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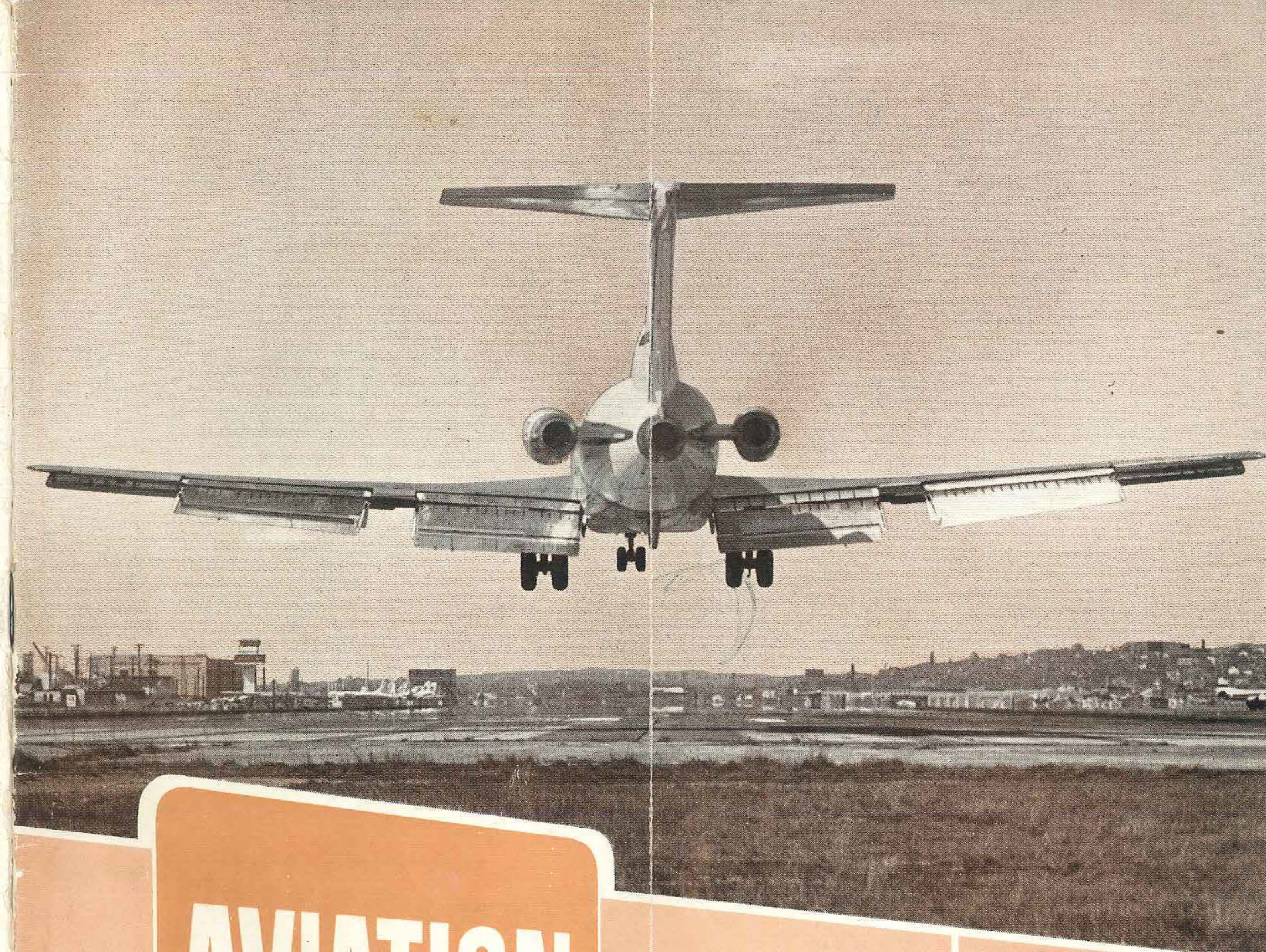


AVIATION SAFETY DIGEST

No. 33, MARCH, 1963

DEPARTMENT OF CIVIL AVIATION

AVIATION SAFETY DIGEST

No. 33 MARCH, 1963

Prepared in the Division of Air Safety Investigation
Department of Civil Aviation

Contents

The Boeing 727, scheduled for Australian domestic services in 1964, about to touchdown after a test flight at Boeing Field, Seattle, Washington.

(Photograph by courtesy of the Boeing Company)

Commonwealth of Australia

LIGHT AIRCRAFT TAKE-OFF PERFORMANCE

Temperature and Altitude Effects

This is the first of a series of articles dealing with the effects of air density, surface conditions, wind effects, take-off slope, etc. It is intended to continue this series in subsequent issues of the Digest.

A review of take-off accidents involving light aircraft has shown that an appreciable number of them can be attributed wholly or in part to a failure to allow for the effects of reduced air density arising from high temperature, high altitude, or, more particularly, from a combination of both.

Two separate effects must be considered:

(a) The effect of reduced air density on take-off distance;

(b) the effect of reduced air density on climb performance.

Both of these aspects will be examined in turn.

The Effect of Reduced Air Density on Take-off Distance

The normal take-off consists of a full throttle run along the ground, a lift off at the take-off safety speed, and a climb away at this speed until a height of 50 feet is reached.

The take-off safety speed is defined as 1.2 Vs, where Vs is the power off stalling speed.

The indicated stalling speed of an aircraft depends, principally, on the aircraft's weight, power setting and flap position. **Changes in air density do not change the indicated air speed at the stall.** Every pilot is aware, however, that under conditions of reduced air density the true air speed is greater than the indicated air speed; thus, in a take-off under high temperature conditions, the prescribed higher true air-speed and the distance required to reach this speed will be greater. Alternatively, for a given take-off distance the gross weight of the aircraft and hence the take-off safety speed will have to be reduced in order to provide for a safe operation within the available distance.

Another major effect to be considered is the reduction of engine power output arising from reduced air density. In most light aircraft, take-off power is the full-throttle setting of its unsupercharged, or normally aspirated, engine. Changes in air density produce changes in the full throttle power of such engines. Any reduced air density means less air available for combustion and a fall-off in take-off power. The reduction in power is approximately proportional to the reduction in air density.* This reduction in available power means that less thrust will be available for accelerating or climbing the aircraft. It can be seen, therefore, that reduced air density will not only demand longer take-off runs to allow the aircraft to accelerate to the higher true airspeeds but it also imposes the penalty of reducing the power available to achieve this acceleration. The take-off distances required are therefore greatly increased even for small reductions in air density.

The information provided in handbooks by the manufacturers of light aircraft is usually insufficient to take account of all the major variables and the Department of Civil Aviation has undertaken the production of the PL Charts (Performance Charts for Light Aircraft) to assist pilots in their calculations. For most aircraft types, the manufacturer's data has been checked by flight testing in Australia and the chart data is based on these test results.

The chart indicates the maximum permissible gross weight for take-off after aerodrome pressure height, outside air temperature, take-off distance available and wind velocity are taken into account. Fifty per cent of the reported head wind component and 150 per cent of the reported tail wind component have been used in the construction of the chart and the take-off distance has been increased by a factor of 1.15 as is shown in the notes on the chart.

The following example illustrated in the chart at page 3 will show how the chart is used.

* In the case of a supercharged engine this effect is overcome, within limits, by compressing the air and thus restoring the air supply.

Airfield pressure height which may be read from your altimeter after setting 1,013.2 mb.	= 920 feet
Outside air temperature measured in the shade	= 113°F or 45°C
Take-off distance available	= 1,550 feet
Wind velocity component	= Nil

(1) Effect of Air Density Change

Enter the chart at "START HERE" and find the intersection of the airfield pressure height (APH) and the outside air temperature (OAT). The point of intersection indicates the density height at which the next segment of the chart to the right should be entered. This density height is determined by the relationship of the APH/OAT intersection with the horizontal lines drawn through the upper three segments of the chart. The bottom line has a zero or standard sea level value as determined by the intersection of the zero airfield pressure and the standard 15°C temperature. Each successive line drawn is a 1,000 feet increment in density height. Thus it will be seen that the density height in this example is 4,500 foot which means that the density of the air under the conditions stated in the examples is the same as would exist at a height of 4,500 feet under conditions of standard atmosphere. At this point it is of interest to note the effect of temperature on density height. If the OAT had been 13°C the density height would have been the same as the airfield pressure height, i.e., 920 feet and, with an even lower temperature of 5°C (41°F) the equivalent of sea level standard conditions would prevail. It will become apparent from this why a light aircraft exhibits a lively performance on a frosty morning. Now move on to further corrections in the example.

(2) Effect of Take-off Distance Available

Move to the right on the chart until you intercept the line representing the take-off distance available and then move vertically downwards to the next correction.

It may be seen that, in the particular conditions of this take-off, no reduction of the maximum permissible gross weight would have been necessary had the available length of run been equal to or greater than 2,400 feet. Since the available length is only 1,550 feet, however, it is immediately apparent that the gross weight for take-off will need to be reduced.

(3) Effect of Wind

Continue to move vertically downwards to intercept the ambient wind velocity line and then move horizontally to the left and read from the scale the maximum take-off weight permitted under these circumstances, i.e., 1.570 lb.

(4) Take-off Safety Speed

Since the stalling speed varies directly with weight, the take-off safety speed will also vary directly with the take-off weight and for this case it may be read directly off the right hand side of the diagram as 43 Kts. I.A.S.

We are now in a position to see that under the conditions prescribed, the combined effects of limited take-off distance available and the reduced air density has demanded a reduction in the maximum permissible take-off weight from 1,825 lb. to 1,570 lb.

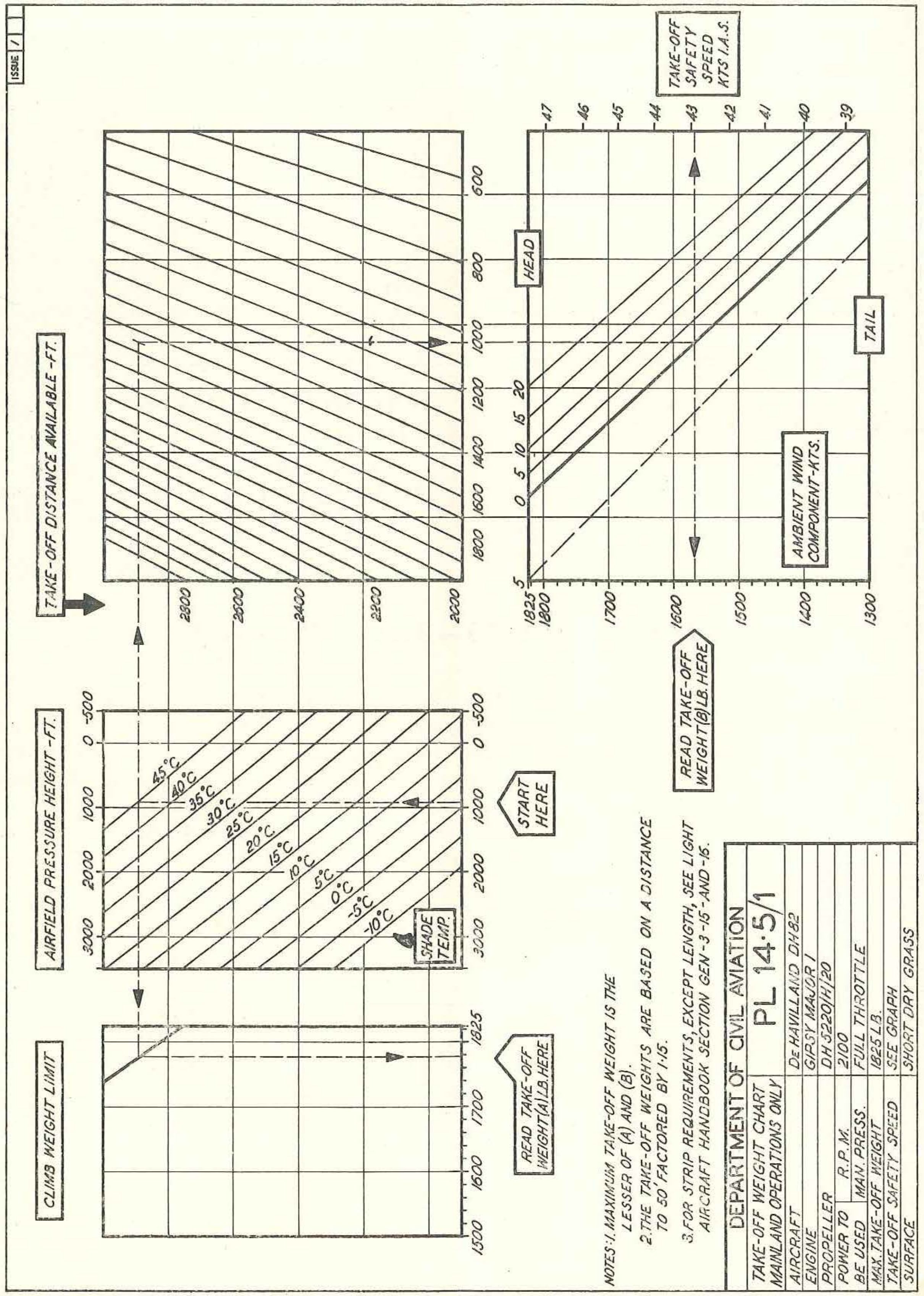
The Effect of Reduced Density on Climb Performance

The Australian performance standards require that all light aircraft have a minimum gradient of climb after take-off of six per cent. This can be expressed as 6 feet of climb for every 100 feet of horizontal travel along the flight path, or 365 feet per nautical mile which is equivalent to a rate of climb of 365 feet per minute if the aircraft's climbing speed is 60 knots (T.A.S.).

The climb gradient is greatly affected by even a small reduction of engine power because the power available to climb the aircraft **is only the power in excess of that required for straight and level flight at the climbing speed.**

We have already pointed out that any reduction in air density produces a proportionate reduction in engine power. Reference to atmosphere tables will show that air density falls about 3 per cent per 1,000 feet between sea level and 3,000 feet, reducing to 2 per cent per 1,000 feet at 16,000 feet. Thus if the aircraft is taking off in conditions of pressure and temperature which are equivalent to a height of 4,500 feet under standard conditions (i.e., a density height of 4,500 feet) the engine output under full throttle at constant r.p.m. will fall about 13 per cent. This amounts to a considerable reduction in the power available for the climb and the gradient of climb is correspondingly reduced. If the density is reduced to a point where the minimum climb gradient would not be achieved, the take-off gross weight must be reduced in order to restore the gradient and thus ensure a safe climb out over obstacles.

To show how this adjustment is calculated we must now refer to the Climb Weight Limit diagram in the PL Chart.



Climb Weight Limit

Enter the chart at the airfield pressure height and move vertically until the line intercepts the outside air temperature. Then move horizontally to the left to the point of intersection with the sloping reference line and then vertically downwards to the gross weight scale where it can be seen that the climb weight limit is 1,775 lb.

Points to be Especially Noted

The maximum permissible weight derived from our previous calculations based on runway length available was 1,570 lb., whilst the weight limitation based on the climb requirements is 1,775 lb. **The lesser of these two is the maximum permissible take-off gross weight, i.e., 1,570 lb.**

If the aircraft's gross weight is held constant the effect of temperature on the length required for take-off at a particular aerodrome may be seen from the chart. Referring to our example again, you will remember that 1,550 feet was the minimum length required to lift 1,570 lb. when the temperature was 45°C (113°F). Drop the temperature to 13°C (55°F), which is standard for a pressure height of 920 feet, and for the same weight the take-off length required is reduced to 1,170 feet. Check this on the chart at the point where a density height of 920 feet intercepts the vertical line of our example in the 'distance available" segment of the chart.

Whenever a take-off in the type of aircraft to which the sample chart applies is to be carried out with a density height exceeding 3,800 feet, **some reduction of take-off (i.e., 1,825 lb.) must be made irrespective of the length of run available.** This arises from the climb weight limitations of the aircraft.

Example:

Now try this example yourself using a ruler and sharp pencil.

Airfield Pressure Height	1,500 feet
Outside Air Temperature	25°C
Take-off distance available	1,900 feet
Head Wind Component	5 m.p.h.

If you have mastered the system you will agree that the take-off gross weight is 1,785 lb. and the take-off safety speed is 47 knots.

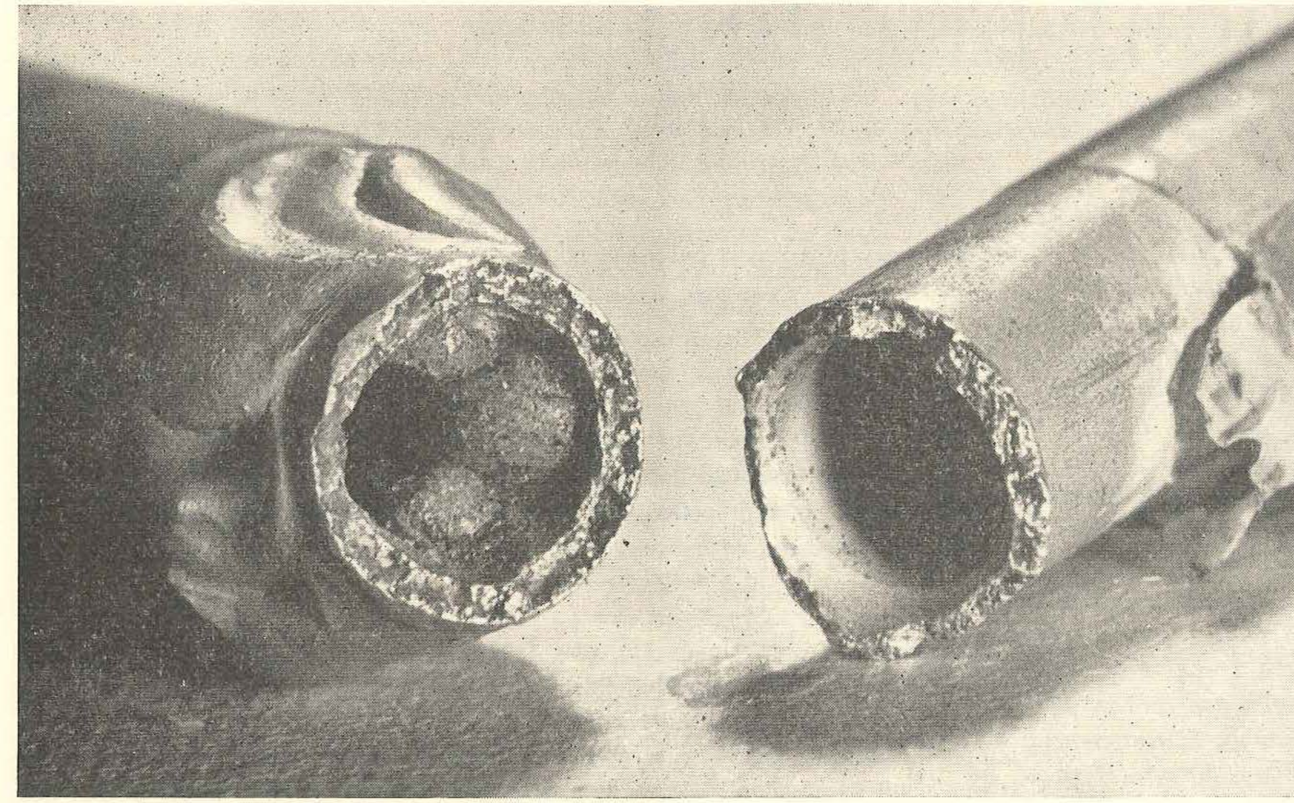
SAFETY DEVICES—ALL AIRCRAFT

Most aircraft installations are equipped with safety devices that are designed to prevent a malfunction of one unit from destroying the complete system or seriously damaging the aircraft. Among such safety devices could be counted fuses, circuit breakers and thermal switches in electrical systems and relief valves, dump valves and blow-out plugs in pressure type systems. The latter group of systems includes hydraulic, pneumatic and Freon systems. Regardless of the type of system they are used in, safety devices are exactly what the name implies: devices that are installed to prevent abnormal system conditions from affecting the safety of the aeroplane.

The blow-out plug is probably the least known of these devices and is sometimes subject to abuse. Recently, Freon system blow-out plugs have been punctured during the process of checking them for being intact. It is well worth remembering that the system may be pressurised (as high as 270 psi) and that the diaphragm of the plug is very easily punctured. Sharp tools, therefore, should never be used to determine whether a diaphragm is good or not. In Freon systems this is extremely dangerous since the diaphragm may be punctured and the Freon may be released under high pressure. As a refrigerant, Freon, when in contact with the skin, may blister (cold-burn) but it could burn your eyes out, too. If you can't look at the diaphragm, use a very dull instrument (like the eraser end of a pencil) and very gently probe the diaphragm; you'll very easily tell whether it is still there or not. But don't use a screw-driver, ice-pick or similar sharp instrument; the chances are about ten to one that you'll puncture the diaphragm before you know it.

Although there are few agents as dangerous as Freon, releasing pressure of any sort in this fashion involves risks that can and should be avoided.

(Extract from Aviation Mechanics Bulletin)



BEWARE! RESTRICTIONS IN WELDED PIPE LINES

During the overhaul of a modern transport aircraft a handling load imposed accidentally caused fracture of a low pressure aluminium pipe line at a welded joint where a ¼-inch diameter pipe had been joined to a ⅜-inch diameter line. This chance break revealed that a severe internal restriction had been formed at the weld, due to excessive welding penetration leaving three "blobs" of residual metal adhering to the inner surface at the joint. The position of these excrescences, which are clearly shown in the accompanying photograph, was such that the effective inside diameter was reduced to approximately ⅛ inch or one quarter of the designed flow area.

Fortunately, this restriction had not materially interfered with the functioning of the static pressure line in which it had been formed. It did, however, provide a natural barrier that could have been instrumental in causing complete blockage. In other situations, such as engine breather lines, sludge or other deposits carried by the fluid in the pipe could quickly be arrested by a barrier such as this and result in complete blockage.

It is always likely, of course, that some degree of penetration residue will form where pipe lines are joined by welding. This is but one of a number of reasons why appropriate couplings are normally used to join pipe lines in preference to welded or brazed joints.

Despite the availability of pipe line couplings for almost every conceivable purpose, cases do occasionally arise where it is necessary to fabricate pipe manifolds and employ welded joints, even in modern aircraft. Under these circumstances welders, and inspectors, should be particularly alert to the need to ensure that the minimum possible restriction is caused at the weld. Where it is not possible to visibly check the interior diameter at the welded joint, flow rate tests or comparison checks may be necessary to ensure that the pipe line will perform its designed function. In addition, more frequent service inspections may be necessary where the pipe carries a sludge-bearing fluid.

NIGHT DITCHING

DC 7 Success in Rough Seas

(Summary of a report published by the Civil Aeronautics Board, U.S.A.)

(All times stated are Greenwich Mean Time)

On 14th July, 1960, a Douglas DC7 ditched in the Pacific Ocean, in instrument meteorological conditions, after reporting fire in the left wing and loss of No. 2 propeller. All 58 occupants successfully evacuated the aircraft. Of these, 44 suffered minor injuries and one woman passenger died.

The flight departed from Okinawa at 0200 hours local time, bound for the Phillipine Islands, and proceeded uneventfully until 0415 hours. At about 0415 hours a drop in BMEP and manifold pressure indicated loss of power on No. 2 engine, although nothing abnormal could be seen on the ignition analyser. As these symptoms suggested carburettor icing, the crew placed the mixture control on rich and applied carburettor heat. Soon afterwards, the oil-outlet temperature in No. 2 was seen to rise and, as the ignition analyser then showed irregular patterns on Nos. 5 and 7 cylinders, the captain decided to stop the engine. The propeller failed to feather and engine speed increased from 2350 to 2900 r.p.m. At this time the oil quantity indicator for No. 2 engine registered empty.

The flight engineer transferred oil from the reserve tank to No. 2 engine but could not succeed in feathering the propeller. It was also noted that high blower ratio could not be disengaged. Co-incident with this action approval was obtained for the aircraft to descend from 18,000 to 10,000 feet.

While the aircraft was descending, with landing gear and flaps lowered, the captain alerted the cabin attendants to prepare for ditching and evacuate the hazardous area in line with No. 2 propeller. Life vests were donned, emergency lights on the vests and in the cabin were turned on, life-rafts were prepared and loose articles were secured. The captain and purser, by means of the public address system, directed the passengers to remove their shoes, ties, glasses and other pertinent objects. Passengers evacuated from the No. 2 propeller area were seated with their backs against compartment walls.

At 0440 hours the Captain declared an emergency, obtained and transmitted accurate position reports and requested an intercept by rescue aircraft.

Shortly thereafter sparks and white smoke were seen to emanate from No. 2 engine but no flames were visible. An attempt was made to stop the engine by actuating the fire-wall shut-off valves, thereby depriving it of lubrication. At this time the fire-warning system activated and was accompanied by sparks and loud thumping noises from the engine. The fire-extinguishing system was discharged into the engine, but without effect. The propeller then wrenched free from the engine, striking the fuselage about in line with its plane of rotation and slashing a hole some 15 inches in diameter above the overhead rack. A red glow, which rapidly changed to white, provided unmistakable evidence of fire in No. 2 engine. A second attempt to extinguish the fire by means of the aircraft fire-extinguishing system proved ineffective.

The captain advised Manila radio that he was preparing to ditch and commenced a 3,000 feet per minute descent from 9,000 feet, at 100 to 115 knots with the gear and flaps extended. The navigator and engineer were ordered to proceed to their emergency stations in the cabin.

The descent was made on instruments and in darkness. Moderate rain showers increased the intensity of the magnesium fire in No. 2 engine. At an indicated altitude of 1,000 feet power was applied, the gear was retracted and the flaps raised to the approach setting of 30°. The rate of descent was held at between 100 and 200 feet per minute, at approximately 100 knots, until the water was sighted. The control column was then brought hard back and, seconds later, the aircraft ditched into rough seas in cloudy, showery weather.

The aft end of the fuselage broke free at the rear of the pressure bulkhead at impact and sank immediately. The right wing broke away from the fuselage, No's 3 and 4 engines tore free and sank, whilst the wing floated for about three hours, temporarily serving as a raft for several passengers. The remainder of the aircraft was relatively intact and sank some eight to ten minutes after impact.

The events which transpired immediately before and after the ditching, as described by the purser, were:

" . . . The propeller sheared off, which I witnessed by being in the tourist compartment, checking life-vests and seat belts. As soon as the propeller sheared and went through the forward passenger compartment, I ran to the cockpit to see if the crew was all right. They were very busy and okay, so I returned to the cabin and gave ditching instructions over the public address. At no time did we have any hysteria or panic among our passengers. They were a tremendous group and followed our instructions to the letter. While this was being done, the stewardess stowed all the loose equipment in the galley area and Mr. Suarez secured the drop door on our carrier holders. They both then proceeded to work through each cabin. I then asked for swimmers and placed able bodied men in positions to handle rafts. We assigned the passengers to the rafts in their area. We had positioned two rafts in the tourist compartment along the overwing exits. Another by the main cabin door and another by the window exit on the right hand side of the aft compartment. All rafts were secured with their lanyards. We then instructed the passengers as to their ditching position . . . "

" . . . I think the ship bounced several times and finally slued to the left and came to a stop. All lights except the emergency lights went out and the cabin started to fill with smoke. Also burning gas seeped in along the right hand wall of the main cabin. We were afraid to open the overwing exits because of the fire on both sides of the cabin. Passengers were directed to the main cabin door from the tourist and forward first-class compartments. At this time, I heard Captain Rall call from up near the cockpit that if we couldn't get out to come forward. I hollered that we were all getting out in the back. I then noticed that the fire had gone out on the right wing side of the cabin and I tried to get the raft that had been prepositioned there out, but it was jammed on the floor between the seats.

"The cabin was now heavy with smoke and filling with water. I then opened the window exit on the left hand side where I had been sitting and got the other raft out on the wing and launched it. I then looked back in the forward first-class and the tourists compartments, and I determined that there were no passengers left in the compartments. The water was then about knee-high in the aisle and the ship in a deep slanted attitude. I went out the window exit and got into the raft which was not fully inflated and had three people in it. I could see the tail lifting (I should say the area where the tail had been) out of the water. I asked one of the men in the raft for a knife with which I cut the mooring raft line that was attached to the ship and we started paddling away with our hands. I heard the engineer hollering in the next raft and yelled at him to throw us a line, which he did. He had just drifted away from the ship when the aft end went straight in the air and the ship sank.

"Everyone was pretty exhausted and I could hear people hollering. We could see some of the passengers in the water and some on a piece of the wing that had broken off and was floating. We started to paddle towards the passengers. They were very easy to see because of the lights on their vests.

"At this time we heard the captain shouting to these passengers and he and the co-pilot paddled their 10-man raft over and picked up these people. We then drew close to the engineer's raft and took some of his people off, as his raft was overloaded. I believe the lower station on my raft was ruptured by the jagged wing in the launching. The lower station was ripped and a small leak was found in the floor. The survival pack was taken out of the centre section of the raft and the gear distributed. We patched the leak and then began using the bailing bucket and sponges to clear our raft. Again, we had no panic or hysteria. As daylight began to break, a rain squall came up. We put up our canopy and collected some rain water in the plastic bags. Most of our people in the raft were ill at various times. We then waited for the Air Sea Rescue people. After hearing, sighting the plane, we fired our smoke flares. Everyone was greatly relieved and then we waited to be rescued."

All of the occupants were evacuated from the aircraft within five minutes after ditching and were subsequently picked up by rescue aircraft which landed in the rough sea and then taxied some 10-12 miles to the shelter of an island harbour.

Examination of the records pertaining to No. 2 engine and the propeller yielded no indication of abnormal operation prior to the flight on which failure occurred. The aircraft sank in 2,100 feet of water and the wreckage was not recovered, consequently the cause of engine failure could be based only on crew testimony and other known facts.

The sequence of events indicate that the initial failure occurred to components in the two-speed impeller drive system. When a failure occurs in this unit most of the supercharging effect is lost, resulting in an appreciable power loss and a sudden drop in manifold pressure.

A failure of this type demands immediate feathering of the propeller, otherwise numerous metal particles are circulated throughout the engine. Believing that their difficulty was due to carburettor ice the crew spent a period of time trying to restore power, the situation being such that it was not apparent to them that an internal failure was in progress until the oil-outlet temperature commenced to rise and the second ignition analyser check showed a change of pattern.

It appears that the increase in engine r.p.m., up to the stage where the propeller was apparently arrested by the speed sensitive pitch lock assembly, was due to contamination of the propeller governor. It is likely that the governor pilot valve became stuck in the "UP" position which would result in an overspeed condition. Other valves in the governor, including the feathering bypass valve, could also fail to function if the particles were restricting movement. It is possible, too, that the oil transfer bearings and seals were damaged by the contaminated oil, resulting in internal leakage which allowed the oil to collect in the nose case rather than flow to the propeller. Failures of this type would also preclude feathering and cause propeller overspeeding.

The loss of oil quantity can be attributed to two causes. As the failure progressed, metal contamination of the oil probably caused failure of the bushes and drives in the scavenger pumps and much of the oil was never returned to the tank. Some oil would also be pumped overboard as a result of the failure of the reciprocating assemblies. The crew stated that late in the sequence of events the tachometer, fuel pressure and oil pressure readings dropped to zero, indicating that the failures had progressed to the point where the respective drives seized and sheared.

It was concluded that the probable cause of the accident was the internal failure of No. 2 engine, resulting in oil contamination, loss of oil supply, subsequent loss of No. 2 propeller assembly and fire in flight, which necessitated a ditching.

In commenting upon the accident the Board noted that the location of survivors in the sea was materially aided by the illumination provided by the lights attached to the life vests.

COMMENT

The successful evacuation of all 58 occupants clearly shows the value of early preparation and crew co-ordination in such an emergency.

Being wise after the event, it is obvious that the accident might have been averted had feathering action been initiated immediately No. 2 engine lost power. This same situation might well apply on a number of aircraft, as the internal tolerances necessary to produce high sensitivity in modern governor mechanisms makes them most vulnerable to oil contamination.

Low Level Aerobatics Cause Fatality

During a dual training flight a DHC-1 Chipmunk dived into the ground in the course of a low level aerobatic manoeuvre in close proximity to another aircraft which was at a height of 400 feet on the final approach to land. The accident proved fatal to both pilots in the Chipmunk and the aircraft was destroyed by impact forces and fire.

Earlier in the day the aircraft was climbed to a height of approximately 3,500 feet in the aerobatic area where several aerobatic manoeuvres were executed. Towards the end of the flying period the aircraft descended in the vicinity of the airfield performing several rolling manoeuvres as it did so. The last of these manoeuvres occurred at a height of some 1,400 feet above terrain near the airfield boundary where gliding was in progress.

After landing the aircraft was refuelled before the instructor departed on this last flight which was for the purpose of converting a private pilot to the Chipmunk. Approximately 20 minutes after taking-off the aircraft was observed in the aerobatic area performing aerobatics which were continued for approximately 20 minutes. The aircraft then descended towards the airfield and again executed rolling manoeuvres down to a height of 1,400 feet after which it glided to a height of 900 feet where power was increased. The aircraft then performed a steep turn to the left through some 60 degrees followed by a shallow dive towards another aircraft which was on a similar heading at a height of 400 feet on the final approach to land. After overtaking this aircraft the Chipmunk pulled up sharply into a climb and rolled or "flicked" into an inverted attitude then entered a steep dive from which it failed to recover.

The investigation revealed no evidence of any pre-accident defect in the aircraft which could account for the low level aerobatic manoeuvre and subsequent loss of control. In view of the pilot's earlier reckless display it is not unreasonable to assume that the accident resulted from a similar disregard of the safety requirements prescribed for aerobatic manoeuvres. On this basis the lesson is obvious.

We Make Our Luck

"Luck", says the dictionary, is "that which happens to a person as if by chance, in the course of events". This is scarcely the definition Astronaut Alan B. Shepard, Jr., placed on the word when he appeared to testify before the House Space Committee, the first of three astronauts to do so.

He had been asked frequently, he said, "Where do you get your luck?".

"We make our own luck", Shepard told the members of the committee, "by careful attention to detail and duty and design and qualification tests".

There is a lesson here for all of us. A first-rate mechanic, for example, gets a raise. Why? Because the boss thinks he's handsome? He gets a raise because he has paid attention to detail and knows what he is doing. This is what makes him a good mechanic, hence eligible for a raise . . . We are much too inclined to think that anyone who is moving ahead is lucky.

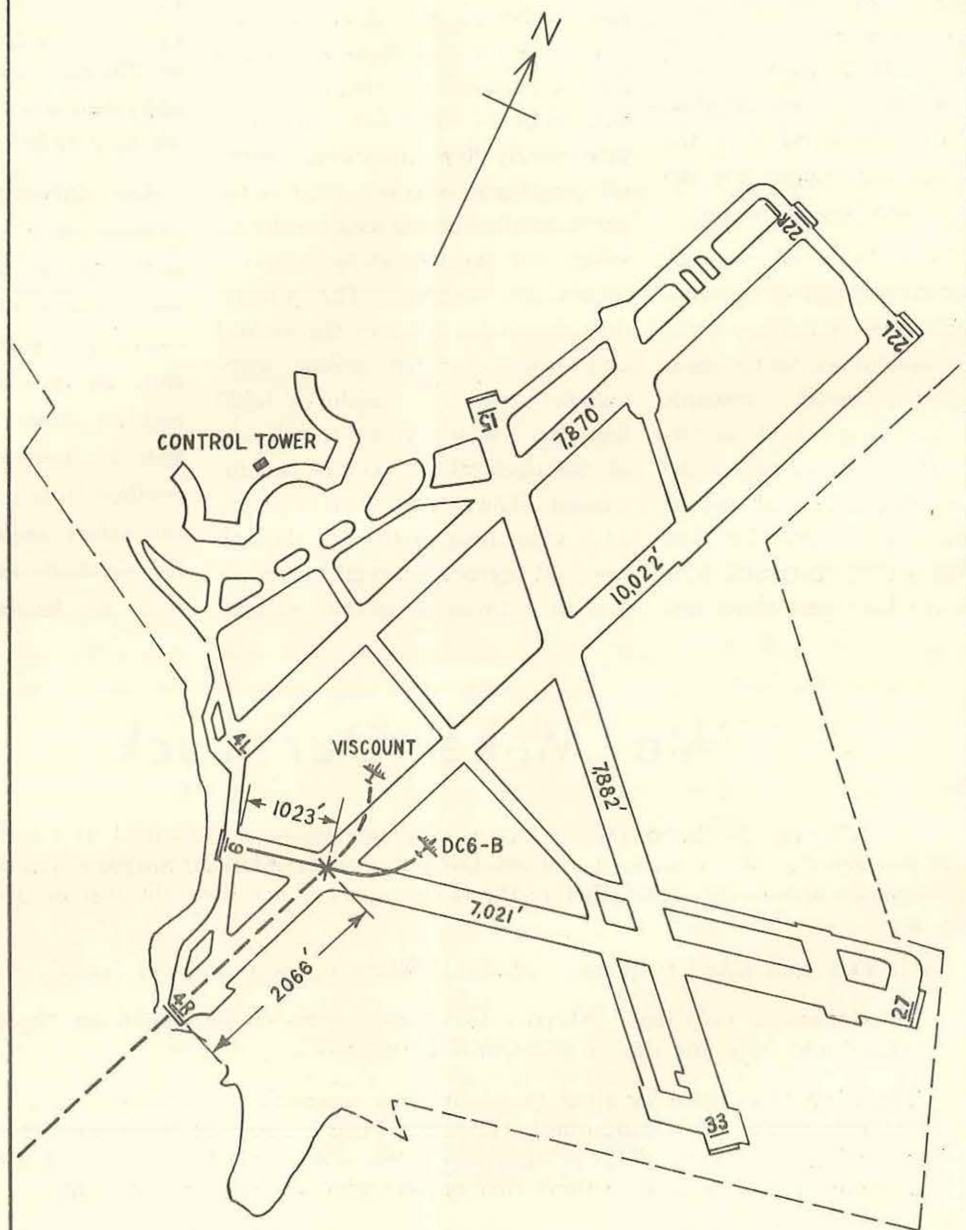
Luck, in the opinion of Cmdr. Shepard, is not something which happens by chance, but something one makes happen. If the luck is good, it simply indicates one has been on his toes, doing the things he should have done, and doing them well. Bad luck happens, not by chance, but because one has not been on his toes and not done the things he should have done.

If this point of view could become widespread throughout the nation as a result of Cmdr. Shepard's testimony, he would have contributed fully as much to the nation's morale and brighter future as he did when he was whirled through space in sub-orbital flight.

(Extract from Business Pilot's Safety Bulletin)

Surface Movement Collision —DC6-B and Viscount

LOGAN INTERNATIONAL AIRPORT, BOSTON, MASS.



GENERAL EDWARD LAWRENCE LOGAN AIRPORT
BOSTON, MASS.

(Summary based on the report of the Civil Aeronautics Board, U.S.A.)

(All Times stated are Eastern Standard)

On 15th November, 1961, at approximately 1710 hours (47 minutes after sunset) a ground collision occurred at Logan International Airport, Boston, between a DC6-B which was taking-off from Runway 9 and a Viscount landing on Runway 4R.

It is estimated that the speed of the DC6-B was about 60 knots and that of the Viscount about 80 knots immediately prior to the collision which occurred at the intersection of runways 4R and 9. There was no serious injury to any of the occupants, but the damage to both aircraft was substantial.

At 1707 hours the Boston Local Controller* cleared the Viscount to land on runway 4R and 1 minute 41 seconds later he advised the Viscount: "No need to acknowledge, your turn-off is down at runway 33, the central's closed".

At 1705 hours the DC6-B contacted the Boston Ground Controller* for taxy instructions and was informed that runway 9 was the take-off runway. There were three other aircraft about to taxy to runway 9 for departure at this time, one preceding and two behind the DC6-B.

At 1702 hours the Boston Ground Controller advised the DC6-B: "Centre can't seem to find your flight plan, what altitude did you request?" The reply was: "8,000". One minute later the DC6-B was instructed to change to clearance delivery frequency to receive the air route traffic control clearance. This instruction was complied with. Since the DC6-B was then in the No. 1 position for take-off and awaiting clearance, the first officer transmitted the following message to the clearance delivery controller at 1706 hours: "Aircraft behind me are ready; would you like us to cross to runway 9?" After checking with the Local Controller, the clearance delivery controller advised the DC6-B as follows: "Cross runway 9 and we will work on your clearance with the Centre". The aircraft moved to the south side of runway 9 and was positioned at a 45 degree angle to the runway for completion of the pre-take-off check list.

The other two aircraft which had previously been cleared to taxy and hold behind the DC6-B were then permitted to take-off. In clearing the second of these two aircraft the local controller advised "cleared for immediate take-off or hold runway 9, traffic a mile and quarter on final — four right". This latter aircraft then departed at approximately 1708.

After receiving the appropriate air route traffic control clearance the DC6-B changed to the local control frequency at approximately 1708:33 and requested take-off clearange. At 1708:36 hours the local controller instructed the DC6-B to "taxy into position and hold runway 9". Receipt of this instruction was acknowledged by the DC6-B at 1708:37 hours by giving the flight number "429". In the mistaken belief that a take-off clearance had been received, the captain of the DC6-B turned on landing lights and manoeuvred the aircraft into the take-off position on runway 9, where he brought the aircraft to a halt and transferred control of the aircraft to the first officer who commenced the take-off. The collision with the Viscount occurred during the ground roll.

The captain and first officer of the DC6-B stated that the local controller's response to their request for take-off clearance was "-429 cleared for take-off", and that there was no doubt in their minds he had cleared them for take-off. The flight engineer, in relating his version of

* The Australian equivalents for the designations "Boston Local Controller" and "Boston Ground Controller" as appearing in the C.A.B. report would be: "Approach Controller" and "Surface Movements Controller".

the clearance, testified that he had heard the local controller say: "cleared for position and take-off." He stated that while he thought the clearance unusual, the deviation from standard phaseology was insufficient to overcome the impression he also had that the aircraft was cleared for take-off. The tower recording of the clearance, the testimony of the local controller, and the co-ordinator, all indicate that the DC6-B was instructed to taxy into position and hold runway 9.

The captain and the first officer of the DC6-B testified that they did not hear a warning message from the local controller and that they did not see the Viscount aircraft in time to take evasive action.

During the interval from the issuance of holding instructions at 1708:36 hours to 1709:32 hours, apparently no one in the control tower observed the positioning of the DC6-B aircraft on runway 9 or the attempted take-off. As the local controller stated, "When I first saw the Viscount aircraft it was two or three seconds before the collision and all I could get out over the microphone was "check the traffic". The co-ordinator stated that when he first observed the DC6-B rolling down runway 9 he turned to the local controller to warn him, but at that moment the local controller was making the transmission "check the traffic".

Approximately four seconds elapsed between the time of the warning message and the collision. There were no tower transmission made to either aircraft during this interval. No attempt was made to warn the Viscount aircraft.

There were five air traffic control specialists occupying the various operating positions in the Boston tower at the time of the collision —a co-ordinator, a local controller, a ground controller, a clearance delivery controller, and a flight data controller. Three of them apparently saw only the collision, while the remaining two controllers first observed the DC6-B aircraft approximately four seconds before the collision.

It was established that another aircraft, a Convair 440, was holding on the north side of runway 9 when the DC6-B made the take-off attempt; that this aircraft made two transmissions to the Boston Local Controller, indicating that they were ready for take-off; that the first transmission was made at approximately the same time as the local controller issued instructions to the DC6-B to taxy into position and hold; and that the local controller did not acknowledge the first transmission nor was it recorded on the tower tape, thereby raising the possibility that a transmission from the other aircraft referred to might have interfered with the control tower holding instructions to the DC6-B.

To explore the possibility of interference the Board conducted a series of communication tests to determine the conditions under which the Boston Tower recorder will function, and the effects of simultaneous or overlapping transmissions from the control tower and aircraft on the same frequency. To simulate the conditions existing at the time immediately preceding the accident, a DC6-B aircraft was positioned on the south side, and a Convair 440 aircraft was positioned on the north side of runway 9, each aircraft then standing in the same position as the actual aircraft occupied at the time of the transmissions.

It was determined that when the main tower transmitter was in use, a transmission from the Convair 440 aircraft made simultaneously with a control tower transmission produced a sharp squeal in the receiver of the DC6-B aircraft, and that when the tower microphone was keyed, no transmissions except the controller's were received and recorded in the tower.

The Board made a study of the phraseology used in the tower transmission coupled with a possible omission of certain words therein and the substitution of any and all of the other aircraft's transmissions. However, an analysis of the results leads to the conclusion that the composite message as possibly heard by the crew of the DC6-B could not have been misconstrued as a clearance for take-off. Thus, neither the testimony of the crew of the DC6-B nor the results of the tests outweighed a preponderance of evidence indicating that the DC6-B was given a holding clearance not a clearance for take-off.

It is estimated that the crew of the DC6-B, after positioning the aircraft for take-off, had approximately 850 feet of runway available for acceleration prior to the point at which the collision occurred. The time for an aircraft of this type to accelerate to approximately 60 knots in 850 feet is computed to be approximately 13 seconds.

The local controller's warning to check the traffic was transmitted approximately nine seconds after the take-off roll had begun and approximately four seconds before the collision. In the absence of regulatory or procedural requirements, it cannot be determined with certainty at what point in time within the 13 seconds the local controller should have detected the failure of the DC6-B to comply with holding instructions. However, it is evident that there were both detection and warning within nine seconds after the DC6-B commenced its take-off roll. Whether the warning given by the local controller was sufficient to discharge his duty to prevent collision requires further examination. The control tower recording tape indicates that the warning message was not addressed to the DC6-B or the Viscount, both of which at the time of transmission were in positions of peril. Although the local controller stated that he directed the warning message to the DC6-B, the crews of the DC6-B and the Viscount testified that they heard no warning. This testimony is given credence by the fact that the warning message did not identify the addressee. The crews of both the aircraft would normally be alerted to danger only by a warning which was specifically directed to them. Since the warning message was not directed to anyone, it is found to have been deficient in that respect.

As the result of this accident the Board recommended to the Federal Aviation Agency that consideration be given to requiring that all restrictive clearances or instructions issued by Air Traffic Control be acknowedged by pilot repetition.

The Board found that this ground collision accident occurred as the result of commencement of take-off by the DC6-B without clearance.

Contributing factors were the failure of tower personnel to provide adequate surveillance of the active runways and to issue an appropriate warning message to the pilot of the DC6-B alerting him to the impending traffic conflictions.

COMMENT

The above summary provides startling evidence of what can happen when a pilot fails to make certain that he understands the terms of a clearance given. Several incidents have occurred at controlled aerodromes within Australia where aircraft have taken off without receiving a clearance to do so. There have been other cases where a clearance has not been properly interpreted and the pilot has proceeded on the basis of assumption.

CORRECTION

At page 2 of Digest No. 32, December, 1962, the figure "800" has been erroneously included in the distance that may be achieved with the 3 mc. frequency under "night conditions". This section of the table should read:

3 mc.: Range may extend up to 500 n.m. without any appreciable "skip".

Muff Heater Fire

Pilots are taught the basic actions to be taken to combat fire in flight early in their flying career and all conscientious pilots continually review the drill applicable to the type of aircraft they are currently operating. Fortunately, emergencies of this nature do not occur often, consequently few pilots are faced with having to cope with an actual fire.

As this is one field where most people would prefer to learn from the experience of others rather than obtain first hand knowledge, the details of one recent incident in which a light aircraft pilot successfully dealt with a fire in its early stages will be of interest to all who operate aircraft not having built-in fire extinguishing systems.

Flying at 4,000 feet over rough country in a Piper PA24, the pilot set the cabin heater control to the position where it would provide warmed air to the cabin and then proceeded to tune a radio receiver. Without warning, exhaust fumes, smoke and engine noise burst into the cabin via the hot air duct, accompanied by a strong smell of burning rubber and bursts of naked flame. As the cabin had immediately become chocked with smoke the pilot opened the small direct vision storm window and placed his nose and eyes into the aperture as far as possible to avoid the effects of his sight and breathing. Realising that a complete failure had occurred in the right hand exhaust stack and heater muff assembly he pulled the nose of the aircraft up to reduce speed, closed the throttle, set the mixture to lean, and turned off the fuel and ignition. As speed was lost the undercarriage was lowered to increase drag and also to clear the nose wheel from the fire area. By this time it was impossible to read instruments or see the undercarriage position lights. By placing his hand on the emergency extension lever, the pilot felt the undercarriage lock down, then turned the electrical master switch off and set the aircraft into a steep dive.

Whilst diving he closed the hot air vents and selected outside air. This forced the smoke and fumes out of the open storm window and quickly cleared the cabin. He also set the carburettor-air control to approximately a midway position to direct cold ram air up the air intake tube to the exhaust. On doing this all smoke from the cowls ceased.

At about 500 feet above terrain the aircraft was eased out of the dive and the pilot make a quick check for fire and smoke by selecting hot air to the cabin. As this produced fumes only, with no semblance of fire, he closed the hot air vents and took stock of the current situation. The nature of the terrain in the immediate area was such that a successful forced landing was impossible, consequently the pilot elected to restart the engine in an attempt to gain a position where a landing coud be affected. Restarting proved that the fire had been extinguished during the dive so he was able to proceed using a low power setting to land normally at an aerodrome.

Examination of the aircraft revealed that the exhaust pipe had broken off within the heater shroud. When the pipe broke it became displaced within the heater, thus permitting the exhaust flame to eject into the metal shroud. The shroud collapsed under heat and fell into the lower cowl, after which the exhaust flame burned the flexible hose of the cold air inlet and warm air outlet ducting.

Exhaust flame and general fire burned the flexible hose from the heater unit to the fire wall bulkhead hot air selector and also the rubber boot from the nose wheel steering actuating rod. Flame and smoke had then entered the cabin through the hot air selector and the nose wheel steering rod aperture. The carpet in line with the steering rod was singed for approximately 24 inches aft of the firewall.

The generator wiring, flexible hose to the air box and rubber covers in the area were burned. Fire had, at one time, existed on the surfaces of the hot air box and the rear bowl of the carburettor, consuming the paint and oil which had been on the surface. These fires were apparently extinguished by the blast of ram air from the partly opened carburettor air control during the dive.

In describing the incident, which he believes occupied only a minute or so, the pilot acknowledges the assistance he had been given by a verbal exchange a short time before with an American pilot who had experienced a similar fire in a PA24. In discussion, the American pilot mentioned that he had overlooked extending the nose wheel in the emergency and as a result the wheel caught fire and continued to burn throughout the dive, finally leading to destruction of the aircraft after the pilot had completed a safe landing with wheels up.

No doubt this discussion was of considerable assistance to the pilot concerned in this incident; nevertheless he is to be commended for the efficiency with which he dealt with a difficult situation. It appears, from the description of the damage sustained by the exhaust and heater assembly, that there was considerable risk of a further outbreak of fire when the engine was restarted but in view of the inevitability of an accident in any attempted forced landing, the decision to restart was obviously justified. The pilot showed sound judgement in using only a low power setting under these circumstances.

Exhaust system troubles of this nature are not confined to any one particular installation, but occur in a number of light aircraft which employ exhaust heater muffs as a means of obtaining warm air for cabin and carburettor air heating. The manufacturers concerned have introduced various modifications in an attempt to eliminate failures of this type. Whilst these have improved the reliability of the systems they have not been sufficiently successful to obviate the need for a careful inspection of the exhaust heater unit at regular intervals. All operators should be observing these inspections as part of the normal maintenance programme carried out in accordance with the manufacturers instructions but so as to highlight the importance of the matter the manufacturer's inspection requirements have been made the subject of Air Navigation Orders.

Prevention of Retractable Landing Gear Failure

An alarming number of accidents involving a gear-up landing or a landing gear collapse are reported annually. Human error may never be eliminated but an increase in mechanical reliability can be expected when frequent and exacting maintenance is performed. More than 10 per cent of the accidents reported in 1961 included the following conditions:

Landing gear warning systems malfunctioned.
Limit switches became inoperative.
Gear uplock failed to release.
Gear downlock failed to engage.
Gears hung up in wheel wells.
Chains jumped sprockets, cables fouled in pulleys, slide tubes became bound due to dirt contamination, torque tubes and drag struts bent when loads were applied for which they were not designed.

Most of these difficulties can be the result of landing gear, rigging problems — but we should also look at some other specific areas.

On today's modern and comparatively complex retractable gear equipped aircraft, good landing gear inspection and maintenance requires adherence to the manufacturer's service data and the use of proper equipment. Pulling one wing tip to the ground while someone shakes the gear on the opposite side is as hazardous as the "it flew in — it ought to fly out" attitude.

Pay particular attention to the cleanliness of switches and valves that are located on struts and in wheel wells. They are apt to collect mud and debris that may cause a false safe light indication or stop an extension cycle before the gear is completely down. Repair or replace any protective boots that may be damaged or missing. With the aircraft on jacks, be sure the shock strut fully extends. A flat strut may not retract into the correct position and cause damage to the structure or fairing doors. Oversized or recapped tyres may stick in a wheel well and prevent gear extension. Inspect the anti-retraction switch or valve for proper adjustment and operation.

The correct rigging in strict accordance with the maunfacturer's instructions is of utmost importance. Every adjustment must be within the limits specified to give trouble-free landing gear operation. Correct lubrication is important too.

Be sure of the warning horn's proper operation. It may be necessary to fly the aircraft to assure that the horn blows at the correct throttle setting.

How often is an inspection of a landing gear system necessary? At least as often as recommended by the manufacturer and required by CARs, but some personal judgment is also needed. If an aircraft is being operated from rough surfaces or being used for student instruction, more frequent inspections may be in order. When a hard landing is experienced or landing gear strikes an object while taxiing, it is wise to inspect for damage. Gear damage may occur and rigging be affected by sharp turns at high taxi speeds or by taxiing off a hard surface into deep mud or snow.

Attention to this area of maintenance inspection can affect a substantial improvement in general aviation safety — something we all strive for.

COMMENT

In Australia, the Department requires that all commercial operators specify in their approved maintenance manual the frequency of inspections, as well as the checks and tests that must be performed. Private operators must conform with the manufacturer's recommendations except where more frequent inspections are required by the Department.

(Extract from Aviation Mechanics Bulletin)

Control Cable Disconnect Destroys Electra

CHICAGO, ILLINOIS, U.S.A.

(Summary of a report adopted by the Civil Aeronautics Board, U.S.A.)

On 17th September, 1961, a Lockheed Electra crashed shortly after take-off from O'Hare International Airport, Chicago, U.S.A. All 32 passengers and the crew of 5 sustained fatal injuries. The aircraft was totally destroyed by impact and subsequent fire. The Board concluded that the accident was probably due to mechanical failure of the aileron control system.

The aircraft was engaged on a scheduled flight from Milwaukee to Miami, which embraced several intermediate stops. Routine maintenance services were completed whilst the aircraft was on the ground at Chicago, a scheduled crew change was made and the flight was despatched with the gross weight and centre of gravity within prescribed limits. Take-off was made on Runway 14R and although the actual lift-off was not observed, eye-witness evidence indicates that the aircraft assumed a normal climb attitude and reached a height of between 50 and 75 feet when 3,000 to 4,000 feet down the runway.

Runway 14R is 11,600 feet long and is 667 feet above mean sea level. It is estimated that at the time it passed the 8,000 foot marker the aircraft had reached an altitude of 100 feet, which is slightly lower than Electra's normally attain at this stage of take-off. When it was between the 8,000 and 9,000 feet markers, eye-witnesses noted a change in engine sound and the aircraft was seen to commence an apparently co-ordinated turn to the right, during which the rate of bank slowly increased. When the angle of bank was of the order of 30 to 45 degrees the crew made a short, garbled transmission. Immediately thereafter, at a bank angle of 50 to 60 degrees, the aircraft began to lose height. The maximum height attained was estimated to have been between 200 and 300 feet.

The right wing struck and severed 38,000 volt power lines which are adjacent to a railway-line bordering the airport boundary. The aircraft then continued on a westerly heading until the right wing contacted the railroad embankment, with the wing about 85 degrees below the horizontal and the nose 10 degrees down.

The aircraft cartwheeled and continued to roll about its longitudinal axis until the nose crashed into the ground 380 feet beyond the point of first impact. The fuselage contacted the ground right way up and slid tail first for a further 820 feet before coming to rest. Disintegration occurred throughout this path with wreckage being strewn over an area 200 feet wide and 1,200 feet in length. Evidence of ground fire was found at various points along the wreckage trail and the major section of the aircraft was demolished by fire.

At the time of the accident the sky was clear, visibility was of the order of six miles, with smoke and haze, and the wind was from the south at eight knots.

Evidence provided by the crew who had brought the aircraft to Chicago established that the aircraft was operating normally during the previous flight. No abnormalities were detected during the routine maintenance checks carried out prior to departure. The despatch and operating procedures were correctly complied with and the crew were properly qualified.

Eye-witness evidence established that the flaps were down to some degree for take-off and that the landing gear was retracted after lift-off. All witnesses agreed that there was no sign of fire or smoke prior to impact with the power line, nothing was seen to separate or fall from the aircraft, no birds were observed in the flight path and there was no abrupt or violent manoeuvre other than the progressively increasing bank to the right. It was subsequently determined that at the time of the principle impact the flaps were at the take-off setting and the landing gear was in the retracted position.

The flight recorder was installed in the forward section of the fuselage. High impact loads had cracked and sheared the cast stainless steel magazine and fragmented the record foil contained therein. Parts of the recorder and foil were found strewn along the wreckage path but the section bearing the record of the final take-off was not recovered. It was possible, however, to define the flight path within narrow limits by observations made of other Electra aircraft taking off on the same runway and by use of performance data. It is believed that lift-off occurred 3,200 feet down the runway, the aircraft reached a height of approximately 300 feet and it was descending at an angle of 5 degrees at the moment of initial impact.

Following acknowledgement of take-off instructions, no further transmissions were made by the crew until the aircraft had assumed a bank angle of 30 to 45 degrees. The garbled transmission made at this time was seven seconds in length, was delivered in a high pitched voice and was poor in signal quality. As closely as could be determined by laboratory examination, the transmission was "We're in trouble (break) uh and all units holding this is (call sign) alert. I still don't have release right turn in no control (intake of breath) (garbled phase which may have been 'can you' or 'have you')". The garbled phrase was higher in pitch and more rapid than the preceding utterances.

Examination of the power plants indicated that they were capable of normal operation and no evidence was found to suggest that the aircraft and its systems, other than aileron control, were not functioning correctly.

Marks made on the inboard closing rib of the right aileron indicated that the aileron was deflected upward three degrees at impact, corresponding to a flight control position of right wing down. The rudder and elevator boost units were found to be in the "engaged" position but the aileron boost unit was found in the "disengaged" setting. These positions however, could not be considered reliable, because of the possibility of cable pull due to break-up forces. Subsequent examination and testing of the boost units revealed no evidence of malfunctioning but showed that the aileron boost unit had seized, due to fire damage, in a position consistent with control movement to produce right wing down.

The angular setting of the co-pilot's control wheel at impact could not be determined, but evidence was available to show that the captain's control wheel had been turned to a position calling for almost full left wing down control movement.

The primary aileron control system consists of two cables which form a closed loop, as illustrated, between the pilots control wheels and the boost unit input quadrant. The cable which connects to the captain's control horn is in tension for a right wing down control movement, whilst that which connects to the co-pilot control horn is in tension for a left wing down movement. These cables provide a signal input from the control wheels to the boost unit when boost is engaged and also serve as the means of manual operation of the ailerons when boost is disengaged.

All recovered cable connections in the control system between the captain's control column horn and the aileron boost unit were found to be normal except for the threaded connector at the slack absorber forward terminal block. This connector was found to be partly backed out of the terminal block and showed that only five to seven threads had been engaged, which is approximately one-third of the normal engagement. In addition, soot and fire damage indicated that the locking wire normally used to safety the connection was not installed at the time of the accident. The absence of this locking wire was confirmed by laboratory examination.

The co-pilot slack absorber unit and the associated control cables were not recovered. Indentations around a guide hole in the still-intact fuselage bulkhead at the station 651 pulley bracket indicated that some object had been forced through the hole in a forward direction. Investigation disclosed that the slack absorber terminal block is too large to be pulled through such a hole, whilst the parted end of a flexible cable would not be capable of making indentations such as those found. The only object which would be capable of making these marks was the connecting swaged end of the flexible cable. Load tests proved that failure of such a cable and swaged end connector assembly first occurs in the flexible cable itself, without any damage to the connector or other components of the system. In view of the natural tendency of the flexible cable to unscrew from its fitting if not lockwired, this evidence indicates that the co-pilot's flexible cable connector had completely disengaged from the slack absorber terminal block and was pulled through the pulley bracket when the aircraft disintegrated.

It has long been accepted that a flexible cable, as used in the primary aileron control system, has a natural tendency to unscrew from its connector when under tension. Tests conducted in 1941 showed that not only could such a cable unscrew, but that the torsional force was sufficient to break the soft brass cadmium plated locking wire currently used by the aircraft industry at that time. After breaking the wire, the connector would turn free of the turnbuckle. Additionl tests conducted by Lockheed Aircraft Corporation, using identical parts to those installed in the co-pilots side of the Electra aileron control system, proved that without locking wire installed the cable has a natural tendency to, and did, unscrew from its fitting.

The manufacturer also demonstrated the effect of a simulated failure of the identical left wing down aileron cable in an Electra aircraft. With hydraulic pressure applied, boost engaged and ailerons in neutral, the cable was severed. Although the person holding the control wheel felt only a slight pulse when the cable was cut and was not otherwise aware of what had occurred, an immediate signal calling for right wing down was imparted to the boost input quadrant. These tests also disclosed a tendency of the cable connectors between the forward flexible cables and the lockclad cables to bind with air-frame structure, sufficient to hold against the in-flight loads and prevent the aileron boost unit from returning to the neutral position.

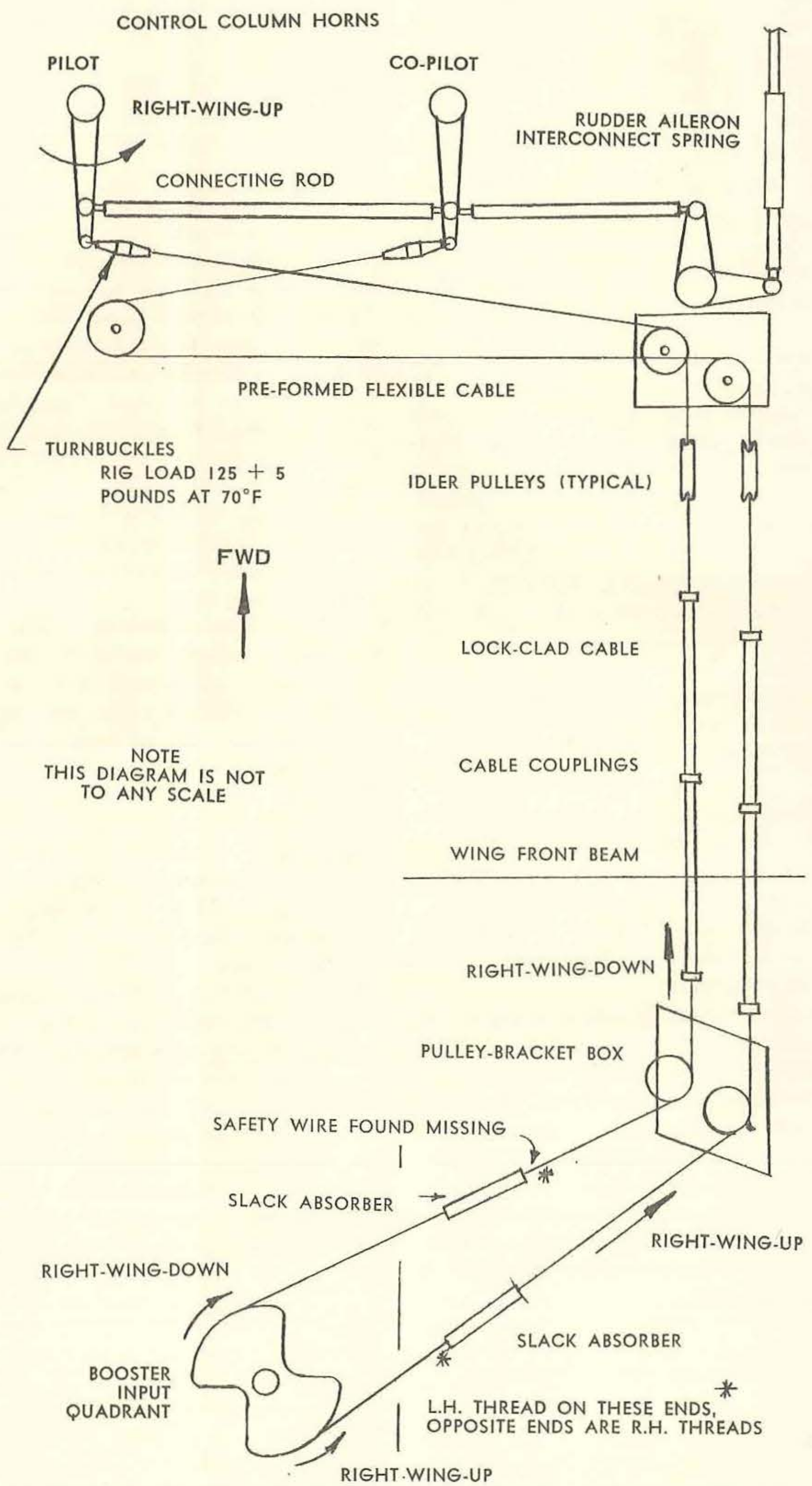
With the left wing down cable disconnected at the slack absorber it would not be possible for the pilot to apply opposite aileron to bring the right wing up. In addition, if the cable connector became caught up in the structure and prevented the ailerons returning to neutral, the situation would become unmanageable. Since witnesses observed the angle increase steadily, and since the right aileron was found in a position consistent with right wing down, there was reason to conclude that the cable became disconnected and then became caught up in the right wing down position somewhere within the aileron control system. Other recovery techniques such as the use of rudder, asymmetrical power and aileron tabs might have been effective in overcoming the increasing bank had sufficient altitude been available.

Tests were also conducted to explore the possibility of interference having occurred between the wing flap and the aileron. With simulated airloads applied to the flap and the outboard jackscrew disconnected it was found that only normal exertion was required to overcome such interference with boost engaged. Without aileron boost a force of 550 inch-pounds, applied and measured at the control wheel, was required. This force is well within the capability of a pilot.

Examination of the mechanical logs of the aircraft disclosed that during the period 27th June, 1961, to 11th July, 1961, eight discrepancies were recorded in respect to the aileron system. These referred to sluggish feel in boost, delayed reactions of boost, sticking or binding of aileron boost, boost pulses at all speeds and ailerons erratic at all speeds. Most of the corrective action recorded indicated the performance of ground checks, one entry showed replacement of the boost valve and hydraulic filter, whilst one carried merely the entry "noted". During this period the aircraft was despatched on a total of 29 flights.

On 11th July the aircraft became due for an extensive maintenance check and as the aileron trouble was still evident it was decided to replace the aileron boost unit. It so happened that this was the first time that the operator's line maintenance personnel had had occasion to replace an aileron boost assembly and the current maintenance instructions required maintenance engineers to follow the steps prescribed in the manufacturer's maintenance manual in regard to removal and replacement of such a unit.

Three shifts were operating in the line maintenance organisation. The boost unit was removed by



AILERON PRIMARY CONTROL SYSTEM

engineers employed on shift 2. Following the steps described in the Lockheed manual, these engineers removed the locking wire from the cable connectors at the forward end of the slack absorber units and unscrewed the connectors to relieve cable tension, thereby facilitating removal of the boost unit.

The replacement unit was installed by shift 3. Neither of the two engineers engaged on the work followed the Lockheed manual step by step, but referred to it only when a problem was encountered. Neither read the removal instructions to determine the components that had been unsafetied, disconnected or rendered inoperative in the removal of the unit. Although both testified that they checked each other's work after completion of the installation, they could not recall having read the instructions relative to re-rigging of the aileron control cables, or actually checking to ensure that the previously loosened cables were properly tensioned and resafetied. The shift crew-chief, who also had not read the instructions in the Lockheed Manual relative to removal and installation of the aileron boost assembly, made a cursory examination of the installation and functionally checked the controls before signing the mechanical log to indicate that the work was completed. He did not ensure that the work was inspected by a company inspector, as required by a maintenance directive.

The operators maintenance manual prescribed a comprehensive system to ensure that the details of work commenced but not completed by one shift were made known to the following shift. In addition it was required that red Unit Inoperative Tags be affixed to pertinent cockpit controls when cables were unsafetied, to prevent the release of an aircraft when work was being performed in inconspicuous places. This directive specified that the tag could only be removed by an inspector, who was responsible for signing the tag after satisfying himself that the affected cables had been tensioned and safetied. Testimony obtained from the engineers and inspectors concerned with the work indicated that these procedures were not followed and that there was a distinct lack of co-ordination between the maintenance supervisors and the inspection department. Although the inspectors were aware of the fact that the boost unit was being changed, they failed to comply with a company instruction and ensure that the completed installation was inspected.

Despite the existence of several managerial controls which would have ensured the proper completion of the aileron boost unit change, the evidence clearly indicated that little attention was paid to the prescribed methods of assuring job continuity between shifts and to compliance with other company instructions. In reviewing this section of the evidence, the Board concluded that the maintenance and inspection personnel concerned with the work showed an ignorance or disregard of published directives and instructions.

In analysing the evidence which had a direct bearing upon the accident the Board concluded that the following chain of events led to the destruction of the aircraft. Shortly after take-off the aircraft developed a rolling movement to the right which could not be controlled by the crew due to a failure in the aileron primary control system between the boost input quadrant and the control wheel.

This failure was caused by separation of the left wing down primary aileron cable from its respective slack absorber on the co-pilot's side, making it impossible for the crew to decrease the steeping bank or affect a recovery by any means at such a low altitude. In regard to the failure experienced, it was established that two months prior to the accident the cable connectors to the slack absorber were unsafetied and loosened during an aileron boost unit change. These cables were not retensioned and resafetied before the aircraft was released for flight. It is believed that in the course of the subsequent flying the cable gradually became unscrewed until it finally separated from the slack absorber immediately after take-off on this last flight.

Commenting upon the eight aileron control defects that were recorded between 27th June and 11th July, 1961, the Board considered that the entries recorded indicated that little effort was made to analyse the cause of the discrepancies and to correct them. It was felt that the manner in which the work was carried out reflected a casual attitude on the part of the maintenance personnel toward a potentially hazardous condition, and that this attitude was also evident in the replacement of the aileron boost assembly.

The board determined that the probable cause of this accident was a mechanical failure in the aileron primary control system due to an improper replacement of the aileron boost assembly, resulting in a loss of lateral control of the aircraft at an altitude too low to effect recovery.

COMMENT

There is little doubt that this accident would not have occurred if the maintenance personnel concerned had complied with the established procedures.

Australian operators employ similar procedures as safeguards against human error. No matter how foolproof these maintenance systems may appear to be, accidents such as this will continue to happen unless each individual becomes acutely conscious of the importance of making it his business to ensure that he is aware of all pertinent instructions and complying with them fully and precisely.

Unexpected Feathering has Fatal Results

(Summary of a report published by the Ministry of Aviation, U.K.)

Bristol 170 at Guernsey, Channel Islands

On 1st November, 1961, a Bristol 170-32 crashed whilst attempting a landing in conditions of low cloud and poor visibility at Guernsey Airport, Channel Islands. Both pilots were killed and the eight other occupants received serious injuries. It was determined that the accident was due to malfunctioning of the automatic pitch coarsening units associated with the starboard propeller.

The aircraft was operating a regular car-ferry and passenger service between Cherbourg, France, and the Channel Islands. Whilst approaching Guernsey Airport at 1,000 feet the flight was advised that the airport visibility was 3 nautical miles with slight drizzle, 4/8ths cloud at 300 feet and 8/8ths at 500 feet. The captain was reminded that the airport radar was unserviceable and was asked to report when over the NDB. Soon afterwards the captain announced that he was flying in broken cloud and requested and received a clearance to make a visual approach. He also requested confirmation of the previously given weather conditions.

The controller offered assistance with radio bearings and a series of QDM's were commenced. Some six minutes later the controller heard the aircraft overhead, at which time the captain radioed that he would go round again since he had descended to his critical height and "couldn't see a thing". Whilst positioning the aircraft for another approach the captain was advised that the surface wind was 240 degrees magnetic at 14 knots, visibility had improved and the cloud coverage was 2/8ths at 800 feet, 8/8ths at 1,000 feet. Shortly after commencing the second approach the captain asked the height of a water tower situated one mile east of the aerodrome near the extended centre-line of the runway. He was told "six zero feet above the airfield". Advice was then given of deterioration in the weather to visibility 1600 yards, cloud 5/8ths at 100 feet and 8/8ths at 200 feet. One minute later the captain radioed that he had crossed the coast some two or three miles from the airport and, after a further two minutes, that he had the airport in sight and would land on the runway aligned 100/280 degrees magnetic. This runway is 4,800 feet in length and was equipped with high intensity bi-directional lighting and low intensity omni-directional lighting. At the time the approach lights were at 30 per cent brilliance and the runway lights at 100 per cent.

The aircraft came under the observation of the controller as it was making an "S" turn to line up with the runway. At a height of about 30 feet it was seen to commence a flare-out as though to touch-down. When approximately 1,400 feet past the threshold, however, power was applied, apparently for the purpose of climbing away. Almost immediately the aircraft swung to the right and flew slowly towards the northwest without gaining height. It continued straight and level for about half a mile, during which the starboard propeller was seen to be rotating slowly. It then banked sharply to the right and the starboard wing struck the ground. The aircraft cartwheeled and the rear fuselage containing the passenger cabin broke away. The main section of the wreckage, which was clear of the passenger cabin, was destroyed by fire.

Examination of the wreckage revealed that the flaps were in the retracted position and all trims were neutral. There was no evidence of fire prior to impact. It was established that the blades of the port propeller were at an angle consistent with take-off power whilst the starboard propeller was in the feathered position. The master switch controlling the auto-coarsening system was ON and "caged".

The engine control levers were in full forward position at impact, the fuel and oil cocks were "ON" and the fuel cross-feed cock was OFF. Samples of fuel obtained from a collector tank that escaped the fire were free of water and sediment. No evidence of defects or malfunctioning were found in the aircraft or its flying control system. Workshop examination of the starboard engine, its propeller and accessories disclosed no evidence of failure or malfunction.

The Bristol 170 Series 31 and 32 aircraft are fitted with automatic pitch coarsening* to reduce the drag of a propeller in the event of engine failure during take-off. The system incorporates two pressure sensitive units known as Engine Cut-out Switches, one for each engine. The micro-switch section of this unit is activated by a diaphragm which senses the difference between the dynamic pressure produced in propeller slip stream and the pressure produced by the forward speed of the aircraft. The switch unit takes up a "high differential" setting, which is equivalent to 4.5 inches of water, when the engines are under power. In the event of engine failure the unit moves to a "low differential" setting and initiates auto-coarsening when the pressure across the diaphragm falls to a value equivalent to 2.5 inches of water. The two cut-out switches are electrically interconnected to ensure that only one propeller can be automatically coarsened and the system functions only when the Boost and RPM control levers are at or close to the maximum power position.

At the time of the accident the Flight Manual prescribed a pre-flight functional check of the auto-coarsening system and a penalty on the all-up-weight at take-off if the system was inoperative. No restriction was imposed on the use of the system after take-off.

Tests carried out on the starboard engine cut-out switch established that it was not operating within the limits prescribed by the manufacturer. The pressure required to move the diaphragm to the "high differential" position varied between 5.1 and 5.9 inches of water, whilst it would move to the "low differential" setting at pressures equivalent to 3.8 inches. These discrepancies would not be revealed during the pre-flight functional checks prescribed at the time of the accident. In addition, strip examination disclosed the presence of a small amount of glutinous matter impregnated with swarf within the unit and there was evidence of pick-up between the moving parts of the mechanism. The backing-spring of the unit was non-standard and a rubber cowl had been fitted to the micro-switch contrary to the manufacturer's drawing.

Auto-coarsening is intended to take place during take-off if one unit falls to the low differential setting and requires that the boost and RPM levers are fully forward. There is a possibility, however, that auto-coarsening could occur during a baulked approach if the master switch was ON. When the engines are throttled back the reduction in propeller slipstream would allow both units to fall to the low differential setting. If a rapid selection of maximum power and RPM were then made, as in an emergency late in the approach, there is a risk that inadvertant auto-coarsening would result. If either of the units were operating at settings above those prescribed for the particular type of aircraft this risk would be increased.

There is little doubt that the pilot initiated a baulked landing procedure, possibly with some degree of urgency. During the landing flare the airspeed should have been decreasing from about 84 knots to 65 knots and was probably of the order of 70 knots at the time power was applied. It appears that the incorrect setting of the starboard engine cut-out switch caused the starboard auto-coarsening system to be activated when the engine controls were moved to maximum power position. Under these conditions the pilot was not only unable to maintain directional control but also had insufficient height to put the nose down in order to accelerate to a speed at which control could be regained. The pilot would not be aware that the auto-coarsening action was not due to a genuine engine failure.

Up to the time of this accident Bristol 170 Series 31 and 32 aircraft had flown 520,000 hours and nothing had occurred to suggest that there was any inadequacy in the maintenance requirements or operating techniques relative to the auto-coarsening system. As a result of the accident, however, the Air Registration Board introduced more rigid overhaul and calibration requirements and also required that the auto-coarsening system be switched OFF after take-off.

COMMENT

Auto-coarsening systems* are installed on Bristol 170-31 aircraft currently operating in Australia. This summary has been published to ensure that pilots understand why it is essential for the auto-coarsening system to be deactivated after take-off and to remind engineers of the importance of accurate calibration of this type of unit. It also serves again to illustrate the danger that arises from unauthorised modifications or the use of non-standard parts.

* When the auto-coarsening system is energised the propeller is feathered by governor pump oil pressure only. The feathering pump is not activated.

Structural Failure
leads to
Fatal Glider Accident

In 1943 a Victorian gliding syndicate designed and built a glider which was based on the "Tutor" type but having a number of design variations due to the wartime shortage of materials. The glider was known as the Merlin.

Flight tests of the glider were quite satisfactory and it was flown regularly until late in 1948 when it was damaged as a result of a stall accident soon after take-off. It was then stored until April 1952 when repairs were commenced.

On the completion of the repairs in September of the same year, the glider was used for a short period which was terminated by another accident. This accident, caused by failure of the tow cable during take-off, resulted in the front of the fuselage breaking off forward of the main bulkhead and damage to the spars in one wing. The glider was stored once more and repairs were not carried out until 1955.

During the repairs it became evident that the timber in the structural members, particularly in the wing, had deteriorated through strain and long term drying. It was therefore decided to strengthen the wing by the addition of a third spar and by covering the leading edge with plywood as far aft as the new spar, thus forming a "D" torsion box. New keel plates were fitted and the nose lengthened to facilitate the addition of a plastic canopy. When test flown the glider exhibited a tendency toward nose heaviness, probably due to the lengthening of the fuselage. To assist in combating the effects of this, the surface area of the elevator was increased and at the same time the rudder area was also increased to improve directional control which was found to be poor at slow speeds.

There followed an extended period during which the glider gave satisfactory service until it was involved in another accident during launching with the result that a fuselage upper longeron was cracked and a large area of the plywood skin on one side of the fuselage was damaged. Not long after the glider had been repaired, the starboard wing struck a tree on the approach thereby causing a heavy landing and once again the front of the fuselage was damaged. During the repairs which followed the wing was not opened up for inspection of the internal structure for damage.

The next and final episode in the glider's life took place on 28th December, 1959, a few days after it had been re-rigged upon the completion of repairs. On this occasion three gliding enthusiasts, one of them very experienced, planned to fly the Merlin and an R3 glider on training flights using a DH-82 aircraft as a glider tug. During mid-morning the experienced pilot made a short flight in the R3 and upon landing he reported having experienced severe turbulence and advised the other two pilots not to fly. Approximately one hour later the same pilot carried out another flight, this time in the Merlin, to find out whether the conditions had improved. The glider was towed to a height of 1,100 feet before release to soar to a height of 4,000 feet where it flew for a few minutes before descending to land. On this flight the pilot encountered sharply defined vertical currents, the speed of which he estimated to be in the vicinity of 600 feet per minute, and again pronounced the conditions to be unsuitable. In spite of this, one of the pilots who was most anxious to fly since he had travelled from Canberra for the day, decided to fly the Merlin and at 1100 hours he was towed to a height of 1,200 feet where he flew briefly in a rising current then landed. He reported the conditions to be turbulent but considerably better than earlier reported therefore he made preparations for another flight.

On the next flight, according to the pilot of the DH-82, there was moderate turbulence during the first thousand feet of climb but it decreased in the remainder of the tow up to 2,200 feet where the glider released the tow cable upon entering a rising current. After release, the glider was seen to circle three times to the left after which it flew straight for a short distance and then turned to the right in a nose down attitude and at the same time descended to a height of approximately 1,000 feet. At this point the glider's wings folded backwards and it dived to the ground, shedding pieces of the wing structure as it did so. The pilot received fatal injuries on impact and the glider disintegrated.

The extent of the damage to the glider rendered it extremely difficult to establish the sequence of break up of the wing, however it was evident from the disposition of the wreckage that the entire wing covering from the leading edge to the trailing edge in the region of the port wing root had become detached during flight.

It was concluded that the initial failure of the wing occurred at the wing root, probably in either the ribs or the drag box. The failure was attributed to poor structural design of the wing root and spars in conjunction with a weakening of the structure due to age, flights in turbulence and possibly undetected damage which would have occurred in previous accidents.

As this type of glider no longer exists in Australia the lessons of this accident have no direct application but the circumstances of repair after repair coupled with doubtful modification and aging are worthy of careful consideration in relation to any type of aircraft.

TRAPPED CESSNA!
Aerial Ag. Fatality

A Cessna 180 agricultural aircraft was engaged in spreading superphosphate over sections of the mountainous terrain near Tumut in south eastern New South Wales. The operation continued until the morning of the third day at which time the foothills area was completed and it was then necessary to survey a new area.

The new area was situated at an elevation of some 1,500 feet above the level of the strip and just beyond a saddle at the end of an upward-sloping blind valley. On the survey flight the pilot executed a 360 degree climbing turn before proceeding up the valley in order to have adequate vertical clearance upon reaching the saddle and the exercise was completed satisfactorily.

The aircraft was refuelled and the hopper reloaded before the pilot again took off to commence spreading over the area surveyed. On this and several subsequent flights the pilot employed a wide climbing turn to gain height instead of a 360 degree turn, as was made on the survey flight, and he continued this procedure until approximately 1245 hours when the operation was stopped for a lunch break.

Following the first take-off after lunch, at approximately 1330 hours, the pilot did not make the wide climbing turn as before and this resulted in very little height being gained before proceeding up the valley. As the aircraft neared the saddle, it was observed to enter a steeply banked turn to the left and commenced discharging superphosphate in the process of dumping. After the turn had progressed some 180 degrees, throughout which height was lost, the aircraft was seen to slip sideways and strike the boulder strewn hillside. The aircraft disintegrated and was consumed by fire with fatal consequences to the pilot.

The examination of the wreckage, including the stripping down of the engine, did not reveal evidence of any pre-accident defect. It was not possible to accurately determine the load state of the aircraft but, in the basis of estimation, the all-up-weight and the centre of gravity were considered to be within limits.

The pilot held a commercial licence with a "C" instructor's rating. He had been flying for a period of a little under six years and during this time had accumulated a total flying experience of 1,040 hours of which 456 hours had been flown in Cessna 180 aircraft and 206 hours on agricultural operations.

It appeared, from the observations of the sole witness, that the aircraft had probably stalled when the pilot attempted to turn back along the valley. Tests were therefore conducted with another Cessna 180 aircraft to determine whether it would have been possible for the aircraft to clear the valley without first gaining height before proceeding up the valley. A reduced weight/power combination was used to simulate the performance conditions of the aircraft which crashed. On the first flight a wide climbing turn was made after take-off with the result that upon reaching the end of the valley the aircraft was able to clear the saddle by a margin of approximately 100 feet. The aircraft was then flown over the path taken by the aircraft on its last flight and this involved turning towards the valley immediately after take-off. When within a distance of approximately 150 yards of the accident site it became apparent that the aircraft would not have sufficient height to clear the saddle and a turn on to a reciprocal heading was made while adequate manoeuvring space remained between the valley walls.

These tests led to the conclusion that the accident was probably caused by the pilot misjudging the rate of climb of the aircraft thereby necessitating a turn in a confined space during which the aircraft stalled at a height from which it was not possible to effect recovery.

Don't ignore the safety message that this accident has for you. If you must fly up a blind valley, take steps to ensure that you will have adequate height to clear the surrounding high ground or, alternatively, do not fly your aircraft into a position where a violent manoeuvre is required to avoid the terrain.

Maintenance Error Causes Loss of Control

CHICAGO, ILLINOIS, U.S.A.

(Summary based on the report of the Civil Aeronautics Board, U.S.A.)

(All times stated are Central Daylight)

At 0205 hours on 1st September, 1961, a Lockheed Constellation Model 049 crashed about nine miles west of Midway Airport, Chicago, Illinois. The crew of five and 73 passengers were killed; the aircraft was completely destroyed.

The aircraft was engaged on flight No. 529 from Boston, Mass. to San Francisco with intermediate stops. The flight to Chicago was routine, where a scheduled crew change was made.

Fine weather conditions existed at Chicago's Midway Airport as Flight 529 departed at 0200 hours, with scattered clouds at 10,000 feet and visibility limited to three miles due to haze and smoke.

Radar contact was established with the aircraft as it proceeded outbound in a right turn. At 0204 hours it was observed to be five miles west of Midway Airport proceeding on course. About a minute later the ground controller observed a flash west of Midway Airport and requested another airborne aircraft to investigate the area as the radar return of Flight 529 had disappeared from the scope. It was subsequently established that the aircraft had crashed nine miles west of Midway Airport.

The aircraft crashed in an open field, striking the ground in a slightly left-wing-low and nosedown attitude on a heading of approximately true north. The aircraft disintegrated, leaving debris over an area 200 feet wide and 1,100 feet long. Five craters were made, each approximately three to four feet deep, as a result of the four engines and fuselage striking the ground.

Examination of the wreckage revealed that the portion of the horizontal stabilizer to which the right vertical stabilizer was attached had separated from the aircraft prior to impact and had fallen approximately 400 feet south of the main impact craters. The stabilizer failure occurred at Stabilizer Stations 240R and 230R of the front and rear spars, respectively. There was no evidence of fatigue on the spar caps, spar web, skin material, or stringers. Further investigation disclosed that there had been oscillatory loads applied to the four spar caps and the two spar webs prior to and during separation. The front spar upper and lower caps had failed in tension and the interconnecting spar web had experienced a tensile tear from top to bottom. The fracture faces of both rear spar caps were brinelled by recontact after failure.

There were several indications that the elevator had been at its maximum upward travel at the time of the failure. The most significant evidence of this was in the deformation pattern impressed in the right rudder by the elevator outboard closing rib in a manner and position such that the elevator had to be full up at the time the right rudder was forced into it during the stabilizer separation.

Examination of the remainder of the wreckage revealed no sign of an in-flight explosion or of collision with foreign objects. No evidence was found of electrical faults, nor was there evidence of any operational failures or malfunction of any engine or propeller component.

Measurements and readings were made of all trim actuators and their associated cockpit position indicators. The variations of readings within each of the trim systems prevented any determination of in-flight trim settings.

Examination of the flight control system revealed that the two aileron boost assemblies and the aileron boost cut off valves were in the boost OFF position. The shift handle in the cockpit, however, was found in the ON position. Since the shifting mechanisms were interconnected by long lengths of cable subject to being pulled by fragmenting structure following impact, the position of the cockpit handle is considered to be a more reliable, but not positive, indication of the aileron boost setting prior to impact. Under functional testing, the components of the left aileron boost package functioned satisfactorily. The right aileron boost package was too badly fire damaged to be tested.

The position of the rudder boost shift handle could not be determined but all affected components of the boost package were in the boost ON position. The components of the boost package functioned normally when tested.

The elevator boost shift handle was found in the ON position, consistent with the setting of the elevator boost package. In the course of examining the elevator boost unit it was found that a 5/16 inch bolt was missing from one link of the parallelogram linkage, which connects the pilot elevator input to the control valve of the elevator boost system. Despite an intensive search, this bolt could not be located amongst the wreckage.

Detailed examination of the bolt hole bushings, grease deposits, scuff marks, scratches, chatter marks and internal thread-like scores in the bushings provided strong evidence to indicate that this bolt had not been properly in place for a considerable time prior to the accident. This evidence coupled with analysis of the loads that could be imposed upon the bolt at impact, and the effect of such loads on the grease deposits, established that the bolt was missing from its installed position at the time of impact.

The construction of the elevator boost mechanism is such that when this bolt became free from its normal location there would be an almost instantaneous application of maximum elevator-up control applied by the elevator boost system. Under these circumstances the boost system would no longer be under the control of the pilot and the only means by which control of the aircraft could be regained would be to change to manual operation of the elevator control system.

The shift to manual operation of the elevator control closes the boost cut-off valve, opens the hydraulic by-pass valve at the actuator and changes the mechanical advantage of the direct pilot-to-elevator linkage. It would appear, on the surface, that such a change could be readily effected and that recovery from the situation produced by loss of the bolt would be a simple and straightforward action. There is, however, a peculiarity in the system which can introduce difficulty.

Changing the mechanical advantage in the elevator controls during the shift-to-manual operation has the effect of lengthening the connecting system between the control column and the elevator torque arm. The lengthening of the control linkage upstream of the shifting mechanism tends to move the control column in an aft direction, whilst that portion downstream of the mechanism tends to move the elevator downward. In the subject case the shift to manual could have been effected if the two hydraulic valves operated and closed off hydraulic power, as the elevators would have then been free to move down assisted by the airload hinge moment. The control column would also have been free to move aft unless the pilots were applying forward control at the same time as they attempted to operate the changeover lever. If, however, the crew were applying forward pressure the difficulty encountered would be proportional to the forward pressure applied. In addition, hydraulic pressure would continue to hold the elevators in the up position until the shift lever could be moved sufficiently to release hydraulic power.

With the boost operating, the elevator travel is limited to 40 degrees UP and 20 degrees DOWN, but is further limited with increasing airspeed by the boost hinge-moment maximum of 49,000 to 50,000 inch pounds. In the manual mode, elevator deflection is reduced to 16 degrees UP and 6 degrees DOWN, due to the increase in mechanical advantage. Therefore, if the shift-to-manual is started when the elevator is deflated UP more than 16 degrees, the elevators must be at, or less than, 16 degrees UP before the change can be completed.

In their analysis of the evidence, the Board considered that the following events occurred when the subject bolt worked out of position in the elevator control parallelogram.

1. When the bolt came out, the unsupported weight of the spool and two of the parallelogram links caused full pressure to be applied to the up-elevator side of the hydraulic actuator.
2. The elevator immediately moved UP to its maximum hinge moment. At the speed at which the aircraft can be

assumed to have been operating this movement would have been less than 40 degrees but more than 16 degrees.

3. The aircraft entered an accelerated stall. As this stall decayed toward a primary stall, the elevator deflection would have increased to 40 degrees.

4. The pilot's natural reaction would be to apply high forward pressure on the control column in an attempt to get the nose of the aircraft down.

5. Whilst this pressure was being applied, the crew would have attempted to pull the shift handle.

6. With the elevator held at or near maximum deflection by hydraulic pressure and with forward pressure on the control column, it would have been difficult, or even impossible to move the shift handle far enough to operate the hydraulic shut-off and/or by-pass valves.

7. With the aircraft stalled, or executing a series of stalls, the nose would have to be lowered to effect recovery. Whilst attempting to do this, the pilots would be applying forces which would be acting against their efforts to move the shift handle.

8. Accelerated stall vibrations would probably have caused damage to the empennage or rear fuselage.

There is no doubt that the elevator was deflected upward 40 degrees at some point during the empennage failure, as shown by the deformation pattern impressed in the right rudder.

In their study of this accident the Board took into consideration reports of similar accidents and incidents involving military aircraft of the same type. Whilst the initial causes of these occurrences were entirely different, the end results were the same. The evidence available from this source supported the view that with extreme elevator deflection applied, the shift to manual control cannot be accomplished if it is resisted by large control forces. In addition, these investigations provided proof that accelerated stalls can produce structural failure in the empennage of this type of aircraft.

It was concluded that the probable cause of the accident was the loss of an AN-175-21 nickel steel bolt from the parallelogram linkage of the elevator system, resulting in loss of control of the aircraft.

The reason why the bolt came out could not be established. A mechanic testified that he installed the linkage at the last base overhaul some ten months prior to the accident. He was sure, at first, that all bolts were properly installed, torqued and safetied, but subsequently added "I do not remember specifically working on plane 555".*

Commenting upon the manner in which the bolt was lost, the Board considered the possibility of the nut having been left off at overhaul, but believed that this explanation was improbable in view of the elapsed time between the overhaul and the accident. The possibility of the shear nut being over-tightened, thereby stripping the threads, was also considered unlikely as the tension loads on the bolt are such that even a stripped nut would remain in place if a split pin had been installed. It was thought that the most probable explanation was that the split pin was omitted at the time the parallelogram was installed and that during the intervening months the nut backed off and allowed the bolt to come out. It was concluded that the immediate valve porting, the rapid onset of hydraulic pressure to the boost actuator, and the resulting maximum hinge moment on the elevator associated with the loss of the bolt proves that the bolt could not have been lost prior to the aircraft climbing out of Midway Airport on the last flight.

As a result of this accident the Board recommended that the shift-to-manual operation be modified so that whilst the lever action remained one continuous motion the sequence of the operation would firstly open the by-pass valve, then close the hydraulic shut-off valve and finally shift the mechanical linkage. With such an arrangement all hydraulic pressure in the boost package would be relieved prior to the mechanical shift action and would thus allow the complete shift-to-manual without restriction regardless of pilot-applied control forces.

* The operator's identification of the aircraft involved.

COMMENT:

The circumstances of this accident serve to illustrate again the drastic consequences that can arise from a maintenance error.

BEACON INTERFERENCE

The automatic direction finding radio compass equipment, together with its associated non-directional beacons and locators, is one of the most important radio navigational aids in our airways system. The functional reliability of the compass equipment and its ability to take accurate bearings depends mainly upon the precision with which it is tuned. Incident reports which advise of interference between beacons and the reception of inaccurate identification signals indicate that mis-tuning does occasionally occur and clearly show the dangerous situations that could arise in critical cases. One recent report drew attention to a case where an aircraft entered the area in which other aircraft could have been holding before the pilot became aware that his aircraft had passed over a locator, due to the fact that the compass was sensing an N.D.B., separated by only four kilocycles in frequency, some 80 miles ahead.

In our September, 1960 issue of the Aviation Safety Digest we drew attention to the need for understanding the limitations of the low/medium frequency direction finding equipment. The article dealt with the various outside influences that can affect the equipment and result in unreliable bearings or apparent malfunctioning. It also dealt with the problems of interference between co-channel and adjacent channel stations and stressed the importance of ensuring that the beacon employed is within a usable range. Reports received subsequent to the publication of this article indicate that adjacent channel interference is the most common source of difficulty with the radio compass equipment.

Only a limited band of frequencies, 200 to 400 kilocycles, is available to Australia for aeronautical radionavigation purposes under the International Radio Regulations within the range of frequencies where the propagation characteristics of the signals are best suited for radio direction finding. The frequencies below 200 kilocycles are reserved primarily for the use of maritime and fixed radio services, whilst above 400 kilocycles they are allotted to maritime radionavigation and mobile services. This leaves only 200 kilocycles in which to allocate the numerous non-directional beacons and locators necessary in the airways network, consequently a frequency separation of only four kilocycles between beacons is inescapable. Even this does not provide sufficient beacons to meet the operational demands.

The Department has, over the years, reduced the N.D.B. frequency separation from five to four kilocycles and changed the operating frequencies of individual beacons to provide the best possible geographical and frequency separation allocation, but this process has now reached the stage where a change in the allocation to one beacon sets up a chain reaction that produces interference at one or more locations. This saturation of the frequency band together with the geographical distribution of N.D.B.'s, particularly in south-eastern Australia, is such that there must inevitably be beacons within mutual interference distance which are separated by only four kilocycles in frequency.

This same situation exists in other parts of the world and the authorities concerned have examined various methods in their attempts to overcome the problems associated with mutual interference and tuning. It may well be that the frequency separation will have to be reduced still further, to three kilocycles. Although it would appear that this would aggravate the trouble, it is believed that it would enable the geographical separation between individual stations to be increased as a result of the greater number of stations available. Increasing the geographical separation would, in turn, lessen the possibility of interference under normal propagation conditions.

The importance of precise tuning and full identification of the beacon to which the equipment is tuned cannot be over emphasised, as experience has shown that where interference has been reported it is often due to mis-tuning of the airborne equipment. The transmission frequency of the ground beacons is crystal controlled. The crystals are inherently stable and are capable of ensuring that the transmitted signal remains within .01% of the desired frequency. This, coupled with close monitoring of the facility, means that the possibility of interference arising from beacon frequency wandering is virtually eliminated.

On the other hand, the radio compass equipment installed in many of the older types of aircraft still operating in Australia is inherently broad in its tuning characteristics. This characteristic can result in the incoming signal being received over a relatively wide range and the equipment appearing to be functioning correctly even though it may not be precisely tuned to the wanted station. It is also possible, however, for the signal of another station on an adjacent frequency, to be received simultaneously and, due to variations in wave propagation, for the signal of the unwanted station to affect the bearing obtained from, or the identification of, the wanted station. Under these conditions the compass selects the stronger of the two signal strengths being received at a given moment. The tuning procedure laid down for each type of equipment is designed to ensure that the wanted station is tuned as nearly as possible to the centre of the tuning curve. If this result is achieved there is little possibility of the signal strength of a station on an adjacent frequency significantly affecting the performance of the equipment.

Occasional interference between stations that are transmitting on the same frequency is inevitable unless care is taken to select the nearest beacon appropriate to the route being flown. The geographical separation of beacons operating on the same frequency is related to the optimum usable range of each beacon. This range may vary considerably due to propagation conditions and the effect of such conditions is most noticeable when pilots are attempting to utilize an N.D.B. at or near the limit of its usable range. Interference from this source frequently occurs when an attempt is made to home on a distant beacon ahead of the aircraft rather than back track on a nearer beacon that has been overflown. It is essential that pilots make use of back tracking procedures to benefit from the higher signal strength of the nearer beacon. It is important also to bear in mind that the lateral separation between adjacent air routes is based on the assumption that track guidance will at all times be obtained from the nearest beacon.

We acknowledge that odd cases of interference will occur between N.D.B.'s, due to propagation conditions, despite strict adherence to correct tuning and operating procedures. Where these cases do occur, pilots will greatly assist those responsible for the planning and establishing of the beacons if they will include in their incident report accurate information relative to aircraft height and position, also the time of day when the interference was experienced.

Throw It Away!

Investigation of a case of malfunctioning of the undercarriage on a Piper PA23, Apache, showed that a restriction existed in the pressure side of the hydraulic system due to a collapsed filter element.

The main hydraulic system filter on this particular type of aircraft has a paper element which had been cleaned and refitted during the previous filter service. These paper filter elements **are not** designed for cleaning — they are a "throw-away" item and should be discarded and replaced with a new element at regular intervals.

Aircraft and engine manufacturers are now using paper type elements in numerous filtering applications in engine and aircraft systems. The standard maintenance practice to be adopted wherever these paper filter cartridges are used should be to discard and replace with new cartridges at the recommended periods regardless of their apparent condition.

FUEL TANK SAFETY

Following is a report from the National Safety Council.

"Inasmuch as a tank explosion could be caused by an ignition source within a tank in any aircraft, this suggestion has been made by one aircraft manufacturer: "As a rule of thumb it is suggested that fuel in the amount of at least 2% of the total tank capacity be added to a tank if it has been empty or nearly empty during the preceding two or three flights".

"In other words, keep freshening the fuel in any tank even though the quantity of fuel added amounts to only 2% of the tank capacity. This fuel can be used any time during the next two or three flights, or may be retained. In either case, it is best to add fuel at intervals to achieve the desired result. If this procedure is followed and the fuel tank filler caps are properly installed, the chance of obtaining an explosive mixture in a tank will be minimised.

"This suggestion is based on the fact that a tank will not explode, whatever the source of ignition may be, if the fuel vapors in the tank are too rich. If only residual gasoline is carried for several flights, the "weathering" effect will progressively lean the mixture and it eventually will reach the combustible range".

(Extract from Business Pilots Safety Bulletin)