ELECTRIC AND FUEL ISSUES

Malcolm once again reappears from behind the paperwork to bring you the knowledge you need to keep flying safely

FROM an airworthiness standpoint, this last couple of months has been a very busy period. Because of the normal prioritising method employed in most small organisations – that is, fire fighting – I have forgotten what the colour of my desk is as it's difficult to see through the smoke; the smoke, in this instance, being a metaphor for the piles of paper that have accumulated. When you're busy, time flies by.

As we walk together through into autumn, looking back wistfully on an awesome summer, I hope to be able to throttle back a bit. I am looking forward to a period of relative calm. We never got it last year, let's see what happens.

"Dib, dib, dob"... I intend to use this (hoped for) calm wisely and will work hard to get the paperwork associated with the various aspects of my job up to date, I promise!

In this month's Safety Spot we've got a bit of a mixed bag for your delectation; I hope that you enjoy the read. Incidentally, in last month's Safety Spot I talked about the three big ghosts, that is, Corrosion, Cracks and Wear.

I don't want you all thinking that that's all there is to being an aircraft engineer, the reality is very different.

Most of the time, an aircraft engineer will be solving system problems, leaks and failures; the word 'system' has grown to define a group of components specifically combined to do a job. Almost all aircraft have one or two identifiable systems. Even my old hang glider has a variometer – it must, therefore, have some kind of static system. It might be 'in the box' but it's there!

This Safety Spot focuses a little on problems that have come to light on Permit aircraft over the last few weeks involving electrical systems and fuel systems. I hoped that you noticed that I said Permit aircraft and not LAA Permit aircraft. The reason for this is that, as I was thinking 'now what shall I write about this month?' I got a call from Sheila, our receptionist. "There's a chap here who wants to show you something." Well, how could I resist?

XAir Falcon - Fuel pump

WHEN I got to our reception area (and for those who haven't seen the hallowed portals of LAA HQ, this takes all of about 20 seconds), I was introduced to a very congenial British Microlight Aircraft Association (BMAA) type who goes by the name of Alan N Green. We sat down and he showed me a couple of pictures of an in-line electrical fuel pump and asked what I thought about it.

I absolutely hate it when this happens because you're immediately placed on the back foot. The fact that somebody is taking the trouble to show you something means there must be something wrong with it and, as the professional airworthiness engineer, one's honour bound to identify the problem at once. It's worse when it's some kind of component, an exhaust valve or something and, as you're looking closer, desperately seeking a clue as to the reason why you're looking at it in the first place, the person hands you a magnifying glass!

Anyway, I digress a little. In this case it was a photograph and I couldn't see much wrong. OK, I've never liked the 'car type' spade connectors but, surely, it couldn't be that, could it? The wires are a bit tight; no, it couldn't be that. I was damned if I could think of anything intelligent to say, so I practised my most penetrating look and went, "Mmme."

Alan then passed me a copy of a letter he had sent to the BMAA's Engineering Department and all became clear. This is what the letter said:

'RE: Some Electric Fuel Pumps can Bite!

From flying school I was taught to switch on the electric fuel pump before taking off and during downwind before landing. This drill I have always observed in the interests of safety.

My inspector recently recommended the replacement of a fuel hose, so the tanks were drained, fuel hose replaced together with the two fuel filters, one before the electric fuel pump and the second just before the carburettors. The fuel tanks were refilled and, in order to vacate the air in the system, the electric fuel pump was started; it whirred away happily as usual, but did not vacate the air and instead just started blowing bubbles back into the fuel tank!

Yes, you guessed it (actually I didn't! MM), the fuel pump was wired in reverse. So if anybody else has one of these fuel pumps please check that it is working in your favour and not against you. What a mercy I spotted it before it bit me – just because it was making the correct noise doesn't indicate that it was working correctly'.

The interesting point about all this is that this pump had been wired up in reverse since before Alan had purchased the aircraft, many flying hours before. So, every time he selected the fuel pump 'ON' he was reducing the amount of fuel available to the Rotax 912 'up front', rather than increasing it. Just at those most critical times during the takeoff or prior to landing when he needed the electric pump to give him an extra safety margin and to keep the fuel flowing if the main pump should fail, the electric pump had been acting against the main one and trying to pump the fuel back to the tank.

The big lesson here, though, is that if any component in a system on an aircraft is changed, then the whole system needs to be checked for correct operation. In the case of a fuel system, this means a proper fuel flow check if components are replaced. To facilitate this, LAA does a fuel flow check sheet to guide you through the process and record the result – it's available off the website. Thanks Alan for dropping in, I enjoyed our chat.

PHOTO Alan Green

This is the reverse-wired fuel pump as fitted to Alan's X'Air Falcon. I didn't spot that it was wired back to front, but I didn't like the tension in the wire very much or, for that matter, the control cables flopping around in the background. It is important to check the complete system after changing any component. Alan did... thank goodness.

Titan Mustang - Ignition module service bulletin

THIS is another item featuring electrical systems and I'm not going to spend a great deal of time here on it. The reason for this is: one, we only have a single example of the Titan Mustang on our books and two, the picture supplied by Titan tells a better tale than I ever could.

The Service Bulletin, the first from Titan, was supplied to us by LAA member Dave Stephens, the owner of the only flying UK machine. His aircraft received its initial Permit to Fly earlier this year and I will stress here that the picture featured is not Dave's machine. Regular readers will remember that Dave's beautifully built aeroplane featured on the front cover of the February edition of *Light Aviation* and the aircraft was given the Francis Donaldson treatment in a brilliant flight test report in the same edition.

Essentially, this is a Rotax 912 ULS-powered ¾ scale kit version of the 1940's US fighter aircraft. Thank you, Dave, for sending in the Service Bulletin that requires the fabrication of a heat shield to protect the ignition module, which (as you can see from the picture) is located a bit too close for comfort to the exhaust, got cooked and failed.

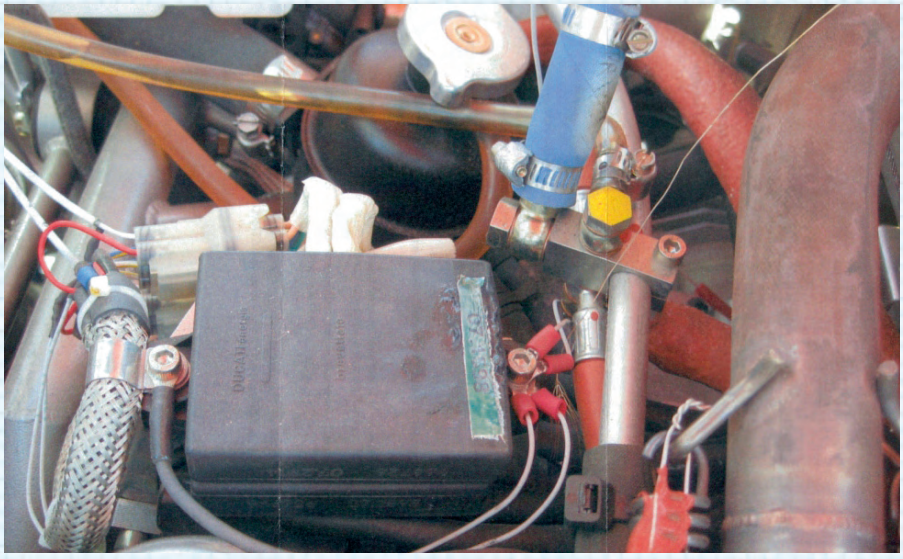

PHOTO Titan Aircraft

This engine installation is a bit of a hotch potch and I suppose that I should have saved it for the Christmas 'spot the error' quiz. If the engine compartment looks anything like this on your aircraft please don't fly it because, if you do, you're just asking for trouble. Note the burnt ignition module and its proximity to the exhaust system.

HiMax - Burnt out electrical connection

I WILL freely admit to the out and out theft of this piece: I nicked it from the fantastic MiniMax Club's monthly newsletter, the Editor of which is LAA Inspector John Hamer. I am a fan of this monthly, especially the 'News from around the Empire' section. I did email the contributor, Gloucestershire LAA'er Andrew John, for his permission to use the piece, so it isn't really theft, perhaps just a bit of a liberty.

The HiMax is the high-wing version of the mid-wing MiniMax microlight. We've only got one of this variant actually permitted as of today, whereas we've 26 of the mid-wing machines flying around.

I shall let Andrew tell his own story – it all started when he noticed that the battery wasn't charging:

'I found the problem, the connector – see attached photo. However, it worries me as it occurred before the fuse, as recommended, which is fitted after the connection and before the battery. The 'short' or 'arc' seems to have occurred inside the male connector on one of the two lighting coils' wire pins. Once failed, power continued to be supplied, and sufficient heat burnt a hole in the casing, as you can see. This would have meant that sparks could have been emitted within centimetres of the fuel pump and supply pipes.

The only indication I had from my panel voltmeter was that the normal in-flight reading, with all systems on, dropped from 13 volts to 12 volts, which remained constant until the battery needed recharging (out of the a/c).

My assumption was a) that the battery was losing its umph or, b) the rectifier had ceased to operate... Wrong!

Only when I began to disassemble all the connections to the engine for an engine-out

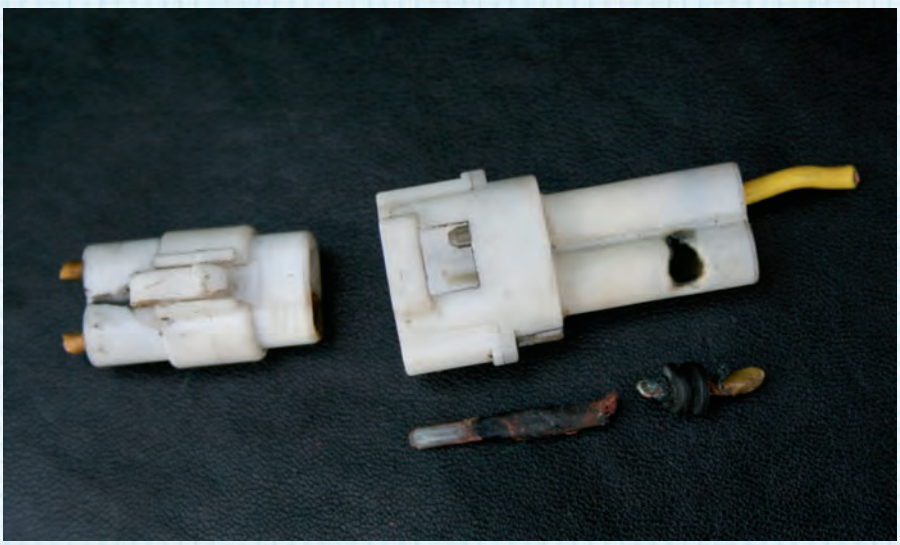

PHOTO Andrew John

You can see from this picture why Andrew's battery was failing to maintain a charge; at some point in the past, the connector pin acted like a fuse and gave up the ghost because it was being asked to provide passage for too many electrons per second (current). It's important to look at a failure like this both from the point of view of the failed individual component, ie is it 'up to the job', and from its context as part of the system – in other words, why so many Amps?

de-coke did I find the obvious problem. And yes, I do have a brand new rectifier for sale!

But, more importantly, I am very concerned that this has happened in the first place. OK, it could be that my original wiring was faulty, hence the cut in power to the rectifier. But then, the lighting coil remained active, as demonstrated by the damage done to the casing of the connector; the consequences could have been disastrous.'

The attached photograph tells its own tale and demonstrates again the need not to assume anything, and to regularly inspect all the individual components within a system for signs of a failure in the making. Just because a system seems to be working, doesn't mean that all is well with it. This is specially the case with rather basic systems like this one, where there is less electrical protection than one would expect in a more sophisticated machine. As Andrew points out, fuses and circuit breakers should ideally be placed as close as possible to the source of power so that the possibility of a short circuit further upstream is minimised. I agree with Andrew that this set-up, often seen with the early microlight engine installations, is not wholly satisfactory and needs to be checked regularly.

As a brief aside, I have some sympathy with Andrew as I once owned a Rotax 462 which, from my experience anyway, was a great engine – except for the charging system. For those not up with the various twin-cylinder Rotax engines, I can tell you that it's a 50bhp rotary valve two-stroke. Mine never gave me a moment's trouble except, as I say, I never got it to be able to charge anything. If my memory serves me right, the flywheel contained embedded magnets that rotated around fixed coils, one of the coils was used to provide electrical power to the ignition circuit, and two 'lighting coils' provided power to charge up the batteries and for external circuits. A magnet rotating around a wire will induce a current in that wire which, if measured, will look like a sine wave; in other words, an alternating current. This raw output first needs to be 'rectified' to make it a direct current, then regulated to an appropriate voltage. In this type of simple system, the regulation is not 'active' and feedback loops do not affect field currents. Instead, the excess voltage is effectively restricted through ballast resistors.

I've just had a quick look through the manual (now I've got started on this subject), and note that the total output available from the two lighting coils is 140 watts (about 10 amps). That's certainly enough power to cause problems in dodgy wiring.

Thanks to Andrew for letting me use his story. I hope you've got the charging system working now, which is more than I ever did.

Well, that's three stories featuring amps and volts to demonstrate still further that there's more to being and aero engineer than cracks and wear. Let's have a look at a couple of problems with fuel systems, one's been around for quite a time now.

Van's RV9 - Leaking fuel sender

EVERY now and again I get a parcel. Today, for example, I received a package with the actual brake calliper featured in last month's Safety Spot. I've put it in a box and will add it to our 'black museum' collection as soon as I get a moment. I expect that you'll see it, along with many of the other items featured in Spot, if you come to the Engineering stand at the Rally.

A while ago, I received a package containing a letter, a few photographs, and a couple of rubber gaskets, one new and perfectly formed, the other distorted and split. The letter tells a sad story of ruined paintwork on an RV9, and cautions about the dangers of leaking fuel.

Have a look at the pictures – you will see the tell-tale stain left by a fuel leak and will be able to work out immediately that the gasket, in this case a fuel sender gasket, has been negatively affected by the fuel and has stopped doing its job. You can see that by the fact that the gasket has taken on a weird shape. If you're good at three-dimensional thinking, you have probably worked backwards and realised that the only way that this shape could have been created is if the material from which the gasket was made had expanded. If you cannot do this in your head, cut out a ring of paper, cut it radially and push the sides apart and you will recognise the shape as it appears.

The package was sent by LAA member John Maplethorpe. I did a bit of digging about to see if anybody else had encountered this problem (and wow, had they!), and picked up the phone to chat to John. He was busy doing the first annual inspection on his machine, but spent a few moments explaining the circumstances surrounding his ruined paintwork.

The story started when he let his Instructor, Ron Perry, use his aircraft to fly to Enstone and back to the strip at New Barn Farm, which is near Bristol. Ron filled up with Avgas at Enstone for the trip back, not far in an RV9. The aircraft was put to bed in the hangar quite normally after this flight and, for all sorts of reasons, was not seen again for a couple of weeks. I should say here that this RV is a tail dragger, and a slippery taildragger at that, and Ron is teaching John how to get in front of the aircraft rather than behind it. He said to me, "I'm doing stuff in the downwind that I used to do on final because it just won't slow down." Anyway, when John finally reacquainted himself with his machine he noticed that the fuel in the starboard tank was missing. The port tank was about ¾ full.

Removal of the wing root fairing revealed the problem. The dye in the fuel had done its work and the leak was obviously coming from the fuel sender unit. To say John was a bit upset would be an understatement; this aircraft was in pristine 'out of the box' condition the last time he had seen it and now, well, you can see the state of the underside of the aeroplane. It had taken John and his wife Sally four-and-a-half years to build (over 4,500hrs). I asked John why he'd painted the aircraft before giving the machine a thorough 'shake down' period and he explained it was cheaper to get the aircraft sprayed bit by bit as it was being built. Quite a few have been done that way apparently.

John was further miffed as he felt that his complaints to Van's themselves weren't treated very seriously and he was just pointed to the supplier of the fuel sender unit, Stuart Warner. They said that none of their products were authorised for use in aircraft and wouldn't comment further. In other words, not my problem, Guv! Further investigation revealed that this problem had been around for ages, and the latest recommendation is that the fuel senders should be fitted using a fluid sealant, something like Proseal. One or two builders, and thanks must go to our very own Harry Hopkins and Mike Barnard for their help over this matter, have suggested totally covering the gasket with Proseal before fitting.

As I explained earlier, John has fixed the leak now and is in the process of carrying out his annual inspection. He's going to leave the respray for a while, which sounds sensible to me. I've talked about the various problems encountered by members with respect to fuels but I think that this is the first time I've heard of a problem where a material originally designed for use with Mogas is negatively affected by Avgas. Are there any biochemists out there that can tell me what might be happening here?

Thanks, John, for letting me know about this.

PHOTO John Maplethorpe

Avgas, or aviation gasoline, has a dye in it to aid in its identification for reasons of both safety (right fuel/right place, spotting leaks) and taxation. Unless it's wiped away immediately from paintwork, especially new paintwork, it will stain. Here, a leak from a fuel sender unit has wrecked the paint job on the underside of the wing on this brand new RV9.

PHOTO John Maplethorpe

You can see from this picture why John came back to an empty fuel tank. It looks like the fuel has reacted with the rubber gasket. Van's now advise that this gasket should be discarded and the fuel sender unit 'potted' using Proseal. I'm not sure that I like the use of screws here – remember, a screw has no plain shank. Perhaps I'm just being old fashioned!

Shadow - Leaking fuel tank

I REMEMBER, many years ago, being involved in a microlight distance record attempt. The attempt was successful in that it smashed to pieces the previous record, but we never achieved our goal of being the first people to fly a microlight from Lands End to John O'Groats in a day. Two aircraft were involved in the attempt and my partner aircraft, flown by ex-Vulcan jock John Tye, had an engine failure and did some underwater flying in Loch Ness after his engine quit. I got another 50 miles or so, but ended up flying into a fog bank when landing, much to everybody's surprise, in the grounds of Inverness General Hospital.

I was reminded of this trip by Rob Hill, the BMAA's Chief Inspector, when he called to see if we had had any problems with Shadow fuel tanks. There were two things that triggered the memory of this long ago adventure; the first, obviously, was a call from a microlighter. The second mental 'trigger' was that the last time I had a problem with a leaking fuel tank was on that trip. I'd had special aluminium fuel tanks made and they had sprung leaks at the welded seams like there was no tomorrow. During the first refuel, somewhere in South Wales I think, the engineer there had the answer – chewing gum. He shot off and came back with five packets. It was a brilliant solution (I had a sore jaw for weeks afterwards) and I'm happy to remember it again. Not that I'm endorsing the chewing gum idea, mind you – that was a long time ago when microlighting was in its infancy, and a lot of luck was involved all round really.

Rob put me in touch with the owner of the Shadow with the problem tank, LAA'er Gary Chater and, after a bit of a chat, he promised to send in a couple of pictures. You can see the problem for yourself, it's full of bits and pieces.

The debris that came out of the tank looks like the remains of a sloshing compound that has detached itself from the inside faces of the tank, but it might just as easily be the residue of the adhesive used during the tank's construction. Either way, this tank is in a bit of trouble. Gary explained that the tank had started leaking a little sometime ago and that he had attempted a repair by 'slightly opening the seams from the outside with a knife, abrading the surfaces, degreasing with Acetone and filling the area with Araldite'. Sadly, this fix didn't work.

The problem here is the nature of the material, effectively a cardboard inner honeycomb core skinned with fibreglass sheet. This kind of structure is difficult to get clean enough for anything to stick to it at the best of times, let alone after being soaked in two-stroke fuel. When these aircraft were being constructed, back in the eighties, I remember Fiona Luckhurst, one of the BMAA's senior Shadow Inspectors then (and now!), was insistent about cleanliness at every stage of the bonding process. She knew that the smallest particle of contaminant in a joint would eventually lead to its failure.

Fair Winds !

PHOTO Gary Chater

Here's the picture of the rubbish that Gary found inside the tank during his investigations into a small leak. Judging by the shape and general look of this crud, I would say that it is possibly sloshing compound. It's very difficult to get anything to stick onto old fibreglass and that's why it's often better to start again and make a new tank if one gets damaged and starts leaking. I have spent a bit of time, as a complete aside, trying to work out that rule; is it just me or is it a bit weird?

PHOTO Gary Chater

Here is the fuel tank from Gary's Shadow aircraft. It was originally constructed from Fiberlam sheets, which were originally designed for use in aircraft flooring. The flat sheets were glued together using Araldite and the tank sealed with Safe TII Poxy. Absolute cleanliness is required when working with these materials.

LAA ENGINEERING SCALE OF CHARGES

LAA Project Registration	
Kit Built Aircraft	£300
Plans Built Aircraft	£50
Issue of a Permit to Test Fly	
Non-LAA approved design only	£40
Initial Permit issue	
Up to 390kg	£320
391 - 499kg	£425
500kg and above	£565
Three seats and above	£630
Permit renewal	
Up to 390kg	£105
391 - 499kg	£140
500kg and above	£190
Three seats and above	£210
Modification application	
Prototype modification	£45
Repeat modification	£22.50
Transfer	
(from CofA to Permit or CAA Permit to LAA Permit)	
Up to 499kg	£135
500 kg and above	£250
Three seats and above	£350
Four-seat aircraft	
Manufacturer's/agent's type acceptance fee	£2,000
Project registration royalty	£50
Category change	
Group A to microlight	£135
Microlight to Group A	£135
Change of G-Registration fee	
Issue of Permit documents following G-Reg change	£45
Replacement Documents	
Lost, stolen etc (fee is per document)	£20

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