

**From Chris Rollings, Former Chief Instructor, Booker Gliding Club, UK**

**Aerotow Upset Accidents.**

Recent discussions concerning the fatal aero-towing accident at the US Air Force Academy last year, made me think that it was possible worth giving wider publicity to the information which I provided to the investigators of that accident, regarding the experiments we conducted some years back into the nature of these accidents.

Whilst I was Chief Instructor at Booker Gliding Club, we conducted two series of tests on the phenomenon variously referred to as 'Kiting', 'Winch Launching behind the Tow-Plane' and 'Sling-Shot Accident', one in 1978 and one in 1982; my memory of them is quite vivid.

Airplanes used were a Beagle Terrier (a side by side, two place, high wing, tail-dragger), fitted with an Ottfur Glider hook for towing (very similar to the Tost hook, dissimilar to the Schweitzer hook) with a 160 hp Lycoming engine for the first series of tests, and for the second series a PA18-180 with a Schweitzer hook. Gliders used were a Schleicher Ka 8b and ASK 13. Tow rope initially used was a heavy (4000 lb) rope with a thinner rope weak link at the glider end (nominally 900 lb, but a well worn specimen could break at as little as 200-300 lbs - laboratory tests, not opinion), the second series of test used the same heavy duty rope with 'Mity' links at each end, 1100 lbs at the Tow-Plane end and 900 lbs at the Glider end - these links use metal shear pins, one under load and a second unloaded, which takes over if the first one fails. This eliminates failure due to fatigue and means that the links always fail at close to their nominal load even after some time in service - again laboratory tested, not just subjective opinion. Rope length was around 180 feet in all cases.

I was the Glider Pilot on all the tests, Tow-Plane Pilot was Verdun Luck (then my deputy Chief Instructor) for the first series of tests and Brian Spreckley (then Manager of Booker GC) for the second. The object of the tests was to try to reproduce the 'Kiting' under controlled circumstances, with a view to developing a Tow-Plane release mechanism that would automatically release the glider if it got dangerously high above the Tow-Plane. All tests were conducted at about 4000 feet agl.

First test: Terrier Tow-Plane and ASK 13 on nose-hook. At about 4000 feet I took the glider progressively higher above the tow-plane, eventually reached about 100 feet above tow-plane (i.e. rope angle more than 45 degrees above horizontal). At about this point, the tow pilot, who had been using progressively more back stick, ran out of back stick and the Tow-Plane began to pitch nose down but not excessively violently. I released at that point. It took a very positive control input on my part to achieve the displacement, we both felt it was something unlikely to occur accidentally, even with an inexperienced glider pilot, and there was plenty of time for either party to release if it did occur.

Second test: Terrier Tow-Plane and ASK 13 on C of G hook. I pitched the glider about 25 - 30 degrees nose up - the weak link broke immediately! Tow pilot reported a sharp jerk, but no significant change to flight path.

Third test: Terrier Tow-Plane, K 8b on C of G hook. I pitched the glider about 25 degrees nose up. The glider continued to pitch up fairly rapidly (as at the start of a winch launch) and substantial forward movement of the stick only slightly slowed the rate of pitch. The glider achieved about 45 degrees nose up, speed increased rapidly from 55 knots to about 75 knots and the glider was pulled back towards level flight (again as at the top of a winch launch). I released at that point. The entire sequence of events occupied a VERY short period of time (subsequently measured as 2 - 3 seconds). The Tow Pilot reported a marked deceleration and start of pitching down which he attempted to contain by moving the stick back, this was followed immediately by a very rapid pitch down accompanied by significant negative  $G$ . "The tow-plane finished up about 70 degrees nose down and took about 400 feet to recover to level flight. We both found the experience alarming, even undertaken deliberately at 4000 feet. Our conclusion was that the combination of the initial pitch down and the upward deflection of the elevator caused the horizontal stabilizer/elevator combination to stall and the abrupt removal of the down-force it provided caused the subsequent very rapid pitch-down and negative  $G$ ."

**Our first conclusion was that, in the event of this sequence occurring accidentally as a result of an inadvertent pitch up by the glider pilot, there was effectively no chance that either the glider pilot or tow-pilot would recognise the problem and pull the release in the available time.**

- Attempts to produce a tow-plane hook that would release automatically were unsuccessful for reasons that became apparent later.

- These tests were repeated a few years later with a PA18 -180 as the tow-plane, Brian Spreckley flying it. The third test described above was repeated and photographed from a chase plane using a 35 mm motor drive camera on automatic (this took a frame every half second - video camcorders of small size were not readily available then). The photo sequence started with the glider in a slightly low normal tow position and starting to pitch up, the second frame has the glider about 30 degrees nose up and about 20 feet higher than previously in the third frame it is about 45 degrees nose up and has gained another 30 feet or so, the tow-plane is already starting to pitch down, in the fourth frame the glider is about 100 feet higher than its original position and the climb is starting to shallow, the tow-plane is about 50 degrees nose down, the final frame shows the tow-plane about 70 degrees nose down and the glider almost back in level flight, almost directly above it (that was about the point that I pulled the release).

- **Sufficiently alarmed by events, Brian Spreckley had been trying to pull the release in the tow-plane earlier and found that it would not operate until my releasing at the glider end removed the tension from the rope. Subsequent tests on the ground showed that the Schweitzer hook fitted to the tow-plane, whilst perfectly satisfactory under normal loads, was jammed solid by the frictional loads when subject to a pull of around 700 lbs with a slight upwards component - not something that a normal pre-flight check would reveal.**

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We solved that problem on our tow-planes by replacing the bolt that the hook latches onto with a small roller bearing. So far as I know, no one has tested the Schweitzer hook as fitted to a glider, but I would not be surprised if it exhibited the same characteristics at high loads.

- The photo sequence also showed that at no time was the glider at an angle greater than 30 degrees above the tow-plane's centre-line. However, of course once the glider has pitched up, considerable extra lift is generated by the wings and that extra lift provides extra load on the rope. With a large, heavy glider it is easy to exceed weak link breaking strains and with a light-weight machine the tension can easily rise to 700 lbs or so. With that much load on the rope, quite a small upward angle provides enough of a vertical component to produce the results described.

- That of course is the reason that attempts to produce a hook that released if an certain angle was exceeded were unsuccessful. The quite small angle needed to trigger the Kiting when the glider is pitched significantly nose-up is not much greater than the amount of out of position commonly experienced in turbulent conditions. We did build an experimental hook and tried it, but, set to an angle that prevented Kiting it occasionally dumped an innocent glider in turbulence, and set to an angle that prevented that, it didn't prevent the Kiting. "What was needed was a hook that responded to the vertical component of the load, not the angle at which it was applied, and that problem we decided was beyond us (at least in a form robust and fool-proof enough to be attached to the rear end of a tow-plane).

- Our conclusions for preventing Kiting were:

- **Don't aerotow gliders, especially lightweight, low wing-loading gliders on C of G hooks intended for winch launching** (I think the JAR 22 requirement for nose hooks to be fitted to new gliders for aerotowing was at least in part a result of these tests). I didn't do any experiments with the 2-33 along those lines, so I'm not sure how to categorise its hook position nor could I predict how well it would Kite. If you feel tempted to experiment, bear in mind that you are effectively going to wind up doing a winch launch at way above the maximum winch launch speed, and most of the 2-33's around are very old and tired.

- **Don't use short ropes.** The speed at which things happen varies directly with the length of the rope.

- **Don't let inexperienced pilots fly at anywhere near aft C of G.**

- **Don't let inexperienced pilots fly solo in turbulent conditions.**

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