FINAL REPORT

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In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 8/11/07, appointed Mr. John Hughes as the Investigator-in-Charge to carry out a Field Investigation into this Serious Incident and prepare a Synoptic Report.

Aircraft Type and Registration:	Piper PA-34-200T, EI-CMT
No. and Type of Engines:	2 x Continental TSIO-360E
Aircraft Serial Number:	34-787-0088
Year of Manufacture:	1978
Date and Time (UTC):	7 November 2007 @ 09.33 hrs
Location:	Co. Kerry, (Shannon CTA)
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 4
Injuries:	Crew - Nil Passengers - Nil
Commander's Licence:	JAR CPL
Commander's Details:	Male, aged 39 years
Commander's Flying Experience:	1,900 hours, of which 250 were on type
Notification Source:	Cork Airport ATC
Information Source:	AAIU Pilot Report Form submitted by Pilot, AAIU Field Inspection

SYNOPSIS

The twin-engined aircraft took off from Kerry Airport at 08.30 hrs on an IFR flight to Jersey. Soon after take-off, the aircraft lost all onboard electrical power, communications and weather radar. The Pilot initially flew the aircraft South and subsequently made an approach to Cork Airport from the sea. The undercarriage was lowered manually. Power was suddenly restored and, after confirmation from ATC that the undercarriage gear was locked down, the pilot landed the aircraft safely.

FINAL REPORT

1. FACTUAL INFORMATION

1.1 History of the Flight

The Pilot-in-Command (PIC) said that they departed Kerry Airport at 08.30 hrs UTC with five persons on board for a private flight to Jersey. Shortly after take-off, the undercarriage was retracted and within a few seconds a complete electrical failure occurred, just as the aircraft was entering IMC (Instrument Meteorological Conditions). The PIC instructed his First Officer (FO) to continue the climb while he referred to the checklist for electrical failure. He completed the applicable checks and when at minimum safety altitude he elected to fly South as they were unable to regain electrical supply. They climbed above an overcast layer of cloud and broke out visually at approximately 6,500 ft. They again tried to determine the reason for electrical failure but nothing was obvious. Their intention was to continue to fly South until they were clear of the coast and to try to find visual contact with the ground in order to fly in VMC (Visual Meteorological Conditions). This was in order to descend safely, to remain clear of controlled airspace, and then land at a suitable airfield with less traffic, probably Kilkenny.

The PIC repeatedly tried to establish contact with Kerry Airport and then ATC at Cork by mobile phone. Eventually he gained contact by mobile phone with ATC at Cork whereby he informed them of their problem and of their intentions. He then lost audio telephone contact. Occasionally, from the point of electrical malfunction to the time of telephone contact which was about twenty minutes, the electrical supply would momentarily return but would phase out again.

Shortly afterwards the PIC received a text message on the mobile phone from the controller at Cork advising him that he had a primary radar signal on the aircraft and that Cork would allow them to land there. The PIC was requested to fly East so that they could verify the primary radar signal being received. They followed the ATC instructions, headed East and after approximately fifteen minutes found a clearance in the cloud, which allowed them to descend safely over the ocean.

They descended to 1,500 ft and were VMC about ten miles South of Clonakilty. They continued North and decided to extend the undercarriage early in case there were any problems with it. As it is an electrically operated hydraulic system they had to use the emergency gear extension system. Just prior to activating this, the FO noticed in the mirror that the gear nose wheel was actually at half travel. They then pulled the gear extension back up knob as the gear went down, but they were not certain that it had locked in the fully down position.

Shortly afterwards, after about three to four minutes, the electrical supply was suddenly restored. They had three green undercarriage lights but also a red “gear unsafe” light. They informed ATC of the problem and advised them that they may have to prepare for a gear up landing. The PIC advised them he could take RWY 25 at Cork as it would mean less disruption to other traffic.

The electrical supply remained normal so the crew retracted the gear and then extended it normally whereby the gear unsafe light went out. They tracked to Cork Airport visually and as a precaution, did a fly-by of the Tower to confirm that the gear was down. They then did a circuit and landed safely on RWY 35.

1.2 Aircraft Information

1.2.1 The Electrical System

The electrical system of this aircraft is capable of supplying sufficient current for complete night IFR equipment. Electrical power is supplied by two 65 ampere alternators, one mounted on each engine. A 35 ampere-hour, 12 volt battery provides current for starting, for use of electrical equipment when the engines are not running, and for a source of stored electrical power to back up the alternator output. The battery and its master contactor (relay) are located in the nose section of the aircraft and are accessible through the forward baggage compartment. The battery is normally kept charged by the alternators.

1.2.2 Manufacturers Comments

The Operator made the Manufacturer aware of this incident. The Manufacturer advised checking the electrical ground points, as a failure to ground certain return lines could cause the problem indicated. The Investigation, suspecting the master relay (**Appendix A**), contacted the manufacturer and received the following:

"*If the battery master relay were to fail the battery is no longer available to supply power to the bus. The alternators would probably stay on line for a period of time. However, without the battery in circuit the alternators would be subject to falling off line while switching electrical loads. The alternators are not self-exciting so getting them back on line without the battery exciting the field would be intermittent at best. The scenario (encountered) is plausible if the battery master relay were to fail."* (**Appendix B**)

1.3 Tests and Research

1.3.1 Aircraft Testing

This aircraft is normally parked outdoors on the aircraft ramp. For the following tests, however, the aircraft was removed to an adjacent hangar. The aircraft was placed on aircraft jacks and the wiring in the nose bay inspected by the Operator's Contractor. The pilot's undercarriage control was set to the "UP" position but the electric motor/hydraulic pack had insufficient battery voltage in order to operate the hydraulic pump satisfactorily. The battery was removed from the forward nose compartment for charging. The master relay adjacent to the battery, Cutler-Hammer No. 604IH105A, was removed. It was noted that the relay had been modified during its service life. A form of epoxy (twin-pack) hard adhesive was found adhered to the rear of the main terminals probably as a form of corrosion protection. The relay was replaced along with its diode assembly.

With the undercarriage permanently down, permission was given for a ferry flight to the Contractor's hangar at Waterford Airport. There, all main earth connectors were removed, terminals replaced, frame earths cleaned and the wiring replaced. Similar maintenance was conducted on the main power earth point. The master switch was inspected and tested satisfactorily. As a precaution the switch and wiring terminals were replaced.

Undercarriage retraction tests were carried out satisfactorily and the "UP" relay replaced. The function checks were satisfactory. The undercarriage motor/hydraulic pack was replaced as a precaution. The aircraft battery was again removed and recharged. The aircraft was flight tested and all systems function tested and deemed satisfactory.

1.3.2 Follow-up Research

1.3.2.1 Investigation Research

The master relay manufacturers had been taken over by another company since 1978 and that company failed to respond to the Investigations queries. However, a test of the relay produced the following results:

Primary Coil: 9.5 ohm resistance. Contacts Resistance: > 20 megohms
Secondary contacts: Closed when primary coil is supplied with 12.75 volts. Contact reistance: 0.3 ohm.

Thus, the master relay appeared to function normally although the contact resistance seemed high.

1.3.2.2 Manufacturer Research

A first Draft Report on this incident was sent to the Manufacturer with a Safety Recommendation to request that they *"should review the requirements for the electrical master relay inspection, servicing or replacement."*

A search of the FAA database of Service Difficulty Reports (SDR) showed that there were two previous occurrences where such a master relay failed in flight. One of these occurred on a PA28 (similar relay type) and the other on a PA34 aircraft. The Manufacturer replied as follows:

"Over 7,000 PA34 series aircraft have been built from 1972 to present, all using a similar type of master relay, mounted in the same location. As part of evaluating the appropriate level of concern, the reliability of this component must be considered. The size of the fleet is just over 7000 aircraft, with an average time in service of roughly 18 years. The 3 failures reported define the MTBF (mean time between failure) to be one failure every 42,000 calendar years. If we assume 100 flight hours per year, the MTBF becomes one failure every 4,200,000 flight hours. This component has been shown to be exceptionally reliable in the specific application.

The maintenance manuals are provided with the expectation that the aircraft will be serviced by trained and qualified personnel, who are capable of using sound judgment regarding when components such as these should be replaced due to age, wear, and deterioration. Considering the evidence available, it is our position that revising the maintenance manual to add specific service, inspection, or life-limit requirements on these relays is not warranted."

Finally, the manufacturer recommended that the Operator verify compliance with mandatory service publication SB836A (Aluminium Wire Inspection/Replacement) and SL858 (Inspection of Landing Gear Relay Wiring).

2. ANALYSIS

The battery and master relay are housed in the nose of the aircraft and are both subject to very harsh climatic changes of temperature and pressure. In addition, the aircraft was normally parked in the open and the aircraft battery was invariably used for engine starting. On a morning in November, it is likely that all aircraft electrical services would be used prior and during take-off and climb out. After engine start, the alternators start to replenish the battery capacity but if take-off follows on rapidly, there may be insufficient time to do this. Raising the undercarriage with the electro/hydraulic pack puts an extra load on the system. If the actual electrical loading is critical at this stage, this is the time when the system would be prone to going off-line.

It is of interest to note that on climb out, the nose undercarriage stuck at half-travel. This is the point at which the electrical power failed. The 60 ampere alternators should have had enough power to operate the undercarriage. However, this power is conditional on the 12 volt battery output being maintained in order to excite the alternator field. Also, the full energy potential of the 35 ampere-hour battery is conditional on the battery being fully charged initially. It is noted that even 10 amperes passing through the secondary contacts of the relay will cause 3 volts across those contacts thereby reducing the field excitation voltage to 9 volts.

The loss of all aircraft electrics during an IFR flight is considered very serious. The Investigation is of the opinion that the master relay had not been replaced during the 30-year life of the aircraft. However, at some stage it had been modified in a way which was not recommended by the manufacturer. Because of the location of the master relay in the exposed front of the fuselage and its importance in the electrical circuitry the Investigation is now of the opinion that the part should have been replaced at that time.

In this incident the positive and proactive initiative of the ATC controller, who, on realising that mobile audio communication from the pilot was intermittent, quickly switched to texting his instructions instead. This contributed to the safe resolution of the incident and, for such, the controller should be commended for his actions.

3. CONCLUSIONS

(a) Findings

1. Soon after take-off, the aircraft lost all onboard electrical power, communications and radar.

2. The alternators failed to maintain adequate busbar voltage.

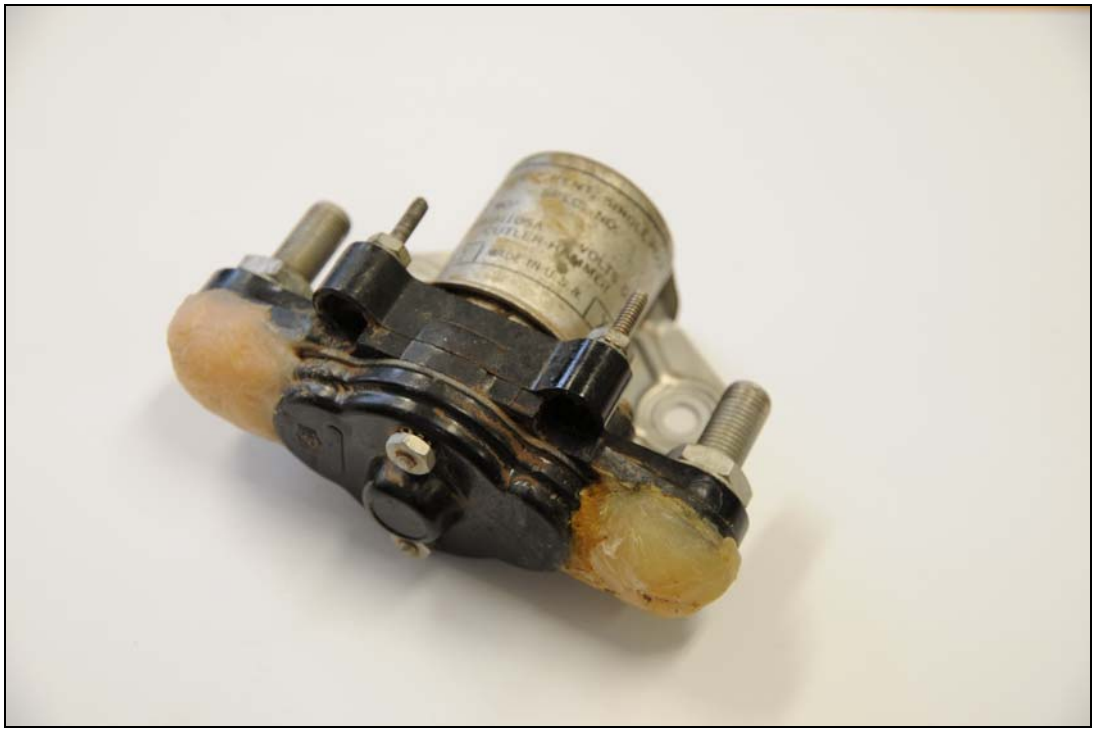
(b) Probable Cause

1. There was insufficient battery voltage to excite the field alternator windings. The poor condition of the master relay combined with a heavy electrical load following take off, could have been a contributory factor.

4. SAFETY RECOMMENDATIONS

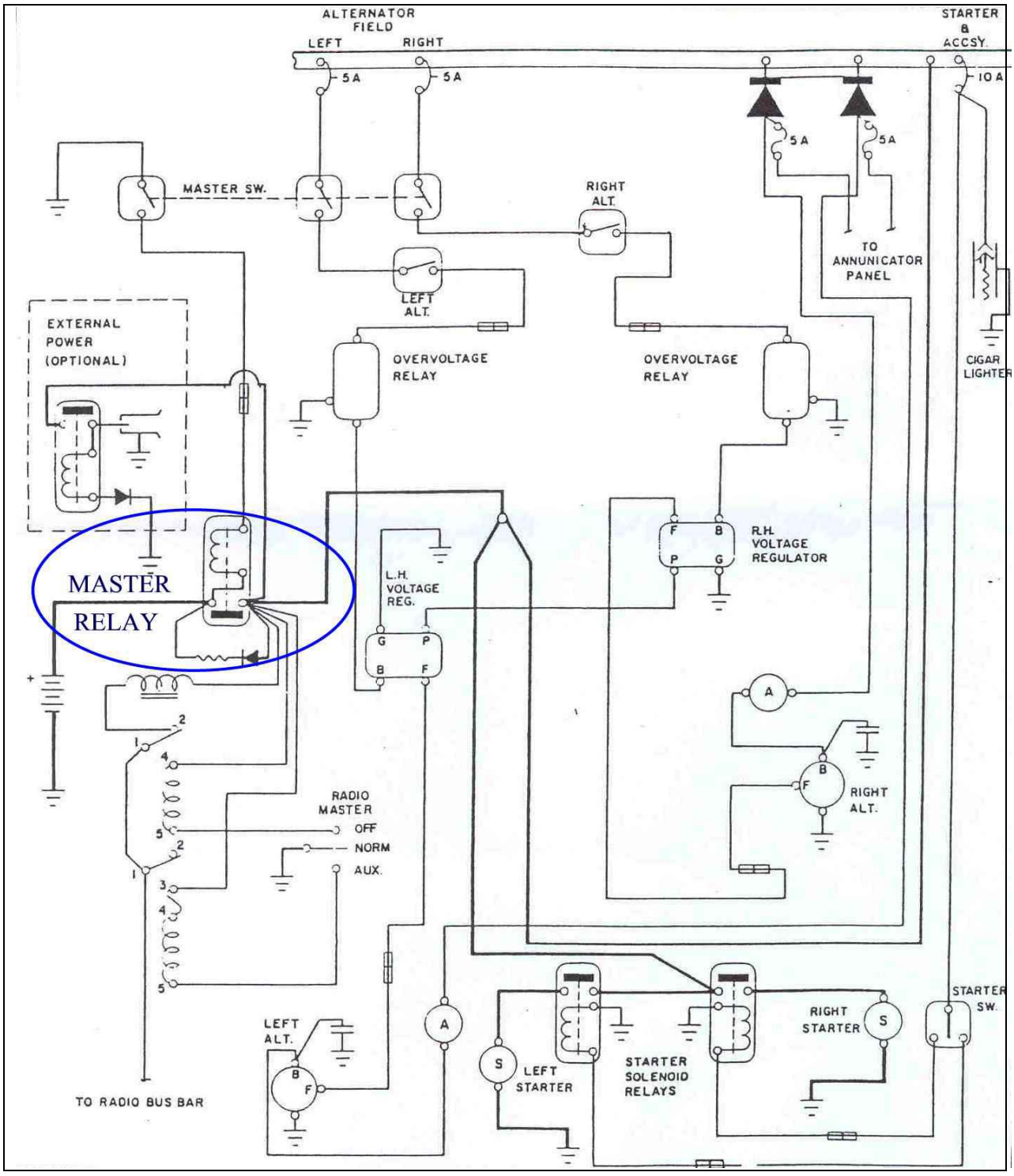
The Operator should verify compliance with Mandatory Service Bulletin SB836A and Service Letter SL858. **(SR 15 of 2008)**

Appendix A



The Battery Master Relay (4.5 X 3 inches) installed in the nose of the aircraft showing the epoxy adhesive modification to main terminals.

Appendix B



The Piper Seneca Alternator and Starter System Schematic

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