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AVIATION SAFETY DIGEST

DEPARTMENT OF
CIVIL AVIATION

No. 37 MARCH, 1964

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

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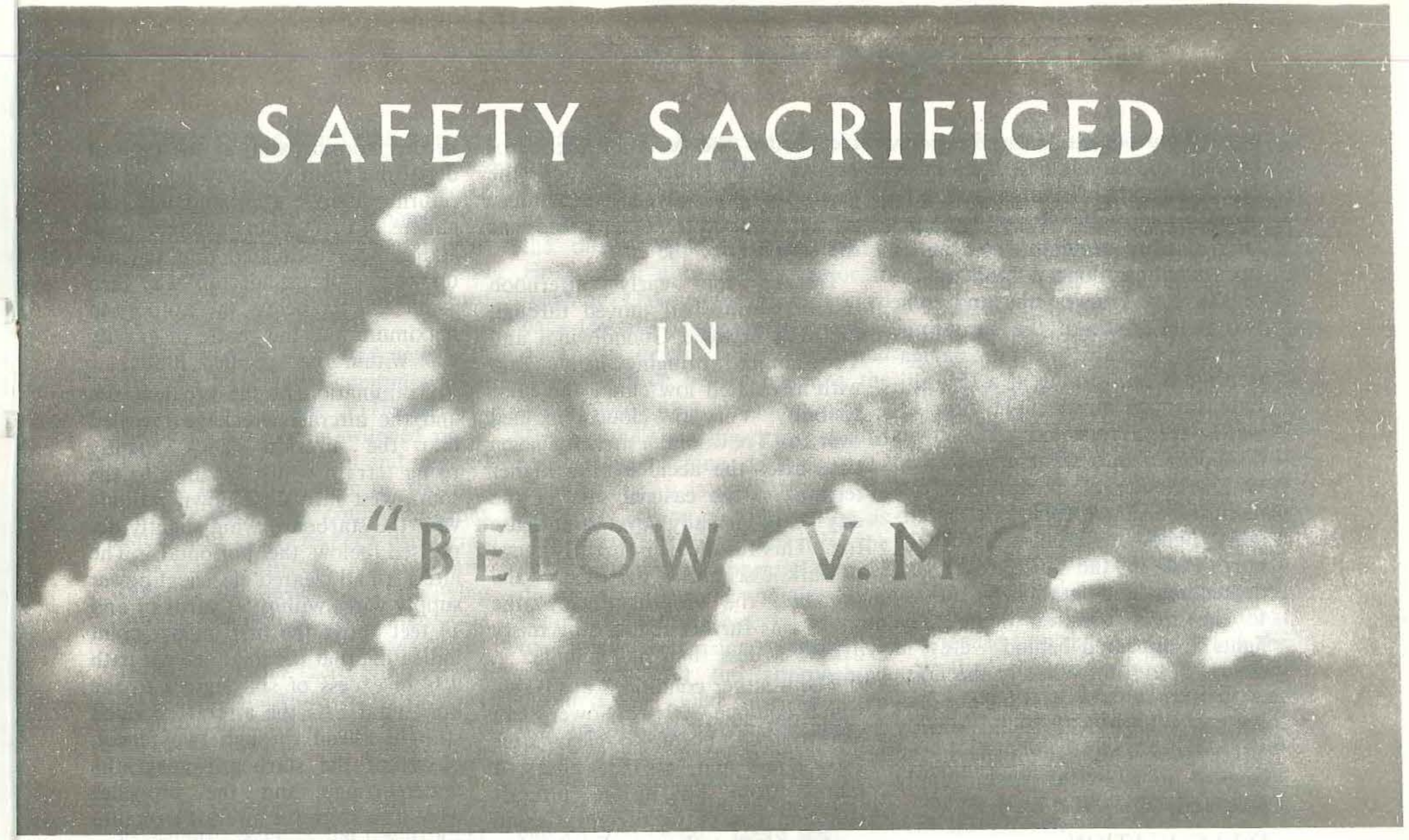


SAFETY SACRIFICED IN "BELOW V.M.C."

Just prior to "last light" on 14th December, 1962 a Cessna 172 on a private flight from Goondiwindi to Toowoomba was destroyed when it struck the ground near the destination aerodrome in conditions of extremely poor visibility and low cloud. The three occupants of the aircraft were killed in the accident.

The aircraft proceeded from Toowoomba to Goondiwindi during the morning of the day on which the accident occurred apparently without incident but thunderstorms developed in the area during the day. When the pilot spoke by telephone to Toowoomba at 1430 hours he was advised that considerable thunderstorm activity had developed in that area also and that a number of aircraft were grounded there. It was suggested to him that he check the weather conditions at approximately 1700 hours and that, failing an improvement by this time, the flight should be deferred until the following morning. If on the other hand the conditions had improved the pilot was instructed to plan the return flight to arrive at Toowoomba well before "last light" which was given as "about seven".

At approximately 1715 hours, after some improvement in the weather conditions in the vicinity of Goondiwindi, the pilot telephoned Brisbane Air Traffic Control Centre, advised details of the return flight and checked the current weather situation. He was told that Toowoomba was still affected by thunderstorm activity but that, in the vicinity of Oakey, some 14 miles north-west of Toowoomba, the weather conditions were expected to clear from the west.

The aircraft departed from Goondiwindi at approximately 1745 hours, and, on the basis of the notified 65 minute time interval, it was due to arrive at Toowoomba at approximately 1850 hours. Last light computed by reference to the darkness graph in th Light Aircraft Handbook was 1909 hours on this day at Toowoomba.

The aircraft appeared to be in normal flight when it was observed approximately midway between Goondiwindi and Toowoomba heading north-east but it was next seen at approximately 1845 hours in the vicinity of Oakey at a position some eight miles north-west of Toowoomba and heading south-east towards Toowoomba. It was flying low beneath the cloud in a light misty drizzle but otherwise appeared to be operating normally. Some 15 minutes later, the two occupants of a motor car travelling along a road on the outskirts of Toowoomba and some two miles south of the aerodrome saw the aircraft, with its navigation lights on, turning at a low altitude through misty light rain towards the aerodrome. The lights disappeared into what appeared to be low cloud but, a minute or two later, these same people saw the aircraft lights materialise from the north-east in the misty darkness, descending and gradually turning to the right towards them. The lights disappeared behind a crest in the road and immediately the noise of an impact was heard. The aircraft wreckage was found shortly afterwards, scattered around the base of an electrical power supply pole and across the road.

INVESTIGATION

The accident occurred in undulating terrain some two miles south of Toowoomba aerodrome and 100 feet above the level of the aerodrome. The aircraft struck the ground within 60 yards of a house set in a relatively open area near the outskirts of the city.

During the early afternoon thunderstorms had moved through the area between Goondiwindi and Toowoomba, bringing heavy rain with associated low cloud and poor visibility. Very low cloud remained over the Toowoomba area for some time after the accident, the higher terrain on the eastern side of the city being virtually covered in dense fog. This resulted in an early onset of darkness and, at the time of the accident, the visibility below the cloud was further reduced by misty drizzle to less than half a mile.

The weather conditions at Oakey, which is some 500 feet lower than Toowoomba, began to clear after 1800 hours and, at 1835 hours, a report from an airline aircraft climbing out of Oakey for Casino confirmed that the weather in that area was clearing.

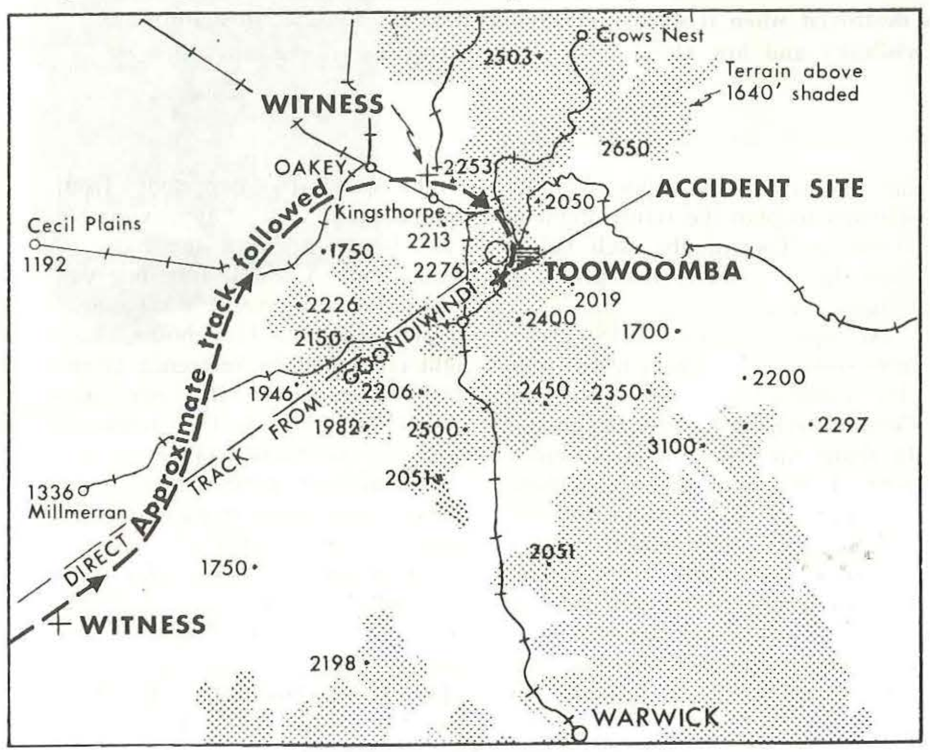
The aircraft fuel tanks were filled prior to departure from Toowoomba in the morning and, at the time of departure from Goondiwindi on the return flight, approximately 22 gallons of fuel would have remained. It has been estimated that the all-up weight of the aircraft was then some 230 lb. below the authorised maximum and the centre of gravity was within the specified limits.

Examination of the accident site and the aircraft wreckage revealed that the aircraft struck slightly rising terrain whilst heading to the south-west in a nose down attitude with the starboard wing slightly depressed below the horiontal. The aircraft had cleared electrical power supply wires within 50 yards of and 14 feet above the first impact point indicating that the final descent path was in excess of six degrees to the horizontal. As the aircraft skidded straight ahead through two fences, pieces of the starboard wing, the undercarriage and the propeller were torn from the aircraft structure which finally crashed with considerable force against the base of an electrical power supply pole. The aircraft virtually disintegrated in this impact, sections becoming wrapped around the base of the pole and the balance, including the engine, being projected ahead for a distance of some 150 feet from the pole.

It was apparent from the nature of damage to the propeller that the engine was delivering substantial power at the time of initial impact. Each of the fuel tanks contained quantities of fuel which were clear and free from contamination.

The flap control was in the first detent position and a bruise in the flap track confirmed that ten degrees of flap was down at the time of impact.

All portions of the aircraft structure were accounted for and all failures appeared consistent with impact. No evidence was found of any defect or malfunctioning which might have contributed to the accident.



The pilot was issued with a private pilot licence in August, 1962, after some 45 hours training in Cessna 150 aircraft in the Toowoomba area. His total flying experience at the time of the accident was 59 hours, six of which had been gained in Cessna 172 aircraft.

The aircraft was fitted with both HF and VHF radio communication equipment and the VHF set was found to have been switched on at the time of the accident and selected to the frequency used by the aircraft owner. The communications equipment at the owner's base however was not in use, nor were any other of the owner's aircraft flying during the period. Although it is possible that the pilot endeavoured to use the radio there is no record of any transmissions being received from the aircraft by any station.

ANALYSIS

It is probable that the pilot's decision to attempt the return flight to Toowoomba was influenced by the expected improvement in weather conditions at Oakey and by the knowledge that he could land there if necessary. In addition it is known that the pilot had strong personal reasons for returning to Toowoomba that day. There is evidence that the aircraft did divert towards Oakey during the latter half of the flight, no doubt due to adverse weather conditions along the direct track to Toowoomba. However, it appears that, prior to reaching Oakey, the pilot turned back towards Toowoomba and flew at a low height below the cloud for some time before reaching the Toowoomba area.

When the aircraft was first sighted in the approaching darkness near Toowoomba, it is possible that the pilot was aware of his position as the aircraft turned towards the aerodrome and disappeared in that direction. There is sufficient evidence to confirm that, in addition to rapidly decreasing visibility in misty rain and the approaching darkness, the cloud base was very low and, in places, on the ground. There is also evidence that, when the aircraft disappeared from view at this time, it did so because it had entered cloud. There seems to be no doubt that the pilot, who had no instrument flying experience, got himself into a position where he could not maintain flight by visual reference to the ground. In these circumstances it could be expected that his reaction would be to turn back in an attempt to reach an area where visual flight could be resumed.

Because of the low and heavy cloud it was prematurely dark at this time in the Toowoomba area and, not only was visual flight virtually impossible, but it would have been very difficult for the pilot to pick out any landmarks by which to navigate.

There is evidence that, at the time of impact, the aircraft was descending at relatively high speed with the engine developing considerable power. These circumstances are quite inconsistent with any controlled attempt to carry out a forced landing. The additional evidence that the aircraft struck the ground in a turn whilst descending at a relatively steep angle indicates that, in all probability, the pilot had become disoriented in instrument flight conditions and was unable to maintain proper control of the aircraft.

CAUSE

The probable cause of the accident was that the pilot continued the flight into instrument meteorological conditions which demanded a higher level of instrument flying skill than he possessed.

Do-It-Yourself

A student pilot in a Chipmunk had to abandon a take-off after reaching a height of about fifteen feet, when the starboard engine cowl commenced to flap severely in the slipstream.

The refuelling procedures of the Aero Club concerned required maintenance engineers to leave the cowl propped open after topping up the oil tank. It was the pilot's responsibility to close and fasten the cowl. In this case the maintenance engineer left the cowl unfastened but not propped open. The pilot, who was checking the port side of the aircraft at the time that the oil tank was topped up, assumed that the engineer had fastened the cowl and did not check it for security.

A flapping cowl or access cover has led to many an accident for various reasons. In some cases the aerodynamic characteristics of the aircraft have been seriously affected, sometimes essential items or fluids have been lost, occasionally the cowl or cover has torn loose and done further serious damage and quite frequently the noise and unexpected nature of the event has thrown relatively inexperienced pilots into a state of confusion.

All this adds up to the fact that there is no room for assumptions or guesswork in aviation. Even omissions which appear trivial can have the most dire consequences.

LIGHT AIRCRAFT TAKE-OFF PERFORMANCE

In the March, 1963 issue of Aviation Safety Digest we discussed the effects of temperature and altitude on the take-off performance of light aircraft. The purpose of this further article is to extend the discussion to the effects of strip surfaces, strip slope and wind on this all important phase of operations.

It has already been indicated that the take-off distance which must be available for light aircraft is 1.15 times the demonstrated distance from start of roll until the height of 50 feet is reached assuming optimum operation under the ambient conditions. Optimum operation infers availability of full take-off power appropriate to the density altitude experienced, climb at the designated take-off safety speed and pilot technique at test pilot standards. The required take-off distance for normal operations is determined from the 'PL' series of D.C.A. performance charts.

In any discussion which is concerned with effects on take-off performance it should be remembered that the take-off can be broken down into two distinct parts. The first is from the commencement of the run to the point of lift-off during which stage the aircraft is accelerated horizontally with its wheels in contact with or very close to the surface. The second stage covers the climb at constant airspeed from the lift-off point to the point at which a height of 50 feet above the surface is achieved. Variations in the nature of the surface will only directly influence the first of these stages but surface slope is a factor during both stages as it will have an effect on acceleration during the first stage of the take-off and will vary the datum for the 50 feet measurement during the second stage. Similarly wind is a factor during both parts of the take-off.

Effect of Surface Conditions

The total drag acting on an aircraft during the first stage of the take-off will be the sum of the aerodynamic drag and the drag due to rolling the wheels along the ground. For simplicity the aerodynamic drag may be considered to vary proportionally to the square of the speed. The wheels drag depends on the load on each wheel and the co-efficient of rolling friction. The following are typical co-efficients of rolling friction for standard surfaces.

Concrete or asphalt	0.02
Hard turf	0.04
Average field — short grass	0.05
Average field — long grass	0.10
Soft ground	0.10-0.30

The load on the wheels during the take-off will be reduced progressively by lift developed by the wing and hence wheels drag will be progressively reduced as speed increases. Increase in lift by adoption of a nose high attitude will tend to further reduce wheels drag but it must be remembered that this apparent benefit is only achieved at the expense of some increase in aerodynamic drag and it is not, therefore, total profit.

When taking-off from a sealed runway the wheels drag is very low and to keep the aerodynamic drag low it is usual to accelerate to a high speed in the low nose position or with the nose wheel of tricycle aircraft on the ground. Only just prior to reaching take-off safety speed is the nose raised for the lift-off and climb. On soft surfaces or long grass the main retarding force is wheels drag and a higher nose position will increase lift and thus reduces the load on the wheels and the wheels drag. Remembering however, that the aerodynamic drag resulting from this attitude is high, even at relatively low speeds, the aircraft must be accelerated immediately after initial lift-off by flying horizontally just above the surface until the take-off safety speed necessary for continued climb is reached.

Surface effect has been illustrated graphically in Figure 1 which shows the variation of force acting on the aircraft during the take-off period plotted against the square of the speed ratio thus permitting straight line relationships. The force-scale used is force expressed as a percentage of take-off thrust at standstill and the "nett force" is the force available to accelerate the aircraft, i.e. the excess of force available over that necessary to counteract aerodynamic and wheels drag. If the nett accelerating force is reduced, acceleration will be less and there will be a consequent increase in take-off distance. The figure illustrates the very large differences in available "nett force" particularly in the lower speed ranges, when taking-off under the two separate conditions of long wet grass and hard turf.

Effect of Slope

If the take-off is to be made up-hill on a slope of, say, one per cent (one foot of rise in 100 feet of length) the power available for accelerating the aircraft will be reduced by the power necessary to lift the aircraft up the gradient against the force of gravity. At a speed of 30 knots, i.e. 50 feet per second, the weight of the aircraft has to be lifted 6 inches every second. For the Cessna 180D at an all-up weight of 2,650 lb. the power required to perform this task is 2.4 h.p. However, within the speed range applicable to take-off mean propeller efficiency is only of the order of 60 per cent and thus about 4 engine brake horse power must be used solely to overcome the effect of the slope. If the gradient or the speed up the gradient is increased the power required would be proportionally increased.

In the down-hill case, engine power is assisted by the force of gravity in accelerating the aircraft and, using our "nett force" explanation, again the nett force becomes the combination of the gravity effect and the excess of thrust over total drag. As the nett force has been increased the distance to point of lift-off will be consequently decreased by comparison with the level surface case.

In dealing with slope we also become concerned with the airborne distance, i.e., the distance from lift-off to the height of 50 feet. This so called "screen height" of 50 feet is measured above ground level at the point of achievement. If we consider a typical aircraft with a mean initial climb capability of 10 per cent at a take-off safety speed of 55 knots TAS then the airborne distance of 50 feet over level ground would be 500 feet. If the surface of the strip has a consistent up-hill slope of one per cent however, the aircraft will have to climb 55½ feet in relation to the height of the lift-off point to achieve 50 feet above ground level and the consequential airborne distance would be 555 feet. An increase of 55 feet in the airborne distance does not sound much but it is better to think of this as an increase of approximately 11.1 per cent in airborne distance and remember that this distance penalty in the up-hill case is additive to the penalty already experienced prior to the lift-off point. Conversely, of course, airborne distance to 50 feet is reduced in the downhill case as the datum for measurement of the 50 feet is below the lift-off point.

The Effect of Wind

The way in which wind velocity affects required take-off distance should need no explanation here. Our purpose in making reference to the effect of wind is therefore only to indicate the extent of accountability of wind effects in take-off performance charts.

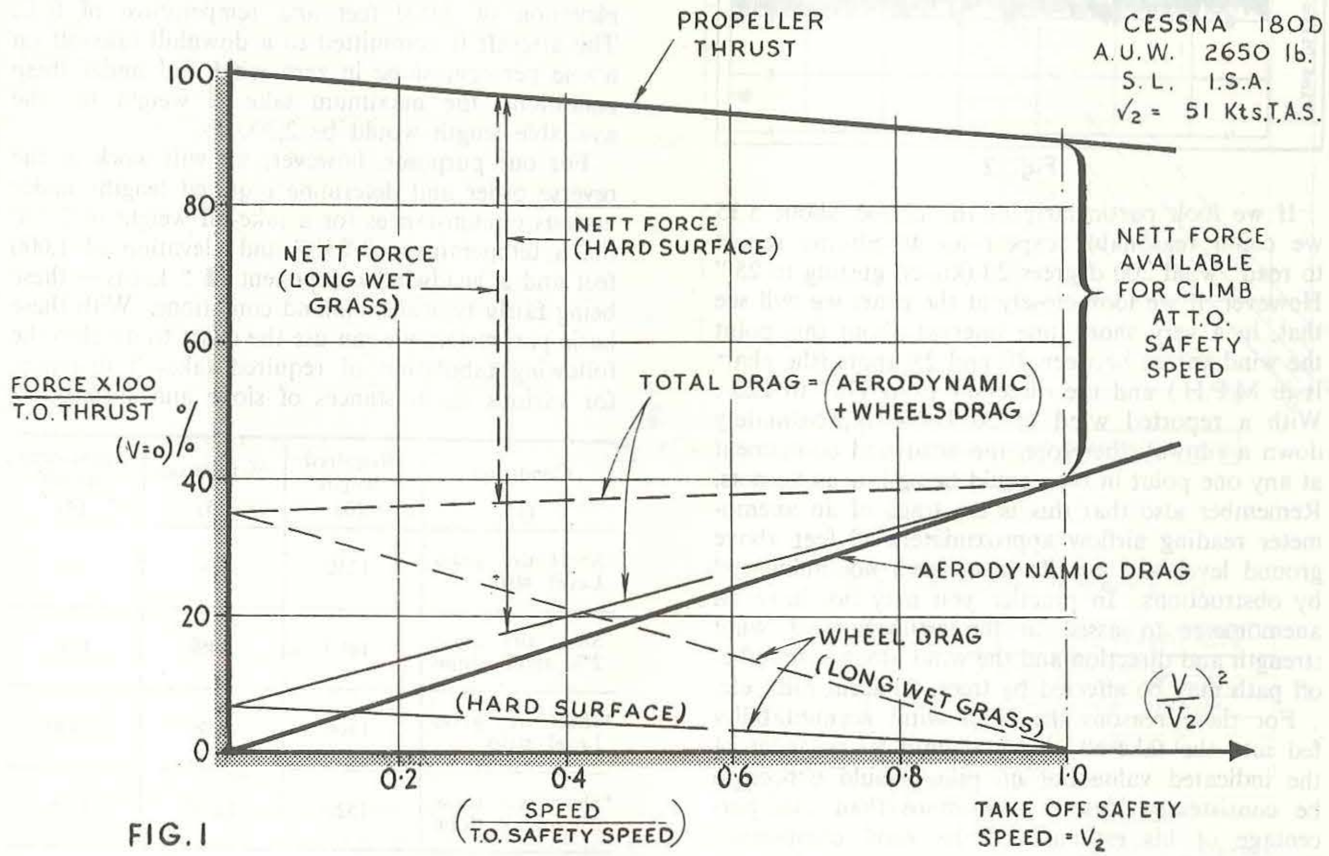


FIG. 1

It is well known to everyone that wind seldom blows with a constant speed or from a constant direction. However, the magnitude of the 'short term' variations is possibly not so well appreciated and, for this reason, we have included at Figure 2 a section of a typical anemometer trace. This trace covers approximately a 7 hour period between 3 p.m. and 10 p.m. during a relatively stable wind situation when the mean wind was of the order of 18-20 knots from the S.S.W.

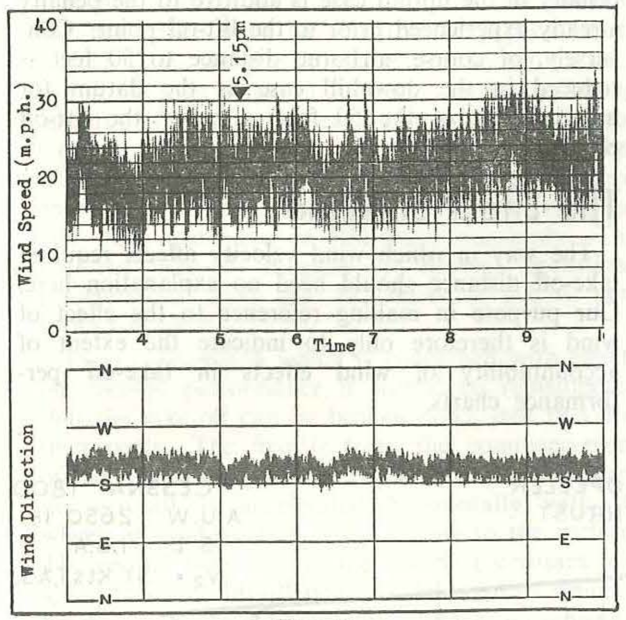


Fig. 2

If we look particularly at the period about 5.15 we could reasonably expect an aerodrome report to read "wind 200 degrees 20 (knots) gusting to 25." However, if we look closely at the chart we will see that, in a very short time interval about this point the wind varied between 10 and 25 knots (the chart is in M.P.H.) and the direction from 175° to 225°. With a reported wind of 20 knots approximately down a runway therefore, the headwind component at any one point in time could be as low as 8 knots. Remember also that this is the trace of an anemometer reading airflow approximately 30 feet above ground level and usually in an area not influenced by obstructions. In practice you may not have an anemometer to assist in the estimation of wind strength and direction and the wind along your take-off path may be affected by trees, adjacent hills, etc.

For these reasons the head wind accountability fed into the take-ofl charts is only 50 per cent of the indicated value but no pilot should expect to be consistently blessed with more than this percentage of his estimate of the wind component. Down wind take-offs are not encouraged but are sometimes unavoidable in relatively light wind conditions. The charts therefore make provision for downwind operations up to components of 5 knots but, for the reasons of variability as discussed for the upwind case, the accountability within the chart is, in this instance, at 150 per cent of the indicated value.

General Applications

We have so far discussed the way in which the various conditions of surface, slope and wind affect take-off performance and it is now relevant to look at the degree of effect in terms of variation of take-off distance for a typical aircraft. For this purpose we have selected the Cessna 180D and, at Figure 3 have reproduced a special take-off chart which includes accountability for slope and some surface conditions. The normal 'PL' chart as used for mainland, private and commercial (non-agricultural) operations would give the same answers as the chart reproduced if zero slope and 'short dry grass' are assumed when using the latter chart.

The method of using the special chart is demonstrated by the dotted line which portrays the situation of a 1,500 foot short wet grass strip at an elevation of 7,000 feet and temperature of 0°C. The aircraft is committed to a downhill take-off on a one per cent slope in zero wind and under these conditions, the maximum take-off weight for the available length would be 2,300 lb.

For our purposes, however, we will work in the reverse order and determine required lengths under various circumstances for a take-off weight of 2,550 lb., a temperature of 25°C and elevation of 1,000 feet and a headwind component of 5 knots — these being fairly typical mainland conditions. With these basic parameters we can use the chart to develop the following tabulation of required take-off distances for various circumstances of slope and surface.

Condition (1)	Required length (2)	% increase (3)	Unfactored length (4)
Short dry grass Level strip	1230	—	—
Short dry grass 2% uphill slope	1400	14%	1215
*Short wet grass Level strip	1300	6%	1130
*Short wet grass 2% uphill slope	1520	23.5%	1320

(* also applies to long dry grass)

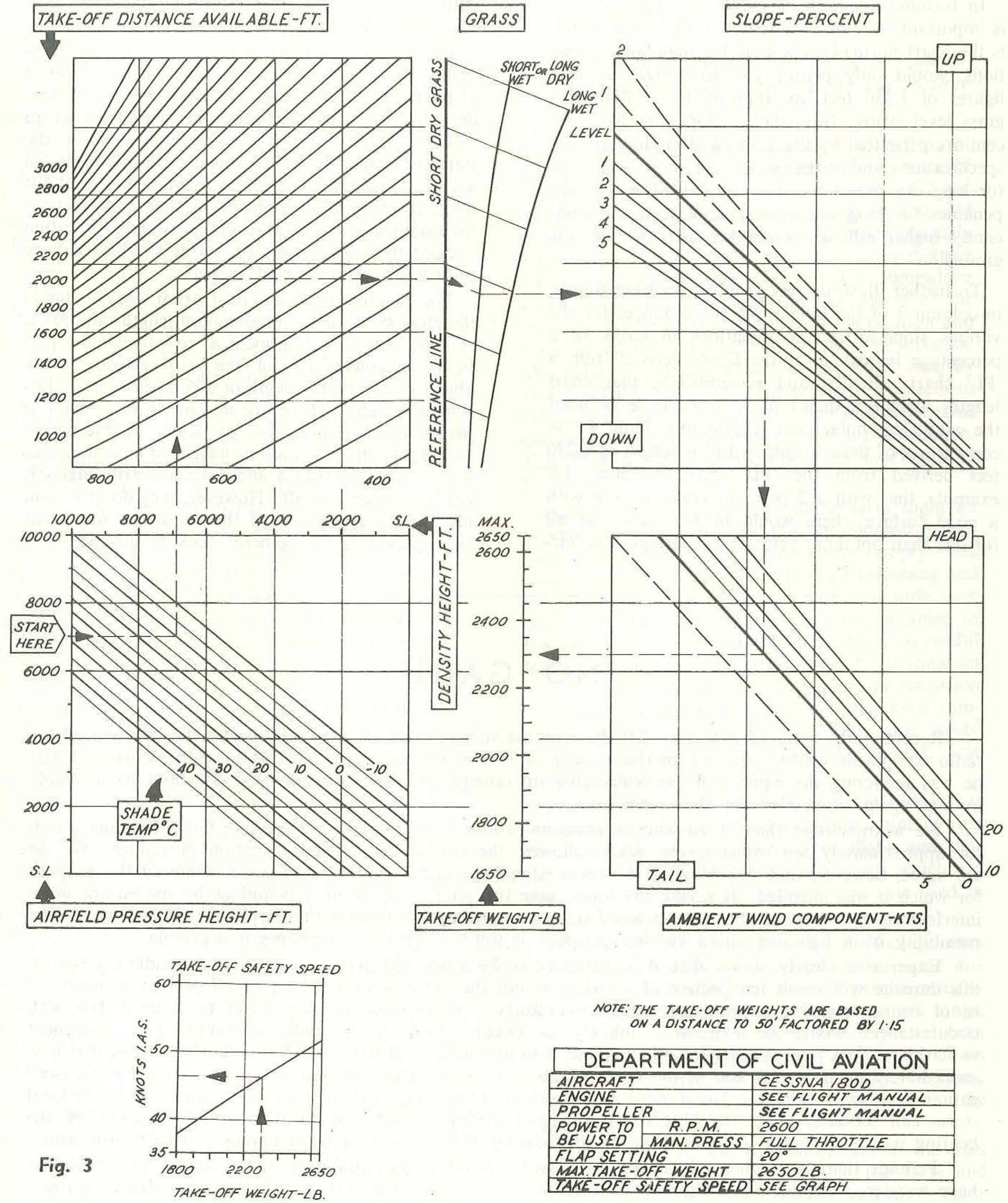


Fig. 3

NOTE: This chart is included for article illustration purposes only, and must NOT be used for operating purposes.

In forming an appreciation of this tabulation it is important to remember that the 'PL' chart which is the chart normally available for mainland operations, would only permit you to derive the first figures of 1,230 feet, as appropriate to short dry grass level strips. Nevertheless slopes up to 2 per cent are permitted by the authorized landing ground specifications and surfaces such as short wet grass (or long dry grass) are not unusual. The distance penalties for long wet grass are, of course, significantly higher still as would be the case for soft ground.

To further illustrate this problem we have shown, in column 3 of the tabulation, the distances for the various slope-surface combinations in terms of a percentage increase over the figure derived from a 'PL' chart. Finally, and remembering that chart lengths include a factor of 1.15, we have included the equivalent unfactored lengths in column 4. A comparison of these lengths with the length of 1,230 feet derived from the 'PL' chart indicates, for example, that with a 2 per cent gradient even with a good surface, there would be no margin at all for less than optimum performance, by pilot or aircraft if length, as determined by reference to a 'PL' chart, was critical.

The decision to omit surface and slope accountability from 'PL' charts was taken in the interest of maintaining relative simplicity in the charts. This decision may, in the future, be varied so as to include surface and slope accountability in the standard charts. However, it is not feasible to design a chart which will completely obviate the need for pilots to exercise a judgment on strip conditions — for example, it is not practicable to embrace within a chart the wide variety of 'softness' which can be present in the surface of a strip.

The lengths as determined from charts should therefore be regarded as minimum lengths and pilots should exercise a judgement as to whether the particular characteristics of the strip warrant availability of additional length or a compensatory reduction in weight. There are no simple rules such as percentage variations for particular characteristics — the percentage variations which we have indicated for the Cessna 180D would not necessarily precisely apply to other aircraft. However, they do give some idea of the magnitude of the variations which can be expected in this general class of aircraft.

NO GAIN

Recently, the pilot of a Cessna 210 became the subject of an incident report when he switched off his radio equipment whilst operating in the vicinity of severe electrical storms. In so doing, he considered that he was rendering the equipment less vulnerable to damage and would ensure that it would be available to him again when clear of the storm area.

We acknowledge that in advising a communications centre that he was closing down listening watch for approximately ten minutes, this pilot followed the correct radio communication procedure. We do not agree, however, that switching off the radio equipment under these circumstances achieved the purpose for which it was intended. It would, no doubt, save the pilot's ears from a pounding by unpleasant noise interference, but most of this can be avoided by temporarily positioning the earphones off the ears. The possibility of a lightning strike causing personal injury through the headphones is negligible.

Experience clearly shows that if a lightning strike is destined to cause damage to the radio equipment, this damage will result irrespective of whether or not the radio is switched on or off at that moment. It is, of course, possible to postulate freak circumstances where some damage might be averted, but such circumstances would be extremely unlikely to occur. Leaving the radio communication equipment switched on does not, as a general rule, expose it to any additional hazard and it certainly ensures that it is immediately available for use in the event of an emergency. This situation also applies to any radio navigation equipment carried — but it must be remembered that in the case of the radio compass, a severe local storm can seriously affect the observed bearings of stations tuned due to the natural tendency of the bearing indicator needle to swing towards the bearing of the strong electrical impulses in the storm centre.

Perhaps there are other pilots who have switched off radio equipment under similar conditions, or have wondered whether or not to do so. Our advice is to leave the radio on but, for a number of reasons, avoid storm areas as far as possible.

FUEL PLANNING

Fuel is the life blood of your aeroplane. The sudden cessation of engine noise following fuel starvation is at best embarrassing, at worst disastrous. It is surprising therefore, that so many pilots pay so little attention to the simple arithmetic that is the basis of fuel requirement calculations.

How do you rate in the following short quiz?

Do you know, to within half a gallon per hour, the fuel consumption figures of the aeroplanes you normally fly?

Do you know how these consumption figures vary according to the cruising altitude, RPM, manifold pressure and mixture setting?

Do you know the quantity of "usable" fuel that should be used for planning purposes for each type of aircraft, or do you flight plan on "full tanks" file a set endurance figure, and hope that you can, in fact, use the "unusable" fuel.

Do you check your fuel before flight, and ensure that "full tanks" really means what it says?

The endurance capabilities of most modern light aircraft are such that full tanks provide a wide safety margin for the majority of flights, hence slight miscalculations or higher than expected consumption rates pass unnoticed. However, as travel flights are extended toward the aircraft's maximum endurance or when navigation errors lead to flight time in excess of that estimated, small errors in fuel requirement calculations can lead to abrupt termination of a flight and an incident report, or perhaps a fatal accident.

In one recent incident an experienced pilot undertook a private ferry flight from a capital city airport to a country centre. The pilot calculated his fuel requirements on the basis of an 11 gallons per hour consumption, which is the figures quoted in the engine manufacturer's Operation Manual for cruise flight on a lean mixture setting. Despite the fact that his flight planning calculations indicated there should have been 50 minutes reserve fuel remaining on arrival, the engine failed when he was in the destination circuit area due to fuel exhaustion. Fortunately he was in a position from which he was able to land on the aerodrome. Rich mixture was used throughout the flight and at this setting the manual quotes a consumption rate of 16 to 16½ gallons per hour. The rate achieved was just on 16 gallons per hour.

In another case three errors combined to defeat the intentions of a private pilot engaged on an extensive travel flight. The total fuel capacity of the aircraft concerned is a little over 43 imperial gallons, of which only 35 gallons are usable in all conditions of flight. The pilot planned on a consumption rate of 9 gallons per hour and apparently reckoned on being able to use over 40 gallons of the fuel on board, as he calculated an endurance of 270 minutes. The flight was conducted at 5,000 feet, at which height the power settings used should have realized a fuel consumption of approximately 9 gallons per hour — in lean mixture. As the mixture was not leaned the rate achieved was somewhere about 10½ gallons per hour. In the course of the flight the pilot became uncertain of his position and backtracked for some time to obtain a positive fix. The extra 27 minutes added to the flight time by back-tracking, plus the incorrect fuel requirement calculations, ate up his reserve fuel and the engine quit when he was a few miles from his destination. This pilot made a successful forced landing in a field.

Prior to take-off on a 15 minute ferry flight an experienced instructor noted that the contents gauges were indicating just a little above empty. He checked the flight times since the last refuelling and calculated that eight gallons, which is a little over one hour's flying for the aircraft type, remained in the two tanks. This pilot too, made a successful landing in a field a few miles short of his destination — with both tanks empty. Subsequent investigation indicated that the aircraft tanks had not been completely filled at the previous refuelling, due, probably, to the attitude in which the aircraft was standing when it was refuelled.

For accurate flight planning it is essential that the endurance be calculated on the amount of fuel that is **usable in all conditions of flight and** that the engine be operated at power settings which are consistent with the cruise consumption rate used in the calculations.

Wherever possible, visually check the fuel quantity before flight, because the fuel gauges in some aircraft are not sufficiently accurate for precise calculations. If calculations are to be based on full tanks, ensure that the aircraft is approximately level both longitudinally and laterally. Sloping ground or an extended nose strut can result in tanks not being completely filled even though fuel flows from the filler necks.

A few minutes spent learning about the fuel system of your aircraft and noting the facts and figures could save much embarrassment. These same few minutes may also save your life.

Stall during Low Turn after Take-off

On the 3rd October, 1963, all four occupants of a Cessna 172D were killed when the aircraft dived steeply to the ground and burnt shortly after taking off from a station property in the far north-west of New South Wales.

The aircraft was being utilised that day by the owner/pilot to transport three stock and station agents to a number of other station properties nearby.

Late in the morning the three passengers left the aircraft after landing at the homestead strip on the property where the accident occurred, the third property visited. Arrangements were then made for the pilot to pick them up at another strip, some 10 miles to the north, and fly them back to his own property.

At approximately 1530 hours the passengers rejoined the aircraft as arranged and the property owner watched the aircraft taxi out and take-off to the south. Shortly after what appeared to be a normal take-off and initial climb he saw the aircraft turn and dive suddenly to the ground. There were no other witnesses of the accident.

INVESTIGATION

The accident occurred in flat sparsely timbered country some 500 feet above mean sea level.

There was no cloud, the visibility was unrestricted, the temperature was 75° and the wind was from the south at 15 knots and gusty.

Examination of the accident site revealed that the aircraft struck the ground with the nose depressed some 70 degrees below the horizontal and the port wing down some 60 degrees below the horizontal. Initial impact was made with the port wing on the front of a motor vehicle which had been parked, out of gear and with the brakes off, at a position some 40 feet north-west of a group of buildings adjacent to the southern end of the strip. The wingtip then passed along the top of the vehicle which was propelled backwards out of the way. The aircraft struck the ground 27 feet further on and then bounced another 53 feet before coming to rest, heading to the north-east, at which point it burst into flames.

Detailed examination of the aircraft wreckage was made difficult by the almost complete destruction of the cabin area by fire. It was possible to establish that the fuel selector was on BOTH, the ignition switch was ON, the flap selector was UP and the elevator trim was two degrees nose down. The aircraft was fitted with full dual controls and a careful examination of the flying control systems revealed no evidence of any pre-accident malfunction. The propeller damage indicated that the engine was delivering considerable power at the time of impact. Although the flaps were damaged in the impact and fire, there was sufficient evidence to establish that they were both in the "UP" position at the time of impact. The actuating mechanisms of the stall warning device could not be checked due to impact and fire damage. No evidence could be found of any defect or malfunctioning which might have contributed to the accident.

There was evidence which indicated that the aircraft was refuelled to full tanks prior to the first flight that morning and this was established to be the pilot's normal practice prior to commencing a flight such as this. It has been estimated that the all-up weight of the aircraft at the time of the take-off preceding the accident was just below the maximum permissible of 2,300 lb. The centre of gravity of the aircraft was within specified limits.

The strip used for the take-off was 2,205 feet long and some 200 feet wide with a hard gravel surface graded over the central width of 150 feet. Considering the computed all-up weight of the aircraft and the weather conditions, the specifications of the strip were more than adequate for the take-off It has been calculated that for the aircraft in the normal unflapped take-off configuration, and for the weather and surface conditions as stated, the unstick distance would be between 1,200 and 1,300 feet.

It was established from wheel tracks on the strip that the aircraft commenced the take-off 240 feet from the northern end of the strip, the operational length then available being 1,965 feet.

The sole witness did not take particular notice of the take-off and could not recollect whether the aircraft was airborne when it passed abeam of his position some 1,300 feet from the point of commencement of the take-off. He did notice that the aircraft, when it was well past his position and approaching the southern end of the strip, was airborne and appeared to be gaining height in a normal climbing attitude. He did not observe the position of the flaps. After the aircraft climbed straight ahead to a height which he estimated as between 500 and 600 feet he saw it level off and commence a left turn "which wasn't very steep," apparently to set course on a north-easterly heading for the pilot's home station. Just as the witness expected the aircraft to straighten up from the turn "the left wing suddenly dropped and the nose dropped sharply at the same time". The aircraft dived steeply to the ground, heading towards the north, with the engine "revving at high speed" and with no apparent change in flight path. He was unable to give an estimate of the distance travelled by the aircraft before the turn was commenced.

Arrangements were made for the witness to observe a number of manoeuvres similar to those he had described untilizing a Cessna 172 and other light aircraft types, operating from this strip, in an attempt to reproduce the flight path of the aircraft. During these tests it was evident that his judgment of the horizontal distance of the aircraft was, in most cases, far from accurate and his estimates of heights, which appeared to be based upon a consistent position of the aircraft above the horizon, were often incorrect. The conclusions reached in this regard were that the aircraft climbed straight ahead to a height of between 100 and 500 feet, and to a distance of between 500 and 1,500 feet from his position, before it entered the turn and that the dive commenced from a position between 100 and 350 feet south-east of the accident site. There was little doubt from his observations that the take-off and initial climb were normal in all respects.

Confirmation was also sought from the witness of his observation that the aircraft was levelled out before turning and that, during the turn, the aircraft "appeared to remain in a level attitude". During the tests he consistently described climbing turns as level turns and stated that the nose of the test aircraft was too low in level turns. This left no doubt that, during the turn originally observed, the aircraft was in a climbing attitude. It also appeared from his observations that the aircraft was banked some 45 degrees during the turn and that it continued in this attitude through approximately 140 degrees before the dive was commenced.

The pilot held a valid private pilot licence endorsed for Cessna aircraft. His flying experience amounted to some 800 hours of which some 540 hours had been gained in Cessna 172 aircraft. There was no evidence that he had suffered any physical disability which might have contributed to the accident.

ANALYSIS

The complete absence of evidence of any defect or malfunctioning of the aircraft suggests that the accident may have resulted from the manner in which it was flown.

It has been concluded from the witness's observations that the aircraft's take-off and initial climb were normal and, in addition, that what he had described as a level turn preceding the dive was, in all probability, a climbing turn, with the aircraft banked some 45 degrees. His evidence that the aircraft's port wing dropped suddenly, then the nose, followed by a steep dive is not indicative of any controlled manoeuvre but is consistent with the aircraft having stalled during the turn.

A Cessna 172D, at an all up weight of 2,300 lb., with power on and without the use of flaps, could be expected to stall in laterally level flight at 44 knots but this requires the nose of the aircraft to be held in an abnormally high attitude. The nose will then drop but the wings will normally remain level and the subsequent loss of height during recovery could be expected to be some 250 feet. The stalling speed in a turn will progressively increase to some 52 knots in a 45 degree banked turn and to some 70 knots in a 60 degree banked turn. Such a stall will almost certainly result in a wing dropping suddenly, followed by the rapid dropping of the nose. The severity of a stall will increase with increasing angles of bank with an attendant increase in the height required for recovery.

The observations of the demonstration aircraft by the witness indicated that the turn was commenced between 500 and 1,500 feet from his position, i.e., between a point close to the up-wind end of the strip and some 900 feet south of this position, after the aircraft had climbed to a height of between 100 and 500 feet. These observations also indicated that the aircraft commenced the dive when over an area between 100 and 350 feet south-east of the accident site. Considering the prevailing conditions, it has been calculated that a normal 45 degree banked turn through some 140 degrees would finish within this area only if the turn was commenced in the vicinity of the up-wind end of the strip.

It has also been calculated that an unflapped take-off and initial climb at 60 knots (take-off safety speed 58 knots) would have placed the aircraft at some 80 feet above the upwind end of the strip and that a 45 degree climbing turn from this position through 140 degrees would have resulted in an increase of height, during the turn, of a further 20 feet only. Accepting the probability of minor variations between the parameters used for purposes of calculation and those existing during the actual flight it is concluded that the dive was commenced from a height of between 100 and 200 feet above the ground. This calculated flight path is similar to that followed by the aircraft from one of the other station strips that morning. The aircraft was then observed to take-off without using the full length of the strip available and to climb straight ahead to a height estimated as "approaching 500 feet" when it banked very steeply in a turn through 180 degrees.

The evidence that the aircraft passed over a building and struck the ground in a 70 degree nose down attitude within some 80 feet of the building, supported by the observation of the witness that there was no apparent change in the nose down attitude during the dive, indicates that, at the time of impact, the aircraft was not recovering from the dive and confirms to some degree that the dive was commenced from a low height.

CAUSE

The probable cause of the accident was that the pilot adopted an airspeed having an inadequate margin of safety and the aircraft stalled during a turn after take-off at too low an altitude for recovery to be effected.

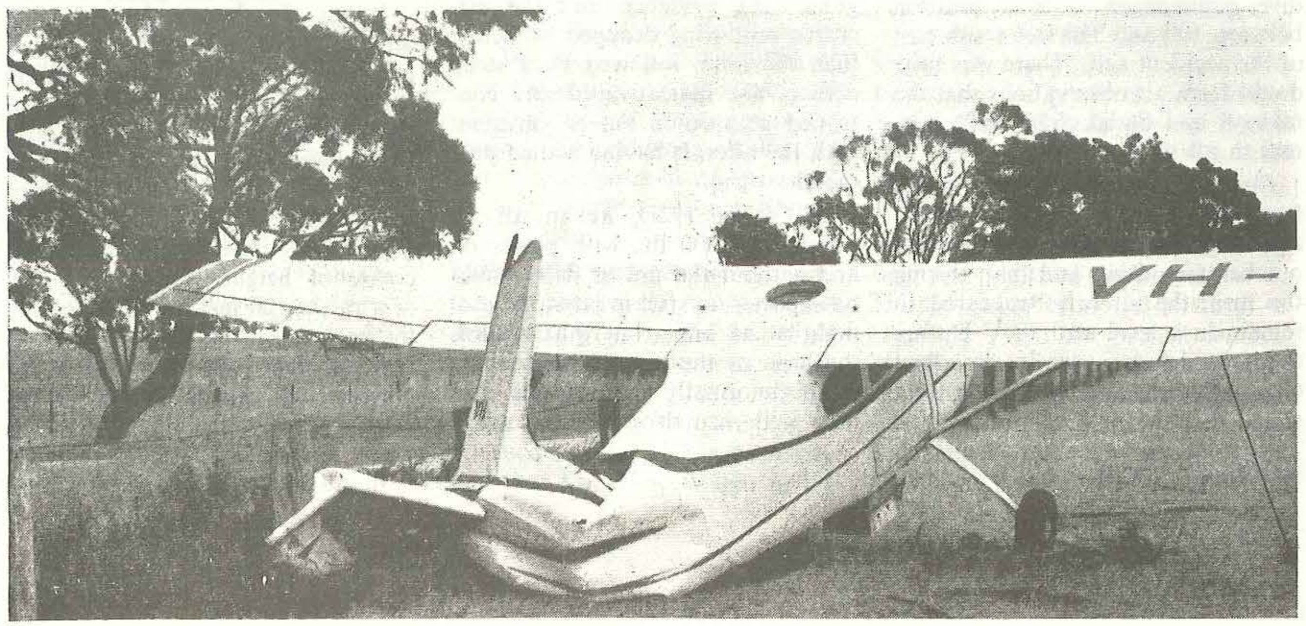
Gone with the Wind

The aircraft pictured here was being refuelled on an agricultural strip when it ran backwards down a slope, under the influence of a sudden gust of wind.

Here is the story, in the pilot's own words:

"At the commencement of refuelling a light northerly was blowing. The aircraft was parked facing north down the strip at the extreme southern end; the truck with the fuel was parked east and west across the front of the aircraft. Mr. . . . . . was on the truck pumping the fuel and I was standing on the port strut attending to the filling of the port tank. During the operation a strong gust spun the aircraft on the starboard wheel and it commenced rolling backwards. I endeavoured to hold the aircraft by holding the hose, this pulled Mr. . . . . . and the three-quarters full drum of petrol, from which he was pumping, off the truck, also breaking the hose. I then jumped down and ran around and endeavoured to climb into the aircraft but the plane's increased momentum, plus the fact that it was rolling backwards, made this impossible. The aircraft continued down the slope and crashed tail first into a fence. The tailplane and fuselage aft of the luggage door were extremely damaged. At the time the aircraft contained a four-bag load of superphosphate."

No doubt the pilot concerned will ensure that his aircraft is securely parked in future. We pass the story on in case there are others who can profit from his experience.



DRY ICE

An Advisory Circular recently issued by the Federal Aviation Agency, U.S.A., draws attention to the possible hazard that may be associated with the sublimation of dry ice aboard aircraft. Aircrews transporting dry ice, or perishable goods packed in it, should ensure that there is adequate ventilation to prevent carbon dioxide building up above acceptable levels and should be aware of the symptoms resulting from exposure to excessive quantities of this gas.

THE HAZARD

Dry ice is solidified carbon dioxide, which has a melting point of minus 78.5°C. Under normal temperature conditions it gradually evaporates and releases carbon dioxide gas. This gas is not poisonous but can cause oxygen dilution in confined spaces where ventilation is restricted. The rate at which carbon dioxide gas is released will vary according to whether the ice is in the crushed or solid form; with temperature, atmospheric pressure and with the amount of insulation used in packaging. Flight experience shows that **as a general rule, an evaporation rate of one pound per hundred pounds of dry ice per hour can be expected.**

In Australian operations small quantities of dry ice are frequently carried on aircraft for the preservation of foods and medicines. On some routes shipments of approximately 150 lb. are often transported in public transport aircraft as freight, whilst larger quantities have occasionally been uplifted in freighter aircraft. The ice is not listed as dangerous cargo under the I.A.T.A. Regulations, nor are there any restrictions applied to its carriage. Under normal ventilation conditions it is not considered to present a hazard aboard an aircraft.

THE EFFECTS

The signs and symptoms of excessive carbon dioxide are headache, dizziness, increased rate and depth of breathing, muscular weakness, drowsiness and ringing in the ears. Removal from exposure results in rapid recovery.

The symptoms are related to the effect of carbon dioxide in the blood on certain bodily processes. Where the breathing environment contains only slightly more than the normal amounts of carbon dioxide its presence will pass unnoticed. As the concentration approaches 3 per cent the depth of respiration will increase, resulting in an increase of air taken into the lungs with each breath. If the concentration is increased to 4 per cent the depth and rate of breathing becomes such that considerable discomfort will be experienced. When the concentration reaches 4½ to 5 per cent breathing becomes extremely laboured and almost unbearable to some individuals. The most that can be tolerated is 7 to 9 per cent and a concentration of more than 10 per cent will cause muscular in-co-ordination and unconsciousness.

Precautions

Where large quantities of dry ice are transported the concentration of carbon dioxide in an aircraft cabin should not be allowed to exceed 0.5 per cent, which is equivalent to 5,000 parts per million. To ensure that this rate is not exceeded a simple formula can be used to determine the maximum quantity that can be carried with safety. This formula is based on a sublimation rate of 8.5 cubic feet (one pound) of carbon dioxide (CO_2) per hundred pounds of dry ice per hour. Assuming that X equals the maximum safe load in pounds, the formula is:

$$X = \frac{(CO_2 \text{ concentration})\ (\text{A/c Volume})\ (\text{Airchanges per hour})}{.085\ (\text{Sublimation rate})}$$

For example:

Aircraft Volume	= 5000 cubic feet
Air changes per hour	= 5
Allowable CO_2 concentration	= 0.005 (0.5%)
Sublimation rate	= 8.5 cubic feet per 100 lbs. per hour

$$X = \frac{.005 \times 500 \times 5}{.085} = 1470 \text{ lb. dry ice}$$

Quantities of this order would rarely be encountered even in freighter operations. Application of the formula to a light cabin type of aircraft with a cabin volume of say 150 cubic feet, however, means that the maximum amount of dry ice that could be carried with safety would be 44 lb. The ice is usually distributed by the manufacturers in 50 lb. blocks, consequently one block would be the maximum that could be used to preserve perishable goods carried in the lighter types of cabin aircraft.

The greatest need for precautions against carbon dioxide asphyxia arises where dry ice is used to preserve goods which are packed in an aicraft some time prior to take-off. In one such case recorded in the United States, a container of fresh game had been packed in dry ice and locked in the aircraft overnight. When the crew entered the aircraft for departure the next morning they experienced sudden air hunger and symptoms of asphyxia. Sufficient dry ice had evaporated overnight to cause a dangerous concentration of carbon dioxide in the unventilated cabin. This situation can be avoided by ensuring that ventilation is adequate. Remember too, that carbon dioxide is heavier than the normal atmosphere, consequently the most effective ventilation would be achieved at or about floor level.

Fuel Ejection

On 1st November, 1963, a Cessna 182 overturned when the nose-wheel contacted a washaway during an attempted forced landing in Central Australia. Later the same month a Cessna 180 forced landed safely in a Kunai grass patch in New Guinea. In both cases all usable fuel had been exhausted in flight, by ejection through an insecurely fitted tank cap.

The Cessna 182 was engaged on a charter operation across desolate country about 300 miles north-west of Alice Springs. It was refuelled to maximum capacity before departure on a 60 minute flight to where a landing was to be made on an infrequently used strip which is part of the flat surface of a dry salt lake. The terrain surrounding the lake is of eroded sandy soil, with a few outcrops of granite, some stunted vegetation and many of the large ant hills which are a feature of the central desert country. There were four persons on board the aircraft.

After take-off the pilot noticed that the starboard fuel gauge was behaving erratically. He checked exterior of the aircraft as far as possible for fuel escaping from the tank cap, but finding no evidence of fuel streaming from the tank concluded that the gauge was malfunctioning. A short time later this same fuel gauge needle settled down at the FULL position. As the flight progressed both gauges were somewhat erratic in their indication but generally indicated the correct levels in relation to the estimated fuel consumption. The fuel selector was positioned to BOTH throughout the flight.

On arrival at his destination the pilot transmitted a circuit area report and then elected to make a low level run to one side of the strip to check its condition prior to landing. He descended to about 200 feet and at this height engine power failed and could not be restored. Realizing that he would be unable to reach the intended landing strip the pilot selected the best available forced landing path and a normal touchdown was accomplished. At a late stage in the landing run the nose strut broke when the nose-wheel struck the edge of a shallow washaway and the aircraft overturned.

None of the occupants were seriously injured and advice of the accident was passed to Alice Springs communications centre via the Royal Flying Doctor Service radio network, using a portable transceiver which was carried in the aircraft. Supplies were dropped and the occupants were rescued some hours later.

Examination of the aircraft established that the starboard fuel tank cap had been incorrectly positioned and that all of the fuel from both tanks had been siphoned to atmosphere during the 60 minute flight.

In the case of the Cessna 180 the pilot had refuelled to maximum capacity before departure on a three hour flight from Daru to Port Moresby, with four persons on board. The flight proceeded uneventfully for two hours forty minutes. When about 40 miles from Port Moresby and at a height of approximately 1,500 feet the engine failed abruptly. As attempts to restore power were unsuccessful, the pilot transmitted a MAYDAY call and made for the only available forced landing area — a patch of kunai grass. He advised Port Moresby Communications centre of his intention, turned off the ignition, fuel, radio and master switch, and prepared his passengers for the emergency landing. The landing was successful, the aircraft coming to rest after running less than 50 yards through kunai grass about three feet in height. None of the occupants were injured.

After ensuring that it was safe to use the radio, the pilot advised the communication centre of his exact location. Supplies were dropped and a rescue was effected several hours later, by a ground party from a plantation in the area.

When the pilot examined the aircraft soon after landing he found that the cover flap over the port fuel tank cap was unfastened and that the port fuel tank cap was missing. Both fuel tanks were completely exhausted, despite the fact that the gauges were registering approximately HALF at the time that the engine failed. The fuel system was selected to BOTH throughout the flight.

In the Central Australia accident the pilot acknowledges that he made only a visual check of the fuel tank cap after it was fitted by another person. The cap was found to be insecure immediately after the accident, so there is no doubt that in this particular case the cap was not correctly fitted. The New Guinea pilot believes that he fitted the tank cap correctly and is equally sure that the cover flap was securely fastened after the cap was replaced. The cap was lost during the flight, so firm conclusions cannot be reached on this point, but there are very persuasive reasons for believing that this cap too was not securely fitted.

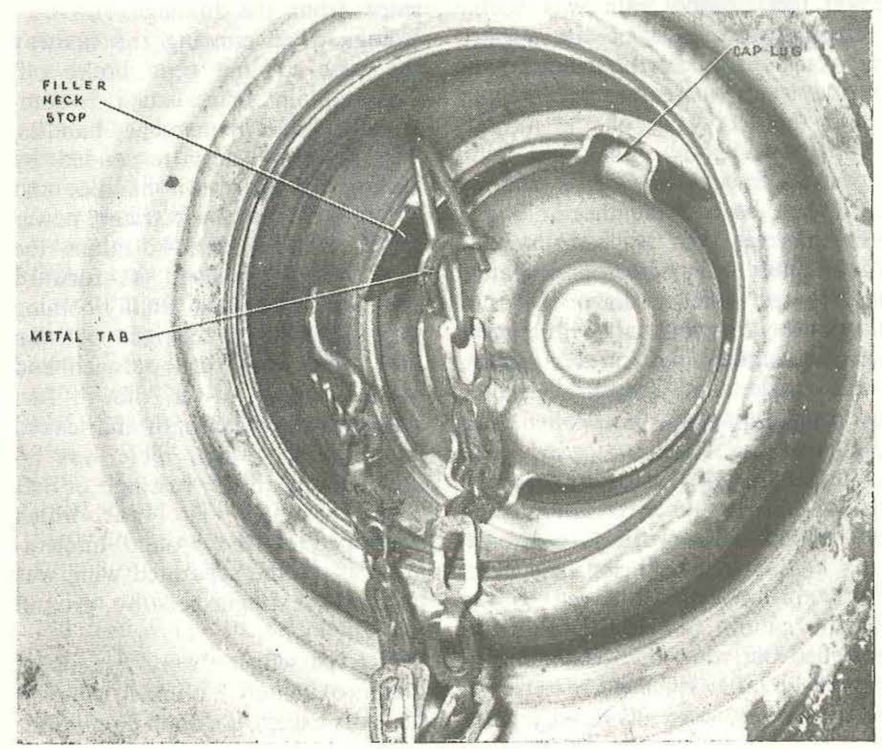
Obviously the pilots concerned must accept the primary responsibility for these incorrectly fitted tank caps. At the same time, however, the investigation into the Central Australian accident revealed that there is a strong possibility that the retaining chain attachment pin may have caused interference which contributed to the errors.

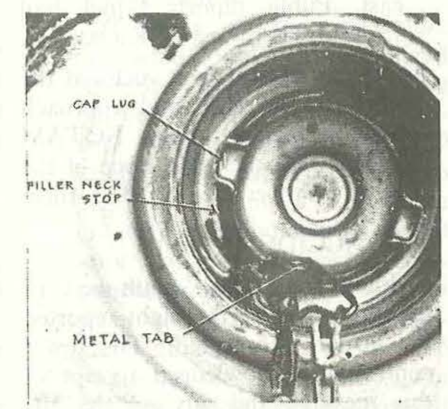
In common with other modern light aircraft, the Cessna fuel tank cap is an automotive type which incorporates a spring clip to hold it in place. The clip moves up a ramp into a detent as the cap is turned approximately 90 degrees, thus forcing a neoprene rubber washer into position to form an air-tight seal against the filler neck. A short length of bath chain is used to retain the cap when it is removed for refuelling. One end of this chain is fastened to a lug within the filler neck, whilst the other end is connected to the inside of the cap by means of a wire safety pin. Normally, the safety pin and chain hang vertically below the cap when it is fitted to the tank. Circumstances can arise, however, where the safety pin positions itself horizontally under the cap, and in this position it can foul the stop on the filler neck, thus preventing the cap from being readily rotated into the locking detents. (See photograph. The inset shows where the cap lug should stop when the cap is rotated to the fully locked position.) If the safety pin fouls the stop in this way the cap feels secure but does not provide an effective seal, thus setting up a condition where fuel can be sucked past the cap into the low pressure area above the wing.

Checks made on a number of aircraft using this type of tank cap and retaining chain configuration revealed that the lug on the undersurface of the tank cap had been twisted as a result of the pin contacting the stop, with corresponding marks evident on the stop. This condition can, of course, be avoided by careful fitting of the tank cap but is difficult to detect once the cap is installed, as there is no ready means of determining whether the cap has rotated into the fully locked position. Witness marks painted on the cap and the adjoining structure, which align when the cap is in the fully locked position, will provide such a reference and are a worthwhile precaution on any aircraft.

The reason why fuel is lost through an insecurely fitted tank cap was explained in Aviation Safety Digest No. 35, September, 1963, in an article entitled "The Breath of Life". The fuel systems in the Cessna 180 series aircraft, in which the two tanks are interconnected through a vent line and the port tank is vented to atmosphere through a forward facing vent, are particularly susceptible to loss of fuel in this way, because the cap venting condition is further aggravated by the "squeeze" effect on the flexible fuel cells.

The relative inaccessibility of the fuel tank caps on high wing aircraft seems to be a factor which is contributing to this type of incident. Our records show that during the past few years we have been informed of 18 cases where the tank caps on light aircraft were insecurely fitted. Only two of these reports concerned low wing type aircraft, on which the tank caps are readily inspected. These figures suggest that the incidents and accidents are generated by an attitude of mind, wherein pilots accept that some other person has checked the tank cap for them, rather than take the trouble to obtain a means of reaching the tank cap and ensuring that the job has been done correctly. Our records show, quite clearly, that such an attitude eventually leads to embarrassment, if not to disaster.





Close up views from underneath tank cap assembly shows (left) retaining pin fouling between metal tab on cap and the stop on the filler neck and preventing further movement to closed position, and (right) fuel cap in locked position.

Electra Aquaplanes off Runway

(Summary of an accident report released by Civil Aeronautics Board, U.S.A.)

KNOXVILLE, TENNESSEE

On 6th August, 1962, a Lockheed Electra landing in thunderstorm conditions at Knoxville, Tennessee, skidded to the right off the runway and struck a newly constructed taxiway, the surface of which was approximately 17 inches above ground level. The right main landing gear failed, the right wing separated from the aircraft and the remainder of the aircraft continued to deviate to the right for a short distance before coming to rest 3,010 feet from the approach end of the runway. All of the 67 passengers and five crew members on board escaped injury except for one passenger who suffered a minor injury.

WEATHER CONDITIONS

The forecast given to the crew before departure from Dallas, Texas, indicated scattered thunderstorms over Tennessee and in the area of the Knoxville Terminal, where the ceiling was predicted to be 3,000 feet, lowering briefly in thunderstorms, with heavy rain, sky obscured and visibility approximately one mile. Nearing Knoxville the flight contacted approach control and was given the following weather report:

"Estimated ceiling 3,000 broken; 12,000 broken cirrus; visibility two zero; thunderstorm. Thunderstorm north moving east-north-east. Public reports $\frac{3}{4}$ inch hail 15 miles northwest of Knoxville".

Approach control then vectored the aircraft to the ILS final approach course to runway 4. A NOTAM indicated that the glide slope of the ILS was inoperative at that time.

THE ACCIDENT

When four miles south-west of the outer marker the flight reported the airport "in sight". The tower controller acknowledged receipt of this message and advised the aircraft that it was in sight, was cleared to land on runway four left and that the wind was north-west 20 knots with gusts to 28 knots. The only additional information requested by the flight was the altimeter setting, which was provided. When the flight was approximately one half mile from touchdown, the local controller transmitted the message: "Gusts now to 35". This message was not addressed to any particular aircraft.

The final approach was made in light rain and light to moderate turbulence was encountered below 300 feet. Heavy rain was visible on the west edge of the airport. At or shortly before touchdown the wind gusts increased in intensity and the left wing of the aircraft came up slightly. The right main gear made contact with the runway 223 feet beyond the threshold and the aircraft then skipped three or four times to a point approximately 1,000 feet farther down the runway. At this point all wheels were on the runway and full left aileron, left rudder and forward elevator control pressures were applied. The flaps were left fully extended. The aircraft was then engulfed in heavy rain and encountered wind gusts estimated by a witness to be 40-50 knots. When the strong gusts struck, the aircraft moved to the right. Full reverse thrust was applied but when the rate of movement to the right increased the power levers were advanced toward the flight idle position, reducing the reverse thrust. The aircraft continued its forward and rightward movement until the right main gear left the runway approximately 2,000 feet from the threshold. After traversing an additional 462 feet the aircraft struck the edge of a taxiway which was under construction, the right main landing gear failed, No's 3 and 4 propellers gouged the concrete and the right wing separated from the fuselage.

Soon after crossing the taxiway the nose landing gear broke off. The captain then issued a command to pull all emergency handles. The flight engineer responded by pulling the shutdown handles and shutting off the electrical power switches. The aircraft, minus the right wing, continued its forward and right movement, finally coming to a stop in an upright position 3,010 feet from the approach end of the runway. Even though fuel spilled in the crash path and leaked from the left wing, there was no fire in or near the fuselage or left wing section. A fire which developed on the ground immediately aft of the separated wing was promptly extinguished by ground services.

The passengers were evacuated in approximately 3 minutes using all the exits except the main cabin door and the right overwing exit. One passenger received minor injuries when she jumped from the galley door against the stewardess's advice.

INVESTIGATION

The aircraft and its powerplants sustained major damage. Both sides of the fuselage were penetrated by pieces of propellers. A section of the propeller twelve inches by eight inches was found in the forward cabin compartment and another piece eight inches by six inches was found protruding four inches through the floor into the cabin interior. One blade had penetrated the cabin interior aft of the lavatory in front of the first passenger seat. The right wing front spar severed at the fuselage in an aft and slightly upward direction.

A detailed examination of the aircraft's structure and systems revealed no evidence of failures prior to impact. The wing flaps were fully extended and the landing gear was down and locked at impact. Inspection of the powerplants revealed that they had been capable of normal operation. These facts were further substantiated by the flight crew who stated that the operation of the aircraft and powerplants was normal with the exception of the No. 1 Beta light, which came on late. The No. 1 propeller was checked completely and operated normally except that the Beta light switch adjustment was found to be set for actuation at a propeller blade pitch approximately two degrees lower than normal.

The runway is 9,000 feet long and 150 feet wide. Its magnetic heading is 045 degrees and the runway slopes upward on a one-degree grade for a distance of 5,500 feet. The pavement is concrete with a crowned cross section and transverse slopes of $1\frac{1}{2}$ degrees to each side from the centreline. The elevation of the threshold is 923.3 feet above m.s.l. Due to an intervening hill, only the touchdown area of the approach end of the runway is visible from the control tower. Examination of the Electra's tire marks revealed that with the exception of the initial touchdown markings, which were black, the remaining marks were light, or whitish, in colour.

Witness evidence provided by experienced pilots indicated that the approach was made in moderate rain and a wind of about 20 knots. Just prior to touchdown the wind increased to 50 knots and the rain became heavier, causing a build-up of water on the runway. A special weather observation, taken one minute after the accident recorded conditions substantially in agreement with these observations.

ANALYSIS

The flight was despatched according to company procedures; the flight crew and the aircraft were properly certificated; the aircraft landed within allowable weight limits and there were no significant malfunctions or failures of the engines, the aircraft or its components.

Before departure from Dallas, the crew was furnished with weather forecasts which indicated scattered thunderstorm activity over Tennessee and at Knoxville Airport. On the basis of the information provided to him by the approach controller it would not have been unreasonable for the pilot to have assumed that all thunderstorm activity was moving away from the airport. As the aircraft neared the airport however, the location and intensity of such activity should have been apparent by visual observation. There is some doubt as to whether the captain received the message "Gusts now to 35". His testimony indicated, however, that he was advised that the wind was 20 knots, gusts to 28.

The Operator's Operations Manual, dealing with the subjects of flap retraction after touchdown and crosswing landings, states as follows:

"Flap Retraction After Touchdown: If heavy water collection on runway, retract flaps immediately after touchdown."

"Crosswind Landings — Keep wings near level, maintaining runway alignment during approach mainly by crabbing. Remove the crab just prior to runway contact, to avoid side load stresses on the gear. Avoid holding the aircraft off during flare; low angles of attack during landing provide positive lateral control."

"26 knots is the maximum crosswind component authorized on a dry runway. When landing on wet runways of normal runway surface characteristics, 20 knots is generally considered to be the maximum acceptable crosswind component. This 20 knot maximum crosswind component would also apply to runways with obstructions immediately adjacent to, or in the threshold of, the runway. On slippery, snow or ice-covered runways, where braking for similar types of aircraft is reported to be poor, a crosswind component of 10 knots is considered about the maximum acceptable; it follows, then, in the interest of conservative operation, landing under such conditions with crosswind components in excess of 10 knots is not recommended. After touchdown, continue to control the airplane in all axes while decelerating to taxi speed or until nosewheel steering and wheel braking becomes effective. Use asymmetrical reverse thrust as necessary to aid in maintainin desired heading during deceleration; however, delay application of reverse thrust until sufficient traction is available to overcome inadvertent asymmetrical reverse thrust caused by throttle rigging or sluggish governor operation."

A north-northwest wind of 20 knots on runway 4 would result in an effective crosswind component of approximately 18 knots. Eyewitnesses confirmed that there was a substantial increase in wind velocity as the thunderstorm approached the airport. Since the initial touchdown was nearly simultaneous with the arrival of the strong wind and gusts in that immediate vicinity, it was concluded that the crosswind component encountered on landing in all probability exceeded the value specified in the company manual. While it cannot be expected that a pilot would mentally compute the exact crosswind component, he should be able to recognize an area of danger. In this instance he should have been aware that there was a signficant crosswind, and that it could be increasing in intensity because of the proximity of the thunderstorm.

The tire marks on the runway indicated that the pilot landed the aircraft left wing high with the right main landing gear touching down first. The mark made by initial touchdown of the nose landing gear indicated that the aircraft heading was 6 degrees left of the runway heading. The facts show that the flaps were not retracted after all three landing gears were on the ground as required by the Operator's Operations Manual. Further, reverse thrust was used, in an effort to control the aircraft, before positive traction and control of the aircraft had been established. Failure to retract the flaps, and the use of reverse thrust under these conditions, is contrary to the requirements of the operations manual.

The light colored or whitish tyre marks observed on the runway during the investigation are the type of markings commonly associated with a phenomenon known as aquaplaning. Aquaplaning occurs when the hydrodynamic lift force developed between a tire and a water-covered runway equals or exceeds the down loading of the aircraft on the tyres. In this condition a film of fluid exists between the tyre and the runway surface, resulting in a loss of ground traction.

Any action by the pilot which would increase the vertical loading on the landing gear would be of value in avoiding aquaplaning. The crew's failure to retract the flaps as required by the company's operations manual for wet runway operation contributed to this phenomenon.

Application of symmetrical reverse thrust to an aquaplaning aircraft that is in a crabbed attitude to compensate for a crosswind will assist the crosswind in drifting the aircraft.

The pilot stated that the No. 1 Beta light came on late and that the slow reversing of the No. 1 propeller caused the aircraft to veer to the right. The No. 1 propeller operated normally when checked except that the Beta light switch adjustment was found to be set for actuation at a propeller blade pitch approximately two degrees lower than normal. This would cause the light to come on later in relation to the other Beta lights, but would not affect the reversing, because the Beta light is a visual indication only. Furthermore, the Operator's Operations Manual states that reverse thrust will not be initiated until after the Beta lights are on.

PROBABLE CAUSE

The Board determined that the probable cause of this accident was the loss of directional control as a result of the improper technique employed in a crosswind landing in adverse weather conditions.

FIRE — by Reflection?

Recently a DH-82 tied down outside a hangar on a country aerodrome caught fire and was severely damaged. The fire occurred soon after midday and was first noticed by a motorist who was approaching the aerodrome along the access road.

The aircraft engine had not been run for two days prior to this fire and some of the possible causes, such as smoking, welding or soldering near the aircraft, were investigated and eliminated. The cause of the fire has not been positively established but it is believed that the ignition was brought about by reflections from an aluminium cowl which was positioned near the front of the aircraft. Tests carried out with this cowl indicated that in hot sun conditions it was capable of raising the temperature of the aircraft fabric sufficient to cause it to ignite.

Involuntary Decompression

Just after commencing descent from 38,000 feet into Singapore a Boeing 707 suffered an involuntary de-compression. The cause of the de-compression has not been positively determined but is thought to have been a faulty outflow valve.

This was not a rapid de-compression — in fact the first indication of de-compression was an instrument noted increase of cabin altitude coincident with the Captain experiencing pressure effect on his ear drums. As cabin altitude continued to rise at a rate in excess of 2,000 feet per minute de-compression was recognised and appropriate de-compression drill implemented.

As far as the cockpit aspects were concerned everything went smoothly. The operating crew were able to don their "quick-donning" (sweep-on type) masks and have them fully functioning within an estimated three seconds after positive recognition of de-compression; the aural and visual de-compression warnings operated at the appropriate times, and the aircraft was quickly established in rapid descent. There was no fogging.

On this occasion the events in the cabin were of greater interest. The Boeing 707 is fitted with passenger oxygen masks stowed in enclosures above each row of seats, so designed that a trap door automatically opens and permits the masks to drop out, ready for use, when cabin altitude rises above 14,000 feet. The operator concerned makes a practice of briefing joining passengers on the operation of the system prior to take-off.

The automatic release of the masks was the first indication in the cabin that a de-compression situation existed (remember that the aircraft had already commenced descent into Singapore). The galley warning light was not noticed.

A steward, on duty in the cabin, experienced pressure on his ears and slight breathlessness immediately before the masks fell. He put on a spare passenger mask and then checked passengers, and found that most had their masks in position. He subsequently walked through the economy class cabin, with the cabin altitude at about 18,000 feet, without using a walk around oxygen set.

A second steward was in the galley. He saw the masks deploy and initially assumed that the mask retaining system had malfunctioned. He walked part way into the cabin and then returned to the galley to secure equipment against the steep descent. Within 30 seconds he felt nausea and was conscious of a lack of co-ordination and was later under the impression that he knocked over several bottles and an ice-bucket. At this point he made use of a portable oxygen set. While this steward was under the impression that he knocked over the ice-bucket he was in fact observed to have lifted it and inverted it. Also he was seen to search for a key which he was holding between his teeth.

A third steward was in a toilet when the mask at that location was released. He also initially assumed a system malfunction and endeavoured to restow the mask. He subsequently appreciated the true situation and moved through the cabin using spare passenger masks as he moved along. Some passengers advised this steward that they did not feel the need to use a mask and did not do so.

With the exception of the one steward located in the galley, there was no significant hypoxic effect on cabin crew or passengers and it might well be asked what lessons can be learnt under these circumstances. Here are a few which could be very relevant to a future incident, particularly one involving a higher rate of de-compression.

The operator is examining means of providing a more effective cabin warning system.

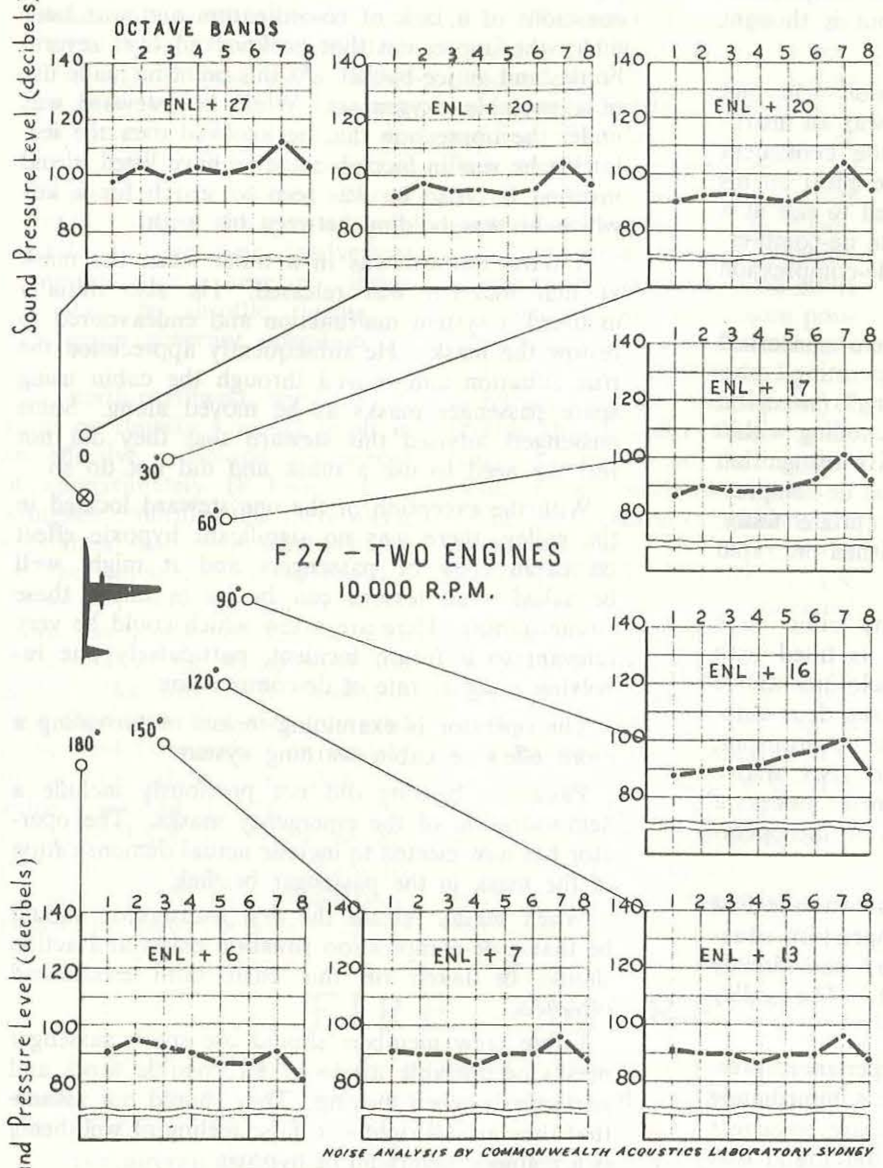
Passenger briefing did not previously include a demonstration of the emergency masks. The operator has now elected to include actual demonstration of the mask in the passenger briefing.

When masks release the first assumption should be that a de-compression situation exists and action should be taken on this basis until established otherwise.

Cabin crew members should use spare passenger masks or portable masks at all possible times and particularly when moving. They should not **assume** that they are all right — a false feeling of well-being is a common symptom of hypoxia.

For the same reasons as above, the average passenger is not fully capable of determining whether he is suffering or is likely to suffer hypoxia. Therefore every endeavour should be made to have **every** passenger breathe ozygen while the cabin is at an altitude where hypoxic effects are likely. (ANO 20.4 establishes this as a requirement.)

NOISE IN GROUND RUNNING



OCTAVE BANDS 1 ··· 37·5 — 75 CPS. 2 ··· 75 — 150 CPS.
3 ··· 150 — 300 CPS. 4 ··· 300 — 600 " " 5 ··· 600 — 1,200 " "
6 ··· 1,200 — 2,400 " " 7 ··· 2,400 — 4,800 " " 8 ··· 4,800 — 9,000 " "

Fig. 1

E.N.L. is **Excess Noise Level.** It is the amount (in db.) by which a particular noise spectrum exceeds the Hearing Conservation Level. It is a measure of the degree of the damage-to-hearing risk of the noise in susceptible people.

All pilots are aware that turbine aircraft, in general, tend to produce higher noise levels during ground running than the levels experienced with piston-engined aircraft. Not only is overall noise level higher the component frequencies involved are such as to make us more conscious of the noise.

For these reasons operators require that ground personnel who have a need to be close to turbine aircraft during ground running should wear protective devices over the ears. While it is the responsibility of operators and individual ground staff to observe this precaution, pilots of turbine aircraft ought also to be aware of the risk of hearing damage which exists close to turbine aircraft starting up or ground running.

A ground running noise analysis, representative of turbine aircraft, was made as part of the investigation of an F27 incident and the setting of 10,000 R.P.M. was selected as being indicative of the normal power setting which would be used during a start on ship's battery.

The analysis is presented graphically at Figure 1 and establishes the noise field around an F27 at a radius of 100 feet, from the centre of the aircraft and also at a point 15 feet in front of the aircraft which would be the normal location of the person responsible for ground control during start up. For each location the graph shows the noise (sound pressure level) in each octave band from No. 1 (37.5 to 75 cps) to No. 8 (4800 to 9600 cps).

The Hearing Conservation level (H.C.L.) is the maximum sound pressure level in the critical frequencies for preserving the hearing over a **full working life** in people susceptible to noise-induced hearing loss. The Excess Noise Level (E.N.L.) is the amount, in db, by which the particular noise spectrum exceeds the H.C.L. It is thus a measure of possible hearing damage.

The figure shows the noise analysis for both engines running at 10,000 R.P.M., but the noise is not much less for only one engine at 10,000 R.P.M., as the following table shows.

EXCESS NOISE LEVEL

position	one engine	both engines
15 feet in front	+23	+27
180° at 100 ft.	+17	+20
150° at 100 ft.	+19	+20
120° at 100 ft.	+14	+17
90° at 100 ft.	+15	+16
60° at 100 ft.	+ 9	+13
30° at 100 ft.	+ 4	+ 7
15° at 100 ft.	+ 0	+ 6

The analysis therefore provides ample evidence that there is a hearing damage risk in the vicinity of an F27 during ground running, particularly at the normal ground control position, unless hearing protective devices are worn. While the noise levels are somewhat different for other aircraft types the lesson is the same.

Careless Talk

The following portion of the tape-recorded voice communications between pilot and ATC was transcribed for the purposes of investigating a recent incident.

Pilot: "Permission to descend from flight level three two zero (320) down to one five (15) to the south."

ATC: "Descend to one five thousand (15,000) on QNH 1018."
Pilot: "Roger 1018."

The pilot's intention was to descend to one five zero zero (1,500) feet, but the ATC clearance was clearly for a descent to one five thousand (15,000) feet.

The pilot did not use the correct term "one five zero zero" and he did not offer a read back of the clearance given by ATC.

ATC did not require a read back when it was not offered.

Flight level or altitude assignments are often critical, therefore the pilot must be in no doubt as to the level or altitude to which he has been cleared.

The lesson is obvious. Loose phrases and failure to adhere to correct air-ground communications procedures may create dangerous situations.

Even in general discussion, phrases used may develop habits which are difficult to eradicate in air-ground communications. For example are you in the habit of referring to flight levels 250, 230, 180 as "two five", "two three", "one eight"? The use of incorrect abbreviations has been noted as quite common in general discussion and although records of incidents directly attributed to this cause are relatively few, the potential for error is ever present.

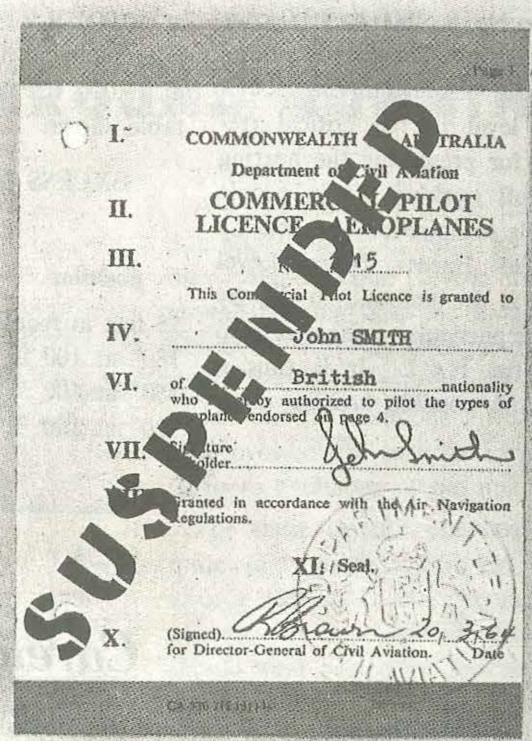
Pilot Licence Suspensions

It has not been our normal practice to use the Digest for the promulgation of policy statements outside the fields directly concerned with accident investigations and prevention. A statement which is concerned with the suspension of pilot licences may not, at first glance, appear compatible with this principle yet, in fact, there is a close relationship between licence suspension, accident and incident investigation and accident prevention.

It has been evident, from references to the subject in other publications and from our discussions with individuals, that there is still some misunderstanding of the statutory obligations of the Director-General of Civil Aviation and the rights of pilots in relation to licence suspensions and cancellations. It is therefore opportune to again acquaint pilots with the regulations and factors which are involved.

Before we look at detailed forms and usages, however, it is important to have an appreciation of the fundamental principle upon which the Department acts in these matters. In the terms of the Air Navigation Regulations the Director-General of Civil Aviation has the responsibility for granting, endorsing, suspending, varying or cancelling the licences applicable to specified occupations in the aviation industry. It is fundamental to the administration of any statutory responibility, such as this, that the person upon whom power is conferred shall act first and foremost "in the public interest". It follows, therefore, that where there is reason to suspect that a licence holder may menace the welfare of any member of the community, while exercising the privileges of his licence, the Director-General must take steps to limit the activities of that licence holder, until there is no continuing ground for the suspicion. Responsibility "in the public interest" is a sometimes overworked and often derided phrase, but if the Department or the industry ever overlooks its responsibility to the people who comprise the community which it serves, then justifiable criticism and declining custom will surely follow.

The safety standard of civil aviation as a whole is an end result of the standards achieved in the various components of each operation — the pilot, the aircraft, the operating procedures and the ground facilities. The accident and incident rate is the measure of the safety level and the indicator of the effectiveness of the individual standards. Accident and incident investigation is therefore equally concerned with all of the 'components' but, for the purposes of this article, we are concerned only with pilots and pilot proficiency. Standards for pilot licensing have been developed in this context and it follows that the effort of accident and incident investigation must be directed to the dual purpose of determining need for variation of standards and establishing whether any individual performance is below the minimum level designed to be achieved by the appropriate standard. The provisions for licence suspension are relevant to this latter consideration.



With this background we can pass to the mechanics of the system and note that there are three separate and distinct provisions under which a pilot licence may be suspended — the so-called 'suspension pending investigation' (ANR 257), the suspension pending the results of a required examination or test (ANR 256) and the ultimate act of cancellation, variation or suspension as provided for in Air Navigation Regulation 258. The most frequently invoked provision is the 'suspension pending investigation' and it is appropriate that this is discussed first.

When the circumstances of an accident or incident give no early suggestion of the proficiency of the pilot being in question, the investigation of the accident or incident proceeds without licence action. However, if questionable proficiency is immediately apparent or is suspected at any stage of the investigation, then there is an obvious need to 'protect the public interest' until the suspicion is confirmed or removed by the completed investigation. Licence suspension pending investigation is therefore invoked but it is essential to appreciate that this action is **not** a pre-judgement of the issue — it is a precaution demanded in the interests of safety.

There is a ready example of the need for this provision in the circumstances of an unauthorized penetration of controlled airspace which appears to be due to a lack of knowledge of the required procedures by the pilot concerned. The investigation of such an incident will involve personal interviews, the transcription of communication recordings, etc. and this action will necessarily take some time but only on completion of this effort can a full judgement be made on the question of proficiency. However, if there was a lack of proper knowledge of procedures and no action had been taken to restrict the activities of the pilot during the period of investigation he would not only have been a threat to safety on the occasion under investigation but also on each subsequent occasion that he flew during the period of investigation. Obviously no organization having the responsibility for safety standards should permit a pilot to exercise the privileges of his licence, even for a single flight, whenever there is reason to doubt that the pilot can still meet the minimum standards necessary to qualify for the licence privilege in question.

The suspension of a licence pending investigation cannot continue for more than 28 days and the regulations impose an explicit obligation on the Director-General to investigate the incident immediately. The suspension ends automatically once the investigation is complete. Incidents are rarely so involved that the investigation takes the full 28 days permitted under the Regulations and the Department's investigation staff have standing instructions to handle investigations involving licence suspension as quickly as possible. Although there is no right of appeal against a suspension pending investigation there would be little real practical value in having such a right since no Board of Appeal could consider the merits of a case until the matter had been completely investigated. Once the Department's investigation is complete, the findings are used to determine what further action, if any, should be taken in respect of the pilot's licence. However, further suspension or variation of the licence does not follow automatically from the establishment of a fault in proficiency. Such action only applies where the shortcoming is likely to be a continuing one as distinct from, for example, an isolated error of judgement.

The provisions for suspension pending examination or test follow as a natural corollary to the discussion on suspension pending investigation. Where the investigation of accident or incident, or information from any other reliable source establishes a doubt as to the proficiency of a pilot the only means of resolving that doubt may be to require the pilot to undergo an examination or flight test. It is again obvious that the public interest must continue to be protected until the doubts are resolved by examination and this protection can only be achieved by suspension of the licence until the examination or test is completed. Proficiency in this context has, of course, a wide meaning and may embrace considerations of manipulative ability or theoretical knowledge or even medical fitness. It is also relevant that a suspension under these provisions does not carry any fixed time limit since the determining factor is the specified examination or test. However, in most instances the timing will be under the control of the pilot concerned having regard to his confidence and his ability to present himself for examination.

The suspension provisions which have been discussed so far may be regarded generally as being precautionary safety measures of relatively short term and the rights and interests of the pilot have been given as much protection as possible in the specification of the provisions.

The only provision for long term suspension, variation or cancellation of a licence is that contained in Air Navigation Regulation 258 and an action taken under this regulation automatically gives the pilot a right to either have the matter submitted to a Board of Review or to appeal to a specified court against the decision. It should be noted that licence action taken as a result of an examination or test must be taken under these provisions and therefore carries the same appeal rights. It is perhaps little known that the scope of the Australan pilot's right of appeal is wider than in any other Commonwealth country and that, in almost all such countries, the decision of the licensing authority is absolute and final. It is important that pilots should be fully aware of their rights of appeal and those who wish to study the rights in detail should refer to Part XV of the Air Navigation Regulations.

There has been some complaint that licence suspensions are imposed as a punishment and, while this is not the intent of the action, it cannot be denied that the act of suspension will impose, on some individuals, circumstances which they would rather have avoided. The grounds for suspension are, however, very definitely limited by the terms of the particular Regulation under which it is imposed and the objective of the Department is only to preserve the proper levels of safety in the public interest. If a suspension does in fact penalise the person involved this is an unfortunate but nevertheless inescapable by-product of the action. The Department will always be concerned to ensure that its action does not penalise the individual in a way which should and could be avoided but this does not mean that the 'public interest' will ever be neglected for this reason. If some form of punshment is warranted in respect of the actions of any pilot it will be for the courts of law to make this decision and Part XVII of the Air Navigation Regulations contain the provisions under which the Department brings the circumstances of any such action under the notice of the courts.

There is no need or intent, in this article, to justify suspensions which have been imposed in the past. However, the views that have been expressed in public and in private by individuals and organizations when some past suspensions have been imposed, certainly warrant this attempt to clarify the role and the obligations of the Department and the rights of licence holders. The principle of 'public interest' has been and will continue to be the Department's guiding principle in these matters.

IT'S IN THE BOOK!

Section IV emergency procedures

Before departing on a private flight the pilot of a Cessna 210 checked fuel quantities and found that the port tank was empty, whilst the starboard tank contained 26 gallons. On estimated consumption figures this quantity provided an adequate reserve for the proposed flight.

Approaching his destination the pilot commenced a normal descent but, due to thermals, height was not lost at the rate expected so he shed the excess height by sideslipping to the right, with the intention of making a powered approach. When the throttle was advanced the engine failed to respond. Realizing that he had insufficient height to glide to the aerodrome the pilot had no alternative but to make a forced landing in a field. Apart from some severe shaking due to a rough surface and crossing a ditch, the landing was safely accomplished.

Whilst landing, the pilot recalled having read that prolonged sideslipping in the direction of the fuel tank in use could cause engine fuel starvation if the fuel quantity was low. He checked the fuel tank and found that about ten gallons remained in the starboard tank. The engine performed normally when started and continued to function satisfactorily thereafter. Undoubtedly, the loss of power was due to the fuel tank outlet ports becoming uncovered during the sideslip manoeuvre.

The warning concerning sideslipping with a low fuel quantity is contained in the Emergency Procedures section of the Owners' Handbook.

Every pilot should be thoroughly conversant with the Emergency Procedure specified in the Owners' Handbook applicable to the types upon which he is endorsed. For those pilots who believe they know the procedures, we suggest you check to make sure that you have not forgotten some vital point. To those who have no recollection of reading the section, or the other basic information provided in the Handbook, we recommend that you catch up on your homework before your next flight. It may save your life.

ERRORS OF VISUAL PERCEPTION IN FLYING

(Based on an article in "MATS Flyer", November, 1963)

It is essential that a pilot should be able to correctly perceive distance, direction and speed in three dimensions. Of the special senses he applies to doing this, vision is by far the most important. He cannot always directly visualize the physical dimensions of his environment, however, and must rely on flight and other instruments for his information. This article will discuss only the illusions (or false perceptions) associated with direct vision.

Visual illusions are potentially common in flying, and result from the pilot's incorrect interpretation of what he sees. This may be due to there being too few visual cues, so that he has to fill in the rest of the picture by drawing on his preconception of the situation, by "seeing" what he thinks he "ought" to see, or simply by guessing. It may also occur when cues presented to the normally master sense, vision, are weak and are in conflict with relatively strong responses by other special senses, particularly that of balance or orientation, which has its sensors in the inner ears.

Visual Bases of Judgement of Distance, Direction and Speed and some of the Illusions which may Affect them

Depth perception relies on two sets of cues, one derived from the "binocular vision" of two eyes focused on an object in unison, the other from "monocular vision" which basically requires only the function of one eye alone. Using two eyes together, does of course, result in quantitatively more monocular vision since it provides two monocular units simultaneously covering a wider field, but qualitatively the cues remain unchanged.

The "binocular" (or "stereoscopic") mechanism is applicable only at relatively short ranges — up to 30 or 40 feet — since its mathematics depend on a "visual triangle" of which the base is the distance between the pupils of the two eyes, about 2½ inches. Thus, although at close range it is the major factor in depth perception, in aviation it does not have the importance formerly attributed to it. Its only real importance is the functions of taxiing and in control identification and manipulation.

The following "monocular" cues are however of prime importance to perception in VFR or "contact" flight conditions at all times:—

1. **Size and shape:** An important way of judging the distance at which an object is seen is to compare the size the object looks now with its known size, or the size we know it would appear if seen close up. But to use this cue we must, of course, positively identify the object. It follows that incorrect identification, if this involves a size discrepency, can generate an error of distance perception.

2. **Linear perspective:** As any pair of parallel lines recede from us they appear to converge and our experience tells us roughly how far away the end is, provided we have some idea of the distance between the lines. In the case of a runway, we assess its length in this way, and, by

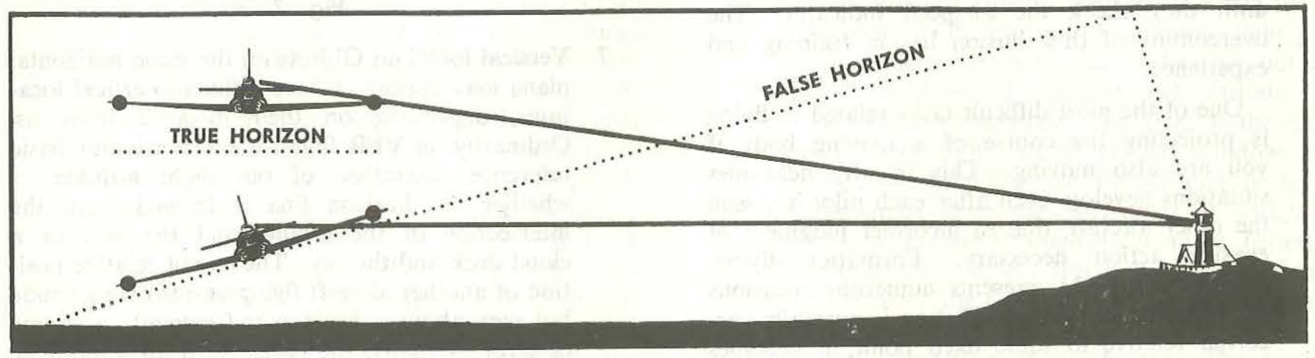


Fig. 1

mentally projecting its sides back towards us, we calculate how far out on final we are.

Variations in runway width can lead to an illusion of which pilots should be aware. Other things being equal, the wider a runway the shorter it appears and the less our altitude above it seems to be. The altitude illusion can be compounded by variations in runway colour. Some of the most experienced pilots have made embarrassingly premature "touchdowns" on wide white runways with which they were not familiar.

3. **Aerial perspective:** In conjunction with size and linear perspective. we automatically assess object distance by clarity of detail. The apparent nearness of some mountain ranges and of some brilliant runway lights under particular meteorological conditions provide excellent examples. This illusion of closeness has caused more than one pilot to come to grief and many to complete an approach on the back side of the power curve. The descent is started too soon and altitude is lost before the pilot realizes he is still too far from the threshold.

4. **Relative motion:** Other things being equal, an object which moves by us quickly is judged to be closer than one which moves by slowly. At extreme distances the movement is so slow that the object may seen to be moving with us for a time, rather than away from us. Instructors converting new pilots onto large transport aircraft frequently find that students taxi too fast, especially when they are on an unobstructed taxiway. The fact that their seat position is higher off the ground than any they have occupied before, and the resultant illusion that their visual cues on the ground are passing at a slower rate, gives them the illusion of taxing at a normal speed. Many of these pilots are also quite surprised on their first take-off because they can't believe liftoff speed has been reached until they check the airspeed indicator. The overcoming of this illusion lies in training and experience.

One of the most difficult tasks related to flying is projecting the course of a moving body if you are also moving. This is why near-miss situations develop, even after each pilot has seen the other aircraft, due to incorrect judgment of evasive action necessary. Formation flying, especially at night, presents numerous occasions for this type of illusion. Motion is normally perceived relative to some fixed point; it becomes much more difficult to determine what is happening when the reference object, as well as your own aircraft, is in motion.

5. **Interposition:** This is the situation in which we recognize that anything standing in front of something else is nearer to us than the object which is partially or wholly hidden. This is so basic that it hardly seems worth mentioning, but there are several rather important applications of the principle! If we are on final into an unfamiliar strip which appears to get shorter and shorter as we approach the threshold, it is a reasonable assumption that it has a hump in the middle, and the "caution button' rather than the "panic button" is the one to press. On the other hand, some unknown object interposing itself between us and one or more of the runway lights while on VFR final at night certainly calls for some immediate action!

6. **Light and shadow:** This feature provides us with a useful cue to the shape and solidity of an object. It also can be confusing enough to get us into real trouble. Many of our cues of height, wind speed and distance during a daytime approach come from shadow interpretation. At night these cues aren't available and more caution must be observed. Even during daylight, light and shadows offer chances for misinterpretation.

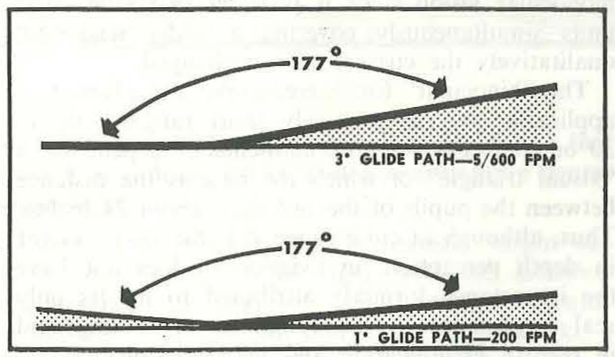


Fig. 2

7. **Vertical location:** Objects on the same horizontal plane may appear to have different vertical locations, depending on their distance from us. Ordinarily, in VFR flight, a horizon is our basic reference, regardless of our flight attitude or whether the horizon line is formed from the intersection of the ground and the sky, or a cloud deck and the sky. The cue of relative position of another aircraft flying at our own altitude but seen above a horizon is frequently a source of error. Usually, the closer such an aircraft is, the higher it appears to the viewer. This illusion can operate in reverse for aircraft flying at altitudes below ours. For example, while flying on an airway, ATC calls and reports an aircraft at 12 o'clock from our position, on a reciprocal course but at the next lower altitude. We search the sky and suddenly, there he is! Of course, we question the validity of his altimeter setting at first, because it looks like he is going to drill us with his nose cone. As he comes closer it is obvious that he is actually lower than we are. The closer he gets, the lower he seems to be flying until suddenly we experience the illusion that he is flying downhill. Fortunately, this is one illusion that won't get us into much trouble.

Some Other Factors which Affect Perception and the Occurrence of Illusion

1. **Experience:** One product of experience in the cockpit is an ability to make correct interpretations with less and less obvious or complete stimuli. The expert will react to cues which the novice ignores. More important, the expert will be able to interpret and react to small parts of the overall pattern while the uninitiated will have to have the complete pattern available. Experience not only enables a pilot to observe the subject matter in his field more accurately and completely but teaches him the art of being selective when important developments claim his attention simultaneously. Experience makes a pilot far less vulnerable — but, be warned, not invulnerable — to illusions.

2. **Fatigue:** Fatigue can prejudice proper response to stimuli in two main ways. Both are based on reduced contact with reality, which is another way of saying on a reduced level of critical perception. This state can lead, on the one hand, to failure to respond to a stimulus change that does call for corrective action — say, a change in a vital instrument indication. On the other hand it can open the way for uncritical acceptance of illusion-producing stimuli which would be promptly rejected by an alert brain.

3. **Flicker:** Flickering light in certain frequency ranges can produce varying degrees of dizziness and nausea and disorientation, depending on the frequency, intensity of the light and susceptibility of the subject. Flashes at rates of 3 to 40 per second have produced this phenomenon, which has the general name of "flicker vertigo" and which is of special importance to helicopter pilots. The problem appears to be maximal when the aircraft is heading into or away from the late afternoon sun, and when the roof panels of the cockpit are transparent. Akin to flicker vertigo is an effect which can be caused by a Grimes rotating beacon. Two Grimes beacons compound the effect. Especially when flying in clouds, the movement of the light beam as it crosses in front of the pilot can produce the illusion that the nose of the aircraft is oscillating laterally. The easiest solution is, of course, to turn it off and to settle down determinedly on your instruments.

The swip-swipe of rapidly oscillating windscreen wipers has also been known to cause a lowered state of alertness, amounting occasionally to drowsiness or even a state of trance in susceptible persons. It is a good principle therefore to keep the speed of the windscreen wipers to the lowest which will provide effective clearance. In addition, do not stare ahead through the wiped windows for too long at a time, but take occasional glances through one of the unwiped panels.

4. **Refraction: flight in rain:** When flying in rain, in addition to poor visibility, there is a refractive error in vision which causes the eye to indicate an horizon below the true horizon. This occurs because the water interface with the sloping windscreen bends the light rays passing to the pilot's eyes in such a way that viewed objects look lower than they actually are. This error can be as great as five degrees, which at a distance of one nautical mile is over 500 feet vertically. The greatest potential hazard is on a circling approach or final approach to landing after making visual contact below the cloud ceiling. To be sure: cross check the altimeter.

5. **False horizontal reference:** At night, if the pilot has only cues such as stars, or lights below him, maintaining straight and level flight is extremely difficult unless frequent reference is made to the instruments. Observation of a remote light produces an accurate indication of bearing but the pilot's awareness of attitude and altitude can be virtually non-existent. In Fig. 1 the pilot sees a single light out of his left window. He assesses his height above the ground in terms of the angle from the horizontal at which he observes this light through his window, believing his wings to be level. But if he is in fact in a slight bank to the right and sees the light through the same area of the window, he receives an illusory impression of his height. The following account of just such an incident was recently published in the Shell Aviation News.

"When passing Dungeness, I made a turn to the left around the light-house to fly towards Folkstone. I was flying below the clouds at an approximate altitude of 150 metres (500 feet) in light rain and visibility of one to two kilometres. After this turn I met certain difficulties in following the coast line as my aircraft developed a tendency to turn to the right, but I did not attach any importance to this at the time. I descended somewhat to improve my observation when the co-pilot suddenly pulled the stick, shouting that I was very low; he could see the reflection of the green navigation light on the sea! My estimation of the distance to the coast was correct but my estimation of the height above the water was completely wrong, as I had indeed the sensation of flying the aircraft in a normal attitude although undoubtedly it was banked to the right".

The same type of fictitious horizontal reference can be produced in certain circumstances by a slightly nose-high attitude. The corrective measures include closer attention to instruments and a realization that illusory altitudes and horizons can lead even the best pilot astray—if he is not constantly aware of the possibilities.

6. **Auto-Kinesis:** The literal meaning of this term is self-movement, but in our context it means the apparent displacement of a light which is actually in a fixed relationship to the observer. In a night flying situation where there are no background reference points such as stars or ground pattern, this type of illusion can be treacherous. If you stare at a single white light intently it will seem to move in spite of your attempts to keep it stationary. This is an insoluble problem if there is only one light, or one small group of lights, in your field of vision. However, it will help if you don't stare steadily at the light, but exercise the eye muscles by glancing away momentarily.

7. **Runway slope:** Some runways slope from one end to the other and this can produce illusions. Suppose a pilot habitually makes his approach at a glide slope angle of three degrees and a rate of descent of 5/600 F.P.M. Putting it another way, he is used to seeing a 177-degree relationship between runways and his eye. However, consider a runway sloping upward at, say, two degrees from the threshold, as in Fig. 3. If the pilot manoeuvres himself to a point in space from which to commence his final approach, at which he achieves his customary 177-degree relationship to the runway, he will of course need to make good a glide slope of one degree (with the greatly increased power requirements that implies) to reach the threshold.

At night the problem is more acute when lights or other cues are not available to warn the pilot of his dangerously low altitude. The flattened approach path induced by the illusion of a tilted runway has caused aircraft to hit as far as a mile or more from the threshold. This has happened, incidentally, in clear weather conditions with visibility in excess of 15 miles.

8. **Time:** Back in the good old days the pilot usually had time to sort out the cues presented to him and arrive at a valid perception of what he saw. Further, the manoeuvreability of the lighter and smaller aircraft allowed more latitude for a second chance if the pilot found himself in trouble. In today's bigger and faster transport aircraft the time element is compressed to the point where split second judgments are the rule, not the exception. The pilot must know what to expect and what to do to avoid those situations and actions which will increase the probability of illusions.

Conclusions

Only if pilots are aware of the situations liable to produce illusions can they exercise the insight necessary to guard against them.

The greatest illusion potential exists at night. Darkness provides excellent camouflage and the eye loses much of its efficiency. Normally used cues such as shadows, colour and detail are not available. Lights must compensate for this loss but lights usually lack sufficient definition to provide more than an outline, an incomplete stimulus to which the pilot may or may not react correctly. At the other end of the scale we may have a profusion of lights. Large airfield complexes have so many lights that frequently there is considerable difficulty experienced in just finding the runway.

In conclusion, remember that illusions must be expected in flying. Also that it is human nature to want to believe our own senses rather than instrument indications. Knowledge of illusory sensations will help because our responses are determined more by the meaning we attach to stimuli than by the stimuli themselves. It is ultimately on the basis of knowledge and self-discipline that we make decisions and select our responses.

Fig. 3

Tapini airstrip in New Guinea illustrates the effect of runway slope.