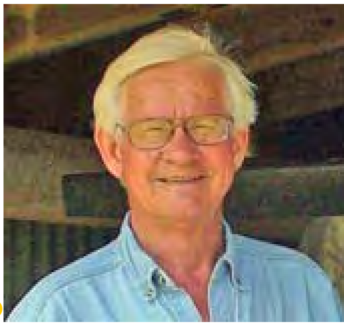

From The Tech Desk: THOSE SQUIRRELLY TAILDRAGGERS

Jack Dueck is the founding President of Chapter 1410 and he holds a CPL with multi-engine and IFR endorsements. He has restored an Aeronca 11AC, a Luscombe 8C/E, and built an RV-4.

He is the Editor of the on-line EAA newsletter "Bits and Pieces" and sits on the EAA Homebuilder's Council and the EAA Canadian Homebuilders Council.

On May 5, 1995, having restored a Luscombe 8C, I set up to do some taxi tests before the first flight. After a bit of slow speed maneuvering, I lined up on the button of runway 16L in Whitehorse, smoothly applied power and controlling the aircraft allowed the tail to lift of the ground in a perfectly normal and expected manner. I certainly didn't want to get airborne, and I cut the power well before reaching lift-off speed. Wow! This aircraft became a tiger! It cut to the left. The left gear left the ground. The right wing came down and scraped the ground, and only with the application of brutal right brake did I manage to prevent that famous instantaneous 360 degree view of the horizon or ground loop.

Nothing like a little excitement to focus one's attention on a specific issue! I subsequently found a substantial toe-in on the Luscombe's right gear, and when corrected, the airplane became the gentle flying machine that so many of us have enjoyed over our flying careers.

I wrote about this incident and it was published as an article in EAA's Flight Advisor publication that fall. As a result of that article I received a letter from Marv Hoppenworth of Cedar Rapids, Iowa, and that's where this story begins.

You may not know Marv, but you know of his delightful "Home of the Originals" pedal driven little airplanes that you may have seen at Oshkosh, and many of us have built for our children and/or grandchildren. Marv asked me to send him a copy of my Luscombe newsletter that actually recommended toe-out for tail-draggers. He had served as an aircraft mechanic in the Army 741 Div. Air Section in Korea, where he found that rigging the Army's air-spotter tail-draggers with a couple of degrees of toe-out made them easier to handle during the transition between flight and touch-down with the reduction in rudder authority when power was reduced.

If this piece saves just one amateur-built light plane, or any plane, from grinding a wing upon landing, I will feel my effort has been justified!

In December of 2004, I received a letter from Marv, together with an article that he had published in 'Light Plane World", back in 1986. Marv's article covers this so well, that with his permission, I am including it in this column.

As a sidebar, in conversation with Marv, he mentions that the Cessna 180 Maintenance Manual recommends a 1/16" toe-in. This is however, with the empty aircraft sitting on its gear in a hanger. Marv points out that with the additional weight of people, fuel, and baggage, the gear geometry is such that this toe-in effectively disappears to a neutral or slight toe-out condition in actual conditions.

If your homebuilt tail-dragger seems to be more squirrelly than it should, check your toe-in/toe-out condition. This may be the problem.

LANDING GEAR – TOE IN, TOE OUT?

By Marv Hoppenworth, originally published in 'Light Plane World", 1986

Several times when landing gears for small, amateur-built aircraft were being welded up, fellows who gathered to watch the fun have come out with this question:

"In welding up the landing gear for a conventional aircraft, should the wheels be given toe-in or toe-out? Automobiles have toe-in, so why not airplanes?"

Every time I heard it, I felt chills run up and down my spine — it was hard to imagine a cute little airplane with toe-in deliberately built into its undercarriage! But, odd questions have a way of leading to interesting and profitable avenues of thought. If you will bear with me, and try to follow my reasoning, I will herewith attempt to show that while toe-in definitely should not be used, there is, in fact, a case for the use of toe-out.

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It is assumed that everyone understands what toe-in and toe-out means, but to be sure we're all speaking the same language, toe-in means that the center points of the wheels — or more properly, of the tire treads — are closer together in front than at the rear when we look down upon a pair of wheels. If unrestrained by axles, the wheels would move closer together as they moved forward. Toe-out, of course, is the exact opposite.

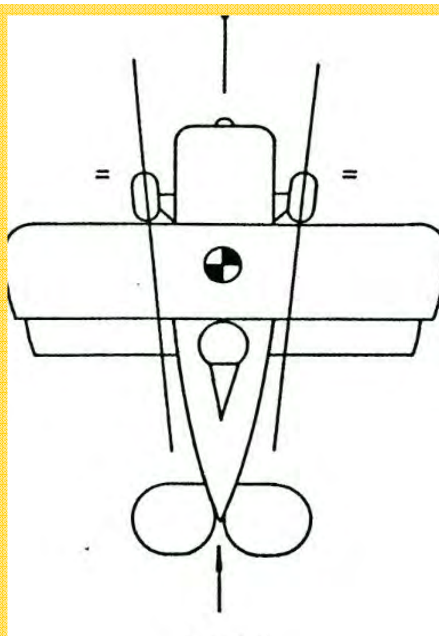

FIGURE 1

My first experience with toe-out was while tinkering with model airplanes. After a nice flight, it was disillusioning to see my rubber powered models complete their landings with ground loops. I built a small scale model for the purpose of experimenting with landing roll control and from it I found that, when the wheels were given about five degrees of toe-out, the landings were straight and happily realistic.

Later models provided yet another lesson. A friend was entered in a flying model event called "Clipper Cargo", in which the model is given the greatest possible load and is allowed to take off with the timer set for a 15 second motor run. The object was to try to make the model remain aloft for 40 seconds. Under the rules, the take off run could last as much as six or eight seconds. In that amount of time we found a model could wander off into a take off ground loop. Seeking to help my friend over-come this problem, I told him about my experience with toe-out. He tried it — and came back from the next contest carrying the trophy for first place.

Somewhat unintentionally, I next had experience with toe-in on an actual aircraft. A J-3 Cub had been used for a season of rough ski flying, and that had evidently bent both axles so they had toe-in.

When the wheels were put back on in the spring, this reputedly docile little airplane acted more like the proverbial "cat on a hot tin roof". Upon landing, it sort of skipped from one wheel to the other on its way down the runway. If the same axle bending had happened on a bigger and faster plane, the resultant ground looping tendency would have been terrific, and I doubt if anyone could have made corrections fast enough to avoid rolling the wings up.

In short, these experiences taught me that toe-in can cause marked instability and that toe-out can, when wisely used, add to stability. I can explain it best with diagrams. Figs. 1, 2 and 3 show typical small biplanes of the kind known to be a little hot to handle on landings. I would point out, first of all, that when an airplane turns or swerves on its landing run, the tire and shock absorber on the outside of the turn compresses and the plane leans to that side. This is because, in the actual airplane, the center of gravity is an appreciable distance above the point of contact between wheels and runway. This, of course, puts a greater percentage of the plane's weight onto the outside wheel. In Fig. 1 the plane is rolling straight and there is equal weight and therefore equal friction on each tire.

But as soon as there is a swerve, however slight it may be, the plane's momentum is great enough to work on the high CG and create a leaning force as indicated by the arrows on the CG marks in Figs. 2 and 3. Also note the plus and minus signs, denoting increase and decrease of the tire-to-runway pressure. The wheel with the most weight on it must obviously have the most effect upon the direction in which the plane will go.

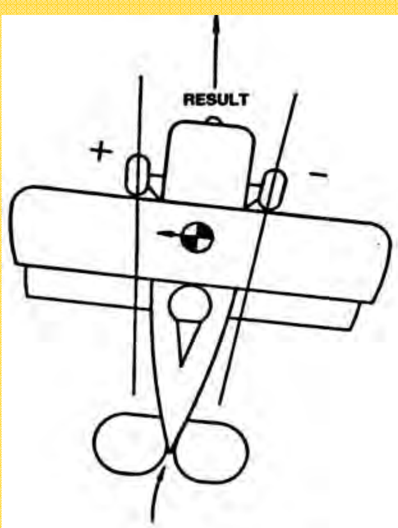

FIGURE 2

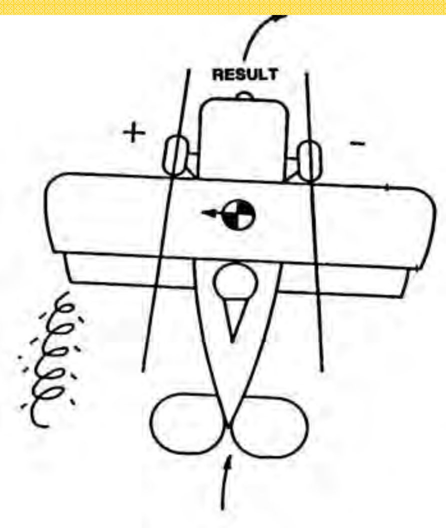

FIGURE 3

With toe-out, Fig. 2, the airplane is caused to move in such a direction that the tendency is to minimize the centrifugal force applied to the

LANDING GEAR – TOE IN, TOE OUT? *(Continued from previous page)*

CG by a swerve, and the reason is that the left hand wheel has the greater load and pulls away from the incipient swerve to the right. The tendency for this layout is to pull the plane back to a straight, stable course.

But when there is toe-in, Fig. 3, the effect of greater weight on the outboard wheel is to make the swerve become tighter. Even where there is no swerve, it is possible down on one wheel first, rather than on both at the same instant to touch. If the plane in Fig. 3 touched down on its left wheel first, that wheel would immediately impart a force tending to drift the ship to the right. The high CG would then go right to work to make the ship lean to the left, further increasing pressure on the left wheel. The forces triggered by landing on one wheel can amplify so quickly that it would be a lucky and highly skilled pilot that was able to stop it quickly enough to prevent a bad ground loop.

With toe-out, corrective force for small tendencies to swerve are automatically fed into the force system as soon as they appear, and the corrective effort tends to amplify itself such as to give the pilot time to make appropriate control movements. In swift, jumpy little airplanes, even a fraction of a second leeway can make the difference between an uneventful landing and a severe ground loop.

In the accompanying sketches, the amount of toe-out has been exaggerated for clarity. My suggestion for practical application of the toe-in, toe-out lessons imparted by this article is to check and double check the completed, installed landing gear on your airplane to make sure there is no treacherous toe-in. It would do no harm to put in a little toe-out. About one or two degrees out to represent a good compromise, for too much toe-out would, in spite of affording a very stable landing roll, introduce the disadvantages of excess tire wear and slight drag on the take off run.

If this piece saves just one amateur-built light plane, or any plane, from grinding a wing upon landing, I will feel my effort has been justified!