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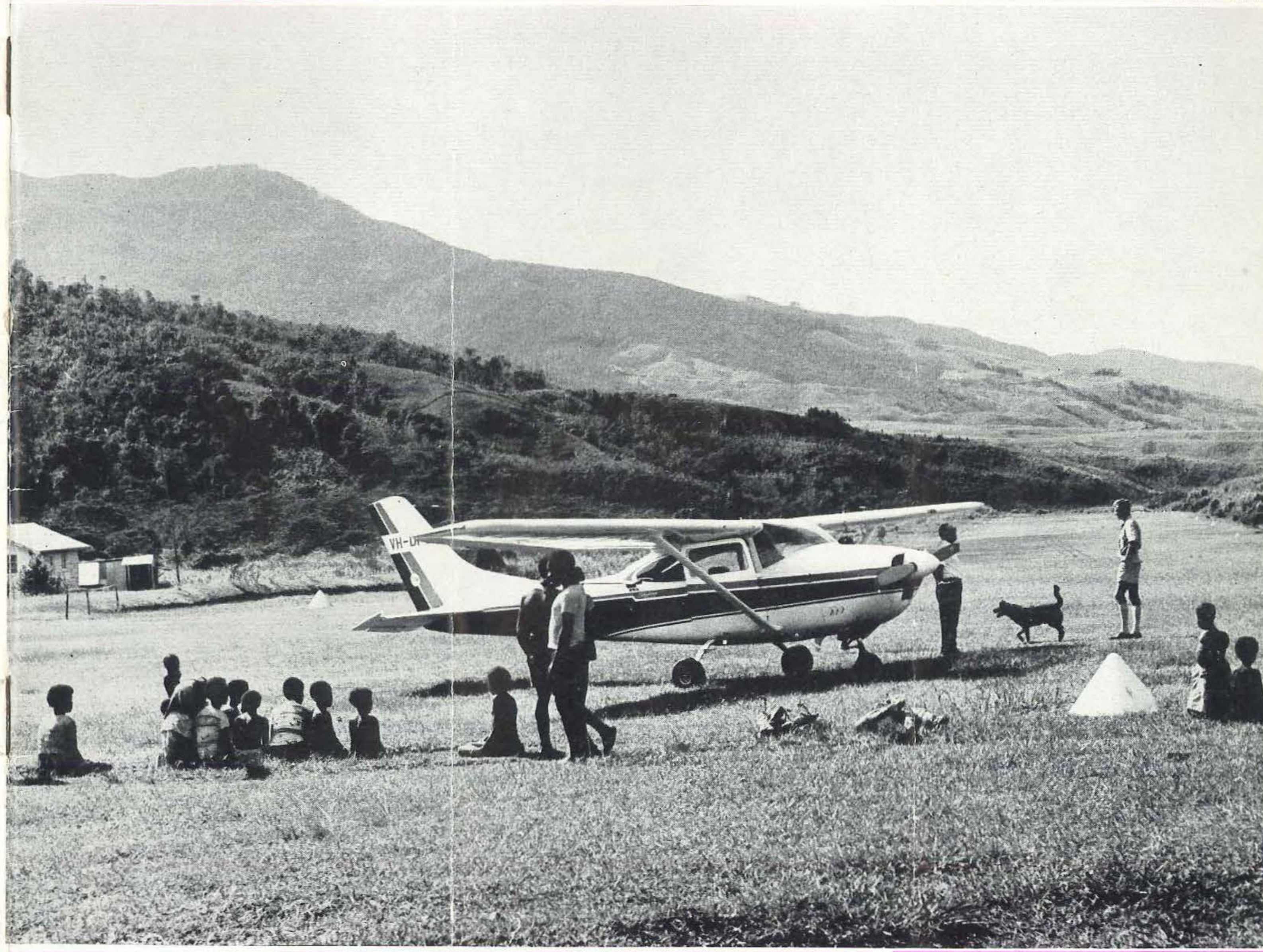
AVIATION SAFETY DIGEST

DEPARTMENT OF CIVIL AVIATION AUSTRALIA



No. 42, JUNE, 1965

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

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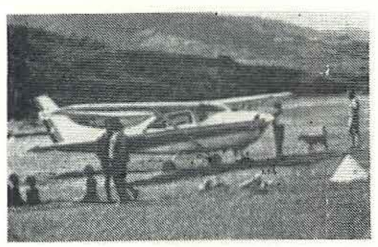


A charter aircraft from Port Moresby waits to pick up passengers from Waitape in the Central District of Papua.

LIGHT AIRCRAFT LANDING PERFORMANCE

Articles in previous issues of the Aviation Safety Digest have discussed the take-off performance of light aircraft as it is affected by temperature and altitude, wind, strip surface and slope (see Aviation Safety Digest No. 33, March, 1963, and No. 37, March, 1964*). This third article in the series reviews the standards adopted by the Department in landing distance determinations and explains the use of the PL chart for calculating landing distances for light aircraft. It concludes with a discussion of the differences between landing distances actually achieved and those obtained by use of the chart.

The act of landing an aircraft and bringing it to a standstill is essentially a process of completely dissipating the energy which the aircraft has by virtue of its motion and its height above the landing ground. To appreciate a discussion on the landing manoeuvre therefore, it is necessary to have some understanding of the basic concepts of this energy.

Energy, for this purpose, takes two forms. The first is potential energy which is derived solely from the combination of the weight of the aircraft and its height above the landing surface. The potential energy is the equivalent of the work which would be necessary to lift the aircraft from the ground to this same height and may be expressed by the formula:

Potential energy $= W \times h$ foot pounds.

where "W" is the aircraft weight in pounds and "h" its height in feet.

The second form of energy is kinetic energy which is derived from the forward motion of the aircraft. This energy is expressed by:

Kinetic energy $= \frac{W}{2g} \times V^2$ foot pounds

Where "W" is again the aircraft weight in pounds, "V" is the velocity in feet per second and "g" is acceleration due to gravity (32.2 ft./sec^2).

The energy possessed by the aircraft at the commencement of the landing phase (i.e. the sum of the potential and kinetic energies), together with the energy equivalent of any power being produced by the engine during this phase, is the total energy that is required to be completely dissipated to bring the aircraft to a standstill.

Energy is dissipated by work performed against retarding forces as, for example, aerodynamic drag, rolling drag of the wheels on the landing surface and applied braking. Any process of increasing these retarding forces will serve to dissipate the energy more quickly. Thus the use of flaps or spoilers to increase aerodynamic drag will speed the dissipation of energy and, consequently, reduce landing distance. It follows, that any reduction in the retarding forces, such as would occur when rolling drag is reduced on a slippery surface, will result in an increase in the landing distance.

The standard adopted by the Department for measuring landing distances is the distance an aeroplane travels from a height of 50 feet above the landing surface to a full stop on a level short dry grass surface, following an approach made at a speed of not less than 1.3 V_{so}, where V_{so} equals the stalling speed of the aircraft in the landing configuration. (See Fig.1).

In the initial phase of the landing the constant gradient approach, which, if continued, would lead to a touchdown at "X", is converted to a "flare" or "round out" at the transition height "Y", and this phase ends at the touchdown with almost no vertical velocity, at the point "Z". The distance from the 50 feet point to the touchdown is referred to as the airborne distance S_A. As long as the touchdown occurs at the same speed any differences due to variations in the height at the transition point "Y" will have a negligible effect on the airborne distance.

The second phase of the landing is the ground run from touchdown to a full stop. During the early stages of this phase, the airspeed is quite high and the wing is producing some appreciable lift. Since the available braking force is limited by the maximum coefficient of friction between the wheels and the sur-

* A limited number of these issues are still available and may be obtained on application to the editor.

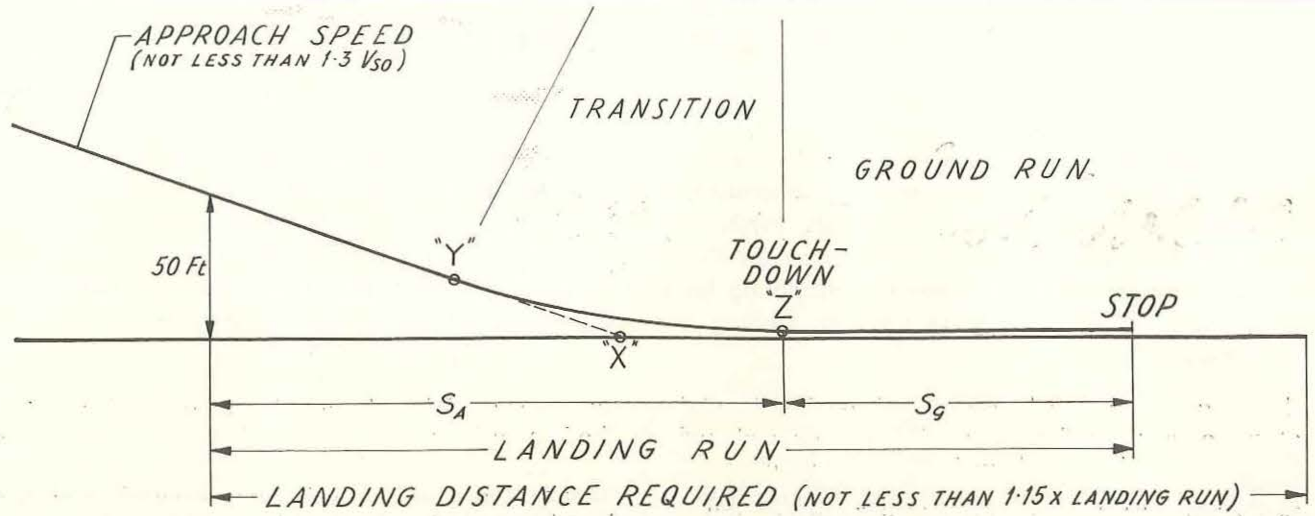


Fig. 1

face and also by the reaction on the wheels, i.e., the weight of the aeroplane minus the lift still being developed, it is necessary to reduce the lift to achieve maximum braking. On nose wheel aeroplanes this is accomplished by lowering the nosewheel as soon as possible after touchdown.

Variations in the surface conditions and differences in the amount of braking applied, both as regards the braking force and the time for which it is applied, combine to make it difficult to specify a ground run standard. When tests are carried out to establish distances to be used for the compilation of the D.C.A. Landing Charts, the situation is covered by specifying that the landing area shall be a level, short dry grass surface and that the pilot shall use maximum braking just short of skidding. This braking is to be applied as soon as practicable after touchdown and continued until the aeroplane comes to a full stop.

From the foregoing, by splitting the total landing manoeuvre into two phases the airborne distances S_A, and the ground run S_G, it becomes possible to apply corrections for the variables such as density, wind, weight and slope, separately to each phase.

PL Landing Charts

From the test results obtained during actual flight tests, the Department produces the landing charts which are issued with light aircraft flight manuals and which are commonly known as PL landing charts.

The landing chart for the Cessna 185 is reproduced in Fig. 2 and it will be seen that the chart allows for variations in airport altitude and outside air temperature, landing distance, wind and landing weight. No separate provision is made for variations in aerodrome slope as the chart is designed for normal operations permitting a maximum aerodrome slope of 2 per cent. In the production of the PL charts, however, a safety factor is applied to the landing distance actually obtained from test results, to provide a margin for variations such as slope, runway surfaces, height at transition, reduction of braking effect or other factors which might cause the actual landing distance to be longer than those in the test conditions. For aircraft below 4,250 lb., this factor is 1.15 and it increases linearly to 1.43 for aeroplanes of 10,000 lb. and above.

In New Guinea it is impossible in many places to build airstrips with slopes of two per cent. or less and the vital role which air transport plays in that country makes it necessary to utilize strips having slopes considerably in excess of the maximum normally allowed, some as much as 10 or 12 per cent. On such landing grounds, aircraft are restricted to "one way" operations, i.e., taking off downhill and landing uphill. Special PL charts providing for the effect of slope have been produced for these operations in New Guinea. These charts assume a degree of pilot competence and experience appropriate to such operations.

As in the case of take-off charts (see Digest No. 37, March 1964), the test results obtained from the effect of wind are modified for their application to landing charts. The head wind accountability in the chart is thus only 50 per cent. of the indicated value, while that for a tail wind is 150 per cent. of the indicated value. This procedure is adopted virtually throughout the world to allow for the continual variations in wind speed and direction and the time lapse which can occur between a wind observation and an actual take-off or landing. It is important to realize that wind has an effect on both phases of the landing manoeuvre. A headwind, for example, will steepen the approach gradient during the airborne phase and will also reduce the ground speed, hence reducing the kinetic energy to be dissipated.

The effect of the various factors is demonstrated on the chart at Fig. 2. The outside air temperature of 25°C and the airfield pressure height of 920 feet combine to give the density height at the point B. (The vertical axes of the first two graphs in the chart represent density height, the value at B being 2,320 feet, at which the density of the air has decreased to 0.934 times its sea level value. In compiling the landing charts however, the calibrations have been omitted from the vertical axes of these graphs for the sake of simplicity).

Using an available landing distance of 1,500 feet (C), the landing weight will be 2,620 lb. under the zero wind conditions (E). Note that for sea level conditions (A) with the same weight and zero wind as before, the landing distance required would have been only 1,400 feet (D). A 7 per cent. reduction in density thus requires about a 7 per cent. increase in landing distance.

Actual Landings

Every landing is different and landing distances differing from the chart values may result from wind conditions, aerodrome surface conditions, slope of the landing surface or piloting technique.

Differences resulting from wind are usually small or conservative, except perhaps in the case of a gusty

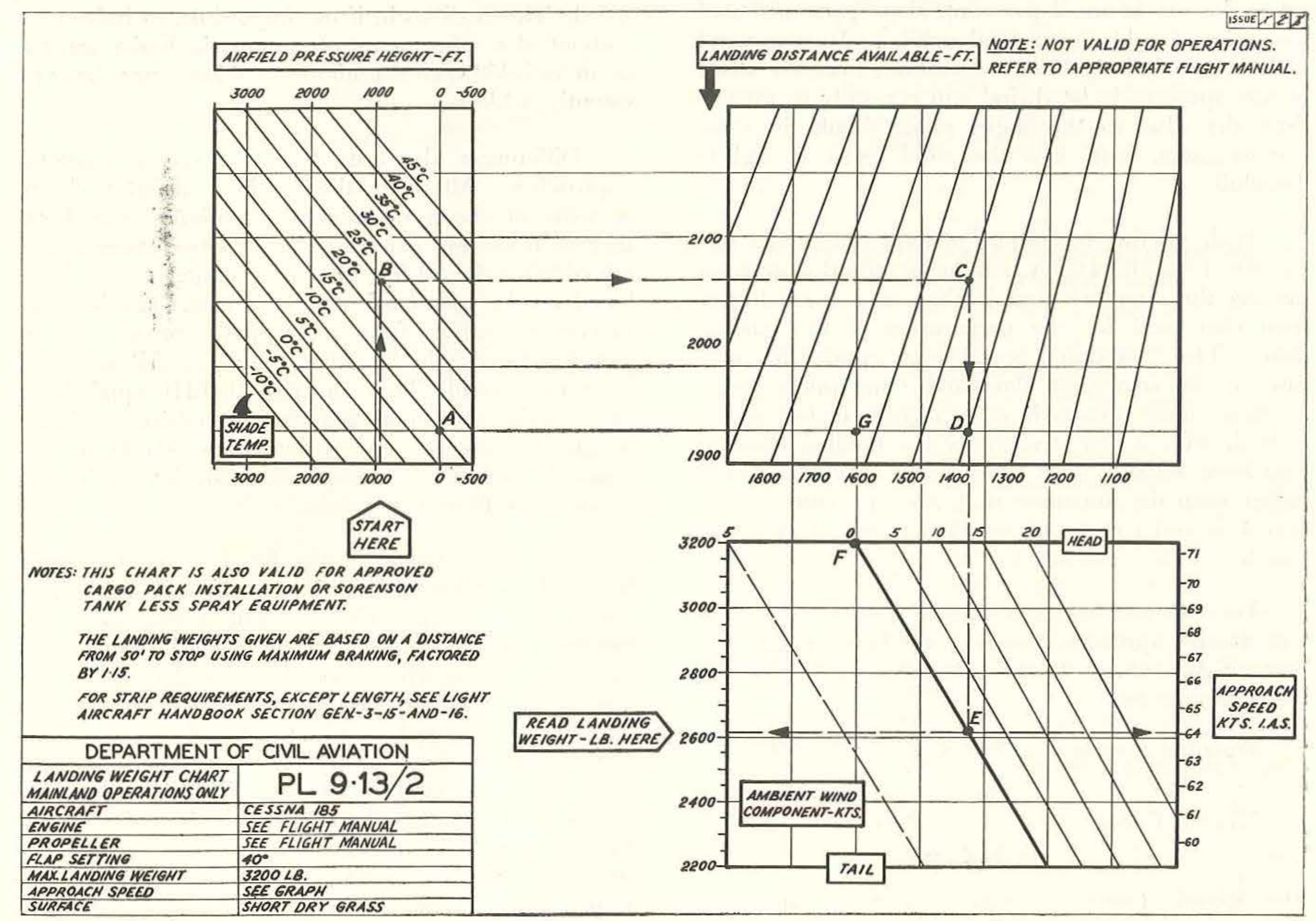


Fig. 2

crosswind, where a pilot may elect to make the landing with less than full flap with consequently less drag, higher approach speed and reduced deceleration. After touchdown, possibly at a higher speed, the pilot may be unable to use full braking because of the need to maintain directional control.

Surface conditions on the aerodrome of landing may also be different from the chart assumption. For example, rain may have fallen or the grass may need mowing.

The effect aerodrome slope has on a landing aeroplane should be familiar to anyone who has pushed a car on even the slightest of gradients. On a 2 per cent. downhill slope there would be a force component acting down the slope, equal to 2 per cent. of the aeroplane's weight. This will be effective throughout the ground run and, for the Cessna 185, will increase the ground run about 10 per cent. This is not the only effect, however. The slope also produces about a 25 per cent. increase in the airborne distance, giving an overall increase of about 13 or 14 per cent. It will be seen that the chart safety factor will only just cover the maximum 2 per cent. slope permitted and that pilots should always land uphill under zero wind or *light* tailwind conditions. However, since the effect of any appreciable headwind will generally be greater than that due to the slope, pilots should in these circumstances, land into the wind, even if slightly downhill.

With piloting technique, perhaps the biggest differences from the D.C.A. landing standard arise from making the approach and landing at a speed higher than that used for the preparation of the landing chart. The "standard" speed may appear in some cases to be somewhat slow and some pilots prefer to make their approach at a slightly higher speed. Indeed, with a few aeroplanes the landing distance tests have actually been flown using approach speeds higher than the minimum of 1.3 V_{s0} previously mentioned, in order to avoid handling problems at slower speeds.

For a Cessna 185, at a landing weight of 3,000 lb. and at the approach speed of 69 knots I.A.S. (71 knots T.A.S. at sea level) calculations will give the following energies—

$$\text{Potential Energy} = 3000 \times 50 = 150{,}000 \text{ ft. lb.}$$

$$\text{Kinetic Energy} = \frac{3000}{2 \times 32.2} \times (119.9)^2 = 669{,}700 \text{ ft. lb.}$$

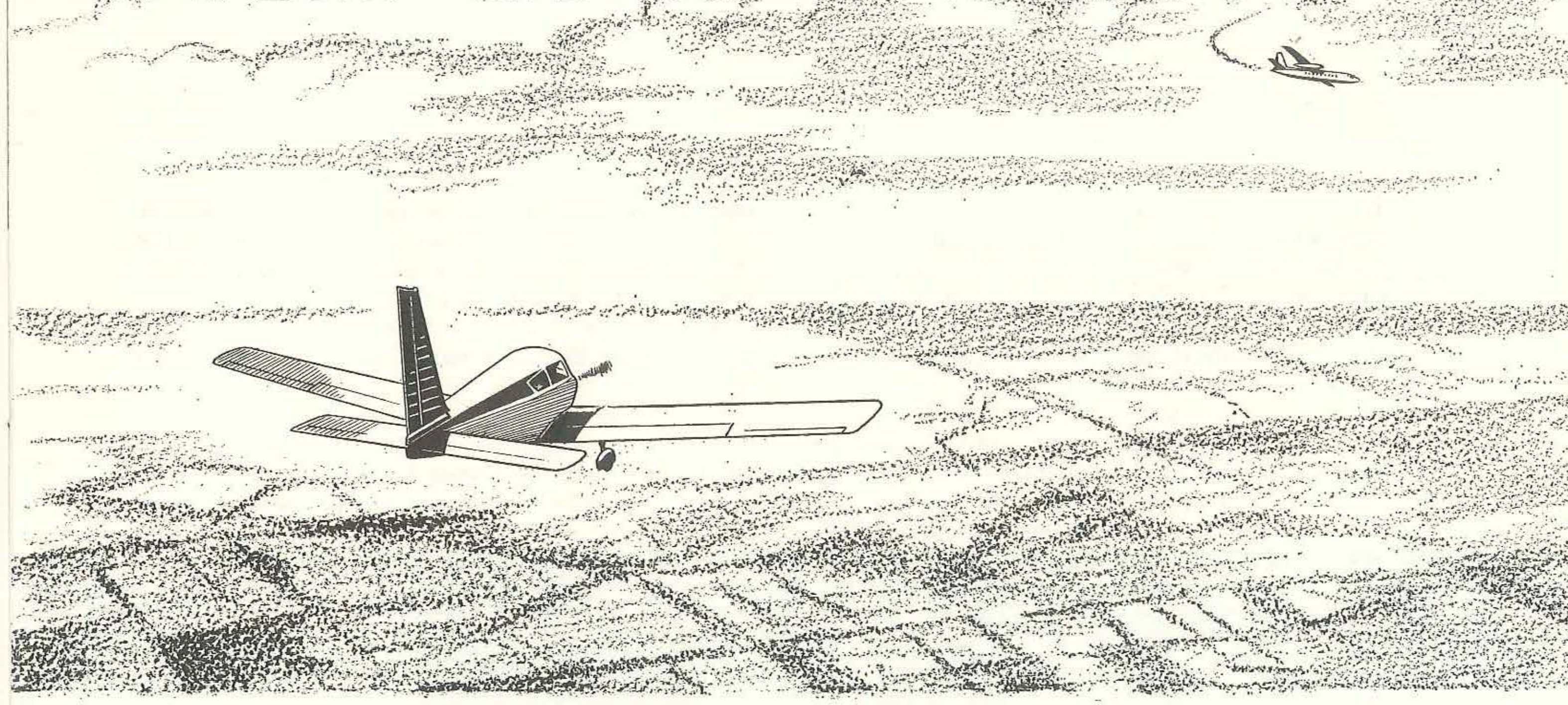
The Kinetic Energy is thus more than four times greater than the Potential Energy. It is worth noting that as well as often being the greater component of the aeroplane's total energy, the kinetic energy increases as the *square* of the velocity. Hence speed variations play a bigger part in the landing distance determination than does the height. It follows that, if the approach had been made 3 knots (4 per cent.) faster, i.e., at 72 knots I.A.S., the Kinetic Energy would have been increased by a factor of $(125.0/119.9)^2 = 1.087$. This is equivalent to making the approach at the correct speed but 40 per cent. or 20 feet higher than normal.

Another source of difference is the degree of braking employed during the landing. Clearly, tests to establish landing distances will usually aim to produce minimum figures. As already mentioned, maximum braking just short of skidding is aimed for during the tests but aeroplane owners and pilots generally would not normally apply such severe braking unless it were absolutely necessary as it is obviously hard on wheels, brakes and tyres. It should be noted that the maximum braking possible occurs before the wheel skids. It occurs, in fact, when the wheel is slowing down between 10 and 15 per cent. below the free rolling speed. This is difficult, if not impossible, to judge and without the refinements of automatic brake control or an anti-skid system, optimum braking cannot be consistently achieved.

Differences also arise from the use of powered approaches. Although the landing distance charts of some of the more modern aeroplanes have been derived from tests carried out with some power maintained after the 50 feet point, the majority have been based on the power off glide approach. The increase in energy resulting from a powered approach can be calculated using the fact that 1 BHP = 550 ft. lb. of work per second. Thus an extra 10 BHP applied for 10 seconds, when corrected for propulsive efficiency would increase the energy by about 30,000 ft. lb., which for a 3,000 lb. aeroplane, is roughly equivalent to an extra 10 feet of height.

The safety factor in the PL Landing Charts is intended to allow a margin for the effect of these variables and yet provide a realistic assessment of the landing distance required. It is obviously impossible, however, for the charts to allow for the cumulative adverse effect of all these factors, such as making an approach fast as well as high; fast and/or high when the surface is slippery; making a landing downhill when also downwind, and so on. For this reason, the charts, in themselves should not be allowed to overrule commonsense and good airmanship, and it remains the pilot's responsibility to see that his aircraft is not placed in a situation where an *adverse combination* of these variables could lead to an accident.

If you change your mind — TELL US !



The importance of promptly notifying an alteration to a flight plan has been vividly demonstrated by an incident in which a Fokker Friendship and a Piper Cherokee passed in close proximity while flying on reciprocal tracks.

The Cherokee was engaged on a dual cross country training flight with a flying instructor in command. It had departed Bankstown for Dubbo with a planned intermediate stop at Mudgee. The flight was operating below the controlled airspace and below 5000 feet, and was estimating Mudgee at 0950. After it had passed Katoomba, Sydney Communications advised the aircraft that a Piper Comanche en route from Dubbo was estimating Mudgee at 0954 and that a Fokker Friendship was taxying at Dubbo for Mudgee.

A few minutes later, at 0945, the Friendship reported setting course for Mudgee with an ETA of 1000 hours and was advised of the respective ETA's of both light aircraft. At 0954, the Friendship reported that it had commenced descent into Mudgee from flight level 75, and requested further traffic information.

A minute later the Cherokee reported that it was "well clear" of Mudgee and was now estimating Dubbo at 1036. This was the first indication to Sydney Communications that the Cherokee had overflown Mudgee, and the Friendship which was now descending in cloud, immediately requested its present position. The Cherokee again reported "well clear" of Mudgee but at almost the same moment the Friendship broke out of cloud at 5500 feet and its crew sighted the light aircraft only a few hundred feet beneath them and turned to avoid it. The Friendship then continued its descent VFR into Mudgee.

The incident occurred because the pilot in command of the Cherokee failed to advise Sydney Communications of his last minute decision to overfly Mudgee instead of landing there as originally intended. Although all three aircraft were operating beyond the confines of controlled airspace, the traffic situation obviously needed watching and it would have been good airmanship on the part of the Cherokee pilot to have kept Sydney Communications fully informed of his aircraft's movements.

The incident also underlines the necessity for VFR aircraft to keep the statutory distances from clouds—in this case the separation provided a margin for error in which the Friendship was able to take a successful avoiding action.

MOUNTAIN WAVE SYSTEMS

How to detect and avoid them

(Adapted from a Civil Aviation Information Circular published by Ministry of Aviation, United Kingdom)

The dynamic effects of mountain waves are well known to glider pilots, many of whom, in different parts of the world, spend a great deal of time trying to locate waves. To pilots of powered aircraft they can represent a hazard of magnitude, and the really powerful waves should be avoided — particularly if terrain clearance is marginal. In this context, there has been some recent speculation on possible further causes for aircraft colliding with high ground. Although the investigations of such accidents have suggested that faulty navigation was a primary cause, in the majority of cases it is conceivable that a lack of appreciation of the hazards involved in flying over mountainous regions, particularly of mountain wave effects, may have been a contributory factor.

Several years ago, the pilot of a Lockheed Lightning arrived over his destination airfield in the Sierra Nevada region of California, only to find that rising dust whipped up by strong surface winds prevented an immediate landing. The strong winds were associated with a mountain wave and the pilot realised that it would be necessary to orbit the airfield for an extended period. Faced with the need to conserve fuel, he managed to locate a region of rising air in the wave system, where he feathered both propellers and was able to soar the heavy aircraft for over an hour, until surface conditions improved sufficiently to permit a safe powered landing. The vertical currents utilised were of exceptional magnitude, estimated to have been about 8,000 ft./min. This method of fuel conservation is strictly for the birds and not for aircraft, but the episode is a dramatic illustration of the dynamic effects that can be produced by the air flow over high ground.

Research carried out on a world-wide scale during recent years has added considerably to the knowledge of the effects of airflow over high ground. The aim of this article is to set out briefly the aviation aspects of mountain waves, and to provide general guidance on how to recognize and avoid the hazards involved. As is generally known, lee waves are frequently produced when, in stable atmospheric conditions, the normal horizontal airflow is disturbed by a mountain range or a substantial ridge of high ground. The resulting wave system may persist at all levels for many miles downwind from the initiating high ground. The wavelengths may be anything up to 30 miles, the average being in the region of five miles. The speed of the vertical currents within the wave system is dependent largely upon the wind speed and the height of the initiating terrain above the surrounding lower ground. Even in the British Isles, vertical currents in lee waves have been known to achieve speeds of up to 2,000 ft./min., and mountains on a larger scale may produce speeds in excess of 5,000 ft./min.

Detection of Mountain Wave Effects

Three easily recognised meteorological conditions favourable for the formation of mountain waves are —

1. A marked stable layer, approaching the isothermal — or an inversion — through some layer of the atmosphere where the air is disturbed by the mountain.
2. Wind blowing more or less perpendicularly to a substantial ridge, the wind direction remaining fairly constant with height through a deep layer.
3. Minimum wind speed at ridge level more than about 20 knots and wind speed increasing with height. The more substantial the increase, the greater the likelihood of wave formation.

Lee waves can often be detected by the presence of characteristic lenticular (lens-shaped) clouds which may form in the wave crests. If there is enough moisture available, the ascending air produces condensation, and the formation of the lenticular or wave clouds which remain more or less stationary, despite the winds, in the crests of lee waves.

When lee waves are operating, the strongest surface winds are commonly found sweeping down the lee slope. These winds may carry the cap cloud down the lee slope during the process of dispersal by adiabatic warming. The waterfall-like cloud so formed is known as the "cloud fall" or "fohn wall".

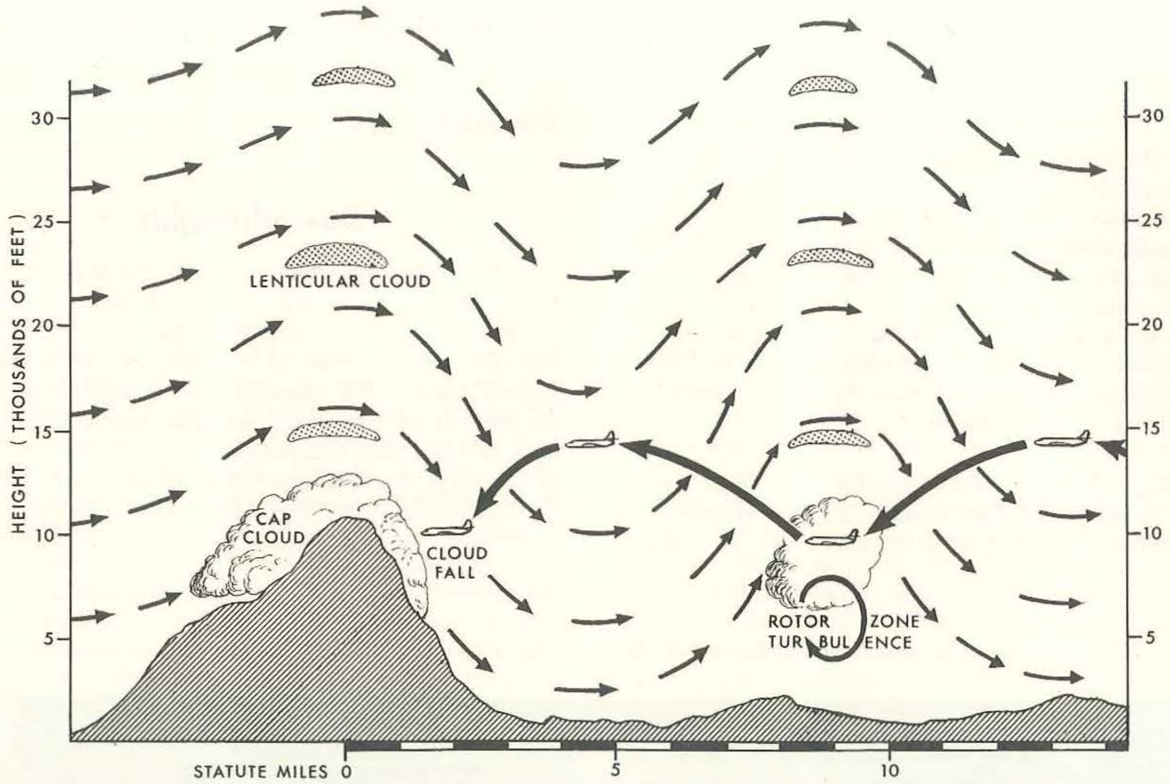
If the waves are of large amplitude, the flow may contain rotors in the crests of the waves. These rotors are commonly found at about the level of maximum amplitude, although roll clouds in the lee of the Sierra Nevadas have been known to extend beyond 30,000 feet. Because of the large vertical wind shear in the region, the characteristic rotor or roll cloud which may form, looks as though it is rotating about a horizontal axis. Violent turbulence is likely to be encountered in the vicinity of rotor clouds.

Although cloud often provides the most useful visible evidence of disturbances to the airflow, the characteristic cloud types may sometimes be masked by other cloud systems, e.g., frontal clouds. If, on the other hand, the moisture content of the airflow is low enough, lee waves may not be accompanied by cloud of any type. In such instances the movement of smoke and dust can sometimes be helpful.

Downdraughts

The extent to which an aircraft's flight path will be affected by mountain waves is dependant not only on the magnitude of the disturbance to the airflow, but also on the type of aircraft and its track and ground speed. For example an aircraft flying along the lee side of a lengthy mountain ridge might remain in a downcurrent continuously until the whole length of the ridge has been traversed. In such circumstances a catastrophic loss of height could occur. It is important, therefore, to be aware of the main topo-

Lenticular cloud in the lee of Big Ben (9,005 feet), Heard Island. ANARE Photo — A. Campbell-Drury



Schematic diagram of Leewave System showing cloud types, rotor zone and aircraft height phase relationships to the airstream when flying into wind.

graphical features of mountainous regions along the route to be flown, and in particular the main ridges and their orientations. An aircraft flying along the Spey Valley in Scotland once experienced a sustained upcurrent exceeding 1,000 feet per minute for seven minutes of the flight. Because this was in a lee wave, the aircraft might just as easily have encountered a continuous down current of similar magnitude had it been flying on a parallel course a few miles nearer to, or farther from, the nearby Grampian Mountains. The example points to the most useful avoiding action a pilot can take if he finds himself in a sustained down-current in the lee of a long mass of high ground. Whether to seek an up-current towards or away from the high ground up-wind depends upon the circumstances. If the aircraft is already so near to the high ground that the down-current is obviously descending the lee slope itself, as distinct from a lee wave further down-stream, no rising air is likely to be found until the ridge is crossed. In such circumstances it is normally wiser to look for rising air further down-stream, subject of course to there being a sufficient height margin available in that direction.

Crossing a ridge of high ground into wind when transverse winds are strong and waves are likely can be much more hazardous than doing so with the wind. There are two reasons for this. First, when flying into wind the aircraft's ground speed is reduced and it will therefore remain in the down-currents longer. Secondly, where no attempt is made to counteract height changes, the aircraft's height variations when flying into wind are out of phase with any airstream waves, so that the aircraft is at its lowest height when actually over the highest ground. This fact, which may be verified by reference to the diagram on this page, is most important when terrain clearance is marginal. For downwind flight the reverse is true, i.e., the aircraft's involuntary height fluctuations will be in phase with the airstream waves and, provided that adequate terrain clearance margins are observed, there is less likelihood of the aircraft being forced dangerously close to high ground by down-currents.

Early this year in Papua/New Guinea, the pilot of an Otter took commendable precautions to guard

against mountain wave effects but was still caught in a downdraught of alarming proportions. Whilst en route from Tari to Mendi in the Papuan Highlands, the pilot received a report that severe turbulence had been encountered in the Tari Gap, which lies between mountain peaks rising to 12,000 and 13,000 feet. The terrain clearance below the cloudbase in the Gap was only 400 feet and in view of the aircraft type's reduced performance at altitude when loaded, the pilot deviated from track to cross the mountain range 10 miles to the south where the ridge is somewhat lower. Cruising at Flight Level 100 to obtain a terrain clearance of 1,500 feet, the aircraft encountered turbulence sufficient to make control difficult as it approached the windward side of the ridge. The pilot had expected turbulence and downdraughts on the lee side of the range but was hardly prepared for what followed. Shortly after crossing the ridge the aircraft struck severe turbulence and entered an uncontrollable descent. The pilot applied full power and climb flap without apparent effect and the aircraft was forced down to within 100 feet of the terrain, before the pilot was able to regain some control. Even then, the aircraft continued to "run down" the lee slope of the ridge for about a mile before the descent could be fully checked.

As this incident demonstrates, the rate at which the height of an aircraft changes may be considerably greater during flight through mountain waves than the rates experienced in normal climb and descent manoeuvres. The vertical speed indicator should, therefore, give adequate warning of height changes caused by vertical currents in waves. Like the altimeter, it should be constantly monitored when conditions are favourable to the formation of mountain wave effects.

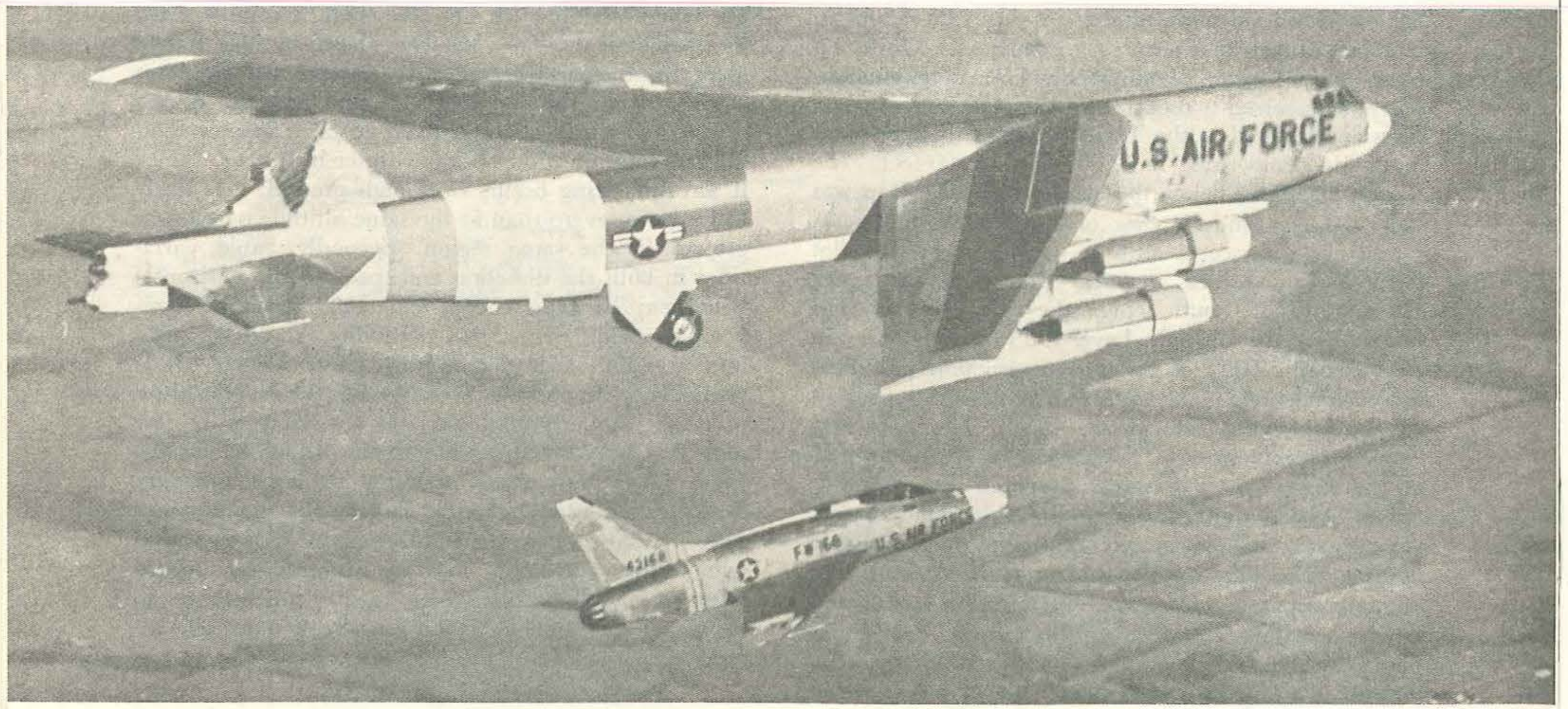
Flight with an altitude-coupled autopilot deserves special mention. In such a case, provided that the dynamic effects of the wave are within the compensating range of the autopilot system, neither the altimeter nor the V.S.I. may give any indication of the presence of waves. The instrumental indication will then be given by the airspeed indicator, as the aircraft is made to climb or descend to correct for vertical currents. The total variation of airspeed may exceed 100 knots and the airspeed may, in fact, fall alarmingly and even reach the stalling speed as the altitude-coupled autopilot attempts to correct for the height changes. In these circumstances, it is advisable to either disengage the height lock, or to revert to manual control. Particular care is necessary when flying over regions of high ground by night, or in instrument conditions.

In addition to the dynamic effects already discussed, there are other hazards that should be allowed for when planning flights over high ground. First, the adiabatic cooling brought about by the forced ascent of the airflow over high ground may result in a lowering of the freezing level and, because of the orographic effect, there is likely to be a greater than normal concentration of liquid water in the air. Thus, if airframe icing occurs over high ground, it is likely to be more severe than at the same altitude over lower ground in the same region. Secondly, rapid variations in both the direction and speed of the horizontal wind may be experienced, and could result in significant tracking errors; this possibility should be taken into account when determining safety heights. It is particularly important because, by the very nature of the terrain, navigational aids are likely to be few and far between in mountainous regions. Finally, there have been some accounts of large altimeter errors experienced by pilots flying over mountainous terrain. However, recent information indicates that while altimeter errors may be induced by airflow effects over mountainous regions, they are believed to be no more significant than the errors normally associated with pressure altimeters.

The subject of airflow over high ground is an extremely complex one, and current techniques for forecasting mountain wave conditions on a qualitative basis are still in an early stage of development and are necessarily limited in application. Pilots encountering wave effects in flight can greatly assist the task of the forecaster by reporting any in-flight encounter with mountain waves, by means of an AIREP or a special AIREP.

Turbulence

At higher levels, flight through mountain waves is likely to be exceptionally smooth, a phenomenon with which soaring pilots are familiar. Within the friction layer, however, and particularly in the rotor or roll cloud zone, the turbulence encountered may be more violent than that occurring in the worst thunderstorms. Thus a region of severe turbulence may be suddenly encountered when height clearance above the terrain has become marginal. A point worth noting here is that although the risk of entering a rotor zone is greater for upwind flight, the risk of structural failure in rotor zone turbulence would be greater for downwind flight. This is because the ground speed would be higher when flying downwind, and, since the rotor zone remains stationary with respect to the ground, the aircraft's penetration speed is related to the ground speed — not, as is normally the case in turbulence penetration, the airspeed. Some idea of the magnitude of rotor zone turbulence can be gained



This B52 bomber lost its fin and rudder in an encounter with extreme rotor zone turbulence. Despite control difficulties the pilot was able to make a safe landing.

from the recent experience of the crew of a Boeing B52 engaged on a test flight along the lee-side of the Sangre de Cristo Mountains, Colorado. After flying through a region of noticeably smooth air, the aircraft suddenly encountered turbulence which the pilot later described as "near catastrophic". The encounter lasted less than 10 seconds, but was so violent that control was all but lost, and the aircraft developed a rapid rolling tendency which required the application of almost full aileron to correct. After checking the controls, the pilot concluded that the tail unit had been badly damaged. This was confirmed by the pilot of a "chase" aircraft, who reported that most of the fin and rudder had been torn away, but that the tailplane was intact. Fortunately, the B52 still had a clearance of about 5,000 feet above the mountains and, after a 3-hour fuel burn-off period, the pilot managed to make a safe landing. Had height over the mountains been marginal at the time of the encounter, the incident might have ended differently.

Generally speaking, when conditions are favourable for the formation of mountain waves, the only sure way of avoiding flight through a turbulent rotor zone is to allow an adequate margin of safety height above the high ground.

Overseas, where there are a number of areas with high and ridged terrain, a "rule of thumb" has been suggested for avoiding flight through these turbulent rotor zones, viz.:— the clearance margin should be at least half the height of the mountains above the surrounding terrain, e.g., when flying in the vicinity of a 6,000 feet mountain range rising 4,000 feet above the surrounding terrain, the recommended minimum cruising level to avoid mountain wave turbulent effects would be:— $6{,}000 + (0.5 \times 4{,}000) = 8{,}000$ feet. It is stressed that, in addition to providing clearance from turbulence, it is necessary to take cognisance of the effects of loss of height by downdraughts.

PRECAUTIONS

A nominal height margin of 2,000 feet should be sufficient to ensure safety of flight for most operations. If, however, there are reasons to expect strong mountain wave effects, e.g., from the available forecasts or in flight reports, from the appearance of clouds or from the pilot's previous experience of the route, the best insurance against encountering severe rotor zone turbulence or sustained downdraughts is an adequate height margin above any high ground on the route.

Don't be tempted to "squeeze through" at lower levels either to avoid icing, to save time or to avoid seeking controlled airspace clearances. It may be necessary and certainly preferable, in some cases, to plan a route diversion rather than risk direct flight over mountainous terrain at heights which, in certain conditions, may be inadequate to ensure the safety of the flight. The altitude-coupled autopilot should be used with caution or not at all if flight in mountain wave conditions is anticipated. Make adequate allowances for downdraughts, particularly in low performance aircraft.

Pilots who have not encountered mountain wave effects are advised not to treat them lightly. Mountain waves have carried gliders to the stratosphere in several parts of the world, and to more than 15,000 feet even over moderate hills in the United Kingdom. Soaring pilots seek and exploit the up-currents in such waves; pilots of powered aircraft must *beware of the downcurrents.*

MURPHY IS STILL AROUND

We hadn't heard anything of old Murphy for some time but it is evident that he is still making his presence felt. A reader in Kenya has now written to tell us of an example of Murphy's Law* which he discovered during a ferry flight he was making in a DC4 from Southend, U.K., to Nairobi, Kenya.

"This incident occurred during the delivery flight of a DC4 which my company had bought at Southend, England.

"We had flown, without incident, direct to Cairo where a night stop was made, and departed again with destination Entebbe at 0400 local time. Five minutes after take-off the oil temperature on the No. 3 engine was observed to be 85 degrees, and while we watched it, rose to 90 degrees. Power on this engine was reduced and climb to our flight altitude of 11,000 feet was made with rated power on the other engines, with the idea of getting into a cooler atmosphere as quickly as possible. During the climb the oil temperature remained static between 88 and 90 degrees, but after settling into the cruise, the cooler O.A.T. and increase in T.A.S. reduced the reading to 80. After some thirty minutes it further reduced to 75 degrees where it remained throughout the rest of the flight.

"At Entebbe an inspection of the cooler was made and we discovered that the 10/32" bolt connecting the rods joining the oil cooler shutter to the ram actuating arm of the thermostatic temperature control unit had been installed back to front, so that the threaded portion of the bolt was fouling the oil cooler. It was apparent from the groove the bolt had made that this example of Murphy's Law had occurred some time ago. It is likely that the colder ambient air temperature of Europe had masked this fault, and the operating crews had not noticed it".

Murphy's Law: * "If an aircraft part can be installed incorrectly, someone will install it that way".

PERILOUS DECISION

During a take-off from an agricultural airstrip, a fully-loaded Cessna 180 failed to climb normally. The pilot dumped the load but the undercarriage struck a contour bank at the end of the strip. The port undercarriage leg was torn off and the starboard leg forced back along the fuselage, but the aircraft remained airborne and the pilot was able to climb away.

Rather than make a crash landing on the agricultural strip, the pilot decided to fly the aircraft back to its base 12 miles away, where better rescue facilities were available for the inevitable crash landing. After reaching the base strip and making a run to alert the ground crew, the pilot completed a successfull belly landing, causing little further damage other than bending the propeller blades.

What he did not know, was that in this type of aircraft, damage to the undercarriage attachments invariably means that the lift strut attachments to the fuselage have also been damaged. When the aircraft was inspected, it was found that the starboard lift strut attachment had been damaged to such an extent that the aircraft might well have lost a wing during the homeward flight. The pilot was present during the inspection and was horrified to see the seriousness of the damage to the strut fitting.

The pilot's decision to fly to a better equipped airstrip for a crash landing was in principle a reasonable one, but judgments of this nature must obviously be made in the light of possible consequences to the aircraft. *A sound working knowledge of his aircraft obviously increases the pilot's chances of making the right decision in an emergency of this sort.*

Is Your Name on Our List ?

Aviation Safety Digest is issued on a personal basis, to all flight crew licence holders (except student pilots, who may study it at Aero Clubs), licenced aircraft maintenance engineers, aircraft owners and operators and to designated medical examiners. Let us know if you are entitled to the Digest but are not receiving your copy each quarter.

Let us know too if you change your address. Quite a number of copies of each issue are returned to us through the post marked "Not Known".

When writing to us, please show your name and address clearly in block letters. This will help us to see that these particulars are correctly included on our distribution list.

Fatal Forced Landing Practice

While engaged on a training flight in the low flying area near Moorabbin Airport, Victoria, a Chipmunk crashed and burned. Both pilot and passenger were killed.

The aircraft was being flown by a seventeen year old private pilot and a friend of the pilot occupied the passenger seat. The pilot was candidate for a Commonwealth Flying Scholarship and an appointment had previously been made for him to be flight tested by a Departmental Examiner of Airmen later in the day on which the accident occurred. He had therefore arranged to make a final revisionary training flight during the morning, before undergoing his test in the afternoon.

The revisionary flight was authorized, by the duty flying instructor, as general flying to be conducted in the training area with one passenger. The type of flying to be carried out was not discussed. The Flight Authorization Sheet was initialled by the pilot, signifying that it would be made in compliance with the organization's operations manual. The manual states that pilots are not permitted to carry passengers while performing acrobatic manoeuvres, spinning or forced landing practice, and that passenger carrying flights will be authorized only if they are to be conducted at a minimum height of 1000 feet above the terrain. Shortly afterwards the pilot boarded the aircraft, the passenger installed himself in the rear seat, and the aircraft departed.

The aircraft was next seen three-quarters of an hour later, when a motorist driving along a road which passes through the low flying area, saw it flying very low over an open field. The aircraft, steeply banked to starboard, was turning slowly, and the motorist assumed that it was about to land in the field. Instead, it continued to descend in a steeply banked attitude until the starboard wing struck the ground, then it cartwheeled and immediately burst into flames. Another witness working on a building half a mile south of the crash site, heard the aircraft approaching with its engine idling, but did not see it. He then heard the engine being opened up, followed almost immediately by the noise of the crash and an explosion, and saw smoke and flames rising from the wreckage.

The field in which the accident occurred was six miles south of the airport in flat low-lying grazing country with occasional scattered trees. The field would have been suitable for a normal landing in a light aircraft. Weather conditions at the time were fine and cool with a light westerly wind and scattered cloud.

Examination of the wreckage and impact marks in the ground confirmed that the aircraft had first struck the ground with the starboard wing tip while in a 40 degree bank. The starboard landing wheel had then hit the ground heavily, dislodging the wing and rupturing the starboard fuel tank. This impact had slewed the aircraft to the right, forcing the nose into the ground, and it had then bounced and slid for 80 feet before finally coming to rest and being virtually destroyed by fire. There was no evidence to suggest that the accident had been caused by any form of mechanical failure.

The flap operating linkage was so badly damaged that it was not possible to determine the flap setting, but the port flap had been torn from its mounting and embedded at an angle in the ground as the aircraft slid sideways, indicating that the flaps had been extended at least partially at the time of the crash. The fuel tank selector was positioned to the starboard tank and the severity of the fire and way in which the aircraft had burnt confirmed that there was ample fuel in each tank. The damage to the propeller indicated that the engine had been developing power at the moment of impact. The unattached rear cockpit control column was found amongst the wreckage with the locking pin and spring clip in place, proving beyond doubt that it was not installed at the time. The concensus of evidence from the witnesses, the examination of the wreckage and the ground marks, and the post mortem examination of the occupants, indicated that the aircraft was not descending at a high rate when the impact occurred. This, together with the evidence that it had struck the ground while steeply banked, suggested that either the aircraft was engaged in a steep turn at low level or that it was recovering from a side-slipping approach.

Having regard for the fact that the pilot's flight test would have almost certainly included a forced landing approach, it is very probable that he would have been practising forced landings during his revisionary flight.

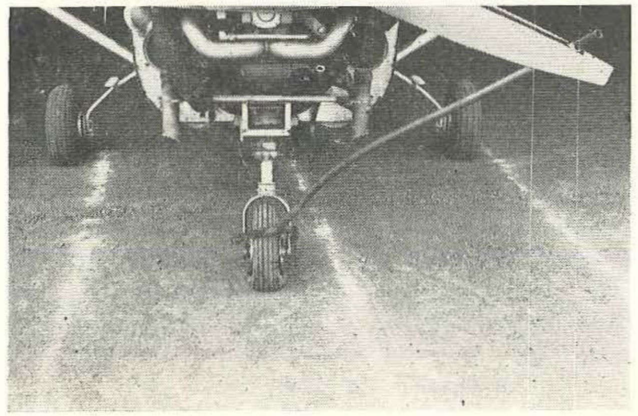
Indeed, a close friend of the pilot who also flew regularly with the same training organization, stated that it had been the pilot's intention to practise forced landings during the period of revision before the flight test.

In view of all these considerations, it is most likely that a practice forced landing was being carried out with the flaps at least partially extended. The final flight path was almost into wind and in a direction which provided the longest available landing run, but the point of first impact was well into the field. Such a practice forced landing would not normally be carried through to the point of touchdown. In this instance the pilot was probably overshooting and side-slipped the aircraft to lose height but recovery from the side-slip was delayed too long to prevent the wing tip from striking the ground.

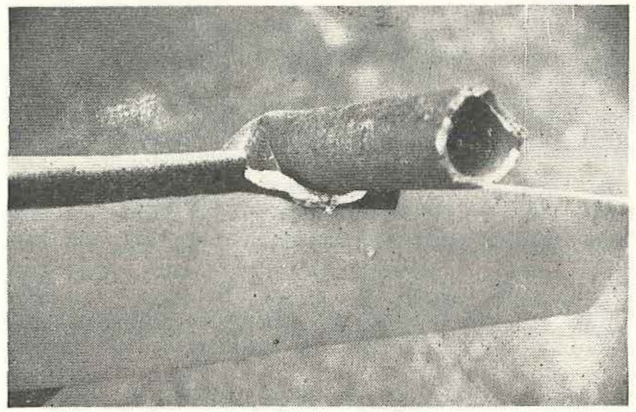
TOW BARS AGAIN

At a station property in Western Australia, the manager was attempting to contact an outstation by use of the homestead transceiver. He was unsuccessful, but decided to try again using the H/F equipment installed in his Cessna 175.

Going to his hangar, the manager pushed the aircraft outside and climbed into the pilot's seat to operate the radio. Again he could not make radio contact so he proceeded to start the engine with the intention of charging the battery and taxiing clear of the buildings for a further attempt. He did not make a pre-flight inspection before starting as he had no intention of flying.



The damaged tow bar repositioned, showing how it had been caught by the propeller blade.



After starting up and taxiing forward a few yards there was a loud metallic bang from the front of the aeroplane. The pilot immediately stopped the engine and climbed out to see what had happened. He found the nose wheel tyre flat, a piece of metal missing from the wheel rim, a badly damaged propeller blade and a cracked reduction gear housing, but could find nothing on the apron that could have caused the damage.

Still unaware of the exact cause of the accident, the manager pushed the aircraft back into his hangar and later reported the occurrence to Perth by telephone.

Two days later, a station employee found the badly bent nosewheel tow bar lying in scrub 75 yards away, where it had been flung by the propeller.

The tow bar, made from ¾" black iron water pipe, had been in position on the nosewheel when the aircraft was pushed out of the hangar, but had not been noticed. The bar was unpainted and its natural rust colour made little contrast with the gravel floor of the hangar.

COMMENT:

This is the sixth accident of this type that we have had to report in the Digest in two years (see "The Importance of Pre-Flight Checks", June 1963, and "Look Before You Leap Aboard", June 1964). On these other occasions we have expressed our amazement that anything as obvious as a tow bar could go unnoticed. We still find it hard to believe, even though circumstances seem to be proving us wrong. This case of the RUSTY tow bar offers a clue to the problem. Perhaps if tow bars were painted in bright colours they wouldn't be so easily missed!

Auster dives into Ground during Aerotow

(Summary based on Report issued by Ministry of Aviation, United Kingdom)

During the initial climb after a glider towing take-off from Lasham aerodrome, Hants., U.K., an Auster tug aircraft dived steeply to the ground and burst into flames. The pilot was killed. The tow rope broke and the Skylark II glider landed back on the aerodrome.

The flight was one of a series of aerotows taking off towards the south-west during the afternoon. The weather was fine with a slight haze and the wind was from 240° at 8 to 10 knots. The sun was low on the horizon to the south-west. The pilot of the tug aircraft was 32 years of age and held a valid private pilot's licence. His total flying time amounted to 450 hours, of which 173 were on Austers. He had completed 140 hours aerotowing in this type of aircraft and was an experienced gliding instructor. The pilot of the glider was 65 years of age and held a Silver 'C' glider pilot qualification. He had accumulated approximately 122 hours flying which included 150 aerotows as the pilot of a glider.

The glider was attached to the Auster tug by 120 feet of nylon rope and when the slack had been taken up the aircraft began the take-off run. As soon as the glider became airborne, its pilot flew level until he saw the wheels of the tug aircraft leave the ground. He then climbed the glider to take up the "high tow" position with the glider high enough behind the tug for him to see over the tug's wings. When he reached this position he was momentarily blinded by the sun shining through the perspex of his cockpit canopy. This was a phenomenon he had experienced previously and since there was no unusual feel in the controls he thought the tug and glider were still properly positioned in relation to each other. However, the glider rose to an unusually high position and when the glare of the sun became less the pilot realised the tug was not where he expected it to be. He at once put the nose of his glider down to find it and as he did so he felt the cable part. He immediately climbed the glider, and was able to make a circuit and land back on the aerodrome. The glider pilot was unaware of the accident to the Auster until he had landed.

During the take-off, an abrupt cessation of engine noise had attracted the attention of a number of persons on the ground and the Auster was seen apparently stationary in the air at about 300 feet in a slightly tail down attitude. It then flicked into a dive and plunged vertically to the ground. The witnesses heard no sound from the engine and saw no sign of any attempt to recover from the dive.

Examination of the wreckage revealed no evidence of pre-crash failure or malfunction of the engine or airframe. The condition of the propeller indicated that the engine was turning at the moment of impact but was not under high power. The tow rope was found about 25 yards from the wreckage. It had broken at the splice round the eyelet at the glider end and had been released from the hook of the tug aircraft. There was no evidence that the rope had fouled either aircraft. Examination of the release hook revealed that it was in good working condition and its moving parts well lubricated. Tests carried out under various loads up to 900 lb. and at tow rope angles up to 45° established that the force required for the pilot to operate the release did not exceed 18 lb.

Aerotowing by Tiger Moths and Austers is a common method of launching gliders and it is estimated that in the United Kingdom some 80,000 aerotows have taken place since 1946 without serious incident during the take-off phase. However, there have been occasions when a glider has climbed to an unusually high position and the pilot of the tug has found his aircraft suddenly diving steeply. In this case, however, the evidence that the Auster had appeared to be stationary in the air before the subsequent vertical dive, indicated that it had stalled.

When an aeroplane is towing a glider in the high tow position, the tension of the tow rope varies with the position of the glider in relation to the tug. This tension may be divided into rearward and upward components. The former affects the performance of the tug by adding to the total drag to be overcome by engine power; the latter affects the fore and aft trim of the tug. As the glider rises above the level of the tug it becomes necessary for the tug pilot to counteract the upload on the tail of his aircraft, and the resulting tendency to pitch nose down, by applying "up" elevator. Calculations show that at a speed of 55 knots and with a tow rope angle of 60° the pilot of the tug would have to apply maximum "up" elevator to counteract an upload on the tail of approximately 150 lb. If the glider continued to climb the upload on the tail would increase beyond this figure and the tug would then be tilted nose down. This would increase the vertical distance separating it from the glider and almost instantly increase the tension on the rope to breaking point.

In such a sequence of events, the aircraft might be pitched steeply nose down but it would not stall.

However, if whilst the tug pilot was using maximum "up" elevator, the upload was suddenly removed, the tug would immediately pitch nose up at an acceleration of 130° per second per second and stall in one-third of a second. If the upload was reduced by the glider descending, the effect would be similar but less violent. For example, if the glider pilot put the nose of his aircraft down so as to reduce the lift by half, the glider would start to accelerate downwards at 0.5g. and the tug would pitch nose up at an acceleration of 60° per second per second and stall in half a second. The nose of the tug would pitch down very steeply at the stall and several hundred feet would be needed to recover.

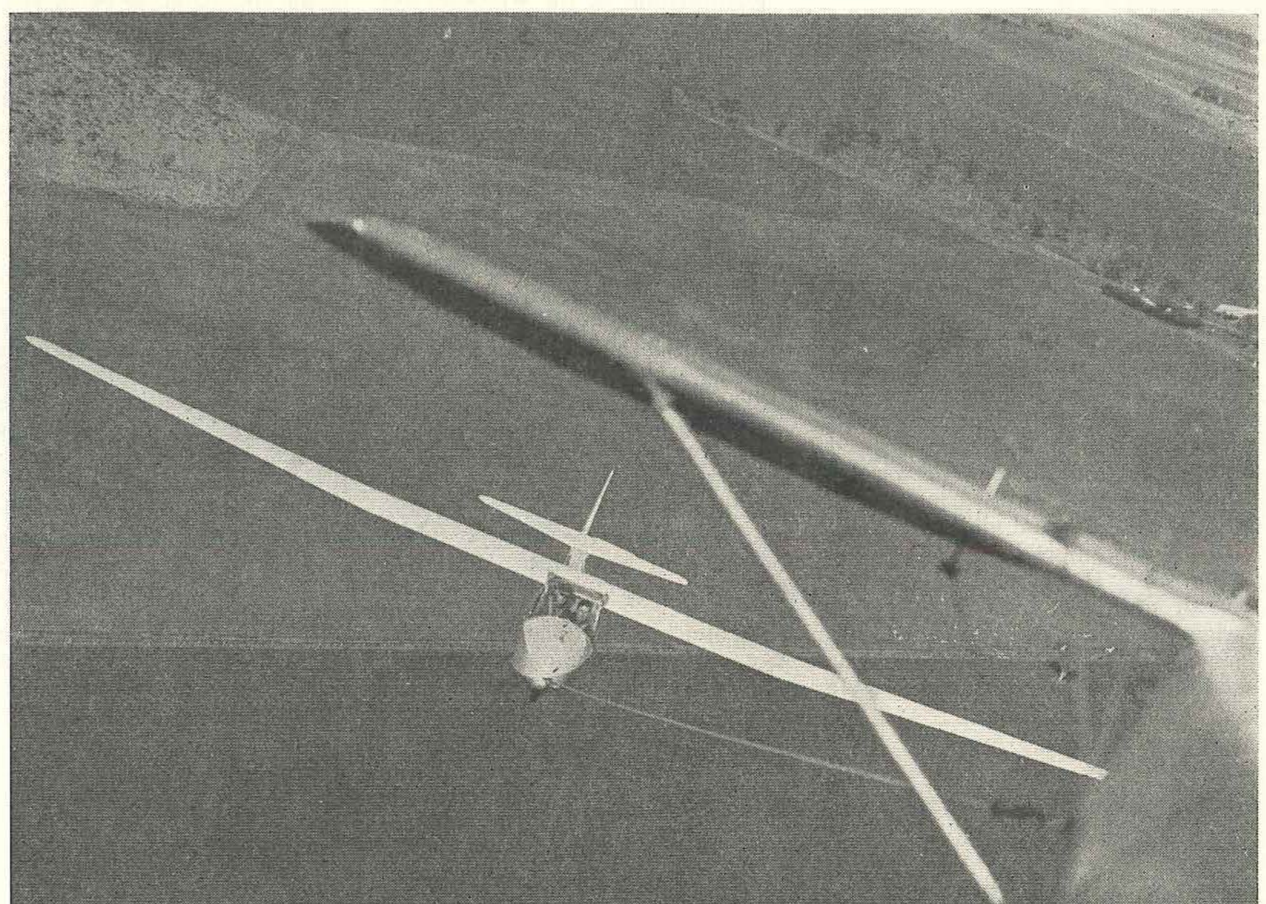
For a number of reasons, the preferred position of a glider on tow is just above the slipstream of the tug. The tug pilot can then see the glider in his rearview mirror, the glider pilot can see the ground as well as the tug, and the tow rope can be released without risk of fouling the glider. In the normal towing position the angle of inclination of the rope is 10° or less. The manual of glider flying training published by the British Gliding Association calls particular attention to the risk of depriving the tug pilot of control by flying the glider too high. Tug and glider pilots are instructed during training to release the tow rope if the glider should get too far out of position, particularly if too high, or if visual contact between the aircraft is lost for any reason. In a Skylark II glider, the pilot would find his view of the tug cut off by the nose of his glider when the angle of inclination of the rope increased beyond 20°.

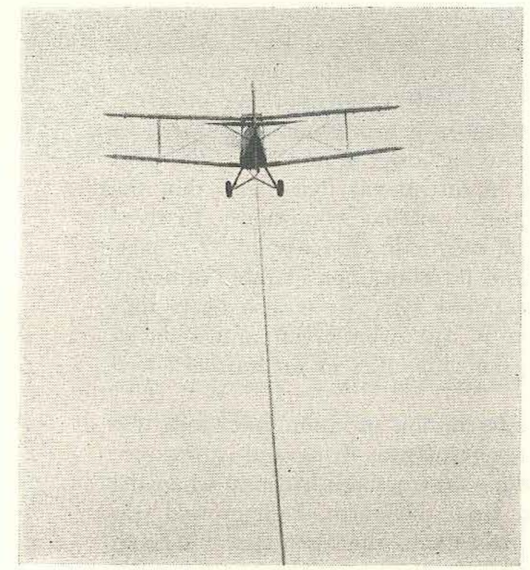
On this occasion it is possible that when the glider continued to climb beyond its proper station, the tug pilot thought it merely an overshoot that would be corrected at any moment and so refrained from releasing at once. The loss of visual contact by the glider pilot, the lowering of the glider's nose to try to regain contact and the breaking of the rope, took place in a very short period of time and it appears that either lowering the glider's nose or the rope breaking caused the tug to pitch up and stall before its pilot could prevent it.

In the opinion of witnesses who were aircraft engineers, the cessation of the noise of the tug's engine was not suggestive of engine failure and no evidence of pre-crash damage or malfunction came to light. It was considered probable that the tug pilot had closed the throttle when the situation in which he found himself became alarming.

The tug pilot was responsible for choosing the direction of take-off and on this occasion, as on his three previous flights, he chose to take-off into wind towards the sun. The British Gliding Association's manual of flying training enjoins tug pilots not to tow towards a blinding sun, but the inadvisability of towing into the sun in this case might not have been appreciated in the hazy weather prevailing. No difficulty had been experienced earlier that day.

Kookaburra glider in low tow position as seen from tug aircraft.





DH.82 tug as seen from glider in low tow position. →

There is little doubt that control of the tug aircraft was lost when the glider pilot blinded by the sun, allowed the glider to climb into an abnormally high position. It is probable that both pilots failed to appreciate how quickly a dangerous situation was developing, and delayed too long in releasing the tow.

COMMENT:

This accident is strikingly similar to one which occurred to a DH.82 engaged in glider towing at Alice Springs in September, 1960.

On that occasion, the aircraft had taken off and climbed to about 200 feet when the glider pilot unintentionally let the glider sink into the tug's slip-stream. In attempting to regain the normal high tow position, the glider climbed abruptly. The tail of the DH.82 was pulled up almost vertically, the tow rope broke, and the DH.82 dived into the ground before the pilot could recover. The pilot was killed and the aircraft completely destroyed by impact and fire. Despite the hilly nature of the terrain below, the glider pilot was able to make a safe landing nearby. Subsequent tests with a DH.82 showed that an abrupt vertical dive, entered from level flight at 65 knots, required almost 500 feet for recovery.

The Gliding Federation of Australia had produced written instructions on aerotowing which stated ". . . if the glider flies badly out of position, the load on the rope may over-ride the tug pilot's efforts, and the tug pilot may have to release the tow rope in the interests of safety". Although the tug pilot had signed as having understood these instructions before flying commenced on the day of the accident, it was apparent that he had hesitated to release the glider when it had begun to pull the tail of his aircraft upwards. The pilot was probably reluctant to release while the glider was at such a low altitude over difficult terrain, but this was believed to be the primary cause of the accident.

Although it has been necessary to go back to 1960 to find an Australian accident comparable to the one described in the United Kingdom Report, this does not blunt the truth that there are very real hazards in aerotowing if the proper precautions are not observed.

The "low tow" technique has been developed by the National Gliding School in Australia to provide a greater margin of safety for the tug pilot. To move from the low tow station into an abnormally high tow position, a glider has to pass through the tug's slip-stream while the tug is in full view of the glider pilot. The glider pilot thus has ample warning that a potentially dangerous situation is developing. This is a considerable improvement over the relatively brief warning period available to a glider pilot flying in the high tow position.

Even so, the fact that the low tow technique is now widely used in Australia, does not preclude the possibility of an aerotowing accident if the correct procedure is not followed or if the pilots concerned fail to appreciate the dangers associated with this form of aerotowing.

To assume the low tow position, after a glider has become airborne in the initial stage of an aero tow, the glider pilot is required to keep the glider about six feet above the ground until the tug aircraft becomes airborne and climbs above the glider's position. As the tug accelerates to take-off and climb speeds this entails exercising a progressive forward pressure on the control column, even with the trim in the fully forward position. Any relaxation of this forward pressure, or a slight backward movement of the control column will cause the glider to rapidly climb away from the tug when the tug has reached take-off or climb speed. This, if not checked, will quickly place the glider in an abnormally high-tow position.

One other vital fact that emerges from the accident in the United Kingdom is the rapidity with which a tug aircraft can stall if an abnormal upload on the tail is suddenly removed. This, together with the fact that a tug pilot has no **real** way of assessing whether or not the glider pilot is getting into difficulties, suggests that some thought should be given to the development of an over-ride release mechanism which would operate automatically if the upload on the tug aircraft's tail approaches dangerous proportions.

Fatal VFR Operation in U.K.

The last issue of Aviation Safety Digest placed particular emphasis on the dangers of flight by inappropriately licensed pilots in weather conditions less than those stipulated as the minimum for V.F.R. operations.

Now that the winter with all its attendant weather problems is actually upon us, it is timely to quote from a report which we have since received from the United Kingdom, describing another similar type of accident. This occurred to a Proctor flying from Paris to Lympne.

The sections of the report headed "Observations", "Conclusions" and "Opinion" quite starkly illustrate the lesson that we have been trying to drive home from our own accident history. We cannot do better than quote them as they are.

Observations

The pilot and passenger departed from Dublin on 5th October, 1963, for Milan and Genoa, 19 days after the pilot obtained his private pilot's licence; it was on the return flight that the accident occurred.

To have embarked on such a flight so soon after obtaining his licence suggests the pilot was very confident despite his limited flying experience. The success of the previous stages of the flight may have induced a measure of over-confidence, for regardless of an adverse forecast for the latter stages of the flight to Lympne, he departed from Paris and took the risk of being caught out in weather conditions requiring instrument flying skill which he lacked.

The flight instruments disintegrated as a result of crash damage and provided no evidence as to their pre-crash condition. Although in reply to a request by the Lympne controller the pilot said something to the effect that his instruments were not working properly, it is not considered that this necessarily warrants an assumption of instrument unserviceability. It has to be borne in mind that the pilot was inexperienced and untrained in instrument flying and that the aircraft was flying very low in adverse weather conditions. In these circumstances the behaviour of the magnetic compass might appear erratic to an inexperienced pilot and introduce considerable difficulty in any attempt to re-set the directional gyro. It is also likely that drizzle caused partial obscuration of the windscreen and reduced forward visibility, thus adding to the difficulties of an inexperienced pilot.

It seems probable that the interruption of communications was due to the low height at which the aircraft was flying and its distance from Lympne. After communication was re-established and when the aircraft was approaching Lympne from the north, high ground was encountered. In the final stage of the flight the aircraft was seen in a valley flying very low on a southerly heading. There seems little doubt that because of the rising ground ahead the pilot turned back towards the north and, when doing so, entered low cloud. It appears he then throttled back the engine to become visual again but a few seconds later saw trees and increased engine power to avoid striking them.

Conclusions

1. The pilot was properly licensed.
2. The aircraft had been properly maintained.
3. There was no pre-crash failure of the aircraft or its engine and, in spite of the reference in a radio message to instruments not working properly, there appears no reason to conclude that there was a flight instrument defect.
4. Lympne Air Traffic Control gave the pilot all reasonable assistance.

Opinion

The aircraft struck trees on high ground when being flown in conditions of low cloud and poor visibility which imposed a task beyond the pilot's training and experience.

Inspect before... you fly!

It is seldom that the incident reporting system reveals weaknesses and inadequacies in the performance of daily inspections on light aircraft. The reason for this is undoubtedly the conscientious attitude displayed towards this vital task by responsible maintenance engineers, authorised commercial pilots and private owners.

Unfortunately, the same diligence is not nearly so apparent in the case of intermediate pre-flight inspections. The reason for this is no doubt circumstantial. Often the aircraft concerned has already flown many miles from its base and far from the watchful eye of its organization's chief maintenance engineer; it may be in the hands of a comparatively inexperienced pilot, or its operators may be rushing to try and squeeze as many hours out of the one day as they can. In addition, the aircraft's usually faultless performance on the first leg of the day's flying has more than likely persuaded the pilot that nothing could be wrong anyway. The nett result is then enroute pre-flight inspections often consisting of a cursory glance at the fuel contents and the oil dip stick. The circumstances of a recent incident provide a timely warning against such "She'll be right" attitudes.

Arriving in Moruya, New South Wales, after a private flight from Bankstown, the pilot of a single-engined Cessna parked his aircraft on the apron and went into town with his two passengers. Two hours later the party returned to the aerodrome and departed for Albion Park, where the pilot intended to refuel before continuing the homeward flight to Bankstown.

During this leg of the flight, the airspeed indicator was registering five knots less than usual at cruising power and the aircraft tended to fly slightly port wing low. After the aircraft had landed at Albion Park, it was seen that something had obviously struck the leading edge of the port wing about eighteen inches inboard from the tip.

The pilot telephoned his maintenance organization at Bankstown and reported the damage appeared to be minor. On the basis of this information, the pilot was told that an engineer's inspection should not be necessary and that if he was satisfied with the condition of the aircraft, there was no reason why he should not continue to Bankstown.

The aircraft completed the flight safely, but later when an assessment of the damage was made it was found that as well as an indentation in the leading edge, the wing had been buckled some distance aft from the leading edge. Further inspection showed that the end rib was severely buckled and that the spar booms were bent.

It was not possible to determine the cause of the damage beyond all doubt, but a thorough investigation led to the conclusion that had someone attempted to drive a vehicle beneath the port wing of the aircraft while it was left unattended at Moruya.

The incident stresses not only the need for proper pre-flight inspections but also the necessity for making an accurate assessment of any damage caused to an aircraft, before it is cleared for flight.

With respect to your Aircraft....

Suppose you were driving in the outback and someone suggested that you should save time and take a short-cut by turning off the road and driving across country at high speed. Would you do it? Of course you wouldn't, even if the country was open and looked safe enough! You would have more respect for your motor car; moreover, you would probably have some serious doubts as to the sanity of your adviser!

However ridiculous such an idea might seem when presented in this way, it is not really so very far removed from what some general aviation pilots are doing every day to their aircraft — machines worth in most cases many times the value of a motor car! It is paradoxical that trained, competent and otherwise careful pilots are time and again causing serious damage to costly aircraft by attempting to land on terrain that "looks all right" from the air. Overall flying experience seems to have little bearing on a pilot's propensity for this type of accident; the list of culprits ranges from aero club private pilots to the most experienced professionals. An account of a few of the accidents that have occurred from this cause during the past twelve months will show what we mean.

March, 1964

The pilot of a Bonanza engaged on a charter flight to a Queensland cattle station was unable to locate his destination after being forced to divert around several storms. Finding a homestead and what appeared to be a cultivated paddock, the pilot decided to land and determine exactly where he was.

As the aircraft touched down, what the pilot had taken for cultivated black soil covered with stubble, proved in fact to be clumps of basalt rock up to 9 inches in diameter. The nose strut was wrenched off completely, both main landing wheels were smashed, and the aircraft itself was substantially damaged as it lurched on to its nose and skidded to a halt on the rock strewn ground.

Although the pilot was unsure of his exact position, he knew the aircraft's whereabouts approximately and there was no operational necessity for an immediate landing. The aircraft was fitted with radio navigational aids and its remaining endurance was 2 hours 20 minutes — more than ample to have enabled the pilot to safely fly to any one of three alternative aerodromes.

October, 1964

A Cessna 210 landed on a station airstrip in western New South Wales where recent heavy rains had softened the ground. Towards the end of the landing roll, the nose wheel of the aircraft sank 18 inches into a mud patch and stopped the aircraft suddenly. The rapid deceleration lifted the main wheels completely off the ground and the whole aircraft pivoted through 35 degrees on the nose strut, then struck the ground again with the port wing tip and the port main undercarriage. The fibre-glass wing tip was shattered and the port wing was buckled in several places.

November, 1964

A PA-24 had been chartered to carry an urgently required machinery part to a farming property in north-western New South Wales. There was no recognized airstrip in the near vicinity but from the air the pilot selected what he considered was a suitable landing area in a paddock. Just after touching down, the underside of the port wing rode over a tree stump 3 ft. 6 in. high. The stump broke through the lower skin of the wing and the force of the impact fractured the main spar. The stump had been burnt and its blackened appearance merged into the surrounding black soil.

December, 1964

While taxying to a take-off position on a privately owned strip in South Australia, an aero club Cessna 172 collided with an unseen tree stump protruding about six inches above the ground. The impact was sufficient to break the rim of the aircraft's nose wheel.

January, 1965

A PA-24 was making a charter flight with four passengers to a station property in the far north-west of New South Wales. The pilot had been informed that the intended landing ground at the destination was a clay pan, where other aircraft had landed previously. He was assured that it was suitable and as well, arrangements were made for the surface to be checked with a truck before the aircraft landed.

On arrival over the site, the pilot saw a vehicle on the clay pan and a landing strip marked out with sheets of paper. A road crossed the up-wind end of the marked strip 200 feet from a clump of trees at the edge of the clay pan. Although the strip appeared to be short, the pilot considered that the aircraft could safely cross the road during the landing run and so utilize more than the marked strip length.

The aircraft touched down 30 feet inside the marked threshold, bounced twice and was then braked heavily. Still rolling fast, it crossed the road with a severe bump and bounced again. The pilot was forced to deliberately ground-loop the aircraft through 90 degrees, and it finally skidded sideways to a stop only 20 feet from the trees.

Inspection showed that the starboard undercarriage leg had been pushed three inches rearwards, extensively damaging the wing structure. It was found that the road had 12 inch shoulders where it crossed the clay pan and that the entire length of the landing run was only 1445 feet. The performance chart for the aircraft indicated a required length of 2,700 feet.

January, 1965

A Cessna 172 flown by a private pilot was enroute from Albury to Moruya, New South Wales, when deteriorating weather was encountered over the Great Dividing Range 15 miles east of Bredbo. The pilot turned back with the intention of landing at Adaminaby.

The aircraft soon flew back into fine weather and on passing over Bredbo again, the pilot decided to land there and remain overnight instead of returning the additional 19 miles to Adaminaby. He chose a paddock and landed safely, despite the fact that the surface was dotted with outcrops of granite a few inches high.

On the following morning the pilot removed a number of loose rocks and selected a take-off path of sufficient length but having a tranverse slope of about four degrees. During the take-off run, the aircraft swung slightly down the slope and ran into an area of rocky outcrops. The nose wheel rim shattered, the nose strut collapsed, and the aircraft skidded 30 feet on its nose, destroying the propeller, buckling the fuselage and fracturing the port wing rear spar.

In some of these cases, the pilots concerned had made what might have seemed adequate enquiries about the suitability and serviceability of their intended landing ground. In the light of subsequent events however, it is clear that the pilots' specification of minimum requirements on their informants' assessment of the area, or even the process of communication between the two, must have been totally inadequate.

Over the years many, many capable pilots have learned to their cost that merely accepting a layman's assessment of a "safe" landing ground can often lead to a very hazardous operation. Your light aeroplane is an expensive and complicated piece of machinery. Treated with respect it can provide you with a great deal of pleasure and profitable utilization. Except in a dire emergency don't endanger it by attempting to land on doubtful surfaces — the risk far more than outweighs what you could possibly stand to gain. Make it a rule not to land on an unrecognized landing area without first inspecting it from the ground yourself or obtaining reliable advice from a *knowledgeable person* familar with aircraft operations !

WATCH THE LOADER

The effective teamwork of experienced agricultural pilots and loader drivers is often a performance well worth watching.

Agricultural pilots must nevertheless be constantly on their guard to see that the high standards of efficiency which they achieve in this way, do not compromise their airmanship — things *can* go wrong sometimes !

In a recent agricultural accident, a loader vehicle stalled as it was backing away after loading a Beaver with superphosphate, then rolled forward again slightly. The pilot, thinking the loader was out of the way, opened the throttle to taxi and the tailplane collided with the vehicle's mudguard, causing substantial damage.

The accident could have been avoided if, before commencing to taxi, the pilot had checked to see if he had adequate clearance from the loader, instead of assuming he had clearance on the basis that the vehicle had started to move away.

Beginner's Luck ?

Familiarity with your aircraft is essential to safe cross-country flying. This private pilot has learned what can happen without that knowledge.

While making a holiday trip with three friends in a Cessna 172, our aircraft was involved in a mishap which only luck prevented from leading to something much more serious.

We had made an early start from Blackall, Queensland and had landed at Winton to refuel before flying on to Mt. Isa. The aircraft had more than a full quota of luggage in the rear compartment and when we parked in front of the refuelling point and climbed out, the tail plane was sitting very low.

We were in a hurry to be on our way again — we had a passenger who was very prone to airsickness and we wanted to make the most of the early morning's smooth flying conditions. As soon as the refuelling had been completed, three of us pushed the aircraft away from the refuelling shed. As it rolled backwards over a small mound the tail swung down and the trailing edge of the elevators dug into the ground. I had a quick look at the elevators but as they seemed to be undamaged and moved in the correct sense with the control column, we didn't wait any longer and took off for Mt. Isa.

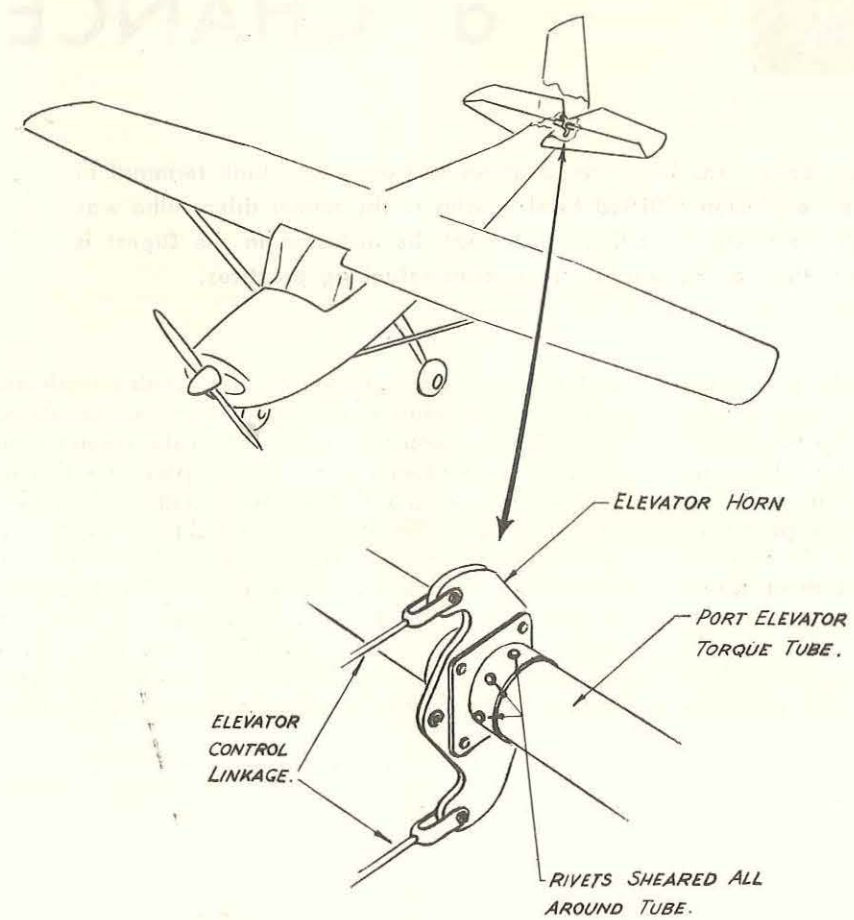
During the flight, though the aircraft was performing quite normally, I had some second thoughts about the matter and after landing safely at Mt. Isa I decided to ask an airline engineer to have a further look at the elevators.

'You were game!' he exclaimed as he examined the port elevator attachments. His inspection had found that all six rivets securing the elevator torque tube to the flanged end fitting, were sheared, disconnecting the port elevator from the control linkage. We had flown nearly 300 miles with only one elevator over a route which is known to be very turbulent at times !

In this case it wasn't a matter of being game, it was just plain ignorance and carelessness ! Until this happened I hadn't any idea what the torque tube was, nor of the way in which the elevators are connected to the control cables.

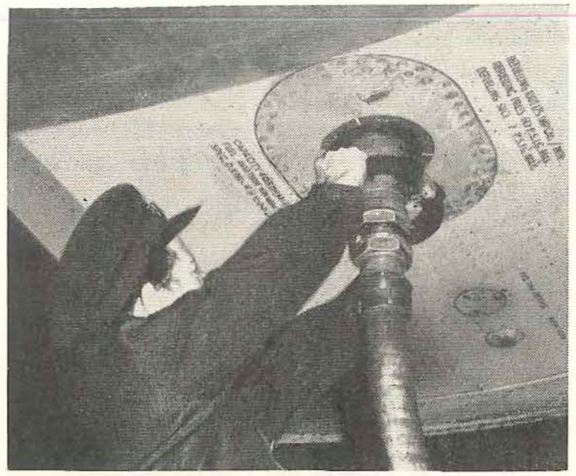
To make matters worse, it was later pointed out to me that the aircraft had been overloaded by some 100 lb. during the flight from Winton. This was also the result of my ignorance. I had no detailed knowledge of the load limitations of the aircraft type and was under the impression that it could carry a pilot and three passengers, each with 30 lb. of luggage, as well as a full load of fuel, without encountering a weight problem.

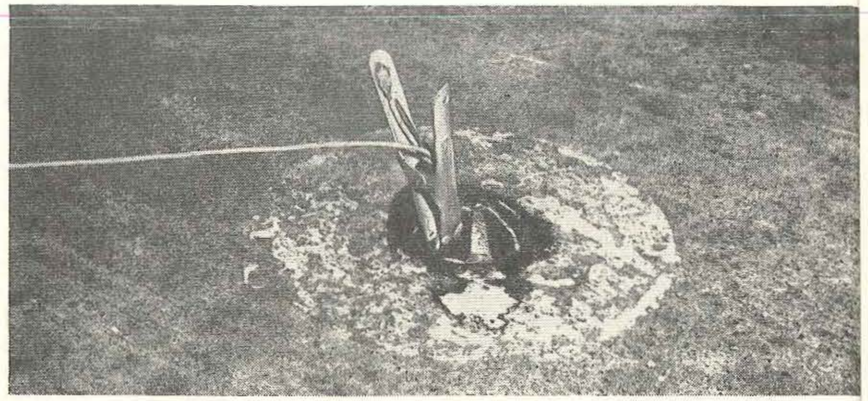
The whole experience very clearly brought home to me the fact that an aeroplane is a machine with which you can take no chances. The manufacturers specify its limitations and provided the pilot flies the aircraft within these limits, it will perform safely. If the manufacturers specifications are exceeded however, it can become an accident going somewhere to happen. Should anything occur, either in the air or on the ground, which could damage or overstress any part of the aircraft, it is essential to have an inspection made by a qualified engineer before the aircraft flies again. Don't make the same mistake that because nothing is obviously wrong, the aircraft must be serviceable !

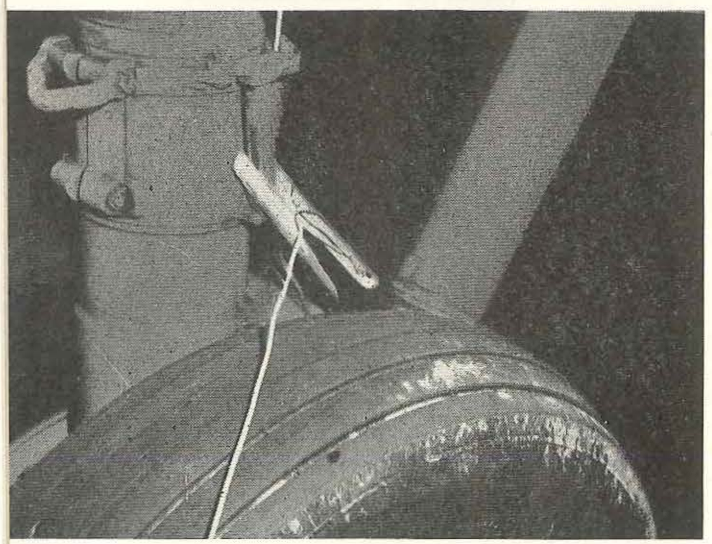


COMMENT:

We can only add that this pilot has had the opportunity to learn a valuable lesson in the hard school of flying experience. Others in similar circumstances haven't always been given a second chance! The real lesson is to ensure that such aspects are properly covered, and absorbed, during early training.







..don't give STATIC ELECTRICITY a CHANCE!

While an aircraft refuelling tanker was being filled at an oil company's bulk terminal at Fremantle, Western Australia, an explosion inflicted fatal injuries to the tanker driver who was conducting the loading. Though not strictly an aviation accident, its inclusion in the Digest is warranted by the obvious lessons that can be applied to aircraft refuelling practices.

The tanker, a semi-trailer unit with a carrying capacity of 6,600 gallons, was being loaded with aviation turbine fuel. On its previous trip the vehicle had carried a load of motor spirit. The vehicle tank comprised six separate compartments, four of which had already been filled to capacity. Compartments three and four in the centre section were being filled simultaneously from separate hoses. When about three-quarters full, vapour in the No. 3 compartment exploded, causing severe and extensive burns to the driver's head, arms and upper part of the body. The driver later died from his injuries. Weather conditions at the time of the explosion were fine with a moderate wind, a temperature of 60° and 45 per cent. humidity.

The explosion was attributed to the combination of inflammable fuel vapour with a spark of sufficient energy to ignite it, and efforts were made to determine how and why this had occurred during what is a normal, everyday procedure in the oil industry. A number of possible external sources of ignition, such as sparks caused by friction, unauthorized smoking, or atmospheric effects, were considered but none could be substantiated. The remaining possible ignition sources were electro-static discharges caused by either

ineffective earthing of the vehicle and filling equipment, or by an electro-static charge generated within the flowing fuel itself.

It was found that the prescribed bonding procedures had been correctly followed, the earthing cable having been connected to the vehicle on its arrival at the filling stand and left attached throughout the operation. The filling stand and pipe line system were tested for electrical continuity and earthing and were found satisfactory. The vehicle and its attachments were similarly tested and showed complete electrical continuity. The vehicle's electrical equipment was also checked and found faultless.

It is well known in the oil industry that a petroleum product flowing in a pipeline system or from a discharge valve, can generate a static charge within itself. This phenomenon is the subject of constant research to develop means of counteracting its effects and tanker loading procedures have been evolved to reduce, as far as practicable, the amount of static charge generated in the flow of fuel through the filling equipment and into the vehicle tank.

Tanker loading operations are carried out in a manner calculated to reduce splashing and turbulence to a minimum. This is accomplished by filling the tanker compartment either through the bottom outlet of the tank or through a tube which forms an integral part of the tank, extending from the filling hatch almost to the bottom of the compartment. With the latter method, the filling stand hose is attached to the top of the loading tube and filling should initially proceed at a slow rate until the base of the tube is submerged. The rate of flow is controlled by a spring loaded valve in the filling stand pipe system, and is actuated by a lanyard held by the person conducting the loading operation. Tension on the lanyard opens the valve; releasing it allows the valve to close automatically.

At the time of the explosion, two hoses were in use, filling two compartments simultaneously. After commencing to load one compartment, it is believed that the driver, contrary to standing rules, had tied down the loading valve lanyard, and had proceeded to fill the adjacent compartment from the second hose. The loading rate through the first hose was thus not adequately controlled during the operation.

To meet customs duty requirements it is usual to measure the temperature of the fuel in the tanker after the compartments have been filled. The reading is obtained by lowering a thermometer into the liquid through the compartment hatch. The type of thermometer used is 18 inches long and is enclosed in a brass casing to which is attached a length of cord for suspending the instrument in the liquid.

After the accident, a brass thermometer case was found in the affected compartment. The non-conductive thermometer cord had been burnt through but its upper end was attached to an external valve handle near the compartment filling hatch and it was estimated that the thermometer would have been about two-thirds submerged at the time of the explosion.

It is known that metallic objects immersed in a statically charged liquid and insulated from the surrounding tank structure, can become the source of a static discharge. In this instance, the brass thermometer case could have acted as a base for the collection and concentration of static charge from the fuel. Accumulated in this way, the charge could then have flashed across to a nearby section of the tank structure, thus providing the ignition for the explosion. It is of interest that the cord on which the thermometer was suspended was made of nylon thread.

In the absence of tangible evidence of any other source of ignition, the investigation concluded that the explosion had resulted from an electro-static discharge from the unearthed thermometer while it was suspended in the partially filled tank of fuel.

COMMENT:

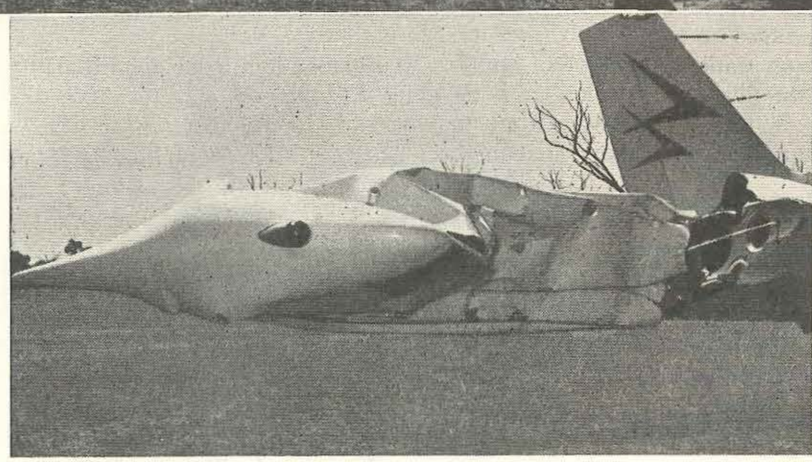
Fuel handling accidents have been responsible for destroying several aircraft in Australia. In at least one case, the cause was attributed to a discharge generated in unearthed refuelling equipment.

There is no room for liberties with the handling of aircraft fuels, and it is essential that all fittings and components used in a refuelling operation be adequately earthed. This is one reason why the Department, and some of the oil companies as well, have warned against the use of plastic containers and funnels for refuelling (see "Petrol and Plastics Don't Mix", Aviation Safety Digest No. 38, June, 1964).

Apart from having an adverse chemical reaction from continual contact with fuels, plastic articles can accumulate a heavy static charge. Because the plastic will not conduct electricity, the charge cannot be earthed properly by earthing cables and clips. A statically charged plastic utensil can therefore quite easily cause a spark when placed close to metal fittings such as a fuel tank filler neck or a refuelling hose nozzle.

We have noticed that some light aircraft pilots who conduct their own refuelling operations in country areas, still occasionally resort to the use of plastic funnels or containers for the sake of expediency. If you are one of these, we urge you in your own interest to discontinue the practice immediately.

Cockpit Checks have a purpose



Strict adherence to a check list of vital actions has long been regarded as a major requisite for the safe operation of an aircraft. As a principle this is of course accepted by all responsible pilots.

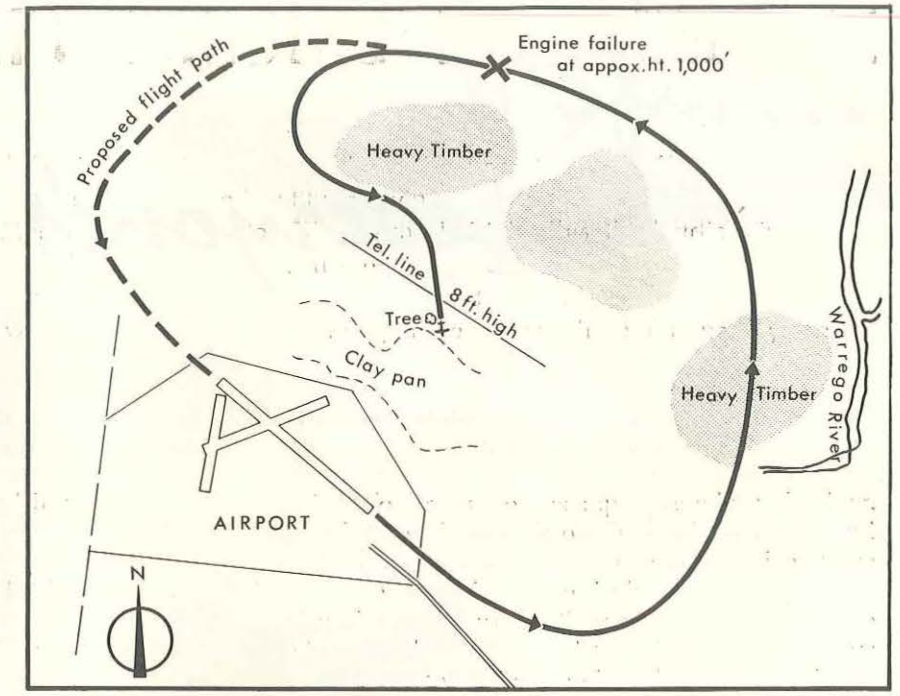
There is nevertheless a danger that although the check list rituals may be religiously recited, the real meaning or effect of the various items may be lost simply as a result of constant repetition. For example, a pilot could call his cockpit check list, touching or pointing to each item in turn as he does so, but without consciously observing the actual position or indication of the particular control or instrument. This very insidious form of complacency was responsible for the damage to the Piper Comanche shown in the title illustration of this article.

At the time of the accident the aircraft was being flown on circuits and landings at Cunnamulla, Queensland, to give a private pilot conversion training on the type. During the pre-flight inspection that was made before the training period commenced, the instructor had remarked to the pupil that "There was plenty of fuel on board". The starboard tank was full and the port tank 1/3rd full. The port tank was selected for starting and after the engine had been warmed, the flying training began.

For the first three circuits the pupil was briefed on circuit patterns, cockpit checks, airspeeds and other procedures, but at this stage his progress was satisfactory and he was permitted to continue without prompting by the instructor. Flying a somewhat wider than usual pattern to allow time to complete the cockpit drills unhurriedly and to get the "feel" of the aircraft, the pupil successfully completed several more "touch and go" circuits. On each one, the pupil recited the down-wind check "fuel on and sufficient", pointing to the port fuel gauge.

During the tenth circuit, while flying the down-wind leg at 1000 feet, the engine failed suddenly and the instructor immediately took over control. The aircraft was beyond the gliding distance from the aerodrome and even the most favourable terrain within reach was lightly timbered. As the aircraft approached for a forced landing however, the surface looked satisfactory and because there seemed a good chance of avoiding the trees during the landing roll, the pilot lowered the undercarriage. A low telephone line was then sighted in the approach path and an attempt was made to force the aircraft beneath the wire but the wire struck the upper part of the fin, shearing off the top three inches. The aircraft landed heavily, bounced and became airborne again for nearly 500 feet, during which the pilot weaved to miss a tree, then touched down again. The pilot braked harshly but before the aircraft could be brought to rest, the starboard wing struck another small tree and was badly damaged.

Investigation showed that the engine failure had been caused by fuel starvation. The fuel selector was still positioned to the port tank which was empty. The pupil pilot had apparently been misled by the instructor's advice that the aircraft had sufficient fuel and did not press the point during the down-wind checks, despite the fact that the fuel gauge must have been indicating almost zero for the last few circuits. Because "touch and go" circuits were being flown, no pre-take off checks were made after the first take off.



On the other hand the instructor had failed to physically check the pupil's cockpit drill on the down-wind legs. The fuel tank selector in the PA24 is located between the pilot seats and can be seen readily from either position. He also failed to carry out the emergency procedures for engine failure as set out in the Pilot's Handbook for the aircraft type. Had the starboard fuel tank been selected when the engine failed, there is little doubt that the engine would have regained power almost immediately.

DRESS OPTIONAL?

Not altogether when flying aircraft! Look at these results:—

At Perth a student pilot flying a Cessna 172 over-ran the runway and bogged the aircraft after landing because he couldn't apply the brakes properly.

Reason: He was wearing thongs.

At an agricultural airstrip a commercial pilot ground-looped and damaged a Cessna 180 when his left foot slipped off the brake pedal.

Reason: The rubber soles of the boots he was wearing were slippery.

Our March issue described another incident in which damage was caused to a DH.82 as a result of a passenger's Father Christmas clothing catching in the dual control throttle linkage.

In citing these examples we don't mean to infer that pilots should never wear rubber-soled shoes for flying, nor do we wish to lay down hard and fast rules for what passengers should wear in an aircraft! Nevertheless we do suggest that some thought should be given to the sort of clothing that one should wear in a light aircraft having in mind the aircraft type and the nature of the operation. A little common sense applied in this way may help prevent another incident!

Most of us wouldn't think of attending a social occasion unsuitably dressed. Isn't our flying at least as important?

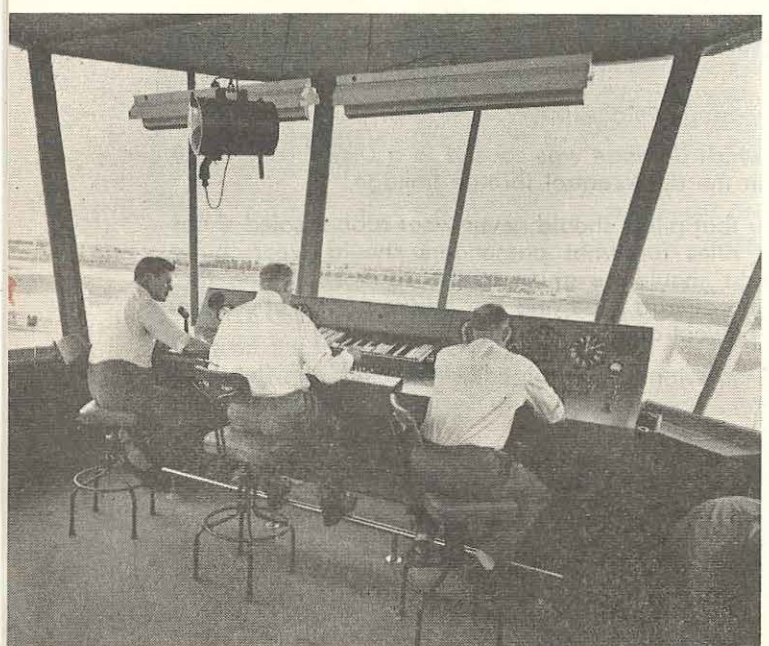
... safety is everyone's business

An incident occurred recently while two airline aircraft were approaching a capital city airport. Both aircraft were operating under instrument flight rules and were being stepped down in the control zone, when the crew of the higher aircraft accepted and acted upon a descent clearance directed to the lower aircraft.

The lower aircraft had been cleared to descend to 3,000 feet and its captain had just completed his "read-back". As he closed his microphone the captain heard what he thought were the last two words of the same clearance being read back from another aircraft. The captain wondered about this, but thinking the approach controller would recognise any misunderstanding that had arisen, he did not query the matter.

The approach controller in fact had not heard the second "read-back", and the unsafe situation which developed was only recognized when the higher aircraft reported "left 4000" in accordance with the terms of a clearance which the pilot had assumed to be directed to him.

In this case, the mistake was detected before there was a complete breakdown in separation. No one was injured and no damage was done, but a happy ending does not make it any less imperative for us to learn from what might have happened.



Practically all incidents are preceded by a chain of circumstances which individually or collectively contain some pointer to intermediate action which would have prevented development of the incident. In this incident —

- The pilot of one aircraft heard something that should not have been said.
- The call signs had the same last letter.
- Neither the pilot of the other aircraft nor the approach controller appeared to be concerned.

The first item should have triggered off action to positively resolve the doubt. The second item, as an indicator of the potential for mis-identification, should have stressed the need to obtain resolution. The third item is significant by virtue of what it did not do. It did not, in any way provide evidence that would resolve the doubt; rather it established, that only one person had an indication that something was amiss. *And he let the ball drop!*

There can be little doubt that those involved in the incident have learned a lesson which they will not forget. Indeed their experience may have been passed on to their colleagues. But this is not enough. No matter what place a person may occupy in the aviation industry, there is an ever-present need for him to exercise vigilance. The value of an aircraft can be assessed but not the lives of those it carries. It is poor consolation to learn afterwards why an accident occurred when with the same knowledge beforehand it could have been prevented. Safety is everyone's business.

As this incident so clearly demonstrates, we should never hesitate to question any information which we believe could indicate an unsafe situation. Leaving it to the other fellow is not good enough. He may be leaving it to you.