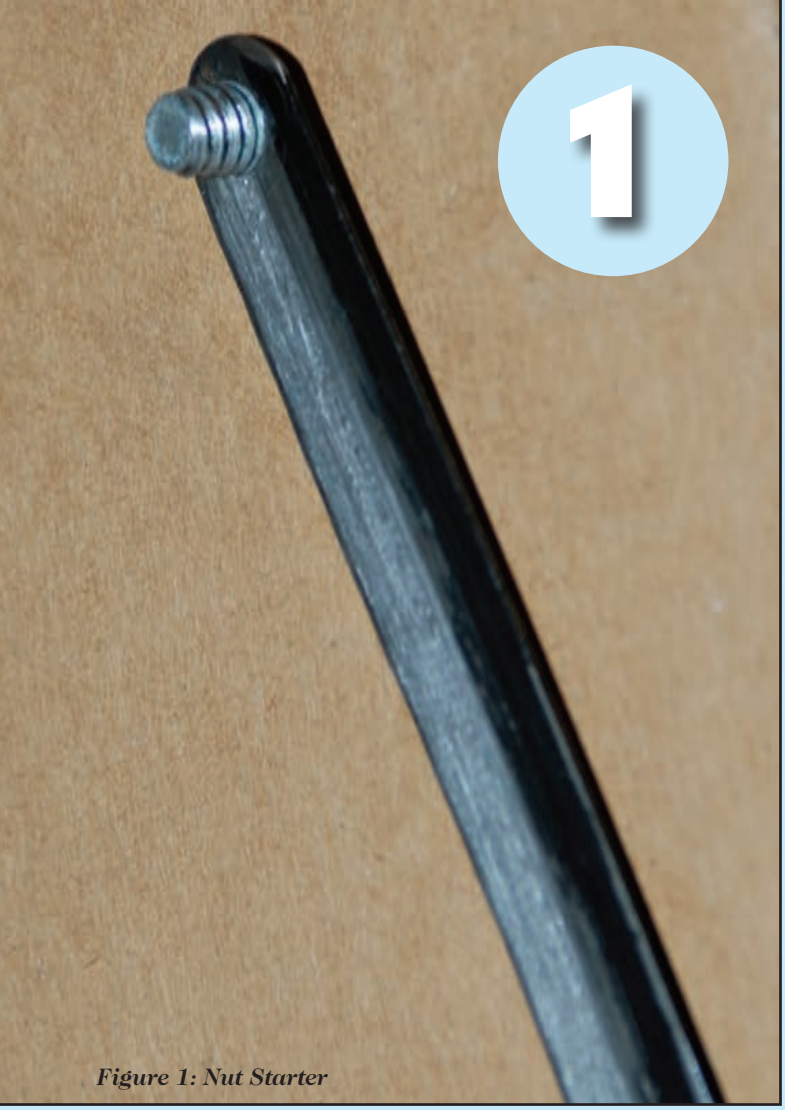

Figure 1: Nut Starter

Figure 2: The nut starter in place.

Figure 3: The nut starter in action.

Figure 4: The special wrench on the lower right nut.

Simplifying Vacuum Pump Installation on a Twin Comanche

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Recently I had to replace a vacuum pump on my Twin Comanche. Before I learned better how to do this, it was a chore I dreaded because of the pump's close proximity to other structures. Its location provides only a very narrow access to the pump's base flange and the four studs on the accessory case, making it very difficult to start the nuts. However, once the nuts are started, tightening the top two nuts on the vacuum pump is fairly easy with an open-end wrench, but tightening the bottom two can be an exercise in frustration. One of those two nuts has been largely tamed by a special vacuum pump wrench; however, the fourth and final nut is definitely the real bottleneck in the repair. To be sure, you could remove the right-hand magneto, a hose or two, and the oil filter to have somewhat better exposure to all four nuts, but in doing so you change a one- or two-hour job, into a wasted afternoon. That method is further complicated because after you have installed the vacuum pump; its very presence impedes the reinstallation of the other parts that you have removed ostensibly to facilitate the repair. Normally I prefer to spend a little more time to save a lot of time and ultimately make a repair easier, but with vacuum pumps, I try to remove as few parts as possible.

To address the initial problem, i.e., getting the nuts started, I came up with an idea for a *nut starter*. About 15 years ago, I took a discarded hacksaw blade and ground off the teeth with a bench grinder. Then I enlarged the hole in one end just enough that it would allow a 5/16-inch coarse threaded bolt to screw into it. I twisted only about 1/4-inch of the bolt through the hole and then I put a nut on it and tightened it down. With an angle grinder, I cut off most of the bolt on the opposite side of the blade until only about 1/16 of an inch was showing. I put it on an anvil with the nut side down and hit the short side of the stud with a hammer, effectively swaging the stud onto the saw blade (see Figure 1).

Putting the new tool to the test, I screwed a fresh nut on the threaded portion and placed it down into that very narrow and nearly inaccessible slot between the vacuum pump and its mounting pedestal (see Figure 2). Then I put the nut up against one of the lower mounting studs, and using a long bladed screwdriver, I started turning the nut until it took purchase on that stud. For a short time, the nut is actually threaded on both the vacuum pump stud and the tool itself; then it leaves the tool and is completely on the stud (see Figure 3). This tool makes starting the nuts on the bottom two studs on the vacuum pump a snap. It turns out that you can easily make a series of these tools and use them in a variety of nooks and crannies that aircraft always have. I make these tools do double duty and put different stud sizes on each end of the hacksaw blade, e.g., a 5/16-inch coarse thread on one end and a 5/16-inch fine thread on the other. Any thin metal strip will work in lieu of a saw blade. Then, as a finishing touch, using either an engraver or some stamping tools, I etch the stud sizes on the nut starter blade.

As an aside, in 2007 a mechanic buddy encouraged me to market the nut starter and some of my other specialty tools. I contacted a tool manufacturer that was very interested in the nut starter, so much so that they did a patent search and made a mockup of a kit with twelve different thread sizes. I had already done an Internet search myself, looking for any tool similar to mine, plus I did my own patent search and found nothing. We were on the eve of starting production of the kits when another friend said that he had seen my nut starter in an online catalog. I was perplexed since I knew this to be impossible. I searched it out and, to be sure, somebody was making a kit almost identical to the one we were planning. Much to our surprise, a patent had been granted to them about a year before. If I learned anything, it is this: don't procrastinate. In addition I found out that patent searches are often very difficult even for the professionals.

Replacing the Pump

Here is how to replace an Airborne or Rapco dry style vacuum pump:

1. First you must prepare the vacuum system to take a replacement pump. This means taking the lines apart and blowing air through them to make sure they are clear of all debris. Don't do any of this with the instruments or the vacuum pump connected to the lines. Often the old rubber hoses will crack and pieces of rubber can break loose and get sucked into the new pump. If you install a replacement pump and it self-destructs early on, and then you send it back to the company, they will not honor the warranty if they find a piece of rubber under one of the vanes. The installation instructions are very specific about cleaning out the vacuum system.
2. This is an ideal time to examine the vacuum regulator garter filter behind the firewall and replace it. You will need to remove the inspection panel on top of the engine nacelle to gain access to it. This is an often neglected, but inexpensive, part that is easy to replace. The filter is Rapco p/n RAB3-5-1. Since you are looking at filters, you might as well check the time on the vacuum system inlet filter in the nose section. If it has been over 500 hours since it was last changed, go ahead and replace it also. It is Rapco p/n RAD9-18-1.
3. Removing the old vacuum pump is only slightly less challenging than putting on the new one. There are two hoses to be removed, one for the intake and the other for exhaust. Inspect those hoses carefully and if they are of indeterminate age or are cracking or brittle, this is a good time to replace them.
4. Remove the tachometer cable from its adaptor to give yourself a bit more exposure.
5. You will need to remove the nuts, flat washers, and lock washers from all four studs that secure the vacuum pump to the accessory case. The top two are readily accessible and easy to remove with conventional tools. The lower two are difficult to reach, and even with removing surrounding parts, you often do not get great exposure. If you think it will help, try removing the oil filter. It is the easiest thing to remove and re-install, but removing other items such as a magneto comes at a greater cost in terms of time expended for benefit gained. The two bottom nuts are usually accessible with a special Rapco vacuum pump wrench, which is available through Aircraft Spruce, and other aircraft tool houses. The bottom right nut is the easier of the two and sometimes the only way you can remove the lower left nut is with a screwdriver and a hammer to break it loose. Although not pretty, this is an accepted method with older mechanics and still persists to this day.
6. Remove both the gasket from the pump base flange and the one from the drive pad pedestal. Carefully clean off all the mounting surfaces where the gaskets were removed.
7. If you are giving up your old vacuum pump for its core value, don't forget to remove the fittings. The new vacuum pump will not have any.
8. Carefully remove the hose adaptor fittings from the old pump. Clean off the fittings and use a small amount of silicone spray lubricant on the threads prior to reinstalling. Screw the fittings in a maximum of one-and-a-half turns and then align them in the proper direction to attach to the hoses. It is permissible to place the pump's base flange into a smooth-jawed vise for this operation, but NEVER put the body of the pump into a vise.
9. Do not use Teflon tape as it can break off and get into the pump. I am told it also will void the warranty if the manufacturer finds it in the vanes.
10. You will need to replace the two fiber gaskets for the vacuum pump accessory case interface. I almost always

replace the Garlock seal around the shaft of the drive pad gear. You should take care to mount this seal properly and not damage it (or the recess in which it resides) in the process of replacing it.

11. Once these gaskets are in place, you can put the vacuum pump back on the studs and start the nuts (after placing the flat and lock washers in place). Here is where I use the nut starter described above. You may need a pencil magnet or a long hemostat to get the washers in place on the studs prior to starting the nuts.

12. As with the removal of these nuts, the top two are fairly easy to get on and tighten. The special Rapco wrench works best on the right lower stud, but you may have to resort to a screwdriver and hammer to tighten the bottom left nut. Don't over-tighten these nuts; 50 inch-lbs is the minimum and 70 inch-lbs is the maximum.

A few years ago, I tried to improve upon the Rapco wrench. I fashioned a slightly different bend in a box-end wrench, welded an extension on it, cut a slot in the box-end just wide enough to allow it to pass over the stud, and made a removable handle to improve the convoluted insertion of the tool into place. While I think my modified tool was slightly more facile on the lower right stud, it did not work any better on the difficult lower left stud than the store-bought tool (see figure 4).

13. Next you re-connect the hoses and adjust the hose clamps. Feel free to change out the hose clamps to an easier type than the ones Piper put on there originally.

14. Start the engine, inspect for oil leaks, and check the vacuum pressure before re-cowling.

15. It is not unheard of during this run-up for the vacuum pressure to have changed when you have replaced the pump, the hoses, and possibly the filters. Now is when you will need to adjust the vacuum regulator valve located on the firewall just behind the vacuum pump.

Although I had been using rebuilt Airborne vacuum pumps, the last time I went to get one, the local aircraft parts house suggested that for a few dollars more I could purchase a new Rapco pump that purportedly employs a more up-to-date technology that will allow small pieces of debris and vane dust buildup to pass through the pump without damaging the mechanism. This new Rapco pump also has an inspection "window" with a kind of micrometer dipstick gauge you can use to measure the amount of wear on the vanes.