ACCIDENT

Aircraft Type and Registration:	Reims Cessna F172N, G-BHDZ
No & Type of Engines:	1 Lycoming O-320-H2AD piston engine
Year of Manufacture:	1979
Date & Time (UTC):	28 October 2006 at 1112 hrs
Location:	900 ft above Snetterton, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	No damage incurred during forced landing, but fire damage behind instrument panel
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	411 hours (of which 334 were on type) Last 90 days - 18 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB inquiries

Synopsis

An electrical system failure which occurred in-flight, but close to an airfield, resulted in flames and smoke emanating from behind the left instrument panel, after the pilot attempted to re-set the alternator circuit breaker. During short final approach to the airfield for a precautionary landing, the engine stopped and the aircraft landed in a field close to the runway.

A combination of a defective battery and a failure of the voltage regulator was identified as the main causal factor of this event. Two safety recommendations are made.

History of the flight

After departing from Great Ashfield on what was intended to be a local flight, the pilot noted that the fuel contents were indicating a significantly lower quantity than on his pre-flight inspection. As a precaution, he decided to call Old Buckenham Airfield, which was nearby, but received no reply. On checking the circuit breakers, he noted that one of them, most probably the 60 amp alternator unit, had tripped. He reinstated it, but this produced a noise described by the pilot as a "phut". He retransmitted his call to Old Buckenham and stated his problem, but smoke and flames immediately issued from behind the instrument panel; he briefly observed that the fuel contents indication was restored to its

original reading. The pilot then received a reply from Old Buckenham, who advised him to turn off the battery master switch. The pilot complied, after having made a 'PAN' call; however, although the flames diminished, smoke continued to emerge from behind the panel.

The pilot positioned the aircraft downwind at Old Buckenham before turning onto final approach for the asphalt Runway 25. At this point, the flames reappeared above and below the left instrument panel, with the associated smoke hindering the pilot's forward visibility. On short final approach, the engine stopped and, with insufficient height to clear obstacles, the pilot was forced to land the aircraft in a field to the right of the runway. This was successful and the occupants evacuated the aircraft immediately. The airfield fire crew had just completed their Saturday morning practice and were able to meet the aircraft as it came to rest. The pilot considered that their prompt arrival most probably saved the aircraft from more serious fire damage.

Examination of the aircraft

The maintenance organisation that subsequently examined the aircraft suspected that a fault in the voltage regulator had caused the fire. This unit, which was a 'solid state' device, together with the alternator, were removed, and tests confirmed that the regulator was not controlling the voltage. The regulator, an Electrodelta VR515GA, was marked with the letters 'FAA/PMA' (Federal Aviation Administration/Parts Manufacture Approval). Reference to the aircraft log books indicated that it had been fitted on 31 July 2002, some 400 flight hours earlier, and that it was fitted as a replacement, according to a log book entry, due to the '*alternator not charging battery*'. It should be noted that G-BHDZ is equipped with a 28v DC electrical system, and that the regulator was the correct unit for such a system.

Damage to the wiring behind the instrument panel was extensive and centred on the area around the magneto/start switch and the immediately adjacent combined battery master and alternator switch. In addition, many of the instruments had been affected by heat and/or smoke, and some of the surrounding plastic trim had melted. It was established that the correct type of battery and alternator ganged switch was fitted, in that a battery OFF selection also switched off the alternator. Photographs of some of the components, including the alternator circuit breaker, are shown at Figure 1, where it can be seen that the circuit breaker casing has suffered an explosive event, with melting of the brass and copper terminal fittings on the associated feed wire.

It was found that the aircraft battery had an '*unserviceable*' label tied to it, together with the words '*Jump Battery*', and the registration of another aircraft written on the casing. Subsequent inquiries revealed that this other aircraft had been de-registered in July 2006. According to the owner of G-BHDZ, the battery had been installed as a temporary measure following problems with the previously installed unit.

The voltage regulator consisted of a circuit board mounted inside a sealed aluminium alloy box. An internal inspection revealed that some of the components, including a transistor and at least two resistors, showed evidence of heat damage. An amplifier block, which was central to the regulating function of the unit, showed evidence of corrosion on some of its terminals. It was considered that this may have been the result of moisture ingress, as was evident elsewhere on the circuit board.

Similar occurrences

The Civil Aviation Authority (CAA) database lists six occurrences, since January 2002, of cockpit smoke in UK registered Cessna 172 aircraft. Most of these reports contained little detail and some did not confirm

View of wiring damage

Ignition switch

Alternator circuit breaker and feed wire

Figure 1

that an electrical problem was the cause of the smoke. However, in March 2005, an incident occurred in which the high and low voltage lights illuminated, and which the pilot attempted to rectify by recycling the battery master switch. This failed to clear the problem and a subsequent burning smell was followed by black smoke issuing from behind the left side of the instrument panel. A Mayday was declared and a successful forced landing was carried out at a nearby airfield. It was found that the voltage regulator, an Electrodelta VR600, had failed: this designation indicates that the aircraft was equipped with a 14 volt system. This incident was not investigated by the AAIB and there was no indication as to whether the alternator circuit breaker had tripped.

In July 2004, the FAA issued a Special Airworthiness Information Bulletin (SAIB), CE-04-72, addressed to owners and operators of Cessna 150, 172, 177, 180, 182, 185, 188, 206, 207 and 210 series aircraft. It related to aircraft equipped with Electrodelta VR600A regulators which had been fitted as replacements for the Cessna-supplied items in 14v systems. Installation instructions for the regulator called for the removal of the Cessna-installed over-voltage sensor and the modification of the wiring. The SAIB was prompted by over-voltage conditions following a failure of such a regulator in a Cessna 172N aircraft, which did not result in the tripping of the alternator circuit breaker. It was determined that the aircraft electrical system was no longer protected in the event of a regulator failure. Owners were therefore recommended to incorporate Cessna Owner Advisory SEB03-3A and Service Bulletin SEB03-3, which, together with an associated Service Kit, replaced the VR600A regulator with a VR600 unit. The Bulletin also required the reinstallation of the over-voltage sensor, and, if the aircraft wiring had been modified, the installation of a VR600A regulator together with returning the wiring to the manufacturer's original configuration.

The FAA had not received any reports of similar problems affecting aircraft with 28v systems, which is why the SAIB was aimed at aircraft with 14v systems. Whilst it is possible that similarities in the design of the regulators could affect 28v systems, the fact that the circuit breaker tripped at least indicated that G-BHDZ had the correct wiring.

Discussion

The evidence suggests that the alternator circuit breaker probably tripped shortly after the engine was started, with this not being noticed by the pilot at the time. It is also likely that the poor condition of the temporary replacement battery accounted for the relatively short time period before the voltage deteriorated to the point where the fuel gauges and radio did not operate correctly. The probable failure mode of the regulator resulted in a high current being applied to the alternator field coil, and in consequence, a high alternator power output. Resetting the circuit breaker thus caused this output to be applied through the circuit breaker to the aircraft wiring, which melted the insulation and led directly to the smoke and flames. It is likely that a cascade of short-circuit conditions ensued within the wiring loom, to the extent that the pilot's action of switching off the battery master was likely to have been ineffective. Almost certainly, the cause of the engine failure was due to the grounding of the magnetos as a result of wiring damage around the magneto switch.

If the alternator circuit breaker indeed tripped at around the time the engine was started, it is perhaps not surprising that the pilot failed to notice it as the aircraft checklist, in common with those of most other light aircraft, only called for a check of the circuit breakers before engine start. It is generally understood, following incidents concerning wiring failures in Commercial Air Transport aircraft, that circuit breakers found to have tripped in flight should

be subject to a once-only attempt at resetting, but then only if deemed essential for continued safe flight. In this incident, this action resulted in dramatic consequences that endangered the aircraft and its occupants. It is fortunate that the aircraft was at a low altitude at the time of the occurrence; indeed, the pilot had already decided to land, prompted by the spurious low fuel indication. Had the aircraft been higher, the additional time required to reach a suitable landing area could have allowed the situation to deteriorate to the point where a potentially more serious outcome could be expected.

There have been a number of incidents in the United Kingdom involving smoke in the cockpit of Cessna 172 aircraft caused by electrical problems, although the incident to G-BHDZ was more severe in terms of the extent of the damage. In America, the FAA has identified issues with single-engine Cessna aircraft equipped with 14v systems, which may be left unprotected following the fitting of PMA voltage regulators. It was concluded that these issues were unrelated to the G-BHDZ incident; the fact that the circuit breaker functioned as intended indicates that the wiring was correct. Nevertheless, since the potential effect, ie electrical fires and fumes, is the same, it is considered pertinent to discuss the matter in this Bulletin. The fact that the FAA transmitted the information in the form of an SAIB, indicated that they did not consider the matter critical to the safety of the affected aircraft. However, it is likely that most owners and operators would prefer to be aware of any dormant faults in the wiring of their aircraft, but it is unclear how many maintenance organisations in Europe routinely trawl through SAIB's.

Safety Recommendations

The majority of popular light aircraft operated in the United Kingdom, such as the Cessna and Piper series, share similarities in the design of their electrical systems, with many of the components being sourced from the same vendors. All have a number of circuit breakers that control the electrical supply to systems such as the flaps and the avionics although, in most cases, only the one in the alternator circuit could be described as 'heavy duty'.

The action of the pilot of G-BHDZ, in resetting the circuit breaker, subjected the aircraft wiring to a high-power surge from an unregulated alternator, which in turn challenges the wisdom of attempting a once-only re-setting operation of 'heavy duty' circuit breakers whilst airborne. In single engine aircraft, the battery, assuming it is in good condition, can sustain operation of the radio, other avionic systems and lighting for more than 30 minutes from the point at which it ceases to be charged. This would normally allow sufficient time for a safe landing to be made. Accordingly, the following Safety Recommendations are made:

Safety Recommendation 2007-048

It is recommended that the European Aviation Safety Agency, in conjunction with the Civil Aviation Authority, publish specific information aimed at discouraging the resetting of high power circuit breakers on light aircraft, such as those that control alternators, whilst in flight unless considered essential for the safe continuation of the flight.

Although the potential problems identified by the FAA, affecting those Cessna single-engine aircraft equipped with 14v electrical systems, were unrelated to the G-BHDZ incident, the information contained in SAIB CE-04-72 may be relevant to European registered aircraft. However, the SAIB issued by the FAA is considered a relatively obscure method of transmitting airworthiness information, and it is possible that many owners and operators are unaware of the potential vulnerability of their aircraft. The following Safety Recommendation is therefore made:

Safety Recommendation 2007-049

It is recommended that the European Aviation Safety Agency, in conjunction with Civil Aviation Authority, promulgate the information contained in FAA Special Airworthiness Information Bulletin CE-04-72, so that European operators of single-engine Cessna aircraft, together with their maintenance organisations, can ensure that the aircraft electrical systems have the required level of over-voltage protection.