Piper PA-34-220T, G-NJML, 6 March 1997

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Aircraft Type and Registration:	Piper PA-34-220T, G-NJML
No & Type of Engines:	2 Continental TSIO-360-KB piston engines
Year of Manufacture:	1983
Date & Time (UTC):	6 March 1997 at 2104 hrs
Location:	3½ miles North East of Southend Airport
Type of Flight:	Freight
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - Serious - Passenger - Fatal
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	4,750 hours of which 2,070 were on type
	Last 90 days - 79 hours
	Last 28 days - 19 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was to operate a chartered flight delivering aircraftspares from Southend to Ostend. It was a night flight. The pilotwas accompanied by a friend who sat in the First Officer's seatbut had no flying experience and took no part in the proceedings. The aircraft was fitted with a single vacuum driven artificialhorizon and as a backup to this instrument the aircraft was alsofitted with an electrically driven turn co-ordinator. The pilotrequested taxi clearance at 2056 hrs and was cleared to the holdingpoint for Runway 06. The route to the holding point includeda number of turns during which the pilot had the opportunity tocomplete a full instrument check. At 2059:37 hrs the pilot announcedthat he was ready for departure and was given an air traffic clearanceto turn

right on track to Ostend and climb to 3,400 feet; he wasthen cleared to take off. The time of take off was logged bythe controller as 2101 hrs.

At 2102:10 hrs the pilot transmitted " LOOKINGFOR A LEFT HAND TURN AND BACK TO THE AIRFIELD WE GOT A HORIZONFAILURE". At this stage the controller could seethe lights of the aircraft, he acknowledged the RTF call, andasked if the pilot wanted to position for Runway 24. The pilotconfirmed that this was his intention and the controller thenasked for clarification of the problem. The pilot replied "LOOKSLIKE WE GOT A HORIZON FAILURE". At this stage thecontroller alerted the Airfield Fire Service and brought themto local standby. At 2102:55 hrs the pilot made a further transmissionsaying "THERE IS A SERIOUS PROBLEM HERE WE'LLHAVE TO GET BACK ON THE ILS". The controller acknowledgedthis call and requested a further transmission in order to establishthe bearing of the aircraft. The resulting track from the aircraftto the airfield of 210_M was passed to the pilot who was thenasked to "REPORT ESTABLISHED ON THE ILS FORRUNWAY 24". He replied "WILCO"and this transmission, at 2103:20 hrs, was the last from the aircraft. During this final RT exchange with the pilot the controller couldno longer see the aircraft lights. From 2105:21 hrs the controllermade repeated RT calls to the aircraft but received no response.

The aircraft had crashed into a field on a bearing of 029_M threeand a half miles from the threshold of Runway 24. A few momentsbefore impact the aircraft was seen flying very fast at an estimatedheight of 15 to 20 feet in a 90_ bank turn to the right. Shortlyafterwards it went behind a stand of trees, still turning to theright, and the witness heard a dull thud as it impacted the ground. The passenger was killed on impact and the pilot received seriousinjuries. He has little recollection of the accident flight buthe has been able to describe the symptoms of the artificial horizonfailure.

Meteorology

An aftercast obtained from the Meteorological Office describeda weak ridge of high pressure advancing across the area from thesouth. Visibilities were generally deteriorating and were probablyaround 5,000 metres, the cloud structure was assessed as scatteredto broken stratus with a base of 500 feet and an overcast layerwith a base of 2,500 feet. The meteorological forecast for Southendwhich was given to the pilot during his pre-flight preparationaccurately reflected this situation and included a 30% probabilityof 3,000 metres visibility with a cloud base of 400 feet.

The next aircraft to depart Southend was airborne at 2147 hrsand the pilot of this aircraft described the cloud base as between300 to 400 feet with poor visibility below the cloud and no clearhorizon. At 2215 hrs the SAR helicopter arrived overheadSouthend and then flew to the crash site at between 200 to 500feet, the crew described the in-flight visibility as between 1,000to 1,500 metres with no discernible horizon or cultural lightingand there was no moonlight.

Pilot experience

The pilot had obtained his Private Pilot's Licence (PPL) in 1979and over time he added a night rating, a multi engine rating andan IMC rating. By 1991 he had accumulated 1,870 hours and wasoffered employment as an air taxi pilot. He completed an InstrumentRating (IR) and was issued with a Commercial Pilot's Licence inOctober of that year. His exposure to 'limited panel' (flightwithout reference to a primary attitude instrument) had consistedof a brief introduction during his PPL training followed by the2 hours required during training for the IMC rating. His limitedpanel instrument flying was then checked during subsequent IMCrenewals, which are

required every 25 months. The final formalcheck of his ability to fly on limited panel had been during theGeneral Flying Test 3 (GFT3) which was undertaken in October 1991in order to obtain his CPL. For pilots who have passed the GFTno limited panel flying is presently required in the IR test.

Following an EMB 110 Bandeirante accident on 24 May 1995 wherethe pilots apparently suffered a failure of an attitude indicator,this pilot decided to conduct some revision of limited panel flyingfor his own reassurance. This consisted simply of two 5 minutesessions conducted to remind himself of the problems and the requiredtechniques.

The majority of his flying has been in Northern Europe and hehas had no significant breaks from flying for at least 5 yearsand hence was in good flying practice at the time of the accident. His IR was valid. This pilot was also authorised by the CAAto conduct air tests for annual renewal of airworthiness certificateson both twin and single engine aircraft.

Engineering

The aircraft had been imported into the UK from the USA at 1521airframe flying hours and was first registered in the UK Transport(Passenger) Category on 23 May 1991. The current Certificateof Airworthiness was valid until 15 June 1997.

The aircraft wreckage was distributed over a trail of approximately90 metres on a southerly heading on level ground in a large field. The right wing tip had made contact with the ground at the startof the trail, and the left wing tip contacted at around 50 metres. The aircraft attitude at initial impact was assessed as a rollangle to the right close to the vertical and a flight path angleof 15_ nose down. Eight propeller slash marks were identifiednear the initial impact point, which gave an aircraft speed ofapproximately 140 kt. The ground marks throughout the majorityof the trail did not exceed 2 metres in width and were characteristicof an aircraft which had cartwheeled.

The right wing had fragmented into many pieces and the main itemof wreckage comprised the cockpit, the left wing from fuselageto engine and the tail. This large piece was heavily crushedand had come to rest upside down.

Secondary Flight Instruments

The secondary flight instruments were taken to an overhaul facilityto determine their serviceability before the accident:

Altimeter (Kollsman 671CK-010): A calibrationcheck on the altimeter showed that it had an error of 3.5 mb ata QFE of 1030 mb and was a bit sluggish, showing an error of -45feet at 4,000 feet (allowable calibration tolerance on overhaulis ±35 feet.). However vibration from the aircraft wouldhave helped to correct that error. The altimeter followed pressurealtitude adequately and would have been satisfactory for use.

Standby Altimeter (United Instruments 5934PAD-1): When recovered this instrument hadlost its pointer, and the case, glass and glass bezel were damaged. The mechanism looked undamaged, but could not be tested in theold case. The instrument was therefore fitted in a new case andthe needles were replaced. A leak check was not possible (dueto the damage to the old case), but a functional check showedthe remounted instrument to be satisfactory.

Air Speed Indicator (United Instruments 8125): The ASI was found to be within calibration tolerances, with nolag on reducing airspeed.

Vertical Speed Indicator (United Instruments7000): When first examined the VSI had an initial offset of +380ft/min. When checked at +2000ft/min the needle went to the stopsatisfactorily and then returned to +340 ft/min; it reached the-2000 ft/min stop satisfactorily. The instrument capsule wasvery fragile and the misplaced datum was probably due to capsuledamage during the impact.

Turn Co-ordinator (Electric Gyro Corp., 1394T100- (7Z): The turn co-ordinator ran up to speed in 10 seconds,but indicated slightly left wing down. The effect of this initialerror was that during a rate one turn the instrument slightlyoverrated to the left - by about 3 mm. The instrument appearedto be generally old and worn, but, apart from the initial 3 mmerror, satisfactorily indicated in the correct sense.

In summary, examination of the secondary flightinstruments after the accident did not reveal any significantdefects.

Vacuum System

The aircraft was equipped with two air pumpsystems providing vacuum to the attitude indicator and pressureto pneumatic de-ice boots. Each of the two engines drove an airpump connected through a vacuum regulator and a check valve toa central vacuum manifold. Each vacuum regulator, which was capableof adjustment, controlled the vacuum pressure applied to the attitudeindicator to achieve a value of between 4.5 to 5.2 inches of mercury,as specified in the maintenance manual. The air inlet to theattitude indicator was protected by a paper element filter.

The system is designed such that if eitherthe left or right-hand vacuum supply failed, it would be isolatedfrom the vacuum manifold by the check valve, allowing the attitudeindicator to be fed by the remaining serviceable system. Theaircraft was provided with lights on the annunciator panel toshow if either pump failed. A vacuum gauge was installed in theinstrument panel to display the vacuum supplied to the attitudeindicator in inches of mercury.

The components of the vacuum system were removedand examined externally at the AAIB facility at Farnborough. No damage to the connecting hoses was found that could have causeda loss of vacuum. The components were then sent to their respectivemanufacturers or overhaul agents for examination:

Air Pumps: Both pumps were in an operationalcondition apart from the ingress of soil during the accident. When this had been removed the pumps were tested between 1,000and 2,700 RPM and, whilst showing normal in-service degradation,were capable of providing enough vacuum to handle the requirementsof the attitude indicator.

Vacuum Regulators: The regulators were originallyequipped with a foam filter on their air inlets, with a manufacturer'srecommended life of 100 hours; the filter was missing from theleft hand regulator and its vacuum switch was defective. Bothregulators contained small internal leaks, but showed vacuum settingsof 6.7 in Hg instead of the 5.0 in factory setting. The effectof a higher vacuum to the manifold would have been to increasethe speed of the attitude indicator gyro from its design speedof 28,000 RPM.

Vacuum Manifold: A check valve on one endof the manifold had been bent, allowing air to leak passed rivets,it is probable that this damage was caused by the accident.

Filter: The filter from the inlet to theattitude indicator was tested over a flow rate from 2 to 10 cubicft/min and had a slightly higher pressure drop across the rangethan a new filter. This was not considered significant.

In summary, the evidence indicated that theattitude indicator was receiving an adequate vacuum supply. Thefailed vacuum switch on the left hand regulator meant that itwould not have operated the vacuum warning light on the annunciatorpanel, however the system was duplicated and a vacuum pressuregauge was available to the pilot.

Attitude indicator

The attitude indicator, which had not beenseverely damaged in the impact with the ground, was taken to thecompany holding the design rights. The instrument casing hadbeen slightly dished in the impact and, after the casing was removed,it was seen that both erection vanes had been displaced but noother internal damage was apparent. The vanes were refitted andthe instrument was tested using 5.2 psi air pressure, but thegyro failed to accelerate. One of the gyro bearings had beencontaminated by a black residue which caused a 'rough spot' duringrotation. The gyro had come to rest against this spot and theair pressure was not able to rotate the gyro through it. Therewere no outstanding Service Bulletins or modifications which couldhave affected the bearing failure.

The gyro had been re-manufactured in March1987 and the manufacturer's seal was still intact showing thatit had not been opened since that date. Although the aircraftrecords from the USA were not available to show when the attitudeindicator had been fitted to the aircraft, it was estimated thatthe gyro had operated for some 1,900 hours before failure. Themanufacturer did not define a design life for the instrument,but typically this class of instrument, with a similar gyro, isdesigned for 1,000 hours operating life. This type of instrumenthas no specified overhaul life and is treated as an 'on condition'item, that is, it is left in the aircraft until reported as unserviceableby the flight crew. The indications are that this particularinstrument had achieved a better than average in-service life.

The symptoms of gyro failure described by the accident pilot:"*after the take-off the attitude indicator presentationlurched violently and repeatedly in both pitch and roll similarto the initial motions during the erection sequence*"were an accurate description of *nutation* , which is essentiallya low speed gyro rotor phenomenon involving an oscillation ofthe gyro axis. It is only noticeable at low speed because theenergy required to displace the gyro at high speed is too great. The contaminated gyro bearing therefore provided a satisfactoryexplanation of the attitude indicator problems seen by the pilot.

Analysis

This pilot was in current flying practice and held a valid ratingfor the aircraft being flown on which he had considerable experience,he also held a current IR. He took off in inclement weather,at night, and suffered a single instrument failure. He subsequentlylost control of the aircraft and crashed.

During this investigation the emphasis was directed to the requirementsfor the training and checking of pilots in their ability to flysafely on 'limited panel'. It was considered that more

exposureto this demanding flying skill would be appropriate for pilotsengaged in operating aircraft where the backup to the single attitudeindicator is a turn co-ordinator or a turn and slip indicator. Meanwhile, changes to the IR test were already planned as a consequenceof the adoption of the Joint Aviation Requirements for FlightCrew Licensing (JAR FCL). These changes, to be introduced witheffect from 1 January 1998, will incorporate 'limited panel' flyinginto the IR test for single pilot operations of single and multiengine aeroplanes. The 'limited panel' element of this revisedtest will include: straight and level flight, climbing and descendingturns, turns onto a defined heading and recovery to straight andlevel flight from unusual attitudes. It is anticipated that thesesignificant changes to the IR test will increase the proficiencyin 'limited panel' instrument flying of those pilots involvedin the operations of aircraft where the backup to the attitudeindicator is a turn co-ordinator or a turn and slip indicator.

Recommendation 97-56

It is recommended that the CAA, irrespective of any delays inthe adoption of other elements of JAROPS, adopt the changesto the Instrument Rating test in line with the proposed JAR FCLwith effect from 1 January 1998.