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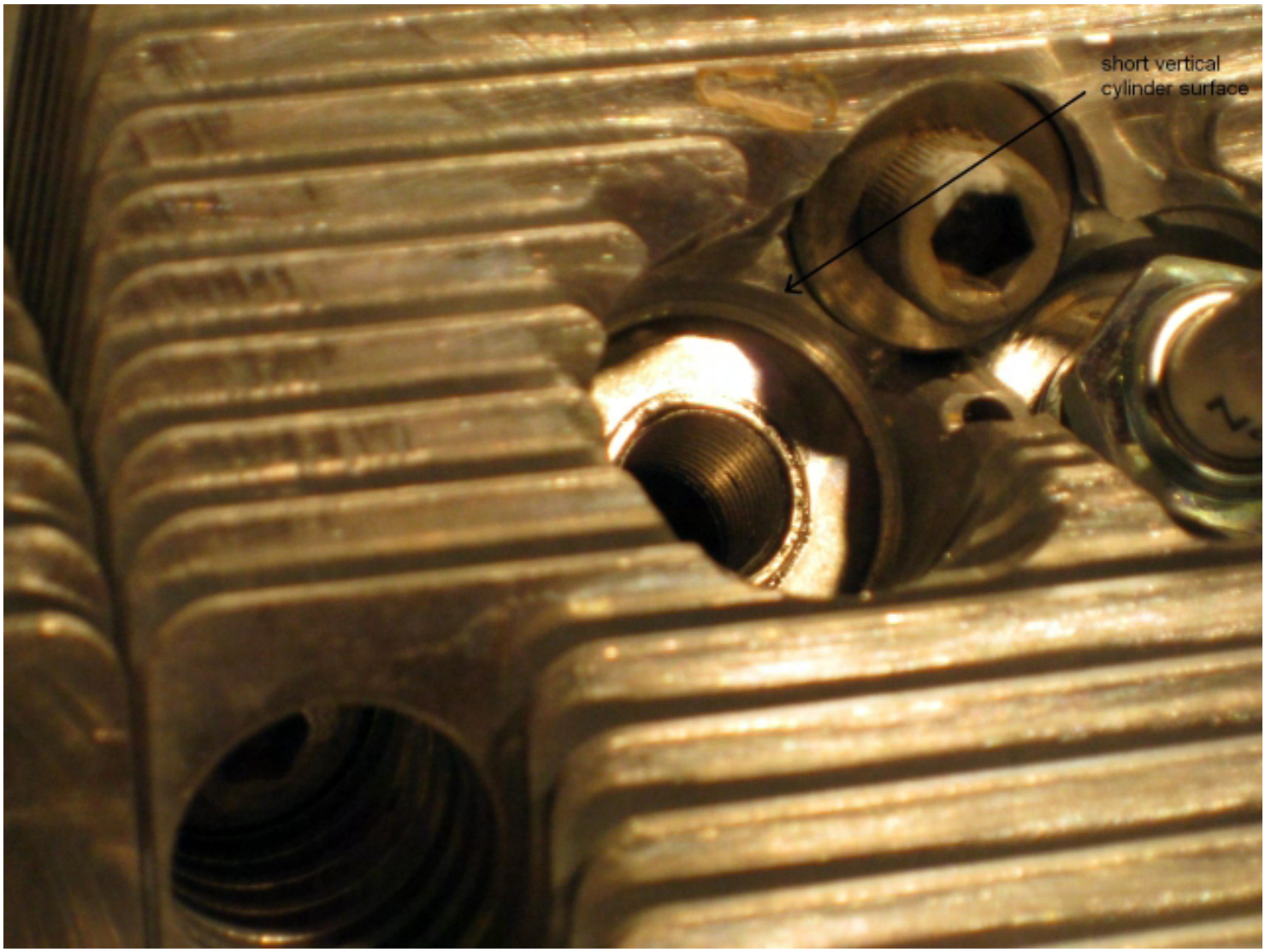
CHT ring sensor installation

The installation of cylinder head temperature (CHT) ring sensors on the Jabiru engine requires removal of metal near the spark plug -- which may be a slightly daunting prospect to some. After all, who would b eager to cut away perfectly good metal from a perfectly good brand new engine? I found that the few pictures and text available from Jabiru and other sources described this process inadequately, at least for me. So I decided to compile detailed closeup photos and descriptions of my installation in the hope it may clarify this for others. For some builders -- perhaps most -- *much of this may be obvious*, and the excessive detail and redundant descriptions *may be tedious*. You've been warned! Nevertheless, I hope some builders who approach this task with trepidation will find this detail is helpful. So let's get started.

In my installation on a hydraulic lifter version of the six cylinder Jabiru 3300, S/N 33A 1014, I used the CHT ring-type sensors that go around the bottom, threaded end of a spark plug. They are made by KS Avionics and sold as part of the engine monitoring components for the Advanced Flight Systems AF3000-series EFIS's. [A document from KS Avionics describing this procedure is available here. Note that it calls for a temperature calibration adjustment for these sensors.] If you have a different sensor, your mileage may vary.

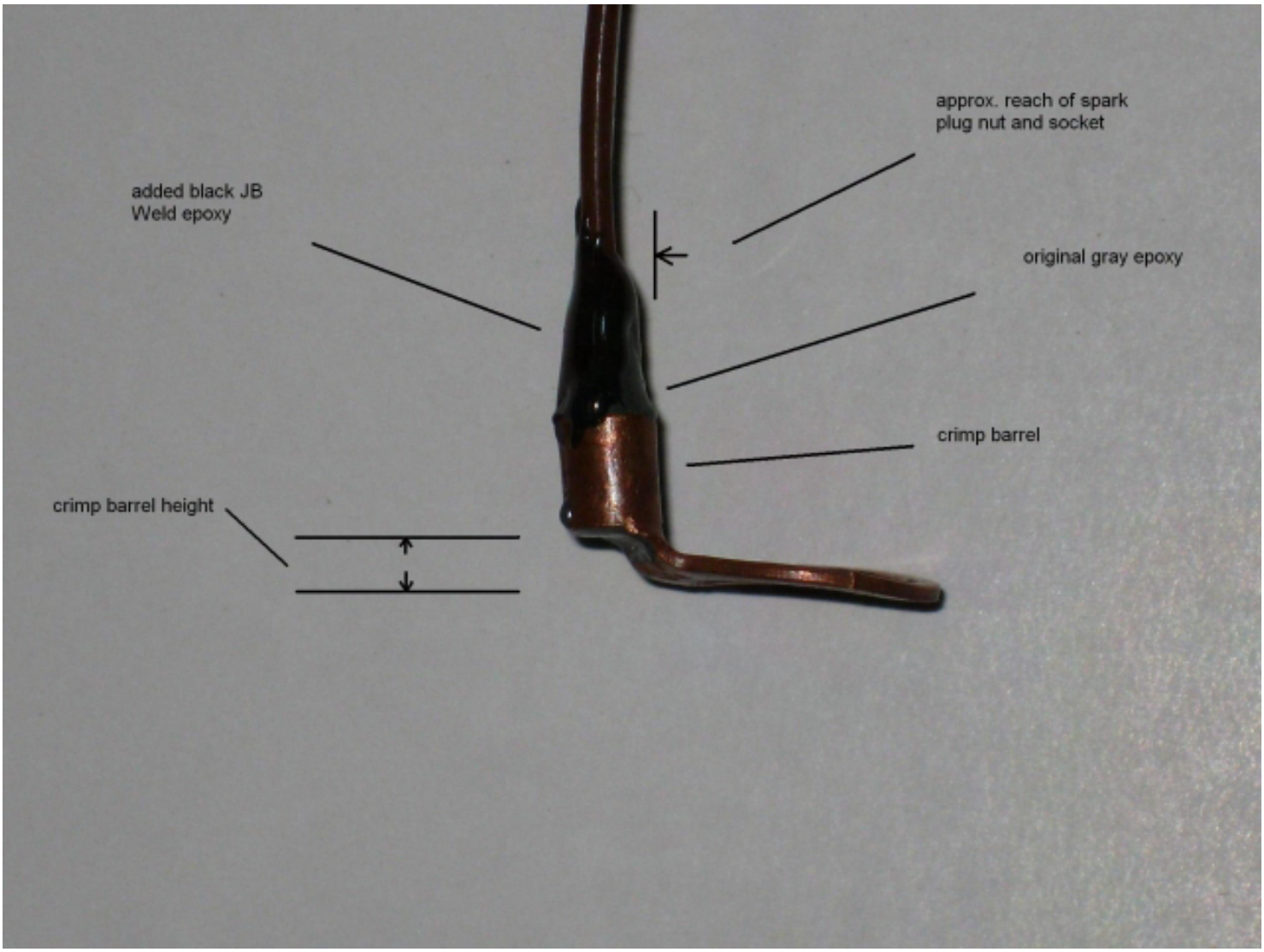
What is the problem? On a new, stock Jabiru engine, there is not enough room next to the spark plug for the sensor to fit, without cutting and grinding away some metal. Some have asked, "Why doesn't Jabiru just modify its design so end users don't have to be machining their beautiful new aluminum engine?" The answers may be complex and/or obscure, but suffice to say A) some owners don't want to install CHT sensors, B) there are several kinds of sensors, with different requirements, and C) it may add some marginal cost. Jabiru may have other reasons. If so, they haven't shared them with me.

The spark plug hole or "well" -- Each cylinder has two spark plugs. For easy routing of the CHT wire to the rear, it's best to install the CHT sensor on the rear spark plug, and it's around the top of that plug that we must remove some metal so the sensor will fit. Let's start with a look at the aft spark plug hole on cylinder #1, with the aft plug removed:



Near the top center, you can see some tan stuff (don't ask) on the cooling fin, at a position approx. 10 o'clock from the cylinder head socket screw. The tan stuff is on the first fin to be modified. Just under the tan stuff, the fin has already been cut away somewhat, but not enough. Just down and left of the tan stuff, about 8 o'clock, you can see another fin with a sort of bulbous end point to the right. Although in some installations you may end up removing a bit of that one as well, for the KS sensors it's not really necessary. All the material will be removed in the area directly below the tan stuff. Next, look at the plug hole threads. Moving from the threads toward 1 o'clock, there is a bright white spot which is the flat face even with the top of the plug threads. The plug's washer contacts this face when the plug is screwed down. Because we don't know any better, we will call this surface the **plug washer seat**.

Continuing up in the 1 o'clock direction, the next thing you see is a band of shadow. At 2 o'clock, the shadow is much wider, caused by the cylinder head socket screw. However, at 1 o'clock from the plug hole the shadow is pretty narrow. That shadow is cast by a vertical surface or face of the plug's cylindrical hole. That cylindrical face is (very) approximately 5/32" high. At 2 o'clock from the plug hole, directly between the plug hole and the socket screw, you can see a shine on this vertical, cylindrical face, which in this photo is actually caused by a back glow reflection from the higher side of the hole opposite the shine. ***The main problem with existing documentation I have seen is that it doesn't really show or describe this short vertical, cylindrical portion of the plug well, and what has to be done to it to fit the CHT sensor.*** Let's take a closeup look at the business end of the sensor to further understand what we need to do:



As we'll see in later photos, this ring sits on top of the plug washer, which you'll recall sits on the **plug washer seat.** We have to create enough room to the side of the plug and the plug nut for the sensor's "crimp barrel" (the copper cylinder at the bottom of the wire.) In particular, the crimp barrel height (see above) is *not quite* high enough to fit over the vertical cylinder portion of the plug well shown in the previous photo. So a portion of the vertical cylinder face -- which is only roughly 5/32" high -- must be removed to allow space for the bottom of the crimp barrel, specifically, space for the "heel" or lower left edge of the crimp barrel as seen in the photo above. The existing documentation for this process that I have seen not only fails to make it clear that a portion of the rising, vertical cylindrical face must be cut or ground away, the documentation doesn't even mention the short, cylinder face around the outer edge of the plug "well" at all. The existing documentation refers to cutting away part of one or more cooling fins -- but nothing about the solid, outer cylinder face of the plug well, which doesn't look like a "fin" in the slightest. If the unwary builder doesn't do anything about this vertical cylindrical face and just screws the plug in, the bottom left edge, or heel, of the crimp barrel will contact the top of the short vertical cylinder and, in short order, the sensor's original, very brittle epoxy will shatter, before the plug washer even gets to the plug washer seat.

The photo above demonstrates the second problem, which is that the sensor's crimp barrel must "lean" outward enough to allow the plug's nut and wrench socket to turn without hitting the crimp barrel. If it does hit the crimp barrel there quickly be a similar bad result -- the original epoxy will separate from the wire and/or shatter. In the photo, I have marked a vertical line labeled "approx. reach of plug nut and socket" to make this as clear as possible. To make the crimp barrel "lean" outward, you must, of course, bend the copper

between the copper ring and the crimp barrel. The bending has to be done carefully, or you will quickly achieve the same, now familiar bad result. To bend the copper, I recommend carefully grasping the copper ring with a small pliers, preferrably one with flat, smooth, non-serrated jaws. I suggest holding the crimp barrel with your fingers, while very carefully doing the bend with the pliers. It doesn't need a lot of bend and of course, you want as little bend as necessary in order to minimize the amoung of metal you're going to have to cut away so the crimp barrel will fit next to the plug.

Finally, the photo above shows how I have added some black, two part **JB Weld** epoxy to the original gray epoxy. (The one in this picture isn't great -- more of the new epoxy should be on the right side.) I did this to add strength, especially at the top, wire exit, and because the JB seems to be just a little bit more flexible when it's cured than the very fragile, brittle original epoxy. Again, you don't want to add more than a smidgen of thickness to the crimp barrel, because it will affect how much metal you'll have to remove.

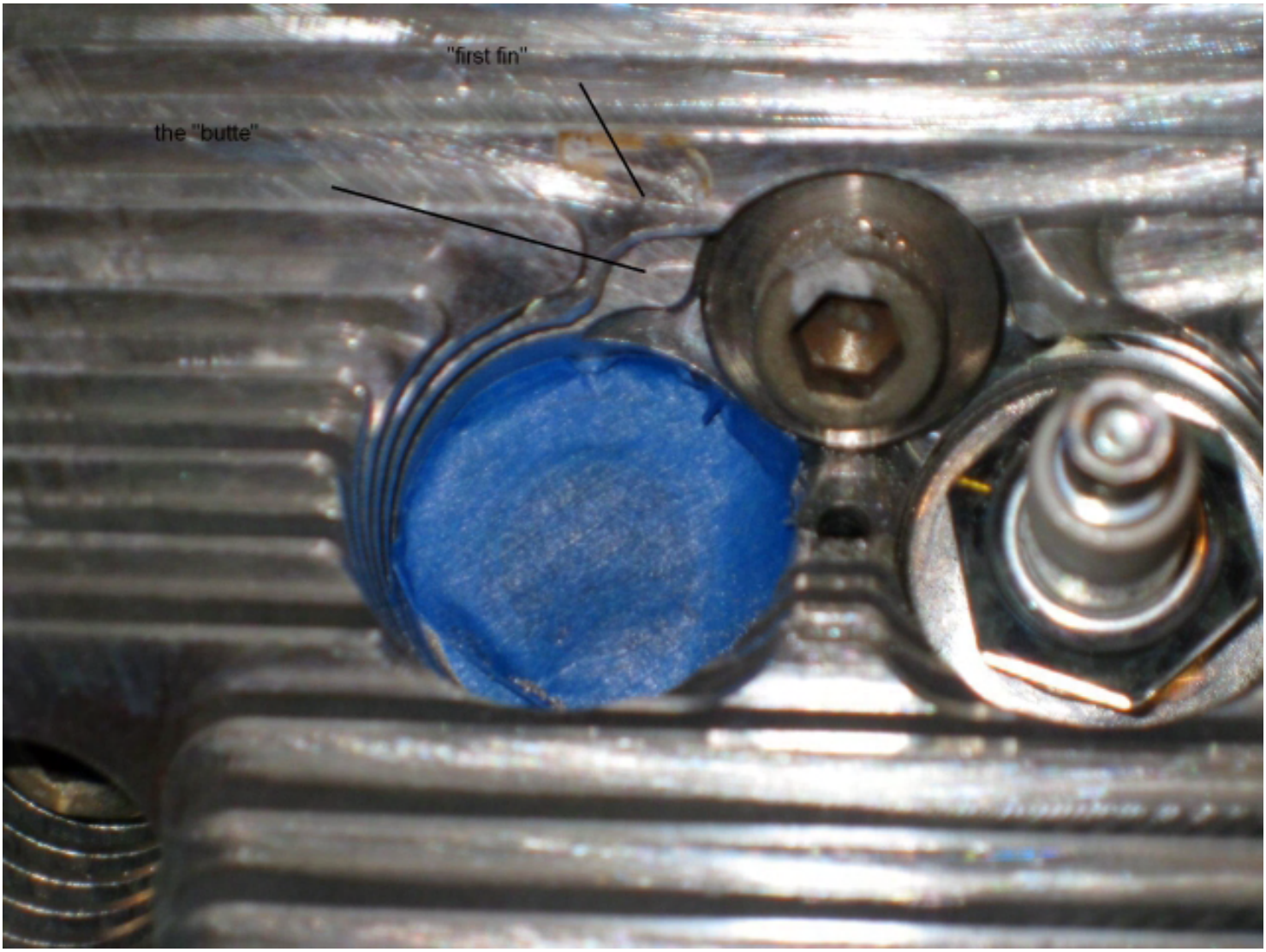
It's time to prepare the hole:

Obviously, we have to keep metal filings from falling into the cylinder, so the hole is covered with tape. (Unlike standard sand colored masking tape, the blue painter's masking tape will not leave residue.) You may need to use a Q-Tip swab to clean oil or whatnot off the plug washer seat first, so the tape will stick. A Q-Tip that is just barely damp with acetone or MEK will do the job. (You don't want to be sending drops of those chemicals down into the cylinder either!)

I cut a circle of tape slightly larger than the plug washer seat, and used a very small flat blade screwdriver to gently tamp it down all around. A non-metallic tool would undoubtedly be better. However you choose to get the tape stuck in position, take care not to scratch the plug washer seat. What isn't shown here is that I also had to gently "tamp" down the tape next to the vertical cylindrical face at about 2 o'clock where we'll be cutting, and we don't want the Dremel tool to dislodge the tape while the tape is covered with metal filings.

Next is a photo of the Dremel tool tip that I used. I think the conical shape is better than the straight-sided cylindrical tip because it allows you to leave a smoother surface at the bottom of the cut, and is more maneuverable in general.

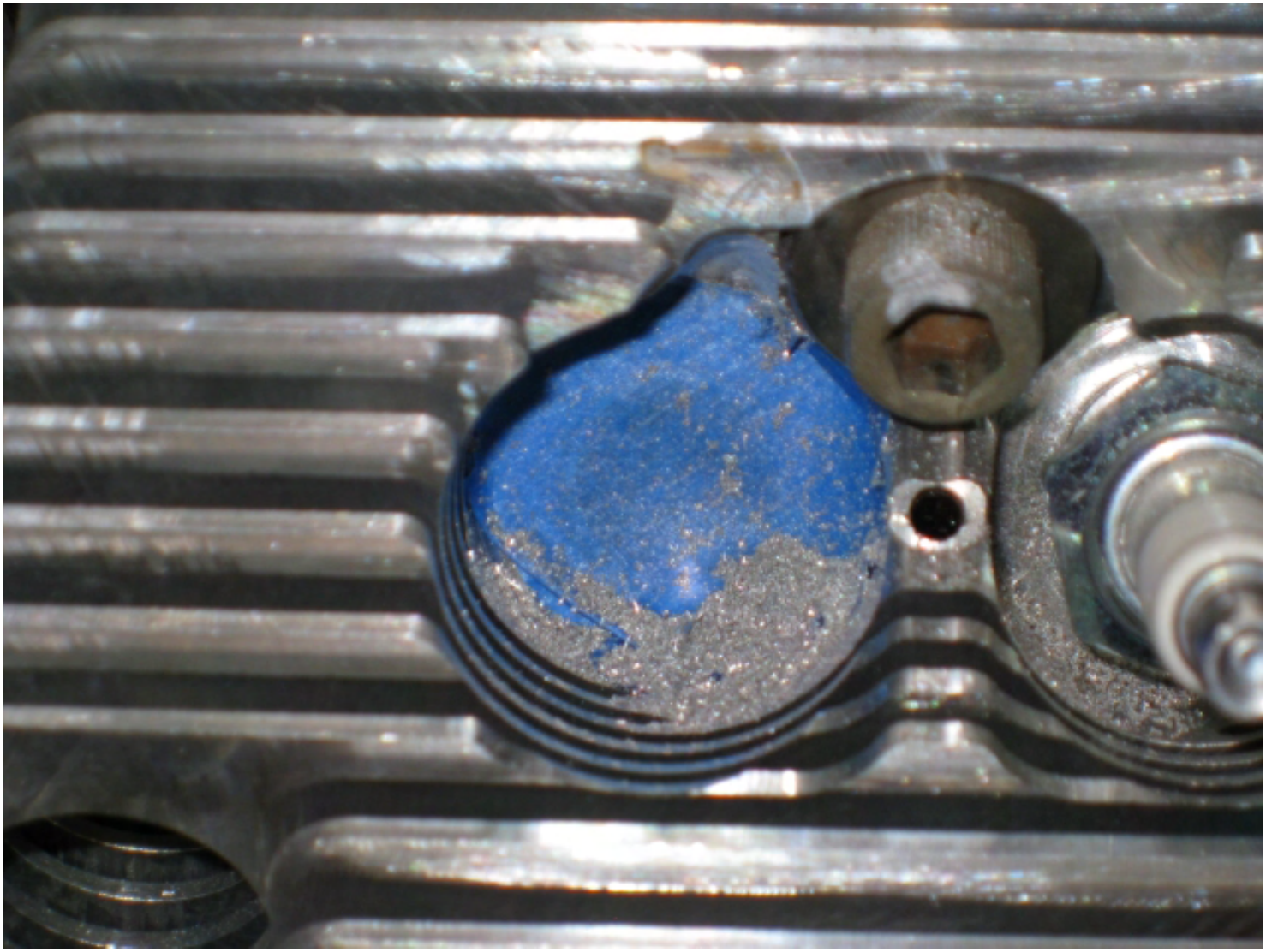
Time to start cutting:



The photo above shows completion of the quarter circle cut in the "first fin". The quarter circle is fairly large. Underneath it you can see what looks like it might be another fin, but is actually a solid, complex shape of metal. It has a small, raised and rounded "point" that points toward 4 o'clock. Think of this as being like a butte in a Western desert landscape. Below this point is a curving "cliff wall" that swoops down toward the vertical cylinder we've been discussing, where the tape here is still up against the vertical cylindrical face -- hasn't been tamped down yet. A good bit of the "butte" ***and its foundation*** are going to be removed. You should have a vacuum (ShopVac or whatever) with a small crevice tool handy to sneak up on the work slowly from the side, not straight on, so you can periodically suck most of the filings out, without also pulling the tape. (In this shot most of the filings from cutting the first fin have already been vacuumed out.) **NOTE:** The careful observer will notice something wrong here. There is a small, dark hole between the taped hole and the second plug on the right, and it's not covered up. ***It should be covered too!*** (If some chips get in there, you can blow it out with a can of compressed air [available at Radio Shack or computer outlets] and the small 1/16" in plastic nozzle tube that comes with it.)

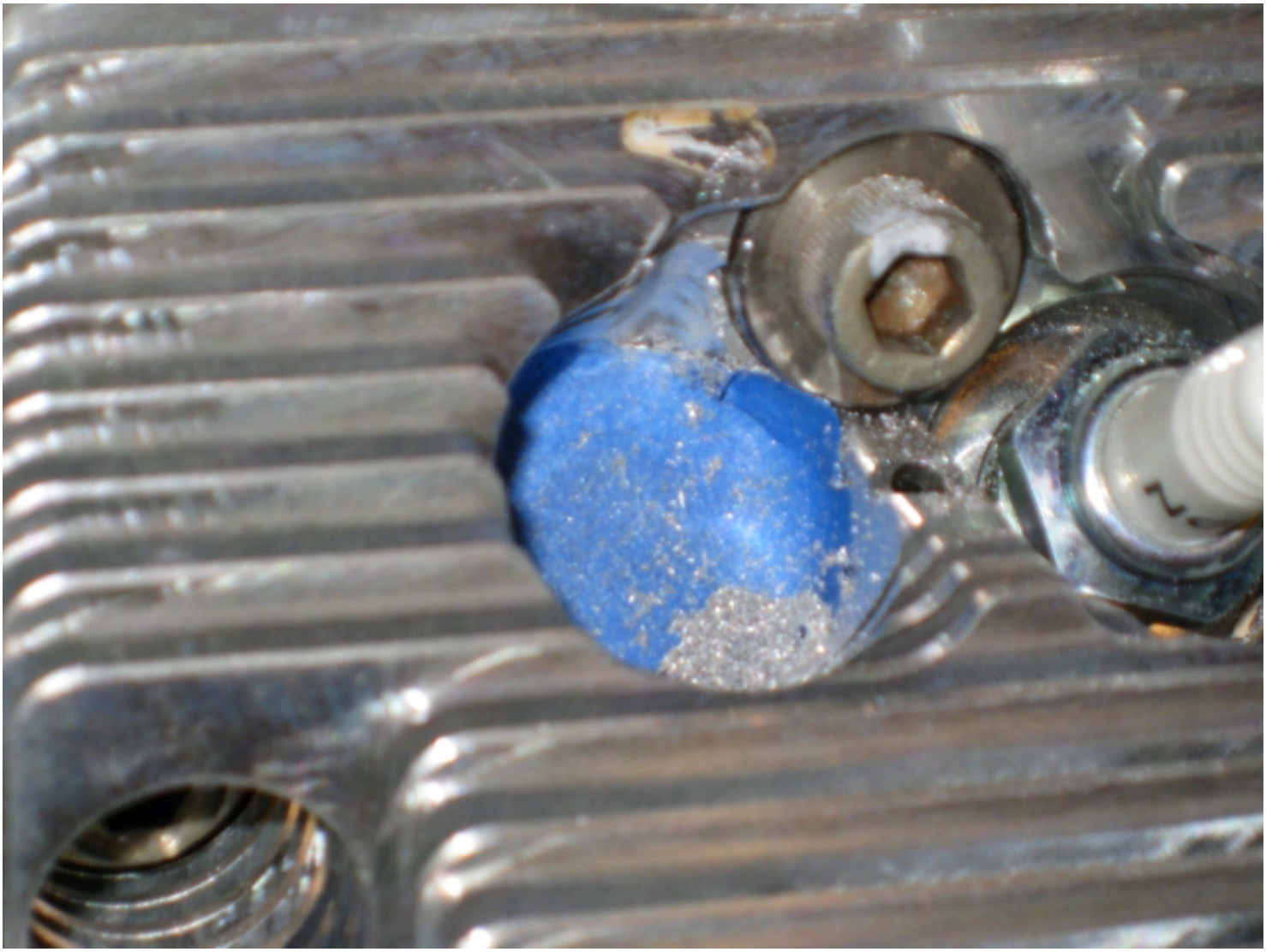
Next, we see that a little more material has been removed, including part of the "cliff" under the "butte":

But... what's shown above isn't yet wide enough or deep enough for the sensor's crimp barrel. so we have to take out more:

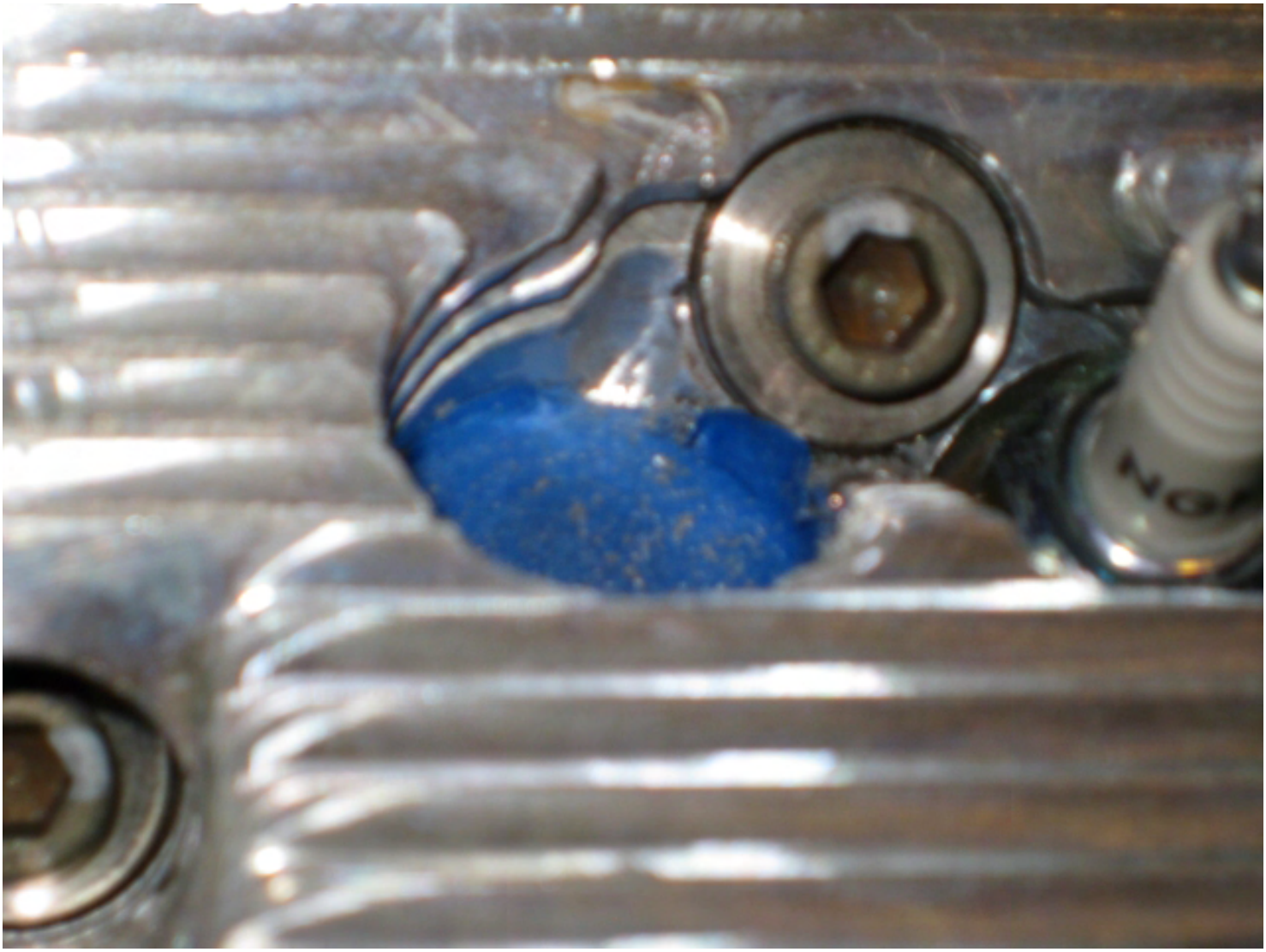


In the photo above, the "butte" is gone and the excavation has begun to go down the side of the vertical, cylindrical wall -- but the tape is still in the way. Gotta get that squished down some more. Again, the small, dark hole between the taped hole and the second plug on the right isn't covered up. It should be.

Here's the next phase, where the vertical cylindrical face or "wall" is pretty much cut away, and the vertical cutting is almost down to the plane of the plug washer seat:



Finally, the cutting is finished, as shown in the next two photos:

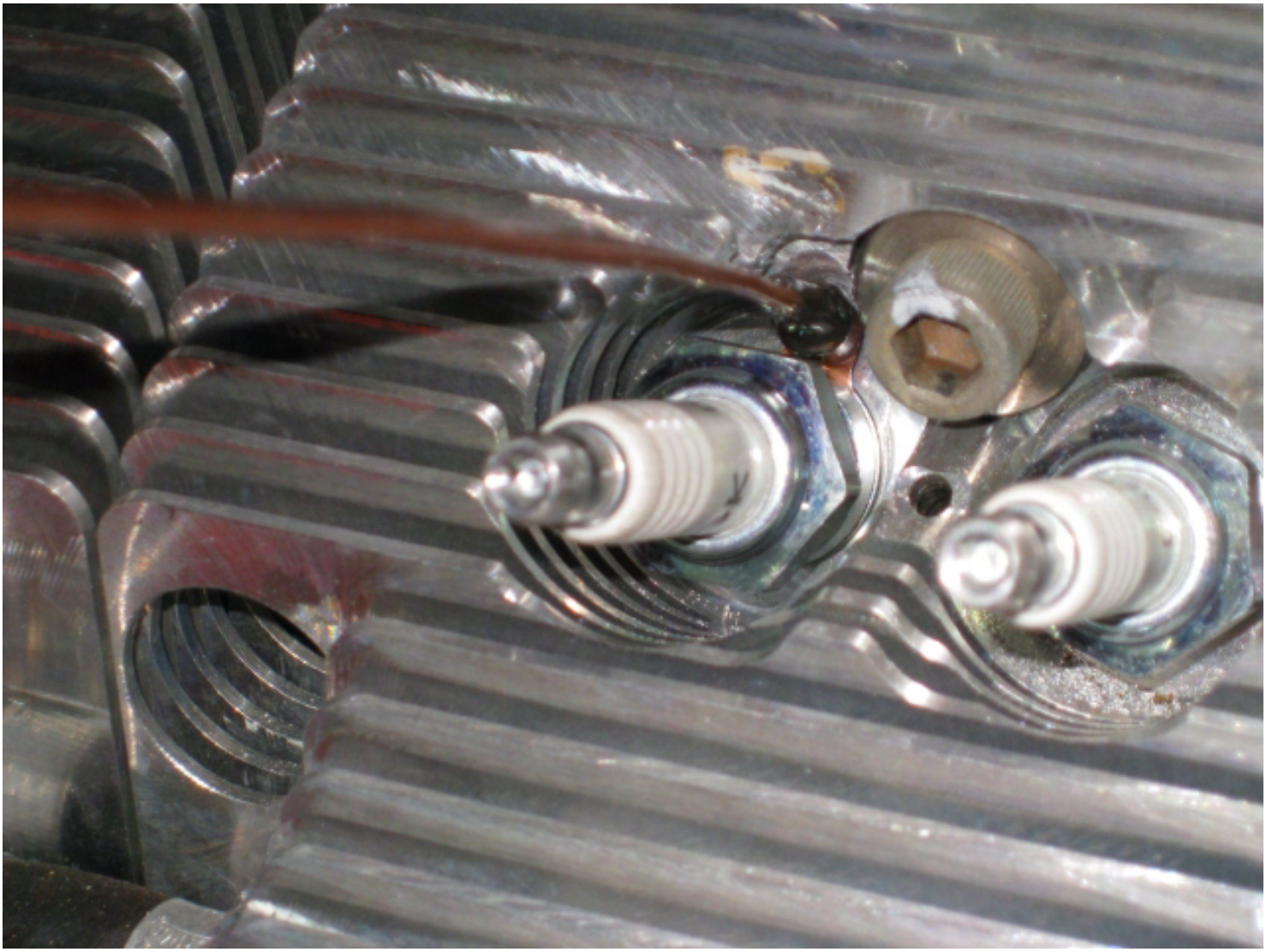


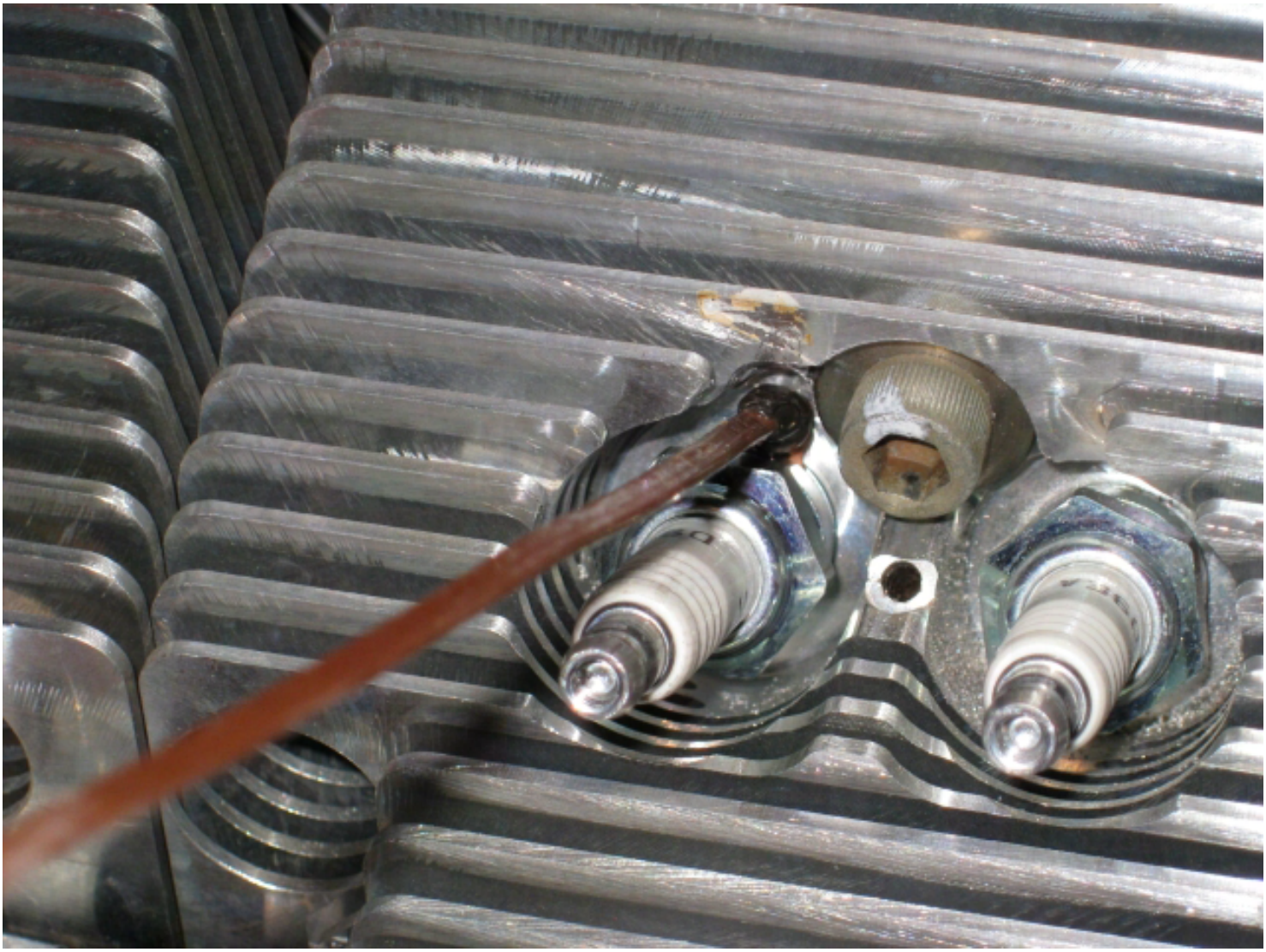
Time to install the CHT sensor and plug. Just a reminder, the sensor screws onto the plug threads first, then the plug washer goes back on, like this:

In the photo above, you can also see how the sensor crimp barrel has been slightly bent out, so it will lean away from the top of the plug.

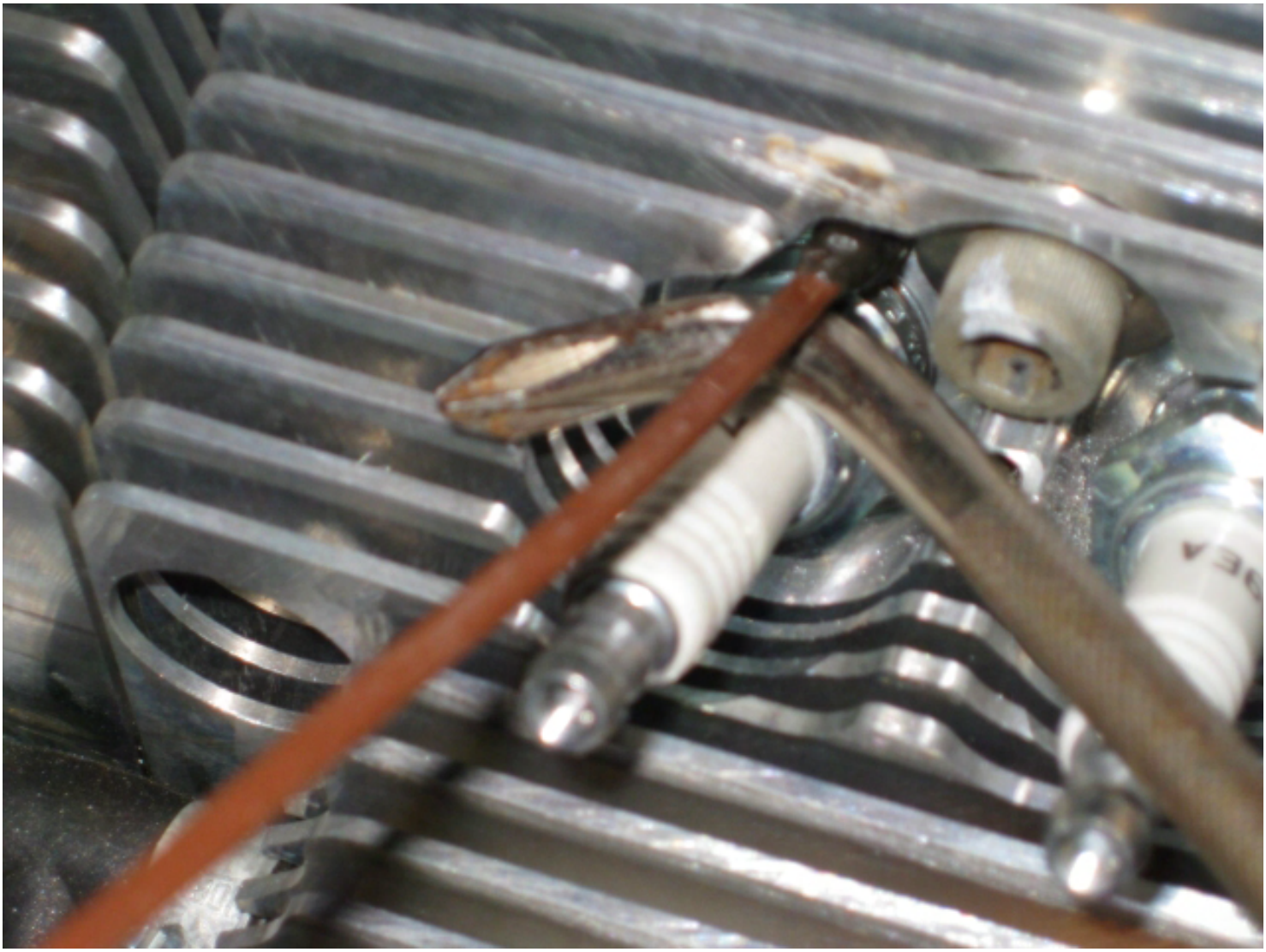
Next, we have 3 photos of the installed sensor, from various different angles. The plug is supposed to be torqued down to 11 Nm (8 ft.lbs.) which isn't much. When turning the socket on the plug, try to ***keep the socket as high on the plug nut as possible***, while still engaging the plug nut, to lessen chances of interference with the sensor crimp barrel. Turn the socket wrench slowly. If there is interference which can't be resolved by a smidgen more "lean" (see the second pic below) then pull everything out, tape the hole again, and do a little more cutting, this time angling down a bit more, i.e., take more off the first fin, and less and less as you go on down, to create more "lean room".

In the second photo below, you can see that the corner of the plug nut is just about to hit the crimp barrel. Time for some more "lean" away from the plug. Fortunately, we've already cut away enough space, so it's only necessary to pull everything out for a little more careful bending with the pliers. Don't try to bend this while it's in place under the plug, because you'll almost certainly crack the original epoxy.



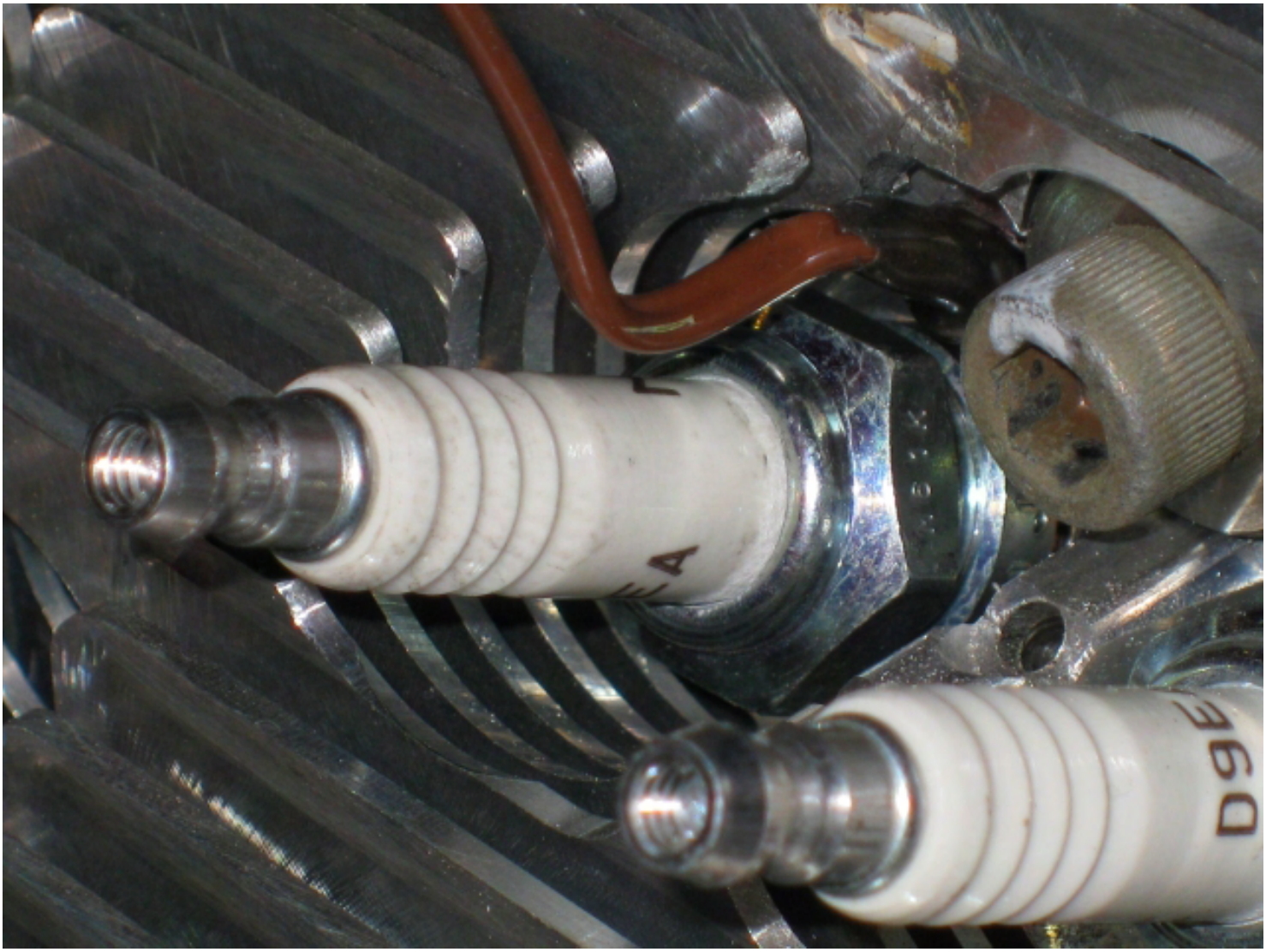


We're not done yet! Gotta tie down that wire -- carefully. The first bend we have to make in the wire has a pretty small radius going toward the lower part of the plug, where the wire will be secured with tie wraps. The point where the wire will be tied to the plug has to be just low enough that the plug wire boot will still fit over the plug, but no lower, because if it's too low, the bend in the wire will be tighter than need be, which is hard on this wire. To make that first bend, use some kind of form against which you can bend the wire, so that the wire coming out of the epoxy will remain upright at all times. I found the corner of a right angle screwdriver was perfect:

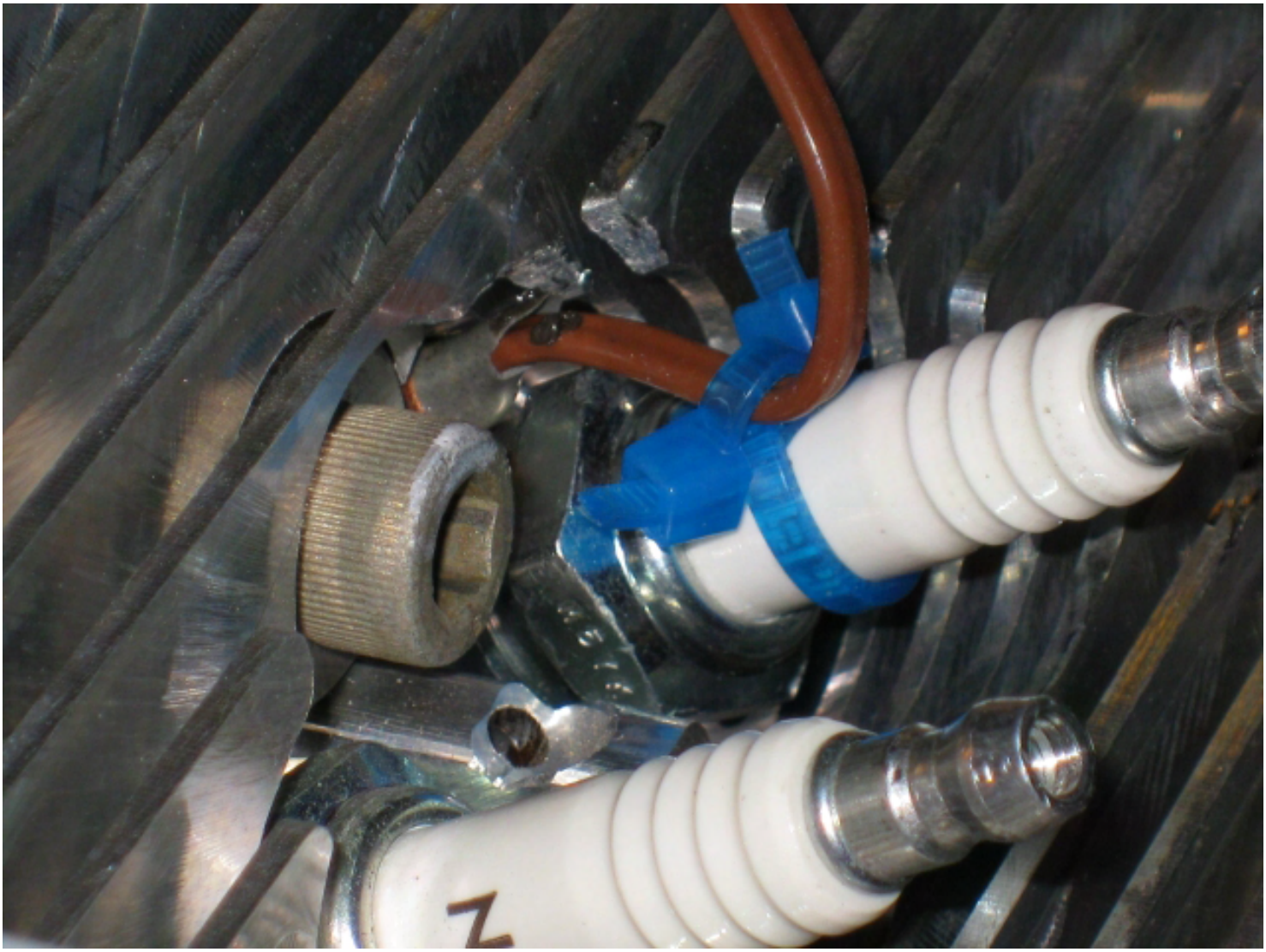


The expoxy in and around the crimp barrel is the most brittle and fragile part of the sensor assembly, but the hard, relatively inflexible wire is also very vulnerable to tight or repeated bending, and should not be bent to a smaller radius than is absolutely necessary.

Next we see the first two bends as completed:

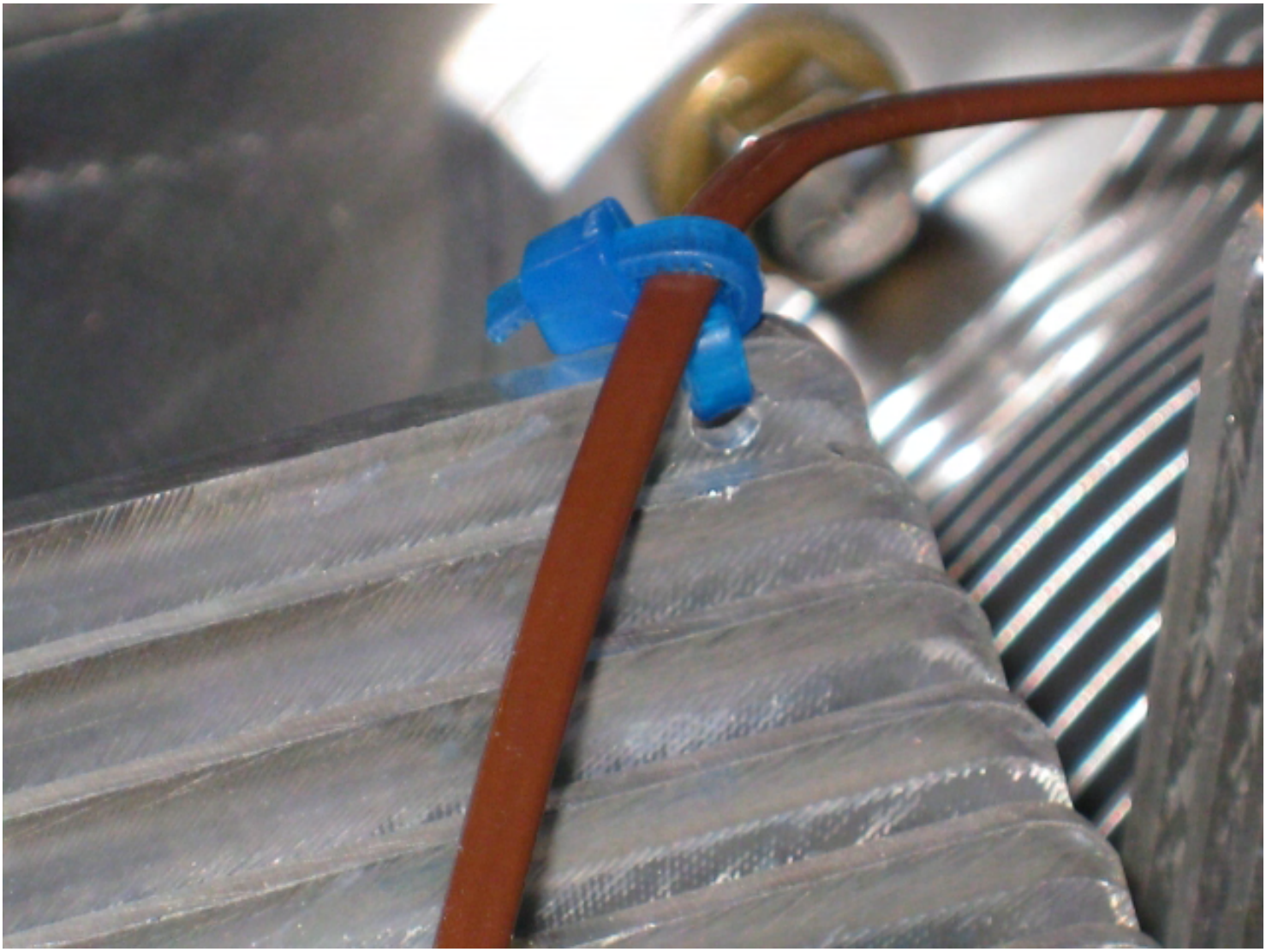


The next photo shows how the wire is secured to the plug with double, high temp Tefzel tie wraps. These are the small 4" long ones available from Steinair, among other sources. (This photo is taken from a different cylinder, on the left side of the engine. The rear of the engine is toward the upper right.)



The double tie wraps secure the wire from further bending at the top of the sensor epoxy, and will hold the wire off the plug slighty, for slightly better cooling and some chafe protection. In the photo above, you can also see how the wire has pulled away (separated from) the original, gray epoxy. It also shows an imperfect early attempt to add **JB Weld** epoxy at the top of the crimp barrel. If it's not too bad, this can be fixed in place, by carefully adding more epoxy.

Almost done. Here's a photo of the small hole drilled in the top, aft corner of the biggest fin with a #36 drill bit (.106") to which the wire is routed and secured, again using double Tefzel high temp tie wraps. From there the wire turns through a smooth radius toward the rear, joining the other sensor wires, enclosed in appropriate fire retardant, anti-chafe sleeving as desired. The bundle of three CHT wires drops down in the rear, exiting out the space at the bottom of the standard baffle duct, so the baffle can be fully removed without disturbing the CHT wiring.



To wrap this up, here's a photo of the whole installation on cylinder #4, nearly complete except for the JB Weld touch up:

I hope this example will be helpful to others attempting this installation. The actual job isn't all that difficult, once you have a good idea of what to do.

The opinions expressed above are just opinions, and your mileage *will* vary. Comments on how this article may be clarified or enhanced are always welcome.

engine