FIRST FLIGHT FAILINGS

This month we focus in detail on a particular accident which highlights the importance of following your Inspector's advice

SOMETIMES things go smoothly, sometimes they don't. I have absolutely no idea what the mysterious forces are that control our lives but, whatever they are, they have conspired against me writing this month's Safety Spot.

I won't bore you with the detail and I hope that I wouldn't deserve a reputation as a whiner but, well let's take today for example. I got in a little earlier this morning, my mind full of ideas about how and what I was going to write, but I thought: "While it's quiet, I'll just have a look at that Aeronca rebuild, see if I can get a Permit Flight Release Certificate raised. I know that they're itching to fly it at the weekend". Some hours later I surface, fingers covered in inky black news print and hair full of dust, from the LAA archive. I managed to sort it all out and duly wrote out the Permit. Well, did I say I wasn't a whiner?

Last month's Safety Spot produced a great deal of response from the membership. Almost all of those responses shared my concerns about the 'culture of perfection' that seems to be promulgated by the various product manufacturers and their agents. Thank you to those who telephoned or wrote in on the subject. As always there is much to get through, so without ado, I had better get going...

"Bad engineering" and the self-destructive Spitfire

WHEN you think about it, a very large proportion of the effort made by aeronautical engineers is expended in the cause of safety. When something fails in an aircraft, however minor that something might at first be considered to be, the aviator is one step closer to a disaster. I remember a chap telling me how he nearly checked off the planet because the clock (time piece) had failed and he hadn't noticed. He managed to land on the airfield in the dark having completely lost track of time, but missed the runway completely. It was only the next day when the full realisation of his narrow escape became apparent, for he'd stopped only a few metres from some stationary agricultural machinery. There but for the grace...

John Broad, one of our EC members, who chairs the LAA safety Sub Committee, brought an interesting item to my attention a while ago. John Broad also represents the LAA as a council member of CHIRP, the Confidential Human Factors Incident Reporting Programme (I hope that most of you read the CHIRP FEEDBACK circular º it's definitely worth the time). The particular item under discussion was featured in issue No. 39 (Spring 2009) and concerns a pilot who found himself running out of runway on take off in his Jabiru 400. The pilot explains, in FEEDBACK, that he was taking off on a grass runway that was wet. He made good allowance for this and added about 60% to his take off distance required but, even with this taken into account, he was very close to aborting the take off when the wheels finally left the ground. The climb rate was also very poor and he ended up "too close to the trees for comfort". Not good.

'The climb rate was also very poor and he ended up too close to the trees for comfort'

He explained that he didn't know the aircraft very well as it was new to him and he later employed the services of an LAA Inspector to go through the technical aspect of the aircraft with him (a very good idea). During this training session it was noticed that the carburettor heat control had become disconnected at the engine end and that the carburettor was receiving hot air all the time. This was very likely the cause of the poor take off performance and subsequent poor climb.

When I heard about this I was a little uneasy when it was suggested that the type of connection used was considered "bad engineering". You can see from the accompanying photograph that the Bowden cable connection is made using solder. I checked that this was normal with the UK agents and they said that this was indeed normal practice for Jabiru Hot Air systems and that, if done properly, this kind of connection shows good service life and that they have never had a report of a failure. Roger Lewis, an LAA Inspector who specialises in Jabiru engines explained that, "the good thing about this type of connection is that it is easily inspectable. A tug will reveal a dry solder joint and the connection will, under this circumstance, fail." Roger has come across 'dry joints' during his inspection career but had never heard of a properly soldered joint failing in service.

There are a few lessons to be learnt here. It is very important to thoroughly check all control connections during the 'check A'. This is the title given by engineers for the first flight of the day check; glider types call this the DI. This event also reinforces the need to check the hot air system on the ground during the ground run phase of the pre-take off checks, get used to the feel of this control, if there's a change in the feel, check it out. Don't get lazy with this check,

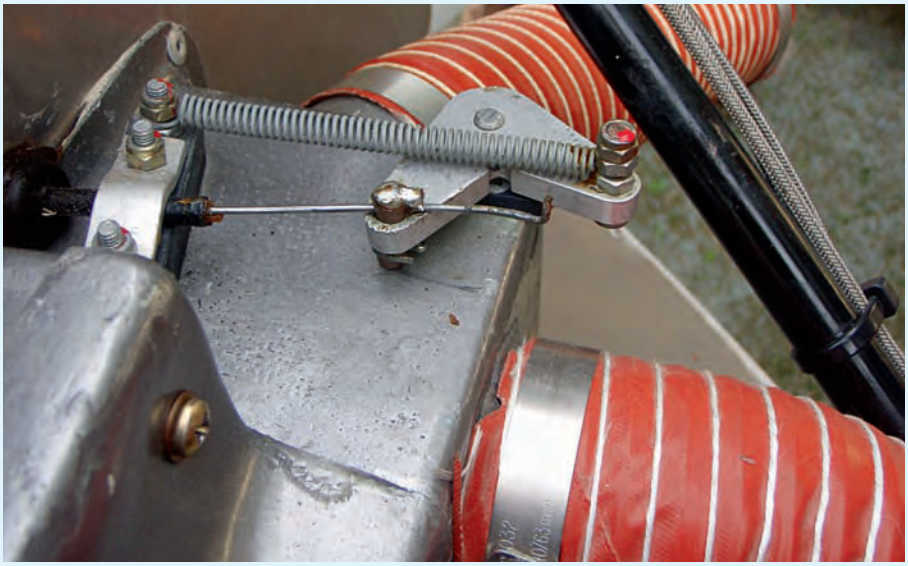

PHOTO CHIRP

The controversial connection which has demonstrated good service so far amongst the Jabiru fleet worldwide. As an aside, I like the way important bolts have been marked but, as an engineer, I don't like the way in which the wire has been left with its bare end unprotected.

A fantastic picture, sent to us by Roger Syratt, of John Pearson's Mk.26 Spitfire strutting its stuff in the hands of LAA Inspector Nigel Huxtable at the recent show at Turweston. In the back is Nigel's son Mark – soon off to join the Fleet Air Arm

PHOTO Roger Syratt

especially as winter approaches.

As hot air is introduced into the induction system, during this check, the lower air density will reduce the engine's power output and the RPM will drop a little. If you are suffering carburettor icing on the ground, the introduction of the hot air will melt the ice binding to the inner surfaces of the carburettor, and the engine may cough as the water is ingested into the engine – a good reason to leave it on for a while. Normally, by selecting hot air off, the RPM should rise back to the original figure. Naturally, all engine/airframe combinations exhibit different characteristics, learning about these is one of the good reasons for differences training. Many Gypsy engines are known for their susceptibility to carburettor icing, the Mk. 10 for example, as used in the RAF's De Havilland Chipmunk, have their carburettor heat control 'wire-locked hot'. Other Gypsy's have an automatic carburettor heat system.

This particular pilot was new to the type and didn't know what to expect, in other words, he was learning on the job. This is a risky occupation, especially with LAA types that are becoming increasingly sophisticated. Regular readers of this feature will know that two or three, often completely unconnected things, going wrong will generally lead to an event and an event is often a pre-curser to an accident. Learning on the job is a significant feature of this next report which concerns some of the reasons why a Spitfire Mk. 26 ended up being badly broken on its initial test flight.

ENGINE FAILURE AFTER TAKE OFF DURING AIR TEST – ONE.

In the August 2009 Safety Spot feature, when the weather was hot and we were all full of the summer sunshine, I briefly reported an incident which severely damaged a Mk.26 Spitfire on its first flight. I mentioned at the time that this was a very sad day for the builder having spent over three years constructing the machine only to see it nearly written off in the crash. There are two bits of good news though, the first, and most important, being that there was nobody hurt in the incident. The second being that the airframe was not as badly damaged as at first thought and is, at this very moment, under rebuild. The engine though, for reasons that will become apparent later, was totally destroyed.

> *'This particular pilot was new to the type and didn't know what to expect'*

THE PILOT'S TALE: Let's first look at the incident which occurred at an airfield in the east by south east of England. The day was quite a pleasant one for July, with a 15 knot wind pretty well down the runway. The Pilot selected by the owner was an extremely experienced and competent chap, who had applied to the LAA for an approval to check fly the type. He had not previously flown the Mk.26 Spitfire but had experience of aircraft with high power to weight ratios, controllable propellers and retractable undercarriages. The Chief Engineer of the LAA, Francis Donaldson, an experienced Mk.26 pilot himself, accepted this application and granted permission, but included a three page letter giving advise with regard to the process generally, and with specific instructions that the undercarriage should be operated by the pilot with the aircraft on jacks in the hanger. The reason for this request/instruction was that the Mk.26 undercarriage is pretty complicated; I will describe its operation shortly. Back to the fateful day. In short, the pilot ran the engine up on the ground and "to make things simpler" elected to conduct the take off with the propeller control set to MANUAL.

The propeller used on this machine was an MT electrically controlled device with two basic settings, MANUAL, where the pilot selects the pitch of the propeller by the use of a spring loaded switch on the propeller control in the cockpit. In this setting it is possible to adjust the pitch of the propeller but, once selected, the propeller behaves essentially like a fixed pitch propeller. The other setting is AUTO, where the propeller effectively acts with a constant speed function. In other words, once enough power is supplied to the propeller to turn it at the pre-selected RPM, further increases in power will be absorbed by increasing the pitch of the propeller blade, preventing a further rpm increase. The MT propeller is cleared by the LAA to a maximum rpm of 2800, which is a bit less than the engine maximum which is 3000rpm.

The astute reader will have noted the pilot increased his workload significantly by selecting the MANUAL setting of the propeller because, having adjusted the propeller pitch manually for a maximum of 2800rpm stationary on the ground, further (continual) manual adjustments would be needed as soon as the propeller unloaded during the takeoff run and at every speed/power setting change. The AUTO setting would have made these adjustments automatically.

The take off was normal and the aircraft settled into a rapid climb as is normal for type (about 1200fpm), and the undercarriage was retracted. The pilot is unsure about what exactly happened next but he noticed a "metallic" smell which he described to me as "more like a taste" and, at about 2500 feet agl he lowered the nose and reduced power. It was apparent to the pilot that the engine was overheating and he decided immediately to set himself up for a landing back at the take off aerodrome. Essentially the pilot had climbed out in a gentle right hand sweeping turn and, by this time, a gentle turn to the right would bring the aircraft back onto runway heading. Smoke started entering the cockpit and it became clear to the pilot that a forced landing would be required.

As a brief aside, I would like to say here that I have the privilege of investigating and analysing this incident from the comfort of my office, and it is difficult to imagine the kind of pressure this pilot was under at the time. My job requires me to highlight what I consider to be the pertinent failure points and I hope that you appreciate that I do this with great humility. This particular incident has a number of protagonists, all of whom have played a part in this drama. Right at this moment we're looking at the pilot's part in the story.

The pilot elected to lower the undercarriage, but it soon became apparent that only the right hand undercarriage leg had dropped and, although difficult to see because of the smoke from the engine, a starboard green down and locked light illuminated. The pilot remembers pulling the emergency gear release but this did no good and he decided to concentrate on getting the aircraft down on the ground. Height was diminishing fast and, now flying into a fairly brisk wind with no power and one undercarriage leg lowered, it became apparent that he was not going to make the airfield. The pilot described to me that he touched down on the right undercarriage perfectly and the aircraft slowed veering slightly to the right in a gentle arc. As the lift reduced on the port wind it dropped to the ground and the aircraft swung fairly gently to port. The starboard undercarriage then failed as the aircraft slewed to a halt.

'It's quite a complicated kit and a high degree of skill is required to assemble the machine'

The pilot secured the aircraft and left the cockpit. He said the propeller was turning when he hit the ground and this was born out by the fact that all three blades were destroyed upon impact. The fact that this pilot lived to tell the tale is a testament to his experience and coolness under pressure, so well done to him.

I will discuss later on what I feel went wrong with the piloting aspects of this incident because I think that there are lessons for all of us but for now, what of the engineering issues?

THE ENGINEERS' TALE: The Mk.26 is a two seat sports aircraft based, fairly loosely, upon one of the best know fighters of the second world war, Reginald Mitchell's Supermarine Spitfire. Naturally, as a small scale home built kit, it isn't armed and is quite a bit slower than the original with a maximum indicated airspeed of 193 knots. I think that the fastest Spitfire produced was a Mk.11 fitted with a Rotol fully feathering propeller (to prevent engine over-speeding) during 'compressibility' tests at Farnborough just before the start of the second War. During one of these tests the propeller, complete with reduction drive, came off during a 45º dive in which the aircraft reached a speed of just over 606mph.

Nonetheless, it's quite a complicated kit and a high degree of skill is required to assemble the machine. The builder registered the project with the LAA in January 2006 and a Permit Flight Release Certificate was issued in July 2009 which is a build time of about two and a half years. The engine fitted to the aircraft is the eight cylinder horizontally opposed Jabiru 5100A which, at 3000rpm produces 160hp. As I mentioned before, the maximum rpm for this aircraft is limited by the propeller to 2800rpm but, looking at the power/rpm graph this reduction in allowable revs only costs about 10 hp. Undoubtedly, the unsilenced roar of a five litre flat eight is one good reason for fitting the engine into a Mk.26 - it sounds great!

As a brief aside, there is a great debate going on at the moment about the relative benefits of variable pitch propellers against fixed pitch units in LAA type homebuilts. The debate is not about whether performance is increased, in most applications it is undoubtedly the case that optimising pitch improves efficiency. The debate centres around whether this increase is worth the very high cost of these units and the concurrent increase in complexity. The propeller fitted to this aircraft is the MT MTV-18 three blade electrically operated variable pitch propeller.

The other complicated aspect about this aircraft is its retractable undercarriage and, at this point in the article, it's probably worth explaining the operation of this mechanism in a little more detail.

Firstly, and quite unusually, each main leg retraction system is independent; it is possible to intentionally raise, or for that matter lower, each leg separately. I have been told that this is so that a more realistic retraction can be performed during displays. I'm not so sure. The mechanical locking mechanism is fairly cumbersome and I think that this had more to do with the independence designed into the system. I mentioned earlier that Francis asked the test pilot to practice the operation of this undercarriage. This was for very good reason; it's a bit of a procedure.

Let's start with the retraction. The

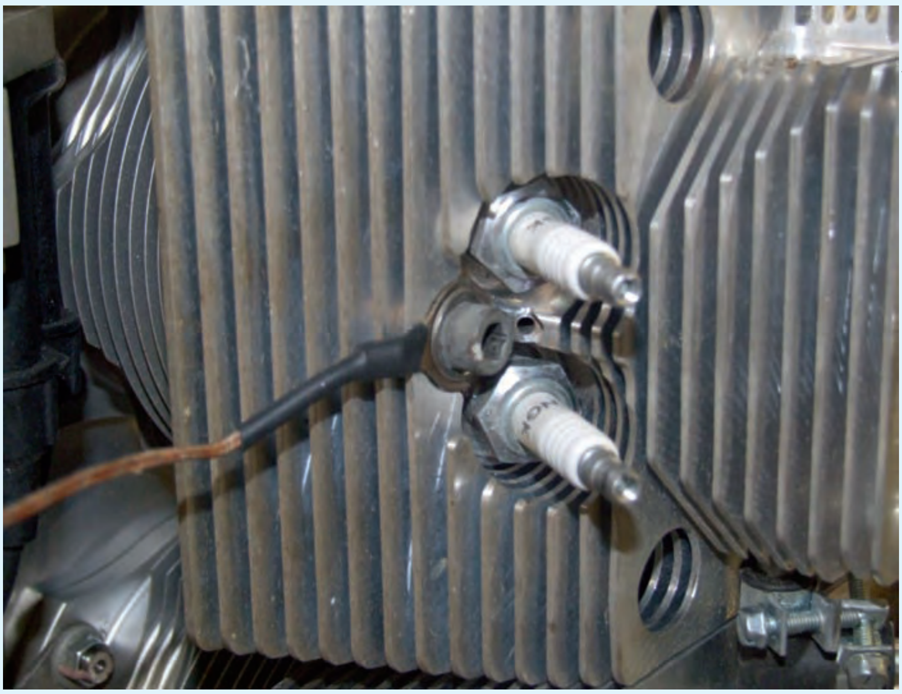

PHOTO Gary Cotterell

This picture reveals the incorrectly positioned CHT probe. This probe is designed to go under the sparking plugs. If fitted in the way shown here, the probe will under read

PHOTO DSC Engineering

The damage to the cylinder head has been caused by the huge forces during detonation combined with molten metal from the piston

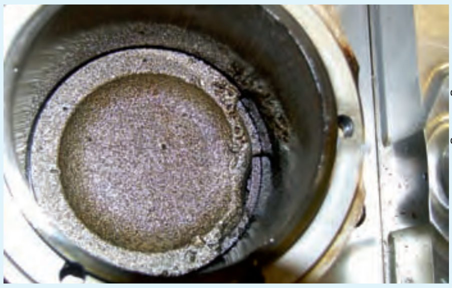

PHOTO DSC Engineering

Corresponding damage to this Jabiru 5100's piston surface. Note the edge of the piston has evaporated, exposing the top compression ring

PHOTO Jim Gale

This shot, from LAA'er Jim Gale, shows that while this piston has clearly overheated, there is no sign of detonation. Mixture is a front runner as the cause but poor cooling shouldn't be ruled out. Small changes in propeller pitch, and therefore mass flow, can often mess up mixture settings

PHOTO Jim Gale

Classic scuff marks on piston through over expansion. Pistons are designed to expand but allowable temperature limit is about 260ºC

PHOTO GRC Engineering

This photograph clearly shows a split nut caused by the thermal expansion of the crankcase material. This is a first for me

undercarriage is raised and lowered electrically, so the first operation is to select the undercarriage switch to UP. Nothing will happen as this switch really just directs the direction of travel. Next job is to release the down lock pins, which is done by pulling each of the separate undercarriage levers backwards a few inches. These separate levers are placed together and form a sort of T Bar - it would be normal, and fairly straightforward, to operate them together. The undercarriage levers must then be pulled fully back to activate separate micro-switches which 'live up' the retraction motors. When the undercarriage legs are fully up the levers must be pushed forwards again to force the lock pins into their up-lock position.

Lowering is a reverse procedure; switch to DOWN, levers back to release up-locks, fully back to activate motors, push forward on levers to engage down-locks. When the down-locks are engaged a green light is illuminated in the cockpit. Phew!

There are other features to this undercarriage, one of which is very pertinent in this case. There are mechanical indicators on the wings to give the pilot a visual indication of undercarriage position. Also, there is a mechanical 'motor-disconnect', operated from the cockpit which allows the undercarriage to free-fall in the event of a motor, or perhaps an electrical, failure. Importantly, the leg won't free-fall unless the up-lock is withdrawn.

The pilot told me that he was conversant with this system but had not sat in the cockpit with the aircraft on jacks to practice this procedure as was initially advised by the Design Department here. He also said that while he was watching the retraction checks in the hanger the port leg jammed up, and he thought that this was what may well have happened on the day of the accident.

What about the other engineering points. Well, on investigation, it became clear that the LAA inspector who signed off the final inspections of this aircraft, was not the inspector that had seen the project through from the beginning. This inspector was changed at the last minute on the direction of the owner/builder. Of course, an owner has a perfect right to do this, but I was concerned that this discontinuity may have been a factor in the cause of the accident and tried to establish the reasons. I have to say here that both the LAA inspectors involved are extremely competent and very experienced chaps and I have the highest regard for both of them but, without dwelling on the interpersonal conflicts that led to this last minute change of personnel, unnecessary last minute changes during this critical phase of the aircraft's life are highly undesirable.

'So, what we have here is a test pilot not fully practiced in the aircraft or its systems'

So, what we have here is a test pilot not fully practiced in the aircraft or its systems, and technical expertise that was very new to type with no experience of the Jabiru engine. During my conversation with the final inspector, I asked about the undercarriage 'up jam' that was reported by the test pilot. He confirmed that this had happened but the lock pin socket had been 'line reamed' and the problem solved.

THE POST MORTEM: After the aircraft was recovered the engine was shipped to GRC engineering which is the engineering expertise base for the UK Jabiru agency. The engine was stripped in the presence of the UK agent and representatives from the insurance company. It became clear very quickly that the engine had got extremely hot, so hot in fact, that the crank case had expanded sufficiently to split the nuts on the through bolts – a failure feature I've never seen before. The engine was seized when it reached the workshop, which is at odds with the report that the propeller was still turning when it hit the ground. When the crank was removed it became clear why: the extremely high temperatures were sufficient to melt the white metal in the bearing journals which, when they cooled, effectively soldered the assembly together. Another first for me!

The report, written by the dismantling engineer makes for some sobering reading but space prevents me from dwelling on the dreadful state the engine ended up in. Suffice to say that it was effectively destroyed. The reason was that the engine, for various reasons, ended up running very lean, probably dangerously so in the climb and destructively so when the aircraft was levelled out at the top at 2500 feet. The pilot was not aware of these dangerous temperatures because the aircraft was not fitted with an exhaust gas temperature probe and the cylinder head temperature sensing probe had been fitted in the wrong place.

Why was the engine running so lean? Well, this is where things get a little complicated and highlights why a high level of specific expertise is required when commissioning a new aircraft. There is a suggestion that the builder was assisted in the final set-up by a small engineering facility based at the aerodrome. There's nothing wrong in this per se but, in this instance, the licensed engineers involved didn't take too kindly to "being inspected by an amateur LAA type" even though the chap had been inspecting aircraft for the LAA since the 1980s. I can see how a licensed chap, used to working in the regulated environs, might fit a CHT probe to a cylinder head bolt; it sort of makes sense. But there's no way anybody who knew anything about the subject would do this. So, human factors have played an enormous part in this accident and this is a specific failure in the management of the project.

During the disassembly of the engine it

PHOTO Malcolm McBride

These 3 pictures tell the story of why a Pietenpol ended up in a field on its first test flight...
1. Showing the caged ball bearing with its open face, this is the face that should be engine side in so that the bearing can receive splash lubrication

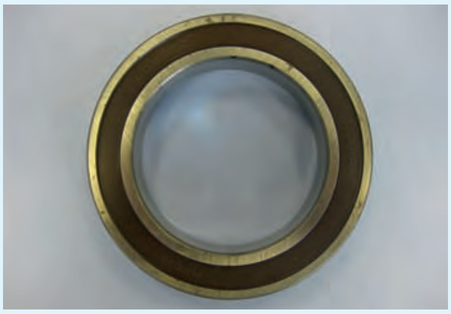

PHOTO Malcolm McBride

2. Here, showing the sealed face

PHOTO Malcolm McBride

3. A close up of the damaged caused when incorrectly fitting the bearing. Fragments of this bearing have damaged the ball cage

was noted that the carburettors were fitted with a "very lean needle and jet set up". Jabiru Service Bulletin JSB 018-9 published in May 2009 deals with this subject (and can be downloaded from the LAA website) but, and this is an important point, there's no such thing as a one stop shop for engine set-up. Getting engines in this class working correctly takes a lot of expertise, the simple 'constant depression' type carburettors used on both the Jabiru and Rotax engines are designed to supply the correct amount of fuel at any particular throttle setting but, with the introduction of variable pitch propellers these fixed mixture devices can struggle a bit. Another factor, relevant in this case, was the fitment of a straight through exhaust. This type of exhaust system inevitably offers less resistance to exhaust gasses and has the effect of reducing mixture strength.

In general, if an engine is running lean it will be running hot, and when the gas temperature rises in the cylinder there is more chance of detonation. A normal burn can be considered as deflagration (where the flame front pre-heats and then ignites the material or gas) and is a relatively slow event (in chemical terms) with the wave front travelling at around 50 cm/sec across the chamber. During detonation the charge explodes virtually instantaneously (during gas pipe experiments 2000m/sec have been recorded). Some engines are designed to operate with light detonation at some points in their operating cycle; aluminium cylinder heads and pistons don't like it at all. This is principally due to the fact that the rapid combustion experienced during a detonation event destroys the protective fuel barrier around these components which serves to cool the metal, offering a sort of 'thermal inertia'. Combustion chamber temperatures often exceed 980º C, which far exceeds the melting point of aluminium (about 750º C). High output engines will destroy themselves within minutes once detonation sets in.

'Failing disasters, try to stick with the same inspector throughout the project'

So, in conclusion, what can be learnt from this awful accident? Well, the list is quite long and the following should not be considered exhaustive.

1. Certainly it's not ideal to do an initial flight test on a completely unfamiliar type. If you're ever fortunate enough to be asked to test fly an aircraft it would be a good idea to get some time in a similar machine (that you know works!) beforehand.

2. Always learn the systems thoroughly. Problems with the operation of the undercarriage and propeller had a direct consequence on the outcome.

3. Failing disasters, try to stick with the same inspector throughout the project; it's a stressful time getting an aircraft ready for its first flight, and tempers can get a little frayed. If the inspector wants to check something, remember he's not there to make things more dangerous – give him/her the benefit of the doubt.

4. If something is not working right then it will probably show itself within the first few moments of a flight, don't use unnecessary systems. In this case the pilot would have been wiser to leave the undercarriage down and do a quick circuit at medium/low power settings. The fact that the engine was getting hot and the propeller was over-speeding would have been noted and something could have been done about it when safely on the ground.

5. If you're not an engine expert (how many of us actually are?) then, before the first flight at the very least, talk to somebody who is.

6. It is essential that all the parties involved with the first flight of an aeroplane ensure that they have read every bit of information about the type. It is especially important to ensure that all the factory service letters and bulletins have been taken on board.

In other words, a first flight should not be a training exercise. There's too much going on to learn on the job. If you're not fully familiar with the equipment that you're testing how is it possible for you to recognise when it starts to go wrong?

ENGINE FAILURE AFTER TAKE OFF DURING AIR TEST – TWO.

This failure occurred during the first flight of a Pietenpol Air Camper, a few days after the aforementioned Mk.26 incident. In this case the pilot, Will Greenwood, has a lot of experience with this type of aircraft and recognised that there was a problem with the engine almost immediately after take off. The engine fitted was a Subaru conversion utilising an AMEX belt drive reduction system, and at about 400 feet agl the engine rpm started dropping. Will immediately recognised the initial signs of seizure and got the aircraft down on the ground quickly. The engine finally gave up the ghost on final into a field but neither the aircraft nor its pilot suffered any damage so, as always, very well done to him.

The inspector in charge of the project noted that the AMEX reduction drive was extremely hot "even some time after the forced landing". When it was stripped it was noted that the main bearing for this device was in the wrong way round and was therefore not receiving any lubrication. When he 'pulled' the bearing he was surprised to see the extent of the damage to it. It wasn't only the lack of lubrication that caused this bearing to fail. It looked like it had been smashed in with a hammer and cold chisel. Makes you wonder sometimes.

Fair Winds.