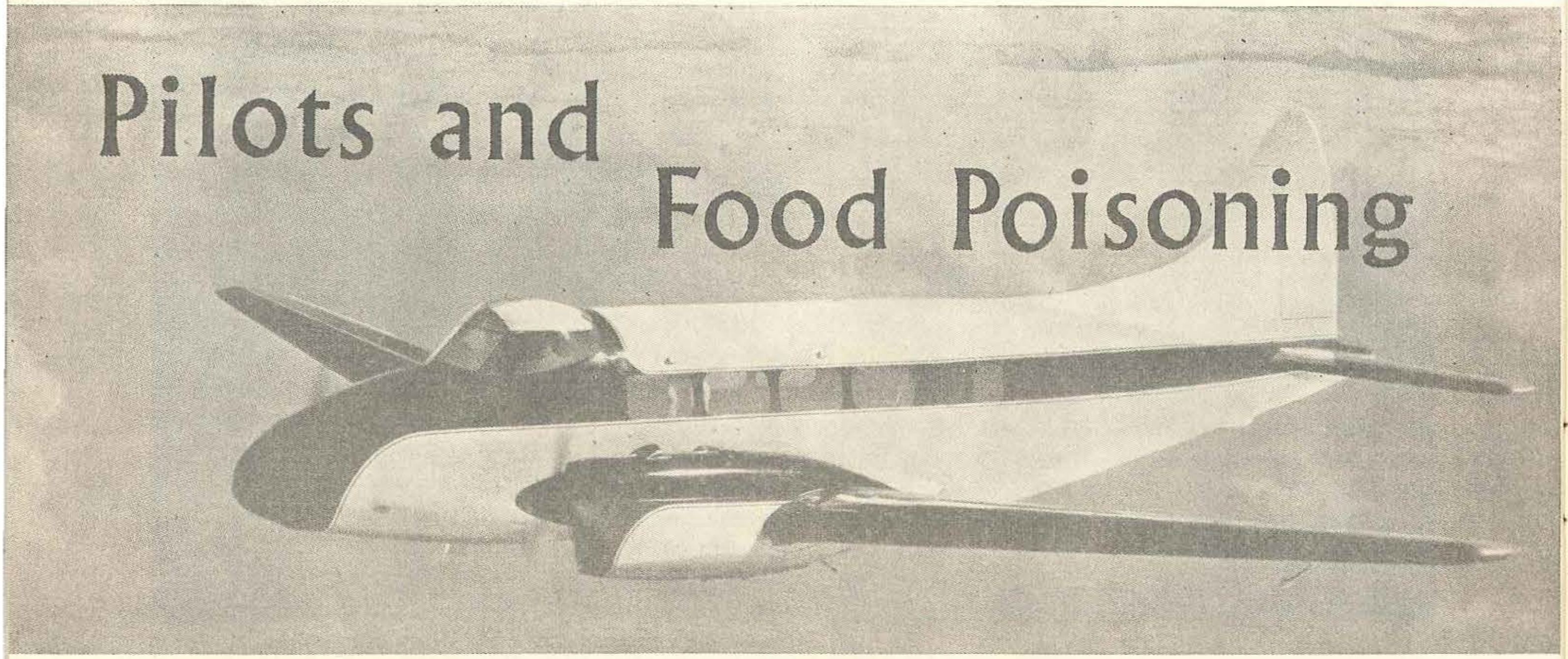
The accident occurred in a field 1400 feet above sea level, located five miles west of Ballarat and two miles south of the aerodrome. The surrounding area is flat with isolated trees, and the field is suitable for landings in several directions. From the distribution of the wreckage, it was evident that the aircraft had struck the ground at a relatively high speed in a slight nose-down attitude. It had disintegrated on impact and the fuel tank had been hurled 120 feet ahead of the main wreckage which itself slid for almost 250 feet before coming to rest and being destroyed by fire. Pieces of the wooden propeller which were flung 145 feet to one side of the engine impact point, indicated that the engine was running at high power at the time of the crash.

A damaged wristlet watch which had stopped at 1220 hours and which had belonged to the passenger in the aircraft, was recovered from the wreckage. This added weight to the belief that the aircraft had crashed very soon after the last reported sighting was made approximately one mile from the accident site.

Both the directional gyro and the artificial horizon were found in the caged position, and as the pilot is understood to have had no instrument flying experience, it can be reasonably deduced that he was trying to fly the aircraft by visual reference to the ground. It is evident that despite the extremely poor visibility, the pilot managed to find his way to the aerodrome. Over and beyond the aerodrome however, there was virtually no visibility and at this stage it seems that the pilot lost sight of the ground completely. He may have then descended in an effort to regain sight of the ground or possibly, having lost visual reference, he may have allowed the aircraft to descend without being aware of it.

Whatever the circumstances of the final descent, there can be little doubt that this accident took place because once again, a pilot persisted with a VFR flight after meeting weather conditions in which visual flight could not be properly maintained. Had he diverted to another landing ground or returned to Moorabbin when first he encountered weather below visual meteorological conditions, there would not have been an accident and more important, two valuable lives would not have been lost.

Pilots and Food Poisoning



From time to time incidents occur in which pilots are affected by food poisoning while in flight. The problem is usually met where aircraft are operating from country or outback aerodromes, and pilots have had to obtain an improvised meal or a cut lunch away from reliable restaurants or other recognised catering establishments.

Two such reports came to hand recently, one involving the pilot of a twin-engined aircraft operating in a remote area of Western Australia, and the other a private pilot flying a Cessna to Bankstown from an inland airport. There have been others, such as a case in Western Australia where the pilot of a Dove became ill from food poisoning when the aircraft was some forty minutes from the nearest aerodrome. On this occasion the effects were quite serious as the pilot experienced severe stomach pains and almost continuous vomiting spasms for the last 25 minutes of flight. His concentration deteriorated and he became so weak that he had difficulty in manipulating the undercarriage selector for landing. The landing itself was made difficult by the pilot's nausea and inability to properly focus his eyes. The pilot collapsed after landing the aircraft and shutting down the engines, and had to be assisted from the cockpit.

Although the consequences are not always as serious, the problem of food poisoning remains a potential hazard and pilots should ensure that all reasonable precautions are taken to guard against its occurrence. This applies especially to single pilot operations in our more isolated areas during the summer months where high temperatures greatly increase the chances of serious food contamination.

This type of food poisoning is caused by the presence of staphylococcal toxin in the food eaten. For the condition to develop, the foodstuff has first to be contaminated with staphylococcal germs while being prepared, and has then to be left at room temperature or slightly above. for several hours. This allows the bacteria to multiply and produce the toxin. The process does not affect the appearance, smell or taste of the food, and the toxin is not destroyed by reheating. Thus, while the problem is one of simple food hygiene, it is usually entirely beyond the pilot's control when he has to eat meals prepared at remote en route stops.

The range of foodstuffs which might be affected in this way is quite large, but some foods are more susceptible than others and although the risk of food poisoning cannot be eliminated, it can be minimized if pilots are able to select those foods least likely to be contaminated.

The following list is not exhaustive but may be used as a guide:—

Safe Foods

- Fresh salad vegetables (but **not** potato salad)
- Hot, freshly cooked meat (but **not** the gravy)
- Fruit, fresh or canned
- Canned meat from a freshly opened can
- Freshly cooked or hardboiled eggs
- Cheese
- Bread, butter, jam.

Risky

- Soup, unless from a freshly opened can
- Cold meats of all kinds (except canned meat from a freshly opened can)
- Cold sausage, or hot sausage rolls
- Spaghetti and similar dishes.

Very Risky — never take a chance with:

- Pies, stews, curries and other made up meat dishes
- Cream or custard-filled pastries and cakes
- Desserts with a cream or custard content
- Home made ice-cream.

Because breakfast usually consists of "safe" foods and the evening meal is normally eaten at the end of the day's flying, the meal most likely to cause trouble is lunch. Food poisoning of this type will normally manifest itself within two hours of eating the affected food, and where pilots are not able to select "safe" foods at an en route lunch stop and the food available is at all doubtful, they would be wise to make do with a cake of chocolate or even miss the meal altogether.

Buffeting traced to wrong screw

During a take-off from an airstrip at a North Queensland cattle station, the pilot of a Cessna 310 experienced moderate elevator buffeting as the aircraft accelerated through 60 knots. The buffeting continued after the aircraft became airborne, reaching a peak at about 110 knots after the undercarriage and flaps had been retracted. At 120 knots it was still present though less severe.

Not knowing whether or not the aircraft's stall characteristics were affected, the pilot decided against returning to the short station airstrip which demanded a precautionary approach, and instead continued the flight to Coen aerodrome 70 miles to the south. After checking that the aircraft could be safely controlled at 85 knots with the undercarriage and flaps extended, a safe landing was made at Coen.

It was found that a screw holding the forward section of the starboard wing root fairing in place had pulled out, allowing the fairing to protrude into the slipstream and disturb the airflow over the tailplane surfaces. The cause of the incident was attributed to a maintenance error when examination of the screw, which was still hanging loosely in the fairing, showed it to be a 8/32" machine screw instead of the specified 10/32" screw. An innocent looking mistake perhaps, but one which could have had far more serious consequences for a less experienced pilot.

Fatal Engine Failure during Training

While a Piper Colt engaged on flying training was making a climbing turn away from a simulated forced landing approach, the engine failed without warning. The aircraft descended in a steep gliding turn, struck a tree and crashed. The student pilot was fatally injured and his flying instructor sustained serious injuries.

The aircraft was owned by a flying school at Mackay, Queensland but was based temporarily at a cattle station near Winton for the purpose of providing flying instruction for several students in the area. On the morning of the accident a student and the instructor, who held a C class rating, rose early to carry out some revision prior to the student's licence test. A daily inspection was carried out on the aircraft soon after first light and they took off a little before 5.30 a.m.

The weather was fine and cloudless with almost no wind, and after climbing to 3500 feet and completing a series of steep turns, the aircraft proceeded to carry out a simulated forced landing approach on to an airstrip at an adjoining station property. The student pilot made a satisfactory approach to land into the east on the property's 095° strip and continued down to a height of approximately 50 feet. Power was then re-applied and the aircraft climbed away. At this stage the instructor took over control and began a turn to the right with the intention of positioning the aircraft for another simulated forced landing approach. A few moments later, at a height of approximately 200 feet, the engine suddenly lost power, back-fired once or twice and then stopped firing altogether. Almost immediately the nose of the aircraft was seen to drop and the turn to the right tightened. The steep diving turn continued until the aircraft was almost on a reciprocal heading. It then straightened from the turn but, with the dive apparently unchecked, brushed through the upper branches of a tree, then struck the ground and the lower portion of a second tree simultaneously. The impact was severe, tearing off the port wing and demolishing the undercarriage. The aircraft skidded along the ground for approximately 100 feet, nosed over and skidded a further 80 feet on its back before coming to rest. The nose, the cabin roof, and the fuselage were crushed and telescoped in the crash and the whole aircraft structure was virtually destroyed but no fire broke out. The occupants were extricated from the inverted wreckage by the property owner and one of his employees.

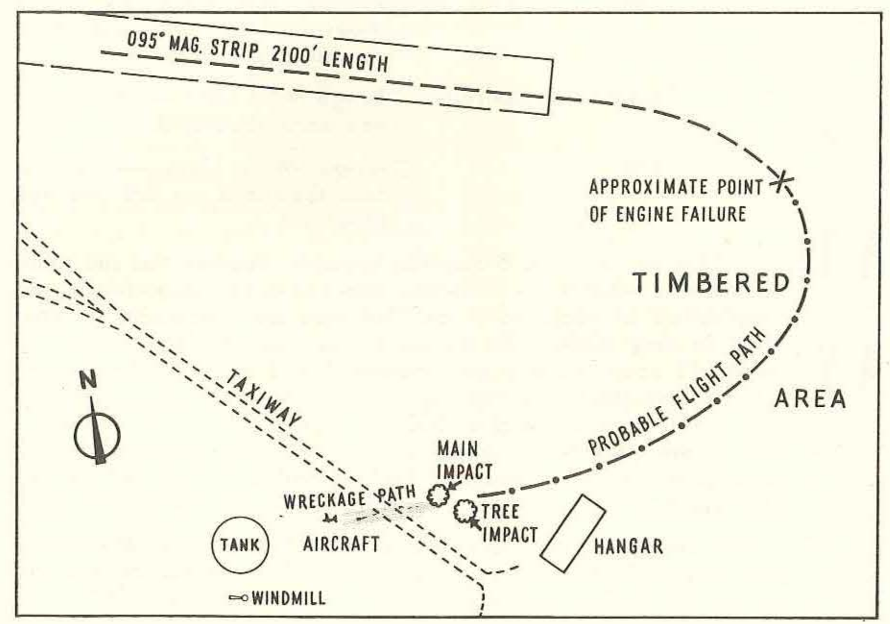
Examination of the wreckage confirmed that the crash had been preceded by a loss of engine power, the damage to the propeller clearly indicating that it was not rotating under power at impact. Subsequent examination of the engine did not establish the existence of any pre-accident defect. However it was found that the entire fuel system was devoid of fuel with the exception of about one quart which remained in the starboard tank. Although the fuel tank caps had come off when the aircraft overturned and both tanks had been ruptured in the accident, it was believed that some fuel should have remained in the fuel lines, filter or carburettor bowl if fuel was being supplied to the carburettor when the crash occurred. The fact that there was no trace of fuel in this part of the system provided substantive evidence that fuel starvation had been the cause of the engine failure.

It was found that since last being refuelled to capacity, the aircraft had flown a total of three hours on the day preceding the accident. The consumption rate of the Piper Colt is six gallons per hour and from this it was deduced that the aircraft tanks contained approximately twelve gallons of fuel at the commencement of the flight. The aircraft had been flying for slightly over one hour when the accident occurred so there should have been approximately seven gallons remaining at the time of the accident. In the Piper Colt, fuel may be drawn either from the main port wing tank or from the auxiliary starboard wing tank, each having a capacity of 15 imperial gallons. Of this quantity, two gallons in the port tank is unusable and the Operator's Handbook specifies that the auxiliary (starboard) tank may be used in level flight only. This means that at the most there was only five gallons of usable fuel in the system at the time of the crash and it would seem that this was distributed between the two tanks. The port tank was selected "on" when the accident occurred and it was concluded that the low fuel level in the tank had allowed the tank outlet to become uncovered during the acceleration and climb away from the simulated forced landing approach, and fuel starvation had resulted.

The injured instructor could not recall his reactions to the engine failure or even the fact that it did fail, but it seems likely that he was attempting to regain either the aerodrome or the adjoining taxiway for the imminent forced landing.

Later in the investigation an attempt was made in another Piper Colt to simulate the sequence of events leading to the accident. During this reconstruction flight, it was found that from a climbing turn, if power were left on, the aircraft behaved normally and could be pulled tightly around by the use of harsh "up" elevator and the nose position controlled in relation to the horizon by the use of rudder. There was no tendency for the nose to drop uncontrollably or for the aircraft to spin. The response to elevator control was fairly sluggish when the same manoeuvre was repeated with the throttle closed but it was found that the rate of turn could be increased considerably by an excessive application of inside rudder. When increased in this way however, there was very pronounced fall away of the nose and once commenced, this could not be corrected until the aircraft was levelled out laterally and then pulled out of the ensuing dive. This manoeuvre was tried on several occasions with entry speeds varying between 50 and 70 knots. In each case the same result followed excessive use of inside rudder. The speed on recovery was approximately 80 knots and the height lost during the manoeuvre was about 250 feet. It was also found that even though the speed during the recovery was high and the elevator control was used to the limit of its travel, the aircraft appeared to squash considerably during the recovery action.

Although this reconstruction of the flight indicated that the attitude and flight path followed by the aircraft was probably caused by misuse of the controls, it is clear that the instructor was placed in a most difficult situation. The aircraft had gained only approximately 200 feet and the area below and ahead was dotted with low trees and it was unlikely that a forced landing could have been accomplished without substantial damage to the aircraft and some hazard to its occupants. The aircraft was already in a turn to the right and seated as he was in the right hand seat, the instructor had a clear view back towards the unobstructed taxiway and open area adjoining the airstrip. In these circumstances he might well have been tempted to try to increase the rate of turn with right rudder in a desperate effort to place the aircraft in a position where a safe landing would be possible. This action would have produced the steep nose-down attitude which the aircraft was seen to adopt when the engine failed. The attempt to pull out of the ensuing dive evidently did little to check the high rate of descent in the height that remained but resulted in the aircraft striking the ground in a comparatively flat attitude.



It is apparent that the primary factor in this accident was the failure of the instructor to ensure that an adequate supply of fuel was available. The other considerations are secondary and can be discussed only as a principle rather than in direct relationship to the accident.

Many engine failures at low altitude force pilots to judge between landing straight ahead in conditions unfavourable to a forced landing, and executing a manoeuvre to reach an area which is more favourable. An inviolate rule is impracticable as there is obviously a height distance relationship from which a landing into the clear is both practicable and safe. The real judgment lies in assessing the capability of the aircraft to execute the preliminary manoeuvre, with the airspeed and the margin of height that is available and having regard to such considerations as increased stall speed during a turn. Only the pilot-in-command, can exercise this judgment at the time, and even when his judgment might appear to have been astray, he cannot always be directly criticized, because the precise circumstances in which he acted cannot necessarily be reconstructed.

All we can say is that history is studded with examples of catastrophic results that have emanated from the "stretched glide" or the "turn back to the aerodrome" and there is much evidence to support the theory that survival prospects are greater during a controlled forced landing on unfavourable terrain than they are in the uncontrollable situation that almost inevitably follows a misjudgment of this sort.

MEAN WHAT YOU SAY

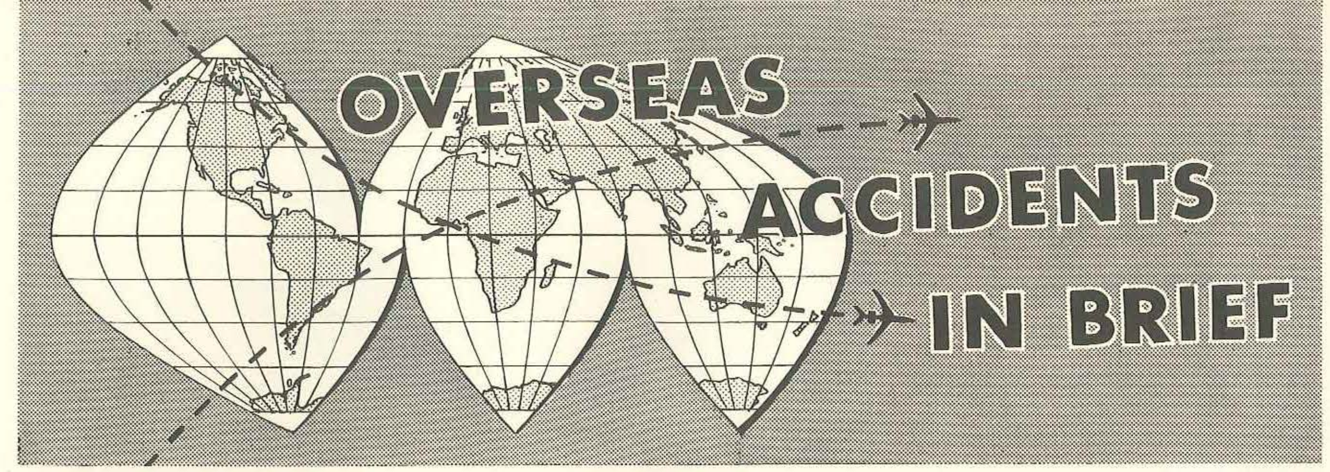
Aircraft separation standards have been discussed on numerous occasions in the Digest. Recently however, an airline captain raised this contentious subject again when he expressed the opinion that in certain circumstances, it was possible for the vertical separation standard to be infringed in controlled airspace. He cited the case of an aircraft reporting it has "left" a level before actually establishing a descent rate of 500 feet per minute. In this situation, if a higher aircraft were immediately cleared to the vacated level, it could cause the separation standard to be infringed.

Consider this example:

Approach Controller:	**"Romeo Golf Hotel" — descend to six thousand".**
RGH:	**"Romeo Golf Hotel — to six thousand — left one zero thousand".**
Approach Controller:	**"Tango Mike Lima — descend to one zero thousand".**
TML:	**"Tango Mike Lima — to one zero thousand — left one one thousand".**

This of course is a familiar enough situation but the point at issue is whether we always appreciate the importance and implication of such words as "left one zero thousand". What then do they mean ? To the Air Traffic Controller they convey in effect, "I have left one zero thousand and am now descending at not less than 500 feet per minute to seven thousand feet and I will then descend at 500 feet per minute to six thousand feet. I am quite happy about your immediately clearing another aircraft to one zero thousand feet, provided it does not exceed a descent rate of 500 feet per minute over the last 1000 feet.

The remedy lies in the hands of pilots themselves. Make sure you have left the altitude and have established the correct rate of descent before you report "left . . . . . thousand".



DC-7 Struck by Lightning

While cruising in IMC conditions at 13,000 feet, a DC-7 was struck by lightning. At the time, the aircraft's speed was being reduced because of moderate turbulence. The crew reported that after the strike occurred, a banging noise was heard coming from the area aft of the cockpit section and some vibration was felt but this decreased as the airspeed was reduced and ceased altogether when it dropped to 150 knots. A precautionary landing was made at a nearby airport without further incident.

After landing, it was found that the top 18 inches of the rudder was missing, the top rudder hinge had arced and welded and there was pitting and signs of arcing on the lower hinge bearing. Burn marks and pitting were also found on the rotating beacon and at numerous points on the fuselage aft of the battery compartments, with small pinnacles of molten metal in the pitted areas. Both battery compartment doors had been forced open by evenly distributed outward forces. There was a $\frac{1}{8}$-inch hole in the radome and evidence of burning or arcing was found on the port A.D.F. sense antenna.

The flight crew stated that the aircraft radar was in operation when the lightning strike occurred, and showed steady rain but no cells or disturbances. Turbulence and rain had increased suddenly before the lightning strike, but no other lightning was seen during the flight.

(C.A.B.)

Pilot Incapacitation Causes Glider Crash

Shortly after being released by a towing aircraft at an altitude of 3,250 feet, a Schweizer Glider was observed 200-400 feet above the top of a nearby mountain. It was seen to make a 180° left turn after which it entered a left spin and crashed on the mountain at an elevation of about 3,100 feet.

Investigation disclosed no evidence of pre-impact mechanical failure and both the pilot and the glider were properly certificated. The pilot was reported to be in good spirits before beginning the flight.

There was a clear sky and unlimited visibility at the time of the flight but the Weather Bureau forecast was for moderate to severe turbulence at altitudes up to 12,000 feet. It is not known whether the pilot received a weather briefing before the flight. The pilot of the towing aircraft reported that he did not encounter turbulence during the tow but stated that the air was very turbulent over the mountain ridge shortly after the accident.

Post mortem examination of the pilot's body revealed that some time before impact he had become ill and vomited. It was also disclosed that he had inhaled vomitus in an amount sufficient to have caused a loss of consciousness. However the post-mortem disclosed no findings of a clinical nature that could have caused the illness.

(C.A.B.)

Premature Undercarriage Retraction

At the conclusion of a ferry flight, the first officer of a DC6B was making the landing from the left hand seat while the captain acted as co-pilot. The first officer's approach was high and fast and near touch down the captain ordered a missed approach. When full power was applied, the flight engineer thought he heard an order to retract the undercarriage. He did so, but at this stage a positive climb had not been established and the aircraft settled until the No. 3 propeller struck the runway. Flight was nevertheless maintained and the damaged propeller feathered. After climbing away, the captain took the left hand seat and made a safe landing.

Investigation showed that the Company Operation's Manual contained the instruction "The pilot not making the takeoff will retract the gear upon command of the pilot making the takeoff". The crew members also stated that it was not the flight engineer's duty to retract the landing gear.

(C.A.B.)

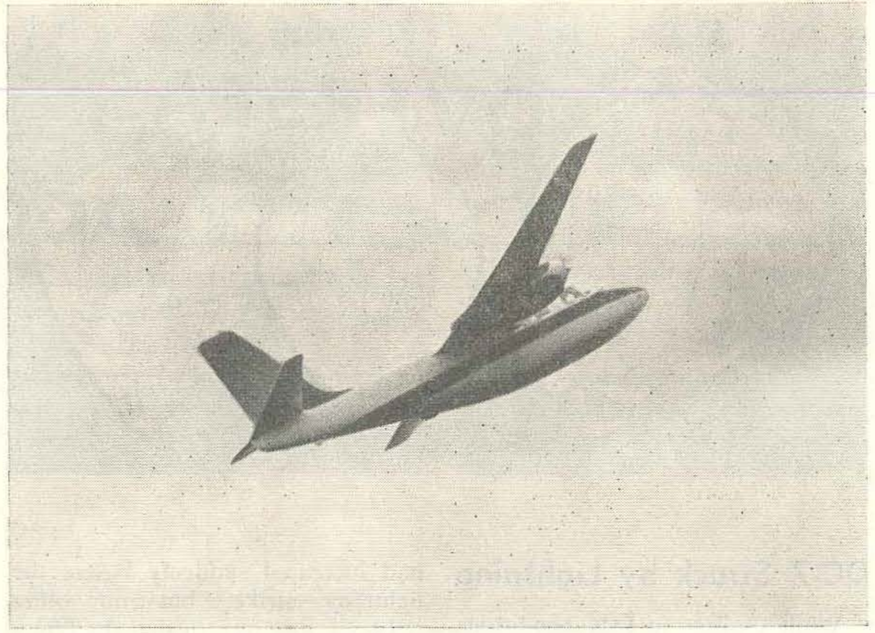
Wing Fails During Excessive Manoeuvres

On arrival over their destination airport, the crew of an Aero Commander reported an undercarriage malfunction and left the circuit area to try to correct the fault. The aircraft was next seen making a series of pull-up and wing rocking manoeuvres. Shortly afterwards, the outboard section of the port wing broke off and the aircraft spun into the ground and burned.

Examination of the separated section of the wing revealed that it had failed as a result of overloading. All failures of the lower stringers and spar caps were characteristic of tensile failure while the upper stringers and spar caps showed compressive failure characteristics. No evidence of fatigue was present. It was not possible to determine the cause of the undercarriage failure because of the extensive impact and fire damage.

The pilot in command had a total of 1159 hours on Aero Commanders, but all except four hours of this time has been flown in earlier models of the aircraft. Flight manuals for some previous models of the Aero Commander recommend the following procedure for lowering the undercarriage in the event of a complete hydraulic failure: "Place the control handle in the 'down' position. If the gear does not extend immediately, make gentle pull-ups". The positive limit load factor of these earlier models is 3.8 G, power off. The model involved in this accident has a positive limit load factor of 3.43 G, and the pull-up procedure is not recommended. An air pressure system is provided in this later model for extending the undercarriage in the event of hydraulic failure.

(C.A.B.)



Accident During Instrument Approach

While making a localizer approach to land at an airport 3,542 feet above sea level, an F 27 struck the ground approximately 9000 feet short of the runway. The aircraft was destroyed, two passengers received serious injuries, two crew members minor injuries, and the remaining occupants were uninjured.

The flight proceeded normally until it reported over the outer marker at the destination airport. After being cleared to land the aircraft entered a continuous descent which was maintained until it struck the ground at an altitude of 3575 feet just under two minutes later. The first impact marks were made by the undercarriage, and the wreckage trail extended for 800 feet to where the fuselage finally came to rest minus the undercarriage, wings and tail unit.

The captain stated that he had remained on instruments until the co-pilot reported the runway in sight. He then looked out and could see the runway lights. At this time his altimeter was indicating about 4200 feet and noting that the runway was still some distance away, he considered that he would have to close the distance before continuing to let down. He was in the process of applying power when the aircraft struck the ground. The co-pilot stated that he observed the runway at 4200 feet and advised the captain. He considered that the aircraft was low when he first observed the runway and had called out "approaching minimums" between 4200 - 4100 feet. At this stage the captain began to add power but he did not recall hearing any RPM increase before the impact. He indicated that about this time he may have been occupied in putting away the manual and that the last altitude he observed was 4000 feet. After this he was apparently not looking at the instruments nor was he looking outside the aircraft. He stated that after the aircraft had struck the ground, both the altimeters indicated the terrain elevation.

The probable cause of the accident was the captain's failure to maintain the approved minimum altitude. The failure of the co-pilot to monitor the final stages of the approach was a contributing factor.

(Department of Transport, Canada)

The Staff of Aviation Safety Digest extend Christmas Greetings to fellow members of the aviation fraternity and wish you all safe flying during the coming year.

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A Cessna 310 of the Queensland Ambulance Transport Brigade based at Cairns, picks up a patient from a North Queensland station property.

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Editorial

A series of tragic light aircraft accidents during our last winter prompted the Director-General to write to all pilots flying aircraft in this category. The theme of the Director-General's letter was to accent the hazard of operations in weather conditions below those accepted as being necessary for VFR operations by pilots not qualified for instrument flight.

Completed reports on the investigations of the accidents which provoked his letter, were not available to the Director-General at the time of writing his letter. He did however, have factual evidence of the qualifications of the pilots concerned and more than adequate circumstantial evidence to indicate that operation in weather below VFR standards was a predominant common factor.

The circumstances of three of the accidents are now described in this Digest and the applicability of the Director-General's letter is made clearly evident. In each case the pilot was not qualified for instrument flight. In each case analysis of the accident has indicated a loss of control following loss of visual reference and, finally, each case indicates that alternative action would have been available to the pilot prior to his entry into the conditions which were the ultimate cause of downfall.

By the time this issue of the Digest is distributed, we will be rapidly approaching another winter season. The majority of pilots will need no reminding that their operations should be limited to those compatable with their qualifications and experience. The small minority who have a propensity to tempt fate, would be well advised to carefully study the accidents covered in this Digest and accept, as a very well established fact, that loss of control and a catastrophic ending is the usual result of I.M.C. operations by those who are not properly qualified and recently experienced, in instrument flight.