Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Aero Commander 680 G-ASHI
Report on the accident at approximately ¼ mile south of Rochester City Airport, Kent, on 19 February 1975.

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4/76	Handley Page Dart Herald 203 G-BBXJ at Jersey Airport, Channel Islands, December 1974	*(forthcoming)*

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Department of Trade
Accidents Investigation Branch
Shell Mex House
Strand
London WC2R 0DP

12 March 1976

The Rt Honourable Peter Shore MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr G C Wilkinson, an Inspector of Accidents, on the circumstances of the accident to Aero Commander 680 G-ASHI which occurred at approximately ¼ mile south of Rochester City Airport, on 19 February 1975.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 5/76
(EW/C512)

Aircraft:	Aero Commander 680 G-ASHI
Engines:	Two Lycoming GSO-480-B1A-6
Registered Owner:	Elliott Brothers (London) Ltd
Operator:	Marconi-Elliott Avionics Systems Ltd
Crew:	One pilot – Slightly injured
Passengers:	Three – Two slightly injured One seriously injured
Place of Accident:	Adjacent to the M2 Motorway, approximately ¼ mile south of Rochester City Airport, Kent. 51° 20′39″ N 00° 30′13″E
Date and Time:	19 February 1975 at 0932 hrs All times in this report are GMT

Summary

Shortly after take-off from Rochester the left engine suffered an almost complete loss of power and its propeller was feathered. During an attempt to return to the aerodrome a loss of power occurred on the right engine and the aircraft made a forced-landing on the verge of the M2 motorway. The pilot and the three passengers were injured, and the aircraft was damaged beyond economic repair.

It is concluded that the accident was caused by kerosene being placed in a petrol supply at Rochester City Airport from which the aircraft was subsequently refuelled. The loss of power on both engines resulted from damage caused by their being run on contaminated fuel.

1. Investigation

1.1 History of the flight

The aircraft was making a business/executive flight carrying three passengers from Rochester City Airport, Kent to Woodford Aerodrome, Cheshire. Because of poor weather at Woodford the pilot delayed the flight departure for approximately 80 minutes. During this time he carried out two pre-flight inspections of the aircraft neither of which included fuel contamination checks.

Shortly after 0915 hrs the pilot and the passengers boarded the aircraft. One of the passengers occupied the co-pilot's seat while his colleagues occupied the two foremost passenger seats in the cabin. Prior to starting, the pilot selected fuel supplies to both engines from the centre tank. The engines were started and allowed to warm up for 4 to 5 minutes before the aircraft was taxied from the hangar apron along a hard surface towards grass Runway 03, the runway in use, at about 0925 hrs. While taxying, the pilot found the right engine slow to respond to small movements of the throttle and two of the passengers heard it 'coughing and spluttering' to some degree. The pilot stopped the aircraft short of Runway 03 threshold then noticed heavier than normal emissions of smoke from both engine exhausts. Because of the smoke emissions, the previous behaviour of the right engine and the ambient conditions he formed the opinion that both engines were affected by carburettor icing. He applied full carburettor heat to the engines for a period of 30 to 60 seconds. This reduced the smoke emissions to normal and the engines ran normally when the carburettor air supplies were selected to cold. No engine malfunctions were observed during the subsequent power checks which were carried out with approximately ¼ carburettor heat selected.

The aircraft was then lined up on Runway 03 where a partial application of engine power was made and approximately ⅔ carburettor heat was selected on both engines prior to take-off. To the best of the pilot's recollection the carburettor air inlet temperatures rose to between +10° C and +25° C as take-off power was applied to the engines. The take-off at about 0930 hrs which appeared normal to the pilot and the passengers, was made with ¼ flap extended and with the correct power indications on the engine instruments.

When airborne the undercarriage and the flaps were retracted, the speed was increased to 120 knots and the aircraft climbed to an altitude of about 800 feet above mean sea level (amsl) before climb power was selected on the engines. At an altitude of about 900 feet amsl the pilot became aware of a gradual power loss from the left engine and observed a decrease in the rate of climb. The aircraft was levelled off below cloud, a shallow turn to the left from the take-off heading was initiated to join the downwind leg of the airport circuit and full carburettor heat was selected on both engines. The pilot could not recall the subsequent readings on the carburettor air temperature gauge. At about this time a witness located some ½ mile north of Rochester City Airport saw three puffs of smoke appear at short intervals to the rear of the aircraft, each puff of smoke associated with the sound of an engine misfire.

During the turn to the left the pilot noted that the left tachometer indicated a loss of 300–400 engine rpm and that the airspeed had decreased to 110 knots. He advised Rochester on the RTF of a loss of engine power but did not reply when offered the choice of Runway 03 or 34 for landing. As the left engine continued to lose power, the left propeller was feathered after the application of take-off power to the right engine. The aircraft subsequently passed over the M2 motorway at an altitude of about 800 feet amsl, at an airspeed of 100 knots turning to the left on to a southerly heading. The flight was continued with a minimal loss of height until the aircraft reached a position some 800 yards west of the centre of the airport. Shortly afterwards it was seen by the person operating the RTF at Rochester at a low altitude west of the airport descending slowly on a south south easterly heading. Although there were no indications of a loss of power on

the instruments of the right engine, the pilot found he was unable to prevent the aircraft descending even after reducing the airspeed to 90 knots. The rate of descent increased and he informed Rochester on RTF that he would force-land on the M2 motorway. When informed by the pilot of the imminent forced-landing the RTF operator at Rochester sounded the airport crash alarm and attempted to dispatch the airport crash tender to the motorway but was told by the crew of that vehicle that it was not licensed for use on public roads, whereupon he immediately alerted the outside emergency services by telephone.

Because of motorway traffic the pilot elected to land on a strip of land on the verge of the southbound carriageway. The approach to the selected area was made at 85 knots indicated airspeed (IAS) with flaps and landing gear retracted and with the throttle of the right engine fully open. The aircraft crossed the motorway at a low height and was manoeuvred to avoid a vehicle before a positive 'tail down' landing was made.

After ground impact the aircraft slid up the verge at the side of the motorway, broke a considerable number of small saplings and slewed to the left as the left wing collided with a wooden fence, then came to rest. The pilot turned off the battery master switch and instructed his passengers to evacuate the aircraft. As he did so he saw that a small fire had broken out near the left wing tip. Unsuccessful attempts to leave the aircraft were still being made by the occupants when rescuers arrived on the scene. One of the rescuers extinguished the fire while the remainder broke in the window by the co-pilot seat, aided from inside the aircraft by the passenger in that seat, and assisted the occupants to safety. The pilot was the last person to leave the cabin. Shortly afterwards the pilot of a light aircraft who had taken-off from Rochester at the request of the RTF operator at the airport located the crashed aircraft, relayed its position to Rochester, advised that no signs of fire were apparent from the air, and that he could see at least three of the occupants including the pilot outside the wreckage.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	–	–	–
Non-fatal	1	3	–
None	–	–	

1.3 Damage to aircraft

The aircraft was damaged beyond economic repair.

1.4 Other damage

A 90 foot section of a wooden fence which bounded the motorway verge was knocked down, and about 30 saplings on the verge were broken.

1.5 Crew information

Pilot:	Male, aged 43
Licence:	Airline Transport Pilot's Licence valid to 16 May 1977.
Aircraft rating:	P1 (in command) – Aero Commander 680, Beechcraft 95, HS 104, HS 114 and PA 23.

Instrument rating:	Valid until 10 July 1975.
RTF Licence:	Restricted VHF only.
Last medical examination:	3 February 1975, valid until 31 August 1975. No restrictions.
Total pilot hours:	8,237.
Flying hours in command on type:	509 hours 45 minutes.
Total flying hours in last 28 days prior to the day of the accident:	29 hours 30 minutes
Flying hours on type in last 28 days prior to the date of the accident:	21 hours 50 minutes.
Rest period:	14 hours 30 minutes prior to reporting for duty on 19 February 1975.

The Certificate of Test for the Aero Commander 680 contained in the pilot's licence was valid at the time of the accident.

1.6 Aircraft information

1.6.1 *Construction*

The Aero Commander 680 is a twin engined, seven seat, high wing all metal monoplane. Provision is made for seating two pilots located side by side. Dual rudder pedals and controls are fitted. Two passenger seats are located side by side and forward of a three place bench seat fitted at the rear of the cabin. The cabin roof is formed in part by the wing centre section undersurface which extends forward to a position above the backs of the forward passenger seats. A cabin entrance door is located underwing in the left side of the fuselage and an emergency exit window is located underwing in the fuselage opposite the cabin entrance door. Each Lycoming GSO-480-B1A-6 six cylinder supercharged engine drives a three-bladed constant speed fully feathering propeller. Only a limited movement of the throttle control levers is required to achieve take-off power.

The propellers use centrifugal force from the blade counterweights and the action of the heavy internal feathering spring to increase (coarsen) pitch. Engine oil under governor-boosted pressure is directed through internal passages against a hydraulic cylinder on the forward end of the propeller hub to decrease pitch. Under static engine conditions the internal feathering spring moves the propeller blades to the coarse pitch position. An automatic centrifugal coarse pitch stop prevents the propeller feathering after engine shut down on the ground. At 900 engine rpm or more the coarse pitch stop is withdrawn under centrifugal force. Feathering can then be accomplished by moving the propeller control lever back past a detent to the limit of its travel.

Provision is made for a supply of heated air to the carburettors when icing is suspected. Two control levers capable of infinitely variable adjustment are located to the right of the engine control pedestal below the instrument panel. Progressive movement aft of each control allows an increasing amount of heated air to be drawn from the muff surrounding the exhaust system into the respective carburettor.

Carburettor air inlet temperatures are indicated on the dual gauge located on the starboard instrument panel. The 'caution range' of operating temperatures from +55° C to +74° C are indicated by yellow segments on the gauge and the 'never exceed' temperatures of +74° C are shown by a red line. Item 17 of the 'before starting engines' procedures contained in the aircraft flight manual reads as follows: 'Carburettor heat controls – Forward'. No other information on the use of carburettor heat for take-off is contained in the manual. However the aircraft maintenance manual states that the carburettor heat controls must be fully forward (cold air) at take-off and landing and advises caution when operating at temperatures within the yellow segment range due to the possibility of detonation.

The aircraft fuel system located in the wing is comprised of three tanks providing a total capacity of 186 imperial gallons. The centre tank consists of five inter-connected cells with a combined capacity of 130 imperial gallons. Each outboard tank consists of two interconnected cells which jointly provide storage for 28 imperial gallons of fuel.

Vent lines from the centre tank pass through their adjacent outboard tank and are then connected to the vent line from that tank; the common line then extends outboard to a vent in the undersurface of each wing leading edge. Fuel supplies for the engines can be drawn from the centre tank or from their respective outboard tanks. The aircraft flight manual specifies the minimum grade of fuel to be used as 100/130 Octane.

1.6.2 *General information and maintenance*

G-ASHI was constructed in the United States of America in 1958 and was exported to Switzerland. It was subsequently placed on the United Kingdom register on 23 April 1963. The aircraft had a valid Certificate of Airworthiness in the Private Category and had been maintained in accordance with the requirements of the Maintenance Manual. Following renewal of the Certificate of Airworthiness on 13 February 1975 it had flown a further 7 hours making a total flying time of 3,615 hours. Out of an authorised life of 1,400 hours the left and right engines had run 1,165 hours and 1,178 hours respectively since complete overhaul.

On the evening of 18 February 1975 the centre fuel tank of the aircraft which already contained about 70 imperial gallons of aviation petrol (Avgas 100L) was filled to capacity by engineering employees of the Rochester Airport Licensee, with the product from the mobile fueller.

Prior to the accident flight the pilot signed a customer advice note which showed that 60 imperial gallons of Avgas 100L had been uplifted into this tank. A tacit agreement existed between the operator and airport employees whereby the latter would check the fuel in the aircraft tanks for water and other contamination prior to the first flight of each day. Such checks were not carried out prior to the accident flight because of the delayed departure, a shortage of staff and pressure of other work.

At departure from Rochester the aircraft tanks contained a total of 150 imperial gallons of fuel. The centre of gravity of the aircraft was within the prescribed 20 per cent MAC (forward) and 33 per cent MAC (aft) limits at take-off.

Calculations using the known weights of the pilot, the passengers and of their personal equipment and allowing 3.5 imperial gallons of fuel for taxying and power checks showed that the aircraft weight at take-off was 135 lb in excess of the maximum certificated take-off weight. Of this weight 26 lb was attributable to the higher specific gravity of the mixture of fuel in the centre tank.

1.7 Meteorological information

There is no meteorological reporting station at Rochester Airport. The pilot assessed the weather conditions prior to take-off as follows:

Weather:	Cloudy with haze.
Surface wind:	North-easterly 10 to 12 knots.
Visibility:	13 kilometres.
Cloud:	5/8 stratus base 600 feet above aerodrome level (aal) with sky visible through the thin cloud.
Surface temperature:	+3° C.

The grass surface of the aerodrome was wet.

An aftercast of the weather within a 3nm radius of Rochester Airport for the period 0900 hrs to 1000 hrs prepared by the Meteorological Office at Bracknell was as follows:

Weather:	Hazy with patches of hill fog.
Surface wind:	North-easterly 6 to 10 knots.
Visibility:	Variable, mainly 5 to 10 kilometres, better to the north but 100 metres in hill fog.
Cloud:	Variable patches of stratus base 400 to 500 feet amsl with tops 1,000 to 1,500 feet mainly on the north-east slope of the Downs (South of Rochester Airport).
Surface temperature:	+4° C to +5° C.
Humidity:	Probably in excess of 90 per cent.

Carburettor icing may have been encountered.

The accident occurred in daylight. The weather was not considered a factor in this accident.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Rochester City Airport was equipped with air to ground VHF radio operating on a frequency of 123.2 MHz. There were no facilities to record RTF communications at the aerodrome.

Satisfactory RTF communications were maintained with the aircraft until shortly before the accident. The last message received from the pilot by Rochester was of his decision to force-land the aircraft on the M2 motorway.

1.10 Aerodrome and ground facilities

1.10.1 *Aerodrome*

Rochester City Airport which has an elevation of 436 feet amsl is licensed as an aerodrome by the Civil Aviation Authority. The surface of the aerodrome is grass covered with two grass runways 03/21 and 34/16. A hard surfaced road leads from the apron outside the maintenance hangar located on the south side of the aerodrome and terminates some 120 yards from the threshold of Runway 03. On the morning of the accident flight the aerodrome surface was wet with some ruts containing isolated small pools of standing water. Licensed Air Traffic Control Personnel are not available at the aerodrome and are not required to be so.

1.10.2 *Ground facilities*

1.10.2.1 The Civil Aviation Authority requires an aerodrome licensee to provide, as prescribed in Civil Aviation Publication 168, satisfactory rescue and fire fighting equipment carried on one or more vehicles capable of reaching any area within the aerodrome boundaries. An appropriate vehicle suitably equipped was available at Rochester City Airport.

1.10.2.2 Fuel storage installation

The fuel storage installation comprised three tanks buried side by side. One of the tanks had been out of use for some years and was kept full of water. The remaining two tanks were used to store aviation petrol and since August 1973 had contained stocks of Avgas 100L only. The larger of the two tanks in use had a capacity of 4,000 imperial gallons and was known as 'No. 1' tank by personnel employed at the aerodrome although the manhole cover above the pit containing its dip and fill pipes was not numbered. The number 2 in red was just discernible on the manhole cover of the second tank. A metal notice was attached to the dip and fill pipes of 'No. 1' tank but the information thereon was unreadable because of dirt and corrosion.

Two Electric Metering Column (EMC) fuelling pumps were located at the end of the storage installation adjacent to 'No. 1' tank, each with its individual overhead delivery swing pipe and flexible hose extending above a small refuelling apron on the opposite side of the pumps to the storage tanks.

The refuelling apron was bounded at the rear by a high wire mesh fence. The products from the two storage tanks in use were dispensed separately by their respective EMC fuelling pumps. The 'No. 1' tank EMC pump was labelled '100/130 grade' and a metal tag labelled '100/130' was attached to its flexible hose. The 'No. 2' tank EMC pump was labelled '80 OCTANE' and a metal tag similarly designated was affixed to its flexible hose.

Four warning notices were displayed at the installation, one mounted on a wall at the rear of the storage tanks, and the remainder attached to the high wire mesh fence. None of the notices contained the words 'Petroleum Spirit, Highly Inflammable'. The Petroleum-Spirit Licence was issued in the name of the Aerodrome Licensee.

1.10.3 *Ordering of aviation petrol*

On 7 February 1975 a written order for '1,500 gallons of 100L Oct' was placed with a fuel company on behalf of the licensee at Rochester Airport. Because of a clerical error which occurred when the order was processed by the supplier 1,500 imperial gallons of JET A-1 (aviation kerosene) was incorrectly consigned to Rochester on 18 February 1975.

1.10.3.1 Delivery vehicle and driver

A fuel company sub-contractor's tank wagon and driver were used to deliver the fuel which was part of an overall consignment of JET A-1 carried in the vehicle and contained in two of its five integral tanks. A metal grade label approximately 2 inches by 2 inches in size with the letters AV Tur was located in a bracket above each of the integral tank outlet pipes on the near side of the vehicle below the guard rail. Unless their position was known the labels were not readily visible. No other notices indicating the grade of fuel were attached to the vehicle.

The driver was experienced in the handling and delivery of aviation fuels, but had not previously delivered to Rochester Airport. On arrival at the fuel storage installation he did not notice the grade labels on the EMC pumps or the contents of the warning notices displayed in the vicinity, apart from the words 'NO SMOKING' contained in the notice on the wall.

1.10.3.2 Delivery and acceptance of the fuel into storage

The delivery driver was met on arrival at Rochester by an airport employee to whom he passed a fuel 'RELEASE NOTE' which showed that 1,500 imperial gallons of JET A-1 were being delivered. The driver told the employee the quantity of fuel being delivered but did not specify and was not asked what grade of fuel was contained in the tank-wagon. The JET A-1 fuel was discharged into 'No. 1' tank which already contained 600 imperial gallons of Avgas 100L. The airport employee subsequently signed the 'RELEASE NOTE' then placed it on the storekeeper's desk in the maintenance hangar.

The airport employee stated that he had not looked at the grade of fuel entered on the 'RELEASE NOTE' as only stocks of Avgas 100L were held at the airport, also that although he had accepted delivery of aviation petrol into the storage tanks on previous occasions he had received no instruction on the procedure to be followed when doing so. As deliveries were usually made in the mornings he had on past occasions been given a form by the storekeeper to hand to the delivery driver but had never signed the form and was unaware of its wording. He did not notice the grade labels located above the tank outlet pipes on the near side of the delivery vehicle.

The storekeeper at Rochester Airport was employed on a part-time basis and was only available in the forenoon. Prior to leaving the airport about midday on 18 February 1975 he partially completed two copies of the 'Form of Certificate' (see Appendix) and left them on his desk to await collection by the delivery driver as he was aware that Avgas 100L was being delivered that day. After reporting for work on the following morning he saw the still incomplete copies of the 'Form of Certificate' and the 'RELEASE NOTE' on his desk. The presence of both copies did not raise any query in his mind about the grade of aviation fuel delivered nor was it evident to him when he looked at the 'RELEASE NOTE' that the incorrect grade had been supplied.

1.10.4 *Refuelling of aircraft*

Aircraft were refuelled at Rochester from a mobile fueller of 250 imperial gallons capacity marked Avgas 100L. The contents of the mobile fueller were delivered into aircraft tanks by the operation of a hand wobble pump through a filter, a sight gauge with rotating vane and a flexible hose and nozzle. When necessary the mobile fueller was replenished from the storage tanks at Rochester via the EMC pumps. After the JET A-1 had been discharged into 'No. 1' tank in error 200 imperial gallons of the mixed product from this tank were transferred to the mobile fueller later in the day of 18 February 1975. The residual Avgas 100L content of the mobile fueller was not determined. Subsequently the centre tank of G-ASHI was refuelled from the mobile fueller. The refuelling was carried out within the hangar in conditions of poor artificial lighting and at a low ambient temperature. The colour of the fuel in the mobile fueller

sight gauge appeared to be the same colour as Avgas 100L to personnel engaged on the refuelling who did not detect by smell the presence of JET A-1. Four light aircraft based at Rochester were also supplied with the contaminated fuel, two on 18 February 1975 and the remaining two on 20 February 1975, the day after the accident flight. None of the light aircraft supplied were flown until 20 February 1975 when one reported a partial loss of engine power while airborne but subsequently landed successfully. The engine of a second stopped while the aircraft was being taxied. It was restarted after several attempts but failed to produce take-off engine rpm on two attempted take-offs. Because the engine of a third light aircraft could not be started engineering personnel at the airport checked the fuel supplied to the engine and discovered the contamination. All the light aircraft involved were grounded pending cleaning of the engines and the fuel systems.

1.11 Flight recorder

Not required and not fitted.

1.12 Wreckage

Examination of the accident site revealed that the aircraft had struck the ground in an approximately level attitude on a heading of 175°M at a low forward speed with a low rate of descent and in a clean configuration at a point where the surfaces of the verge and carriageway were almost level with each other. It then slid over uneven ground at a diverging angle to the motorway, up a 1 in 11 gradient and broke a considerable number of saplings before the left wing collided with a wooden fence. This impact slewed the aircraft to the left through 155°. It came to rest tail first, on its belly, in a left wing down attitude but substantially structurally intact and 135 feet from the point of touchdown. During the ground slide the aircraft broke its back in line with the wing leading edge and the wing-centre section was displaced downwards. Because of the resultant damage to the cabin structure, the cabin door and emergency exit window were badly distorted and jammed so that they could not be opened after the accident. Pressure from the undersurface of the wing centre-section which forms the rear roof of the cabin had collapsed the backs of the two individual passenger seats and generally distorted their structure. The back of the three seat bench at the rear of the cabin had also collapsed under pressure from the same source.

Both wing leading edges were extensively damaged outboard of the engine nacelles by impact with saplings and the wooden fence. There was evidence that a small fire had occurred just inboard of the left wing tip where the leading edge had been stove in by contact with the fence. The common vent pipe connected to the vent in the undersurface of the outer wing had ruptured which led to ignition of the fuel it contained at the time. After the aircraft came to rest, fuel, most probably from the centre tank, started draining into the ruptured vent pipe. Subsequently the vent pipe was plugged, but as a result fuel from the centre tank transferred via the vent system into the left outer tank contaminating its contents.

There were no signs of any pre-accident damage to the aircraft or its flying controls.

The bottom sparking plug in number three cylinder of the left engine had blown out, probably in the air, and was found still attached to its lead. The corresponding sparking plug in the right engine had blown out and stripped the cylinder head thread. Both engine carburettor heat controls were found to be selected to the maximum heat position.

Both propellers were found in the high pitch (coarse) position. The condition of the blades of the left propeller was consistent with its being stopped prior to impact and damage to the blades of the right propeller was consistent with rotation under power at impact.

A strip examination of the engines and propellers was made with the following results:

Left Engine

There was evidence of overheating on some of the cylinder barrels. Numbers 1, 2, 4 and 5 pistons had burned through from the crown past the top rings to the inside adjacent to the gudgeon pins and were partially seized in the barrels. The lubrication system was badly contaminated with metal swarf. The number 3 cylinder bottom sparking plug had blown out. The general condition of the engine was consistent with severe detonation and overheating. It is considered that an almost complete loss of power must have occurred before the engine was shut down.

Right Engine

Cracks were found in the heads of Numbers 1, 3 and 4 cylinders. The bottom sparking plug in No. 3 cylinder had blown out and the cylinder head thread had stripped. Number 1, 2, 4 and 6 piston showed evidence of scuffing. Two small pieces had broken from the edge of the number 4 piston crown at diametrically opposite positions and the top ring of number 5 piston had broken. Damage to the engine was less severe than that sustained by the left engine but its general condition was consistent with severe detonation and overheating which would have resulted in a significant loss of power.

Left propeller

The blades of the propeller were found on the high (coarse) pitch stops. The design is such that impact forces on a feathered propeller can force the blades back through the stops towards fine pitch. When these forces are removed the blades can, in the absence of governor oil pressure, be pushed by the feathering spring back onto the high pitch stops. It is considered that this is what happened to this propeller.

Right propeller

The blades of the propeller were found on the high (coarse) pitch stops. It is considered that they were pushed onto the high pitch stops, by the feathering spring after the propeller had stopped rotating.

1.13 Medical and pathological information

The pilot and two of the passengers suffered minor injuries, mainly bruising. The third passenger who occupied the co-pilot seat suffered a spinal injury and bruising to the legs and face. He was detained in hospital for treatment and discharged after 31 days.

1.14 Fire

Shortly after impact a small fire occurred just inboard of the port wing tip where a fuel system vent-pipe had ruptured. It was promptly extinguished with handfuls of damp earth and grass by a passing motorist who stopped his car on the hard shoulder on the northbound lane.

1.15 Survival aspects

The main cabin door was jammed and could not be used for the evacuation; the emergency exit window opposite the door was also jammed. Under the direction of the pilot and assisted by the passenger in the co-pilot's seat passing motorists managed to break the right cockpit window. All four occupants then evacuated the aircraft through

this window. By 0945 hrs, 12 minutes after the accident all rescue services, police, fire, and ambulance services had arrived at the accident site.

The pilot and his three passengers had their seat lap straps fastened during the flight. These restraints remained intact with the exception of the inboard lap strap of the co-pilot's seat. The cable attaching this strap to the structure of the seat suffered a tensile failure. As far as can be ascertained all the occupants with the exception of the pilot jack-knifed on impact, and when the aircraft came to rest one of the two passengers occupying seats in the cabin found himself in a supine position face upwards. It was not possible to determine the degree of injury caused to the passenger occupying the co-pilot's seat by failure of his lap strap. It is probable that the two remaining passengers were in the jack-knifed position and were saved from serious injury when the back of their seats collapsed as a result of pressure from the wing centre section undersurface following its downward displacement at the time the aircraft broke its back. The accident was survivable.

1.16 Tests and research

Fuel samples were taken from the aircraft, 'No. 1' bulk storage tank at Rochester, and the 250 imperial gallon mobile fueller. The samples were analysed with the results tabulated below.

Source of fuel	Colour	Approx % Avgas 100L	Approx % JET A-1	Approx Octane Rating
(a) Aircraft centre tank	Green	70	30	84
(b) Aircraft left outer tank	Green	70	30	87
(c) Aircraft right outer tank	Green	100	–	101
(d) No. 1 bulk storage tank	Pale Green	10	90	Not determined
(e) Mobile fueller	Green	20	80	58

Avgas 100L is the civil designation used for aviation gasoline meeting the Ministry of Defence specification D Eng RD 2485 (Issue 7). As a result of the analysis it was found that all fuel samples with the exception of (c) failed to comply with the specification for distillation and engine rating. The non-compliance was due to the presence of aviation kerosene.

1.17 Other information

1.17.1 *Detonation*

Detonation may occur in spark ignition internal combustion piston engines when a lower grade of fuel than that specified is used. It results from the spontaneous combustion of the air/fuel mixture when the pressure in the combustion chambers rises to a value higher than that which the octane rating of the fuel can tolerate. The detonation can usually be heard as a 'knock' and the accompanying abnormal temperatures and pressures within the combustion chamber can lead to loss of power and mechanical damage. Existing detonation may be accentuated by pre-heating of the air/fuel mixture such as occurs in supercharged engines or by the application of carburettor heat.

1.17.2 *'Petroleum-spirit'*

The following interpretation is contained in the Petroleum (Consolidation) Act 1928, Section 23:

' "Petroleum-Spirit" means such petroleum as when tested in the manner set forth in Part II of the Second Schedule to this Act gives off an inflammable vapour at a temperature of less than seventy three degrees fahrenheit (+73° F).'

When so tested Avgas 100L gives off an inflammable vapour at a temperature of −40° F approximately whereas Aviation Kerosene does so at a temperature of not less than +100° F.

1.17.3 The Petroleum-Spirit (Conveyance by Road) Regulations, 1957 Regulation 16 contains the provisions relating to the transfer of petroleum-spirit from a carrying tank into a storage tank and reads in part as follows:

'16. (5) Before delivery of petroleum-spirit into a storage tank is begun, the licensee shall secure that some competent person who is not the driver of, or any other person employed to be in attendance on, the vehicle from which the delivery is to be made, is in charge of the storage tank for the purpose of the delivery.

16. (7) Before delivery into any storage tank is begun the person in charge thereof shall on each of two copies of a certificate in the form specified in the Second Schedule to these Regulations in the first column opposite thereto enter the quantity and grade of petroleum-spirit which is to be delivered into that tank, and the person attending the vehicle from which the delivery of petroleum-spirit into the tank is to be made shall not begin delivery until the person appearing to him to be in charge of that tank has in his presence signed his name on each of the said two copies in the third column opposite to the number of that tank in the first column.

16. (10) The person in charge of a storage tank for the purposes of a delivery of petroleum-spirit into that tank shall give a copy of the certificate on which entries have been made in accordance with paragraph (7) of this Regulation in connection with that delivery to the person attending the vehicle from which the delivery is made and that copy shall be kept by the employer of the last-mentioned person for a period of not less than six months after the delivery, and the other copy of the said certificate shall be kept by the licensee for the like period.'

A copy of the Certificate referred to in Regulation 16 (7) and 16 (10) is shown in the Appendix to this report.

1.17.4 The licence issued by the Local Authority for the storage of Petroleum-spirit in bulk at Rochester City Airport was granted subject to conditions which specified in part that:

'22. The following warning notice shall be marked conspicuously with 2 in plain block red letters on a white background or white letters on a red background and displayed in a prominent position in the vicinity of the pumps (and the tanks when they are in a position removed from the pumps):

"PETROLEUM SPIRIT
HIGHLY INFLAMMABLE
NO SMOKING
SWITCH OFF ENGINE"

and petroleum spirit shall not be delivered into the fuel tank of any motor vehicle while the engine of such vehicle is running.

26. The licensee shall bring to the notice of all concerned the provisions of No. 16 of the Petroleum Spirit (Conveyance by Road) Regulations, 1957

(S.I. 1957 No. 191) which relates to the precautions which have to be observed in delivering petroleum spirit from a tank wagon or tank trailer into a storage tank.'

1.17.5 There is no specific legislation related to aviation fuel storage at aerodromes to ensure quality control of such fuel.

1.17.6 On delivery of the aviation kerosene to Rochester Airport a 'RELEASE NOTE' was passed to the customer by the tank-wagon driver. The form was pre-printed with provision made for indicating delivery of one or more of seven aviation products – three fuels and four oils. It contained, *inter alia,* a number of boxed divisions. The consignors brand names of the seven products were printed in columnar form in one of the divisions and the grade of fuel was printed next to its brand name on the appropriate line in the adjoining column. Additional columns used to indicate the method of packing and quantity of products supplied were completed prior to delivery. The 'RELEASE NOTE' passed to the customer at Rochester contained written entries which showed that 1,500 imperial gallons of JET A-1 were being delivered in bulk.

2. Analysis and Conclusions

2.1 Analysis

The accident resulted from a forced landing made when the right engine suffered a considerable loss of power about one minute after the left engine had been shut down and its propeller feathered because of an almost complete power loss. Evidence from the pilot indicated that apart from the loss of power suffered by the engines, the aircraft, its flying controls and other systems operated satisfactorily during the short flight. The only pre-crash defect found during examination of the wreckage was the severe internal mechanical damage which had occurred in the engines. The damage had resulted from overheating and detonation and was more pronounced in the left engine than the right. Throughout the flight the engines had been running on contaminated fuel the octane value of which was below the minimum specification they required. This analysis is therefore mainly concerned with how the contaminated fuel came to be in the aircraft and its effect upon the engines and their operation.

2.1.1 Of necessity a very high standard of quality control over aviation fuels is exercised by fuel companies at all times. However, on this occasion although the correct grade of fuel was ordered in writing an incorrect grade was supplied. The procedure operated within the supplier's organisation was such that only one person processed a customer's order. In this respect it is considered to be unsatisfactory as no provision was made for detecting and correcting an error that person might make. In this case such an error was the first of a sequence of errors and omissions which led to the accident.

Following a standard procedure a fuel company sub-contractors vehicle and driver were used to deliver the fuel. The vehicle was loaded in accordance with the suppliers written instructions at their own fuel terminal. The driver therefore did not know that he was delivering an incorrect grade of fuel to Rochester, as he had not made any deliveries to that aerodrome previously. However he was experienced in the delivery of aviation fuels and knew that he was not required to collect a copy of the 'Form of Certificate' when delivering aviation kerosene.

The driver saw only one of the warning notices displayed in the vicinity of the bulk fuel storage installation and observed that it read in part 'NO SMOKING'. It is a matter for conjecture whether he would have been alerted to the error in the fuel delivery if this notice had contained the words 'Petroleum Spirit, Highly Inflammable'.

The only indicators on the delivery vehicle showing it contained aviation kerosene were grade labels located in the vicinity of the outlet delivery pipes. Their location was such that they were not readily visible unless positively looked for and on this occasion were not seen by the person accepting the fuel delivery. If additional grade labels had been prominently displayed on the body of the vehicle it is possible that their presence might have alerted the person accepting delivery to the fact that an incorrect grade of fuel was being supplied before it was discharged into the 'No. 1' tank.

The procedure for accepting aviation fuel into bulk storage at Rochester is considered to have been unsatisfactory. As one grade of fuel only is used at the aerodrome the possibility that an incorrect grade might be supplied does not appear to have occurred to the relevant personnel employed there and suggests an inordinate reliance on the infallibility of the supplier. The Petroleum-Spirit (Conveyance by Road) Regulations 1957 require in part that a competent person be secured by the licence holder to accept Petroleum-Spirit (which by definition includes Avgas 100L) into storage tanks and that such a person complies with Regulation 16 (7) and 16 (10) in regard to the 'Form of Certificate'. There is considerable doubt about the competence of the person to accept delivery of fuel who was employed to do so on this occasion. Although he had previously accepted deliveries of fuel at Rochester he had received no instructions on the procedure to be followed.

Because of this he was in part unaware of the regulations in regard to the 'Form of Certificate' and therefore did not comply with them. Had he done so it is possible that the delivery driver would have queried the grade of fuel being supplied. Moreover he signed the 'RELEASE NOTE' given to him by the delivery driver without looking at its contents.

On the day following the delivery of the incorrect fuel the 'RELEASE NOTE' was seen by the storekeeper at the aerodrome. He did not notice that it related to JET A-1 and not Avgas 100L. It is possible that the 'RELEASE NOTE' which caters for delivery of seven different aviation products requires too close a scrutiny of its contents to ascertain which product is being supplied, and that this should be made self-evident. The storekeeper took no further action when he found the incomplete copies of the 'Form of Certificate' on his desk after the fuel had been delivered. This lack of action suggests that he was not aware of the importance of the 'Form of Certificate' in relation to the delivery of aviation petrol as opposed to aviation kerosene.

Once Avgas 100L has been contaminated with JET A-1 and depending on the severity of the contamination its presence is not easily detectable whether by colour or smell. After the contamination had occurred at Rochester the mobile fueller was replenished with the mixed-product from 'No. 1' tank but the person who carried out this operation did not look at the colour of the fuel in the vehicle's sight glass. However when the Aero Commander was subsequently refuelled from the mobile fueller the colour of the fuel in its sight glass appeared the same as that of Avgas 100L to hangar staff engaged in the refuelling and no smell of JET A-1 was evident. No samples were taken from the aircraft fuel systems via the drain points prior to the accident flight to check for water or other contamination. However it is unlikely that this particular form of contamination would have been discovered even if this had been done.

2.1.2 Calculations show that the aircraft weight at take-off was 135 lb in excess of the maximum certificated take-off weight. Although the precise effect of the excess weight could not be determined it must have resulted in some degradation of the aircraft performance.

There is little doubt that the untoward engine symptoms observed by the pilot prior to take-off were the result of the engines running on the contaminated fuel although the possibility that carburettor icing had also occurred at the time cannot be entirely dismissed. In retrospect it is considered that the pilot's decision to carry out the take-off with 2/3 carburettor heat selected was ill-advised, especially as he did not note the maximum carburettor air inlet temperatures which were achieved at the time. However his decision to do so is understandable to some degree as he had previously formed the opinion that both engines had been affected by carburettor icing. Moreover the aircraft flight manual does not expressly forbid the use of carburettor heat on take-off.

The mechanical damage to the engines is considered to have been caused by their running on contaminated fuel. Nevertheless it is probable that the use of carburettor heat was to an undetermined extent a contributory factor. In the circumstances its partial use during the take-off and climb may have contributed to detonation and the subsequent application of full carburettor heat to both engines made when the left engine suffered the initial loss of power may well have accentuated existing detonation. The application of full carburettor heat suggests that the pilot still suspected the presence of carburettor icing.

After the left engine had failed the pilot intended to carry out a circuit and landing on the remaining engine. However because of a subsequent loss of power on the right engine he was faced with a forced landing in difficult circumstances on unsuitable terrain which he carried out with a commendable degree of skill. It is probable that the skill which he exercised ensured his own and his passengers' survival.

The occupants experienced difficulty in evacuating the aircraft as both the cabin door and the emergency exit window were jammed in the closed position during the accident.

It is possible that they would have suffered further injury but for the prompt actions of those rescuers who extinguished the fire and assisted their escape from the aircraft.

There is no requirement for aerodrome fire/rescue vehicles to attend accidents outside the aerodrome. When, as in this case, the vehicles are not licensed for use on public roads and an accident occurs close to an aerodrome, drivers of such vehicles are placed in an invidious position as either life may be lost by non-attendance or individuals have to break the law in order to attend.

2.2 Conclusions

(a) Findings

(i) The pilot was properly licensed and experienced to carry out the flight.

(ii) The aircraft had been maintained in accordance with the requirements of the maintenance manual.

(iii) At take-off the aircraft was 135 lb in excess of the maximum certificated take-off weight.

(iv) The pilot selected approximately 2/3 carburettor heat on the engines for take-off as he had previously formed the opinion that they were suffering from carburettor icing.

(v) Shortly after take-off the pilot experienced a gradual but almost complete loss of power on the left engine which he attempted unsuccessfully to rectify by the selection of full carburettor heat on the engine. At the same time he selected full carburettor heat on the right engine.

(vi) During the latter part of an attempt to return to the aerodrome in single engine flight the aircraft would not maintain height and the pilot was compelled to carry out a forced landing on the verge of the M2 motorway.

(vii) The pilot exercised considerable skill in force-landing the aircraft.

(viii) It is possible that the aircraft occupants would have suffered further injury from fire but for the efforts of those rescuers who first arrived at the accident site.

(ix) Analysis of the fuel in the aircraft centre tank from which both engines were supplied throughout the flight showed that it consisted of approximately 70 per cent Avgas 100L and 30 per cent JET A-1 and that it had an octane rating of 84.

(x) Analysis of the fuel in the mobile fueller at Rochester City Airport showed that it consisted of approximately 20 per cent Avgas 100L and 80 per cent JET A-1 and that it had an octane rating of 58.

(xi) Analysis of the fuel in 'No. 1' storage tank at Rochester City Airport showed that it consisted of approximately 10 per cent Avgas 100L and 90 per cent JET A-1. Its octane rating was not determined.

(xii) On the day before the accident the 130 imperial gallon aircraft centre tank had been filled to capacity with 60 imperial gallons of the fuel from the mobile fueller at Rochester City Airport.

(xiii) Prior to the refuelling of the aircraft the mobile fueller had been replenished with 200 imperial gallons of the fuel from 'No. 1' storage tank at Rochester City Airport.

(xiv) Prior to replenishment of the mobile fueller 1,500 imperial gallons of JET A-1 had been discharged in error into the 'No. 1' storage tank which still contained 600 imperial gallons of Avgas 100L.

(xv) The despatch of the incorrect grade of fuel to Rochester occurred because of a clerical error within the fuel company organisation.

(xvi) The Petroleum Spirit Licensee at Rochester City Airport did not provide an adequate organisation to supervise the acceptance of fuel deliveries.

(xvii) The fuel contamination was not discovered until after the accident.

(xviii) The engines were substantially damaged by overheating and detonation during the short period of operation as a result of their being run on unsuitable fuel. It is possible that the damage was accelerated or accentuated by the use of carburettor heat.

(xix) The Rochester City Airport emergency service vehicle was not licensed for use on public roads and could not legally attend at the accident site.

(b) Cause

The accident was caused by kerosene being placed in a petrol supply at Rochester City Airport. The aircraft, which had been refuelled with the mixed product from the supply, suffered a loss of engine power after take-off. This led to a forced-landing in difficult circumstances on unsuitable terrain. The loss of engine power resulted from damage to the engines due to their being run on contaminated fuel.

3. Recommendations

It is recommended that:

(1) Mandatory procedures should be introduced governing the handling, storage and quality control of aviation fuels at aerodromes.

(2) When aviation fuel deliveries are made to aerodromes the grade of product being supplied should be self-evident from the associated documentation.

(3) Aviation fuel bulk storage tanks at aerodromes should be clearly marked with the grade of fuel they contain.

(4) When emergency service vehicles are required to be provided at an aerodrome, the vehicles and drivers should be appropriately licensed so that the vehicles can be used outside the aerodrome boundary.

(5) Where appropriate, aircraft flight manuals should contain specific information as to the application of carburettor heat on take-off.

(6) Consideration be given to the provision of selective couplings to ensure that incorrect grades of aviation fuel cannot be discharged into bulk storage tanks at aerodromes.

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