GROUND LOOP PREVENTION, A CAUTIONARY TALE

by Paul M. Redlich

Part 1

When T-6 pilots get together discussions of ground loop accidents inevitably become the hot topic, and all Texan pilots can agree the ground loop is a constant threat. But, why?

During WWII the military was training kids to fly the T-6, some of whom didn't even have a driver's license and whose biggest machinery operating experience was tractoring on dad's Farm-All. Now granted the military wrecked lots of T-6's which they were willing to accept in the name of production line flight training, and the majority of those kids made it successfully through Advanced without ground looping and went on to fly fighters. In today's Warbird world most of our T-6 pilots did not benefit from the tail wheel oriented training that was the norm in military and civilian flying in the 1940's, 50's, and 60's. What newer generations of pilots are left with is the mystique and myth that has grown around the T-6 as told in often-repeated hangar flying sessions. Namely that the Texan is one ground looping SOB. In my opinion this ego-driven (Look at me, I'm a REAL pilot cuz I can handle this beast) chest pounding has enshrined the T-6 with the reputation of a man-eater, when in fact ANYONE with proper training and experience can learn to safely handle the T-6 in the air and on the ground.

Nonetheless T-6's do ground loop and planes do get damaged. In an effort to understand how this happens we need to look at the physical characteristics of conventional landing gear (tail wheel) aircraft. Obviously training plays a huge part in any pilot's ability to handle a conventional landing gear plane during landing and rollout, but what are we training for? The short answer is we are training to keep the airplane from swerving off the runway. Having said that, the question becomes why does it want to swerve off the runway in the first place?

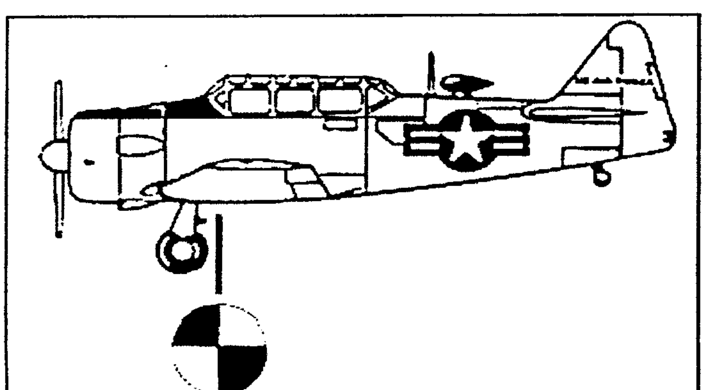

fig 1. T-6 center of gravity is located behind the main wheels

Aircraft designers, looking for maximum take-off performance, ground clearance for large diameter propellers, and an attitude that allows landing at the slowest possible speed, all naturally gravitated to the tail low, steering-wheel-in-the-back configuration. Aircraft so designed were "tail draggers", the term "conventional" didn't come about until the nose wheel or "tricycle" landing gear became common. In order for an aircraft to rest with its tail wheel on the ground it's center of gravity (or the point at which the entire mass of the aircraft is centered) must be placed behind the main wheels. (See Figure 1) This simple fact of locating the aircraft center of gravity BEHIND the main wheels breeds all forms of misbehavior into tail wheel aircraft as it makes them DIRECTIONALLY UNSTABLE.

Consider a wheel landing with a right cross wind. During a moment of inattention you allow your T-6 to touch down while drifting to the left, although the nose is pointing down the runway. When the main wheels contact the ground they arrest the sideways drift, immediately the nose swerves sharply to the right, and the beginnings of a ground loop are created.

What causes the nose to swerve after the main wheels contact the runway? It's simply the mass of the plane powered by inertia from the sideways drift acting at the center of gravity located behind the main wheels.

When the main wheels contact the runway they stop all sideways drift but the mass of the plane (all 2 1/2 tons of it) wants to continue the sideways track (remember- "a body in motion tends to stay in motion"? That's inertia). This continued sideways

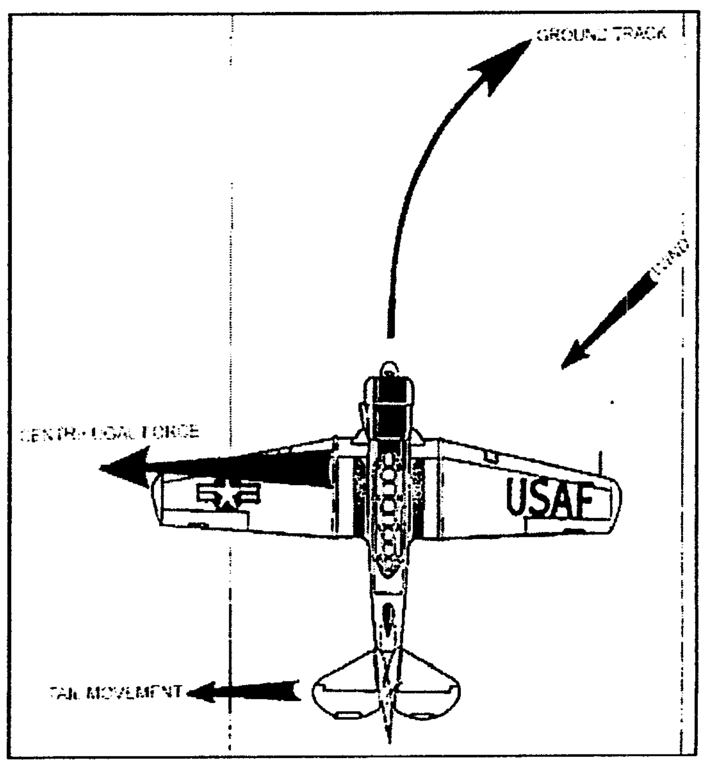

fig 2. Centrifugal force acting behind the main wheels plus the tail to the left, swerving the nose to the right when the plane hits the runway drifting left

motion concentrated at the center of gravity is resisted by the main wheels. Since the main wheels cannot be pushed sideways the inertial mass of the plane forces the tail to the left and thus swings the nose around in a swerve to the right. (See Figure 2).

This swerve would in itself not be particularly bad but for an evil character lurking in the background- CENTRIFUGAL FORCE. Centrifugal force is the same force felt when swinging a weight on the end of a string. When any conventional gear aircraft swerves the center of gravity moves in a circular path around the main gear, just like the weight on a string swinging around a central pivot point.

As the inertia induced swerve begins to move the mass of the plane in a circular path around the main landing gear centrifugal force increases in strength applying an even greater force to pull the tail further around causing the swerve to increase in intensity.

[Going back to the weight on a string- the faster the weight is moved about its circular path the greater the centrifugal force. In fact centrifugal force is so evil it's not happy to increase a reasonable amount with changes in velocity, it wants to increase with the square of the speed (Cf=velocity2)]

In our landing scenario hitting the runway with cross wind drift sets up an initial swerve to the right. With this initial swerve comes an exponential increase in centrifugal force, which pulls the tail around faster, tightening the turn, which again increases centrifugal force, which further tightens the turn, and so on until a full-blown ground loop develops sending the hapless plane in an ever tightening curved path off the runway to certain ruin. Due to the friction of the main wheels on the ground and the T-6's naturally high center of gravity ground loops rarely develop into a complete spiral. Centrifugal force, because it's acting from a point well above the main wheels, will also cause the plane to heel over to the outside of the turn until a wing contacts the ground or the landing gear collapses. (See Figure 3)

It is important to remember that because conventional landing gear are directionally unstable by design, ANY force which causes the tail to swing will induce a centrifugal force reaction on the mass of the plane, which if left unchecked, will develop into a ground loop. This motive force can come from a cross wind, uneven settling of the main gear struts, rough ground, sloped runways, inadvertent braking, or any number of other causes. As the pilot you are trying with rudder, brake, and tail wheel steering to keep the airplane heading down the runway, not so much to maintain a straight path but rather to keep the center of gravity centered behind you. If the center of gravity is never allowed to venture outside the plane's nose-to tail centerline while rolling down the runway, then centrifugal force cannot unleash its evil power. Rudder, brake, tail wheel steering, and engine thrust are the only tools at our disposal to keep centrifugal force in check.

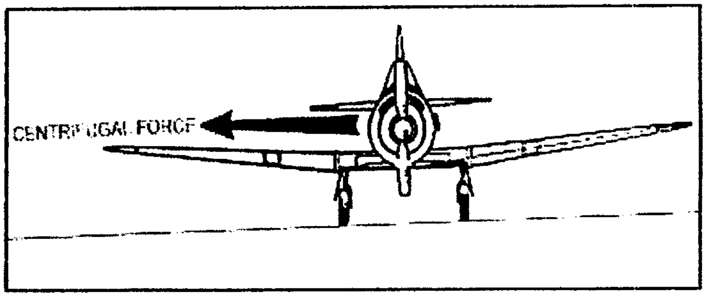

figure 3a. Centrifugal force acting above the main wheels causes the plane to heel over to the outside of the turn

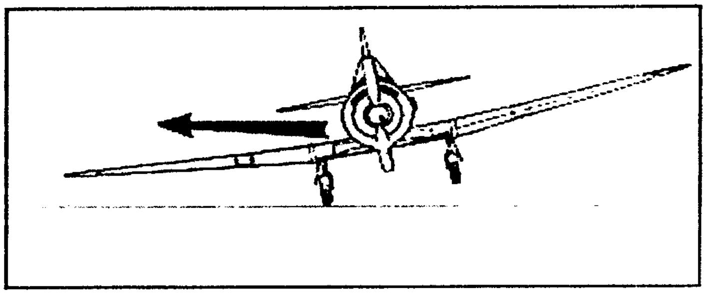

figure 3b. ..with often..

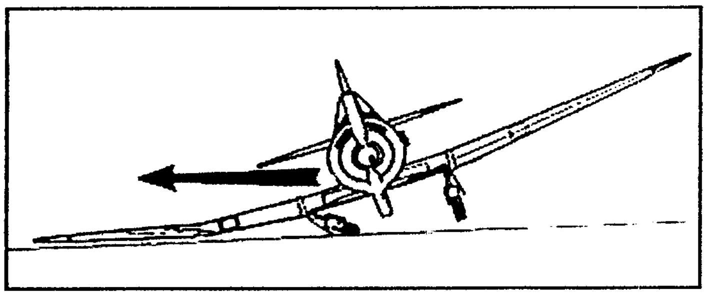

figure 3c. ... disastrous results

FLYING IS A DISCIPLINE

SAFETY IS AN ATTITUDE

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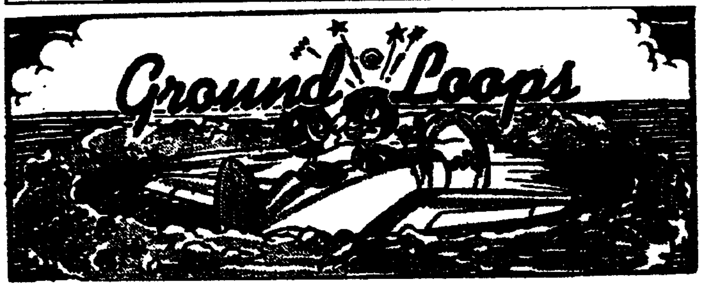

by Paul Redlich

Part two

In part two we talked about the forces working on tail wheel aircraft that cause them to be directionally unstable with a built-in willingness to ground loop. We know our primary goal as T-6 pilots: Lessen the chance of ground looping on landing by keeping the aircraft center of gravity (C/G) in line behind the plane' nose-to-tail axis. Allowing the C/G to swing outside this centerline unleashes the powerful evil of centrifugal force, causing a simple uncorrected swerve to develop into a full blown ground loop.

Rudder, brake, tail wheel steering, engine power, and one I forgot to mention last time (Sorry Rick!), adverse yaw steering, are the only tools we pilots have to fight centrifugal force and its unrelenting desire to wreck our planes. "Do you wheel land or three-point?" is always a hot topic among T-6 pilots. Everyone has their own favorite method and reasons why it works. My preferred method is always to make three-point landings except landings after a formation flight when keeping an eye on the guy ahead is paramount. In polling T-6 drivers about their landing technique wheel landings are by far the popular option. I don't like wheel landings because they deprive the pilot of the most important tool available for directional control, usually when it's needed most. I never like to express an opinion about why something should be done a certain way unless there is some logic to back it up, so here goes... your experiences may lead you to different conclusions.

When T-6 pilots are first checked out they usually have little or no heavy tail wheel flying experience and probably have never flown a plane with such limited forward visibility. The moment of truth in any check-out situation is the landing. The instructor asks for a three-point landing to which the student becomes apprehensive when attempting to judge the flaring attitude with so little a view of the runway ahead and invariably a poor landing results. For the next go-round a wheel landing is requested of our student. With much improved over the nose visibility and a faster touch down speed a better landing is executed and the first seeds of doubt about three-point landings are sown. There is no question if consistently smooth, paint 'em on landings are your goal - don't waste your time with the three-point; but disaster is waiting patiently in the corner for the right set of circumstances and when they occur, ground loops and tears will follow. The Venerable David Fain says (and David I hope you don't mind me quoting your wisdom and experience) and I paraphrase, "Make wheel landings and you're going to lose your plane."

Let's take a look at the typical wheel landing. The pattern is flown in the normal manner with the exception of a slightly higher speed over the numbers. The plane is not allowed to rotate into a nose high attitude prior to touch down but rather is flown into contact with the runway in a nearly level flight attitude. Once contacting the ground forward stick is applied which plants the wheels down and further improves forward visibility. This tail high attitude can be held until airspeed decays and further forward stick travel cannot support the tail, or the tail may be flown down as airspeed decreases by smoothly applying back stick until the tail wheel is on the runway. Sounds peachy don't it? Or do it?

The dynamics of a wheel landing involve controlling the fore-and-aft position of the C/G in an effort to reduce the moment centrifugal force exerts of the mass of the plane. Remember for a plane to be a tail dragger it must have its C/G located behind the main wheels. The further forward the C/G is allowed to move relative to the main wheels the less centrifugal force can be exerted and the more directionally stable the plane becomes. Picture the T-6 rolling along a runway in a slightly tail low attitude with the C/G behind the mains. Now raise the tail and visualize how the C/G moves forward in relation to the mains. Our low time student remembers that after a smooth touch down with a good view over the nose his wheel landing became predictable after an application of forward stick. As the tail came up the plane's desire to swerve and dart around diminished. Directional control was easily managed with applications of rudder and maybe a little brake. No sweat! But it's not over yet, the tail still has to come down and here's when it can all come unglued.

Remember back to your early flying days when in haste you blasted the tail up during a hurried take off only to be greeted with a huge swerve to the left that took a boot full of right rudder and brake to correct? What caused that moment of ill temper from your otherwise content T-6? None other than gyroscopic precession. A gyroscopic precession swerve can occur anytime the rotating mass of the propeller is caused to tilt in any direction. To understand gyroscopic precession we must hearken back to those dusty text book days of yore when we learned that any force applied to a rotating mass reacts on the mass 90 degrees in the direction of rotation. Looking to the swerving take- off experience we see that the rotating propeller disc was forced to rapidly tilt to a more vertical position (i.e. the top of the propeller was caused to move forward). Since the force applied acts 90 degrees in the direction of rotation (which is clockwise when viewed from the pilot's seat) the result was a forward movement of the right side of the rotating propeller disc, causing a sharp swerve to the left. Exactly the same centrifugal force is generated when the tail is lowered to the runway after a wheel landing except that this time the applied force is in a direction to move the top of the rotating propeller disc aft, and the resultant force pulls the plane to the right. The amount of right swerve is directly proportional to the speed of the change of direction of the rotating propeller: the faster the tail comes down the harder the swerve to the right.

There is another force that pulls the plane to the right. Next time you are standing beside the fuselage of your T-6 look at the leading edge of the vertical stabilizer. Notice how far it's offset to the left. That left offset helps reduce the amount of right rudder needed to keep the ball centered when flying at low airspeeds and high power settings. (Incidentally, that's also why you need increasing amounts of left rudder trim to keep the ball centered in cruise as airspeed builds) This right turning effect is present as the plane is slowed and the tail lowered during a wheel landing. Couple those two right turning tendencies with a right cross wind and now you've a recipe for disaster.

Let's go back to our pilot, his check-out long finished, shooting the approach back at the home 'drome with a back seater on their very first ride. A quick low pass to check the sock reveals a gusty cross wind from the right, but no problem for our boy. Now to impress the troops a smooth touch down is a must so a wheel landing is the order of the day. After squeaking it on our intrepid aviator rolls down the runway with increasing forward stick to keep the tail up and small jabs with rudder and brake to keep 'er straight... no sweat, nothing to these cross wind landings! As the runway end draws closer and airspeed decays the stick is brought smoothly back and ... whoa !!... that SOB's heading for the toolies. A panic stab on the rudder fails to straighten out the swerve, so its quick to the brakes, but hell he's going too fast for that, the tire's only skidding. And the next thing you know our boy's off to the races, fighting a rapidly developing ground loop. What happened? As in most aviation accidents it's not just one thing that brings us to grief but a culmination of several factors acting at once. The right turning tendencies of the T-6 coupled with a right cross wind set up to cause a swerve to the right. But why wasn't our pilot able to stop it with techniques he had used successfully in the past?

Lets consider the tools we have to keep the T-6 straight as it rolls down the runway: Rudder, brakes, tail wheel steering, engine thrust and adverse yaw steering. In our accident scenario the plane swerved to the right and the pilot's first instinct was to apply opposite rudder, but in this case it had no effect. As the T-6 rolls out after landing with the flaps partially or fully deflected they create a turbulent down wash of air which flows aft from the flaps toward the empennage effectively blanking a large portion of the lower rudder.

(You can experience for yourself the destabilizing effect flaps have on the yaw axis of the T-6. Next time you're flying in smooth air slow the plane to the middle of the flap extension speed (85-90 KTS) and fully lower the flaps in increments of 10 degrees. Trim for neutral pitch and holding a wings level attitude place your feet on the floor. In a matter of seconds you will feel the plane begin a gentle hunting oscillation, with the nose yawing 5 degrees or so from either side, due to the blanking effect of the extended flaps. Slowly retract the flaps in increments and trim to maintain the same airspeed. Again place your feet on the floor and notice no yawing tendency with flaps up. The amount of instability increases with the amount of flap extension.)

Rudder will work marginally for most directional control situations when flaps are extended giving pilots a false sense of security, but when push comes to shove and a quick application is needed to stop a swerve the rudder's going to let you down. When blanked by the flaps the rudder will not be an effective tool in stopping a fast developing swerve. Some T-6 pilots get around this problem by retracting the flaps on roll out. This will help (although it's an unnecessary distraction when concentration should be on directional control) but even with flaps retracted the rudder is still partially blanked by the center section. Failing rudder the next instinctive reaction is application of brakes. The stock drum brakes on the T-6 have a reputation for being weak, but even weak brakes when applied fully in a panic have enough power to skid the main tires. In an impending ground loop friction from a skidding tire will not stop a T-6 from swerving. When retracing the path of a ground looped T-6 I've almost always seen a black skid mark left from the outside tire as it traced an arced path off the edge of the runway. With rudder and brakes off the team, who's left? Tail wheel steering! Certainly tail wheel steering can save the day. But wait - how can tail wheel steering work if the tail wheel is not on the runway? It can't, and in that lies the hidden trap with all wheel landings. 99 times out of a 100 wheel landings come to a successful conclusion, but that one time when rudder and brakes fail to produce results you need something else to fall back on; something that will give instant and positive control and that something is tail wheel steering. But because the tail is still in the air when landing the single most powerful direction control tool has been thrown away by the pilot making wheel landings. Even a T-6 equipped only with a locking tail wheel is better off with the tailwheel on the ground preventing the tail from turning than having it in the air where it can do no good at all.

Having bad mouthed wheel landings let's have a look at the relative ups and downs of three point landings. I like the challenge of a three point landing. Judging the height of the wheels in the landing flare is the most difficult and satisfying aspect of making a good three point landing. And by good I don't necessarily mean smooth. I figure only about 20% of my three point landings are smooth and only once in a while do I truly lay on a greaser (usually when I'm alone). But I don't care about smoothness, I want control, and the best means of control is keeping the tail in place either with tail wheel steering or with a locked tail wheel firmly planted on the pavement. I feel too many T-6 pilots give up on three point landings because they don't like the fact that often the arrival ends with a bump or a bounce. Lack of confidence in judging the flaring height also drives many from the three point camp. Judging the flare height in a T-6 is just like any other aspect of flying- you are not born knowing it, you can only learn by instruction and repetition. Flaring high, stalling, and dropping a wing before hitting the runway, or flaring late and bouncing are problems with three point landings that can be cured by practice. Learning to accurately judge the flare height shows a greater degree of mastery over the machine. In my years of repairing T-6's I've never fixed one that was damaged from a stall during a three point landing, but I've fixed several ground loops from wheel landings gone bad. Three point landings also mean a lower touch down speed which in turn reduces the amount of centrifugal force acting on the plane when a swerve starts to move the C/G out of the nose to tail centerline. A reduction in centrifugal force makes swerves easier to correct, and of course having the tail wheel on the ground where it belongs reduces the tendency to swerve in the first place.

Of the two remaining directional control tools, adverse yaw steering is the least understood and least used technique for supplementing directional control. As we remember from primary flight adverse yaw is caused by the downward deflected aileron in a banked turn producing more drag than the upward deflected aileron. This increase in drag causes the nose to move in a direction opposite to the direction of turn. This same nose turning tendency can be used on the ground to aid in directional control. Consider a landing with a left cross wind. As the plane rolls out it wants to weathervane into the wind (turn left) and lift the upwind (left) wing. Applying left stick to lower the wing also produces the added benefit of pulling the nose around to the right, resisting the weathervaning into the wind. This technique can also be used in non cross wind landings as a means to control the position of the nose. If a swerve to the right begins applying right stick will allow adverse yaw to pull the nose around to the left as well as helping to keep the right wing down.

Finally, when all other directional control sources have come to naught engine thrust may yet save the day. If the plane is heading off the runway and nothing you do can stop it sometimes the application of full power will apply enough prop wash over the rudder to make it effective plus P-factor will also help straighten things out in a right turn ground loop. If nothing else, provided you don't hit anything or stall on the go-around, full power will get you back in the air and back around to try the whole mess again.

Good luck (no matter how you land) and Fly Safe.

"ITS JUST TOO MUCH"

Tail dragger, I hate your guts! I have experience, license, ratings and such but to make you go straight is driving me nuts. with tires a - screeching and the controls in my clutch, it's give a little rudder - no that's a little too much!

You see, I learned to fly in a tricycle gear with one up front and two back here. She was sleek and clean and easy to stear, but this miserable thing with wires and struts takes a li'l bit of rudder - easy, that's a little too much!

It demands your absolute attention on take - off roll or it'll head toward the Joneses as you pour on the coal. Gotta hang loose, don't overcontrol. This wicked' little plane is just too much! Give'er more rudder - oops that's too much.

With a lotta zigzagging and words obscene, I think I've mastered this slippery machine. In fact, I think I'm going to like this thing! It's not so bad if you have the touch. Just a li'l bit of rudder - easy, not too much.

I relax for a second and out of the corner of my eye I suddenly realize with a gasp and cry that's my own tail that's swinging by! You ground - looping wrench! I hate your guts! Quick, give'er the rudder! Great scott! That's waaay too much!

by Dale Roberts

Stephen L. Gipson writes

I had an interesting introduction to the wily aspects of the SNJ several weeks ago which I would like to share with your readers. On a clear day with a little right quartering wind, I fired up my SN-J4 for a pleasure ride around the patch. I always follow the preflight check list and this day was no exception, although I may have been a little less attentive than usual. At 1600 rpm I depressed the power actuator to check the hydraulic system. The gauge registered 1200 pounds, then I depressed the flap handle and watched as the flaps extended fully. I then fumbled with a map for a second or two, then pulled the flap handle back to the UP position. At that point, the next item on my check list is to exercise the prop. I cycled the prop three times and completed my preflight check. All items fell within normal parameters. I lined up on 18 and slowly opened the throttle. The first thing I noticed was the tail jumped up very early. It occurred to me that the flaps were still extended. A glance down to the indicator panel and confirmed my intuition and I thought to myself, this is not a problem, it is just like a go-around, with which I was well familiar.

As expected I broke ground early and more slowly than usual. I pushed the nose down and continued a straight track building speed slowly. It was here that I made my mistake, no I didn't dump the flaps, at least not intentionally. At about 50 feet I decided to retract the gear to improve my climb. I depressed the power actuator and immediately I realized I was in trouble. The gear and flaps retracted very quickly. The SNJ sank and I pushed the nose to the ground and puckered in ground effect for an eternity. Gradually I developed speed and climbed inches above the trees at the end of the runway that now seemed so much taller than any previous flight.

I reflected on what had gone wrong, then it occurred to me a nefarious set of events had conspired to do me in, or in this case teach me a dear lesson. My power actuator will activate the hydraulic system for about 70 seconds, after which it automatically shuts off. If the engine is running at 1600 rpm, as it is during the test stage, the hydraulic pump is happy to provide 1200 pounds, however at 1000 rpm it is not so effective. After I depressed the power actuator and observed the pressure build up, I watched the flaps go down fully. Next I fumbled with the map for a second while the shut off timer was ticking by, then I pulled the flap handle back to the Up position. I immediately cycled the prop which dropped the rpm to 1000 , where the hydraulic pump performs poorly when cold. Then the timer shut off the pump and there I sat with a UP flap handle and DOWN flaps operating off of a closed hydraulic pump. Once airborne, I realized the flaps were down, but didn't make the connection that the flap handle was in the UP position. When I cycled the actuator to raise the gear, the flaps were immediately activated to the UP position. It was here that my learning curve caught up with my circumstance. Yes, I could have left the gear down, put the flap handle back to the DOWN position or looked at the flap indicator prior to take off. Only the last measure would have kept me out of this precarious situation. I write to report this incident that others might learn. I know I will not forget this scenario. Many thanks for your publication.