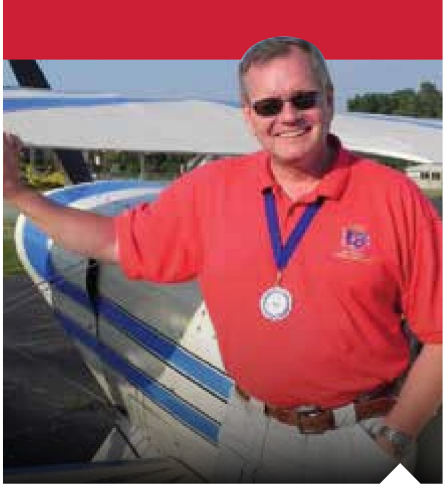

The Immelmann, or the Roll off the Top

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GERMAN WORLD WAR I ace Max Immelmann's wing-warping Fokker Eindecker could not have physically performed the maneuver he is now famous for. It appears Immelmann actually used what we now call chandelles and wingovers to vanquish his enemies during the Fokker Scourge of 1915-16. Many believe that RFC/RAF pilot extraordinaire D'Urban Victor (D.V.) Armstrong, in his all-red Sopwith Camel, was the first. This topic is covered well by author Annette Carson in her 1986 book, *Flight Fantastic: The Illustrated History of Aerobatics*, and her new book, *Camel Pilot Supreme: Captain D. V. Armstrong, DFC*. So, what is an Immelmann today, and how is it flown in the modern age?

The Immelmann maneuver is defined as a vertical half-loop up followed by a half slow roll to upright, with no line between the half-loop up and the half-roll. The British call it the "roll off the top."

It is not a hard maneuver to do, but it incorporates many aerobatic elements, throws the pilot around the cockpit, eats up a lot of energy, and is an easy one to fall out of. It is rewarding when done well.

It is also a great maneuver to put right before a spin. The half-loop up makes up for some of the altitude you are about to lose in the spin, but mostly the Immelmann gets you slowed quickly to spin entry speed.

The biggest problem, especially for those with low-power/high-drag airplanes, is not having enough energy on the top of the half-loop to do the half-roll. If done with too little energy the half-roll can turn into an inverted spin entry. If no spin entry occurs the second problem is the possibility of wallowing and sinking during the half-roll. The third problem is finishing the half-loop early. The fourth is sagging or settling after the roll. The last is finishing off heading to the right from the left roll. Let's begin.

First, let's talk about the sacred circle from Swiss aerobatic champion Eric Mueller and British aerobatic champion Alan Cassidy. It is the circle (or half-circle in this case) that the tip of the nose makes from the pilot's perspective while looking over the nose during the half-roll to upright. Since the pilot's eye line is above the tip of the nose, the tip of the nose is rotating around that eye line. This circle rotates around a point on the horizon while looking 10 miles out straight ahead. You must stay on this point throughout the roll.

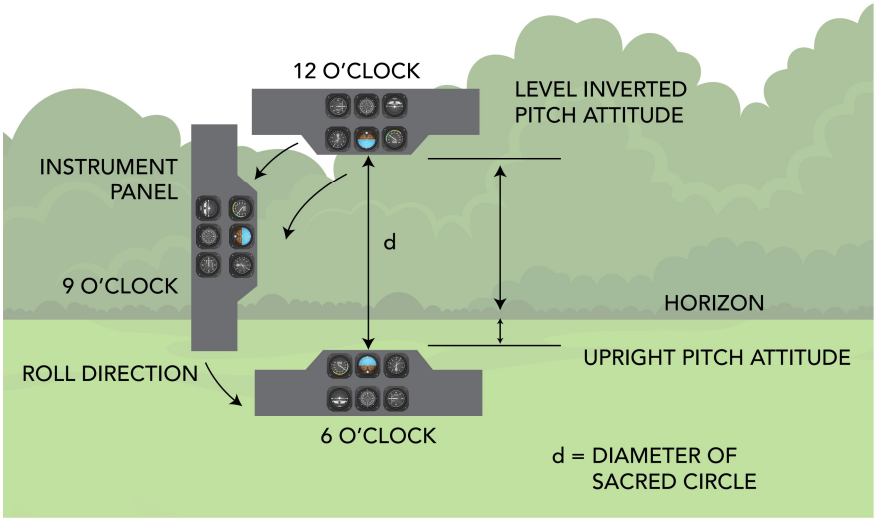
In this article, we are going to roll left, which is easier in an American, or clockwise-turning, engine.

Looking straight ahead, the pilot must imagine an old-fashioned analog clock. When in inverted level flight, the tip of the nose of the aircraft is at the 12 o'clock position on this imaginary clock. As we begin our left roll, the tip of the nose will move counterclockwise from 12 o'clock, down to 9 o'clock when in the knife-edge position (90 degrees of bank), and finish at 6 o'clock in level upright flight. See Figure 1.

To create the sacred circle, first we must define two points — sacred points — straight ahead. One is how low the nose is below the horizon when in level upright flight at the slow speed in which the roll is to be performed. The second point is how high the nose is above the horizon when in inverted level flight at the expected speed.

When we finish the loop up, we are in inverted level flight. We then begin the left roll "whilst drawing an exact circle with the nose that passes through the sacred points (Carson, Mueller, *Flight Unlimited 95*, 1994, page 39). You can see that the size of the circle will vary depending on the speed of the aircraft and the aircraft type.

FIGURE 1



Next is the slow roll itself. Rolls can have different, sometimes confusing names. Each roll also has been called by the name of one of the other rolls throughout history. To add to the confusion, the roll most of us learn in aerobatic competition's Aresti Language as the slow roll is called the aileron roll.

The slow roll used here is not the 1*g*, smooth, *coordinated* ballistic aileron roll that the great Bob Hoover does when pouring iced tea upside down. (See his YouTube video. https://youtu.be/V9pvG_ZSnCc.) In this case, we mean the uncoordinated roll where, if we reduced the aircraft to a dot at the center of gravity, this imaginary CG dot would make a straight horizontal line while the roll is being performed.

To force that dot to make that straight line, we must push to -1*g* while inverted, and then hold "top" or "sky" rudder when in knife-edge flight (90 degrees of bank). The pilot is now falling to the low side of the aircraft. The aircraft is not coordinated until finished. More on this later.

And now for something that is more important to aerobatics than you realize — trim.

As you learn any aerobatic maneuvers, you want to have consistent pressures in the controls at each point in the maneuver. You are developing muscle memory while learning the maneuvers. You must not set the trim differently each flight or set it differently for each maneuver. You need to set the trim exactly the same for every flight and leave it there throughout the flight. But what position should that be?

Alan Cassidy in *Better Aerobatics* says you are trimming for where you spend the most time, which is in high speed level flight in between each maneuver. This keeps the airplane level and on track as you check for traffic, check for entry speed for the next maneuver, or check your sequence card.

In *Flight Unlimited 95* Mueller has you note the trim position for upright flight, then note the trim position for level inverted level flight. Now you set the trim between the two. This is called the zero *g* trim. There are other methods also, but they all approximate zero *g* trim.

It works. This nose-down trim position helps in inverted flight so you don't have to push so much to hold altitude, and helps in high speed upright flight between maneuvers. Another advantage is that the aircraft won't try to pitch toward the pilot's head until reaching trim speed, so your vertical down lines will tend to be straight without having to push.

The Immelmann entry speed, if one is provided for your airplane, must be considered a minimum. More is better, especially if you're new. If an Immelmann speed is not provided, the maneuver must be flown at least 5 to 10 mph faster than the looping speed for your airplane.

The other two good bits of coaching I've received on this maneuver is to not float the top portion (last 30-45 degrees) of the half-loop like you would the top of a regular loop. Also, you must pull another ¼*g* to ½*g* at the beginning than you would for a regular loop. Why?

First and foremost, you must have enough energy at the end of the half-loop up to perform the half slow roll. Starting the looping segment faster for more roll energy at the end makes sense. The counterintuitive part is to pull harder. While pulling harder seems like a drag increaser, and it is to a point, you are making a smaller looping segment. This actually feeds more speed into the top for the roll.

Second, we must not finish early. Finishing early means finishing the half-loop before being overhead the starting point. By pulling an extra ¼*g* to ½*g* at the beginning and not floating the top, you are more likely to penetrate forward while inverted to finish directly above that starting point.

One must not draw a line between the end of the half-loop and the beginning of the half-roll, but the judging criteria requires that there *must* be an end to the half-loop *before* the half-roll is started. The loop and the roll must not be blended. To quote the IAC rulebook, "The (no line) criterion is not meant to imply that one element (roll or loop) must start before the preceding element is completely finished. A brief hesitation between elements (similar to opposite rolls) must not be downgraded."

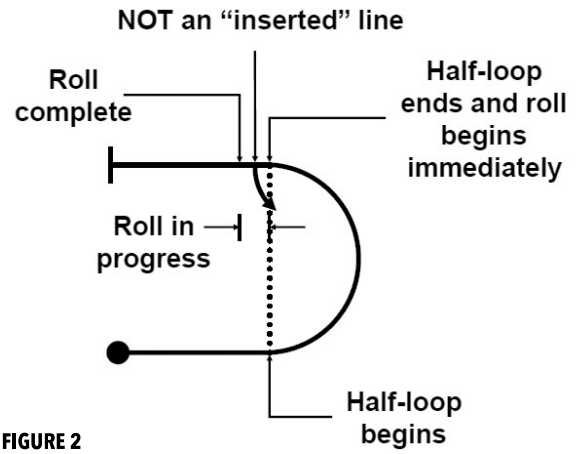


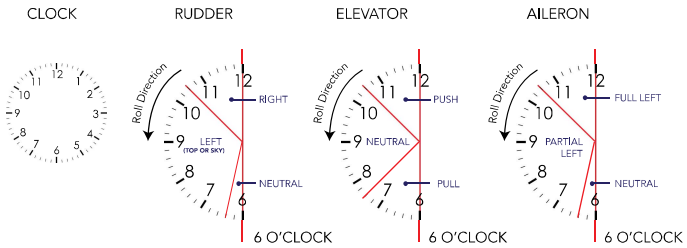
FIGURE 2

One must not draw a line between the end of the half-loop and the beginning of the half-roll.

Newer people tend to finish the Immelmann off heading to the right for a few reasons, one being they aren't coordinated when they start the half-roll. Rudder must be added to overcome aileron drag at roll initiation. If the nose is not yawing left or right as the roll is begun, then the aircraft is coordinated. ***Remember, opposite rudder is coordinated rudder when upside down and holding negative g.***

Hold enough opposite rudder to be coordinated as you initiate the half-roll, and hold it until about 45 degrees of roll have been completed. That means the nose has moved from the 12 o'clock position to about the 10:30 position on the nose clock. Then switch to the "top" or "sky" rudder, which is left rudder. You are now uncoordinated. I tell my students to make it like a dance step: *step* (right rudder)/*switch* (left rudder).

By *step/switch*, I mean that as the stick is moved left to begin left the roll, they must *simultaneously* step on the opposite/right rudder pedal. About a second later, they switch their feet from right rudder to the left/top/sky rudder while continuing to roll left. (Refer to Figure 3.)



Control movements in relation to nose flight path on horizon in left half-roll to upright.

FIGURE 3

Inverted Dutch rolls are a great exercise here to learn inverted coordination while pushing at the same time.

As it says in *Better Aerobatics,* a tiny push toward your feet with the elevator about the same time as the feet are switched (to the "top" or "sky" rudder) will also keep the nose pointed in the right direction as the rolling motion continues. This step will make the tip of the nose draw Mueller and Cassidy's sacred circle around the desired point on the horizon.

Don't push too long. The elevator needs to be at neutral by the time the nose gets to the 9 o'clock/knife-edge position on the sacred circle.

Additionally, once the rudder pedals are switched, the roll rate will increase, which is a downgrade. Ease off the aileron a bit when the rudder pedals are switched so the roll rate stays the same.

Both Cassidy and Sunrise Aviation's Michael Church have an easier, alternate roll portion, mostly for aircraft without inverted fuel and oil systems. It involves stopping the pitching around the loop approximately 30 degrees prior to the top.

From Michael's *Primary Aerobatics*, "Once there, you need to sharply relax all the elevator pressure, *unloading* the wings to zero *g* but not progressing forward into negative. Now, roll briskly ... because you have fully unloaded the wings by reducing angle of attack to zero, the roll will start with no aileron drag (and no rudder)."

As you get close to upright flight at the finish of this roll, back elevator will have to be added, which means adding coordinated rudder.

Make sure to finish with the nose high enough, whether doing the regular slow roll or the alternate zero *g* roll, to hold level flight. No sagging after the roll, please!

I have students hold the steel tube in the Decathlon with their left hand during the roll. This action keeps them from bracing themselves on the rudder pedals and, amazingly, they discover more rudder travel!

I make sure the student can do a half-Cuban-eight before introducing the Immelmann, or roll off the top. Then I have them do the Immelmann with a line between the half-loop up and the half-roll, followed by having them get rid of the line. Building blocks, right?

Fly safe! IAC