ALUMINUM BODY

Far better it is to dare mighty things, to win glorious triumphs even though checkered by failure, than to rank with those poor spirits who neither enjoy nor suffer much because they live in the gray twilight that knows neither victory nor defeat.

Theodore Roosevelt

Our employees at Kirkham Motorsports Poland are incredible craftsmen. Photo by Kirkham Motorsports Poland.

In 1988, I heard rumors of a local, elderly gentleman from England, named Dennis Balchin, who worked for Rolls Royce before WWII. I tracked him down and persuaded him to teach me the subtleties of welding thin aluminum sheets together with an oxyacetylene torch. He passed to me his incredible knowledge of panel-beating aluminum into liquid lines and fluid forms—an art that is now virtually extinct.

In March of 1995 I traveled to Poland to explore a bankrupt MiG fighter factory. There, I wandered through the dark, silent hangars which produced 3 MiGs a day at the height of the Cold War. The once thunderous skies over the "People's Aircraft Factory" were still.

Aesthetics are secondary in dogfights and their MiGs showed it. So I was able to pass along many of those graceful automotive panel-beating skills to the eager Poles who would later become Kirkham employees at the MiG factory. They are true Old-World craftsmen.

The raw bodies for the prototype and the final car were made at our factory in Poland, along with the hood and trunk skins. We completed the hood and trunk lid in Utah. The doors, were completely made in Utah.

Making a hood on a stretch press is much like stretching cellophane over a container of food.

Checking to make sure the aluminum sheet is seated in the far jaws.

Aligning the jaws to grab the aluminum sheet uniformly on both sides.

Closing the jaws to clamp the aluminum.

Stretching the aluminum over the form.

Using a rubber mallet to define the edges of the hood.

Closeup of defining the edges of the hood.

Releasing the hood. Notice the rear cowl form in the foreground.

Finished hood skin, ready for trimming. Photos by Kirkham Motorsports Poland.

The left, front fender is made completely by hand. The craftsman is pounding in the "reverse curve" into the aluminum. He is pounding on a "slapper" with a hammer to spread the blows. If you look carefully, you can see this panel is formed by hitting it hundreds of times—all by hand. Photo by Kirkham Motorsports Poland.

In this view you can see the headlight area coming into shape. The clamps hold the aluminum in place while it is being formed. Photo by Kirkham Motorsports Poland.

The holding clamps are tightened as the aluminum is shaped. Photo by Kirkham Motorsports Poland.

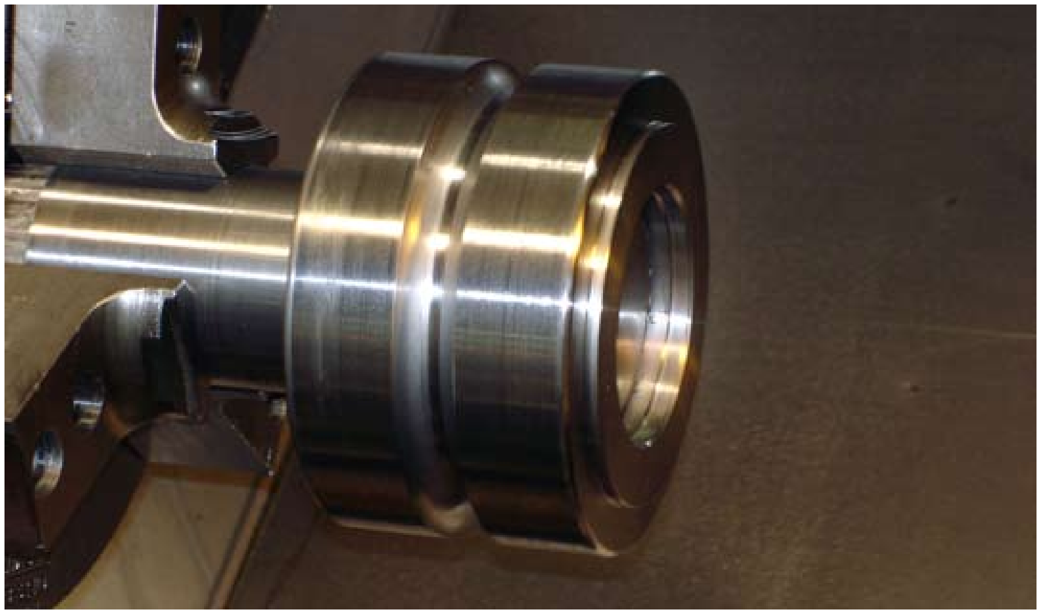
The panels are then trimmed and welded together with an oxyacetylene torch. We gas weld panels together for a number of reasons. Gas welding is much faster than TIG welding. Gas welding leaves the metal very soft and malleable, whereas TIG welding tends to make brittle welds. Finally, gas welding leaves a very flat bead that is easy to completely erase with a file. Photo by Kirkham Motorsports Poland.

When we received the bodies for the prototype and final car from Poland, they were rough welded together.

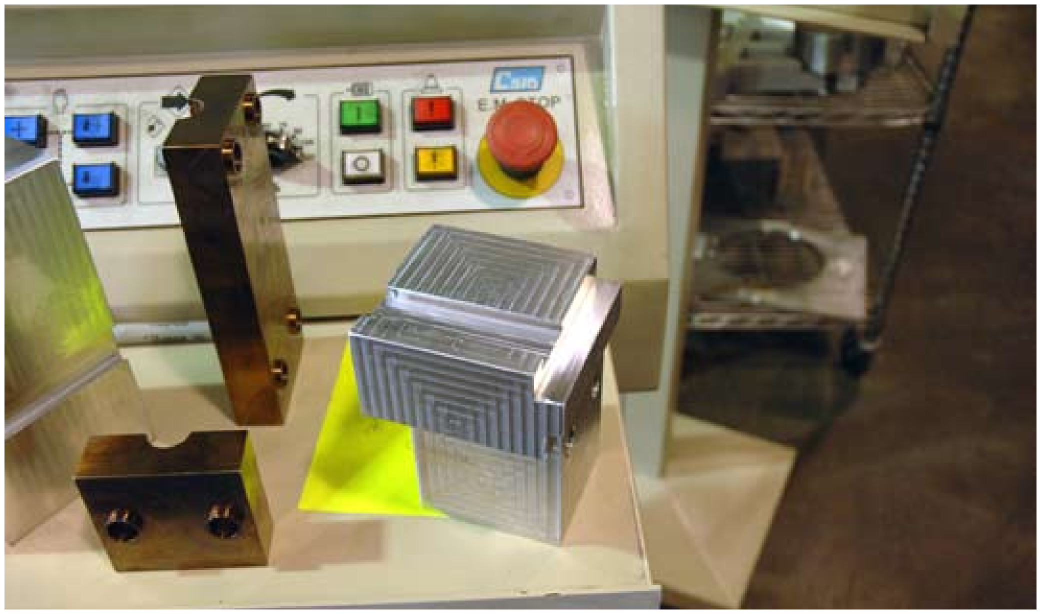
Here is a closeup of the body welds. The Poles are magicians with thin aluminum welding. The welding process warps the panels, and they have to be straightened by hand. Before we can straighten the panels, however, we have to make the 3/4 inch tubing substructure to hold the body in place.

We cut the required 3/4 inch substructure radius right into our custom-made axle. We then machined a pocket in the axle for the clamp die.

We made the "C" axis clamping collet for the push bender.

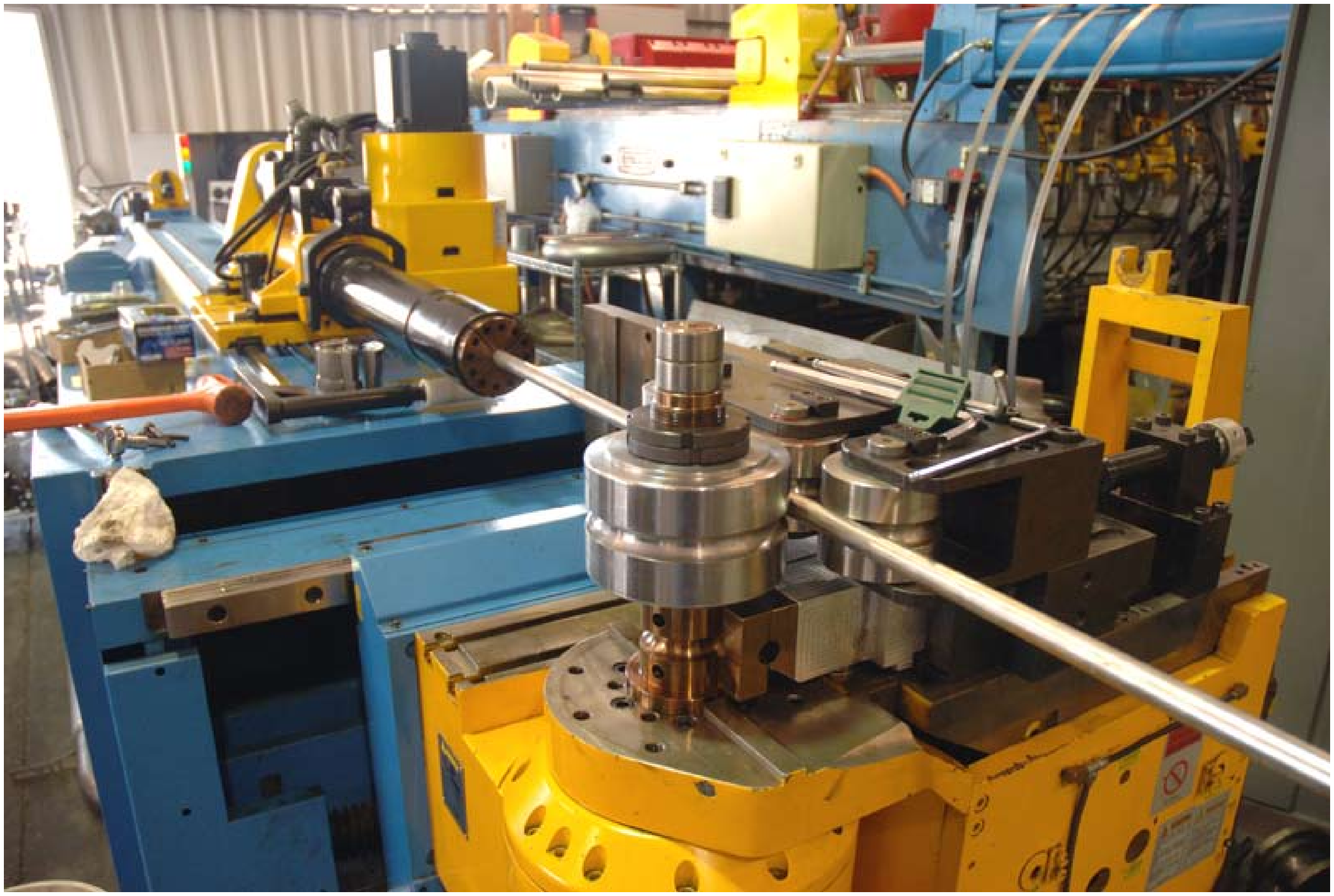


We also had large, graceful arcs to bend. We designed and made three-roller dies as well for our machine.

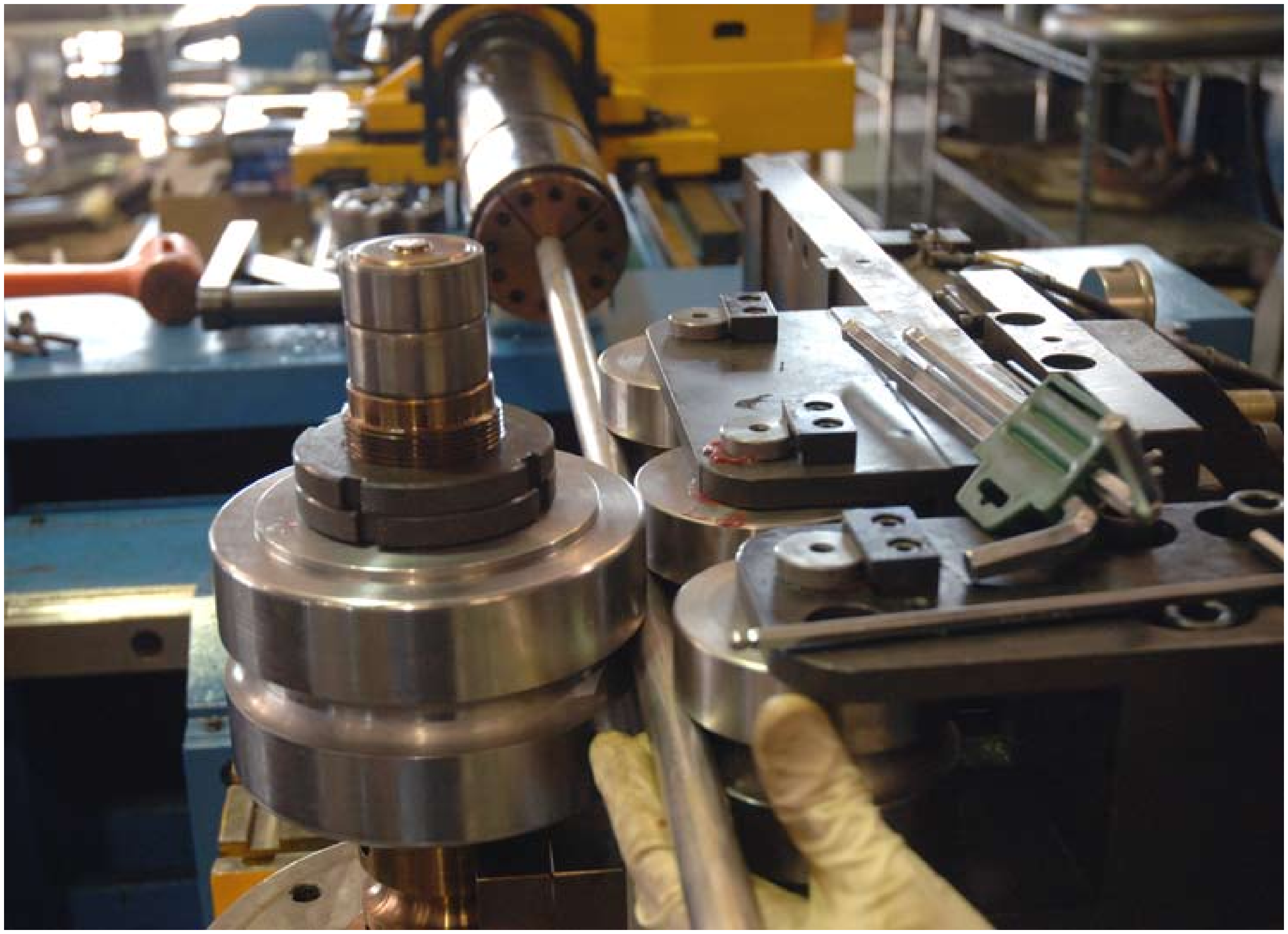


Custom clamp tooling for the 3/4 inch substructure. The working dies were made from 17-4 PH stainless steel.

To support the aluminum body, we had to make a 3/4 inch round tube substructure. The body is mounted on the tubes and secured in its final position before it can be straightened. We used our CNC tube bender to make the substructure. However, our tube bender is designed for 2-inch tubing and the substructure tubing is only 3/4 inch. We called the manufacturer of the tube bender and asked for 3/4 inch tooling—they said it was impossible to bend the 3-inch radius we required on our machine because our pivot axle was too big. So we designed and machined a new pivot axle and cut our required radius right into the axle. Then we machined a pocket in the axle for the clamp die. We used the actual pivot axle as the new bending die.



A tube ready to be bent on our CNC tube bender.

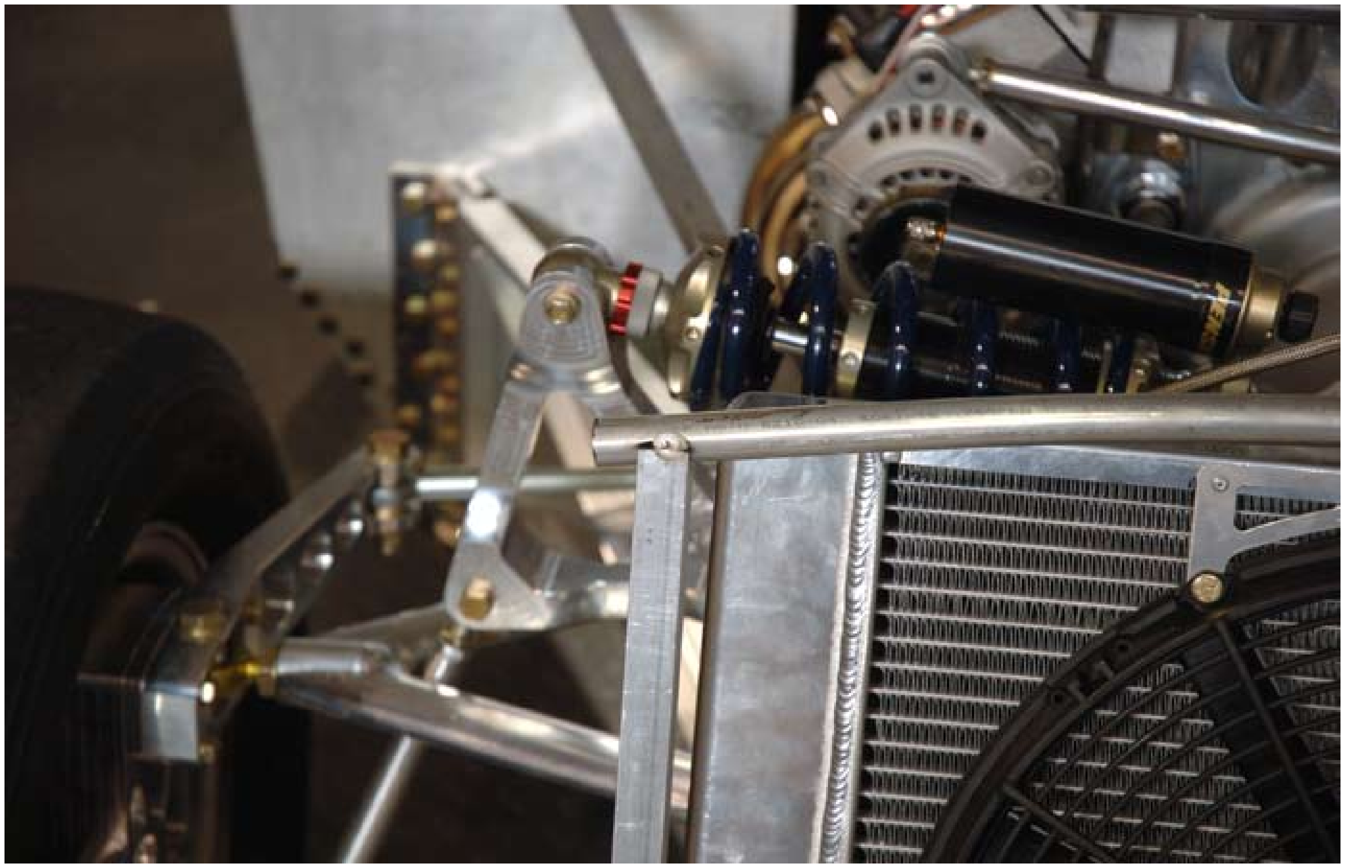


The top three rollers are for push-bending large arcs. The small, closest roller (which Sandwich is touching) moves in an arc to bend the tube. The machine can even do variable radius bends.

All of our 17-4 parts are heat treated in an oven we specially modified with high-accuracy thermocouples.

The clamps had to be made to very tight tolerances because we were bending heat-treated 6061 T6 tubing without annealing it. We had to buy a special, drawn tube for the bends we wanted.

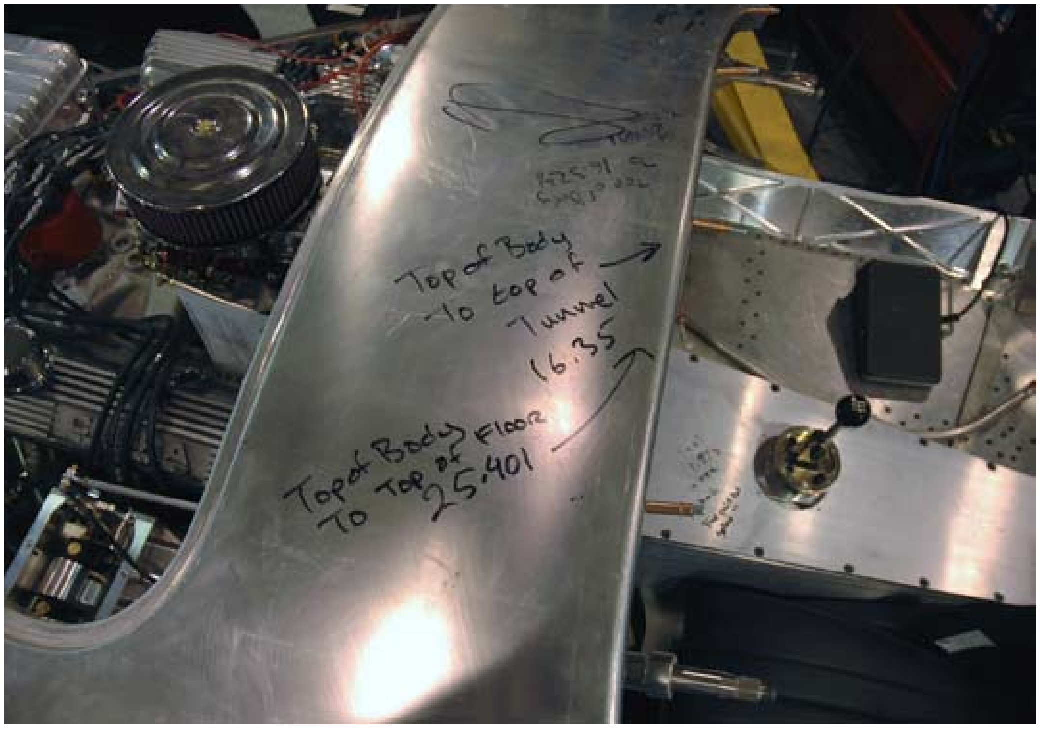
The CNC tube bender allows the operator to program the tube and virtually bend the part to make sure nothing crashes.



Once we could make the tubes, we decided to make the hood tube first. We had to square the entire car to that point. Notice the tack welds—so they could be easily moved to line everything up.

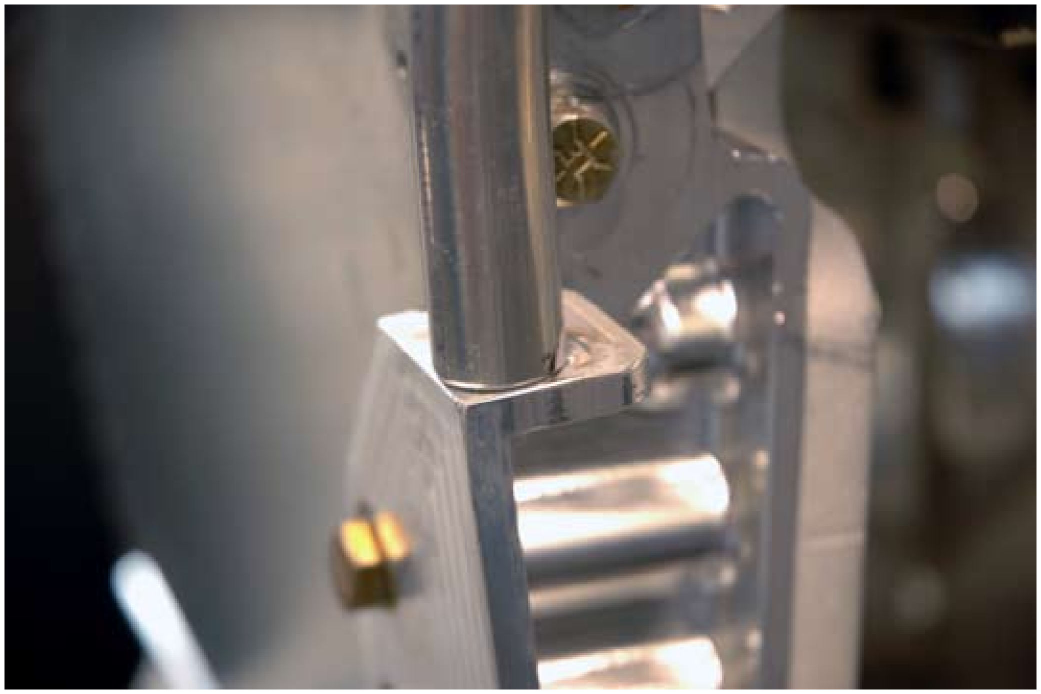
Once we established the correct height of the leading edge of the hood, we bent tubes and laid them into the underside of the body. We were very careful to have the tubes fit so there would not be any stress on the body when it was mounted.

We sheared a piece of aluminum to the exact length from the CAD program. We were very careful to make sure all the edges were square. We placed the sheet of metal on a known base (in this case the top of the front suspension box) and placed another square piece of aluminum on top of it to measure exactly to the tube. Then we knew the body was in the same location as the CAD program.



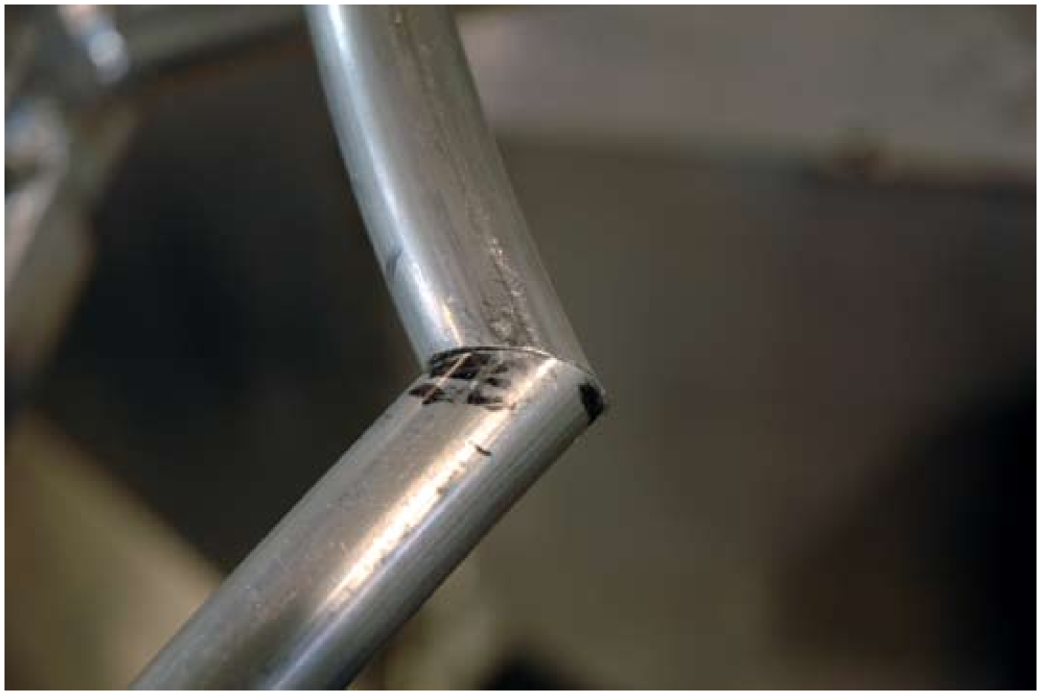
Once the leading edge of the tube was mounted, we were able to pivot the body on the hood leading edge tube. If you look at the writing on the cowl, you can see the measurements we took off the CAD program to position the body in the right place.

Once everything fit, we welded brackets onto the tubes that would bolt the substructure to the billet chassis. The substructure is necessary to support the body.



As we built the substructure tubes, any tube that needed a little tweaking was bent in the press between blocks of wood.

We were very careful to make sure all the tubes lined up. This is the top of the driver's door hinge brace. There is no gap that has to be filled in with weld. If you leave a gap, the hot weld material will shrink and distort the tube as it cools. When the tubing fits together, the opposing part helps to keep distortion to a minimum.

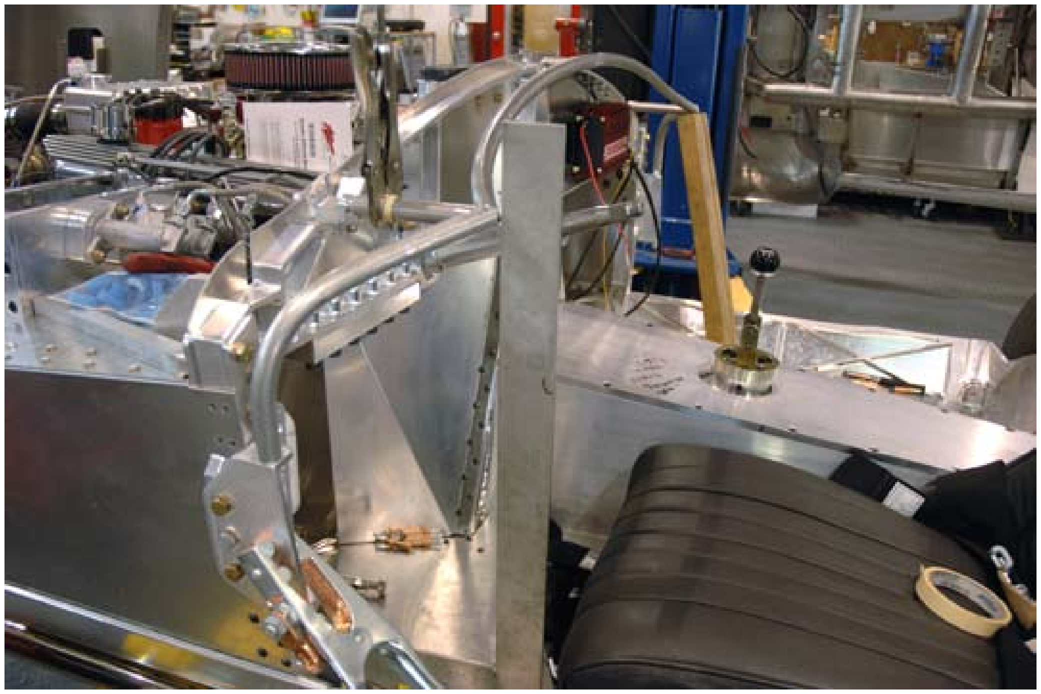


Precise joints...

make beautiful welds.

To make the nicest possible joints, we milled the fish mouths into the end of the tubes.

The front substructure cage after welding.



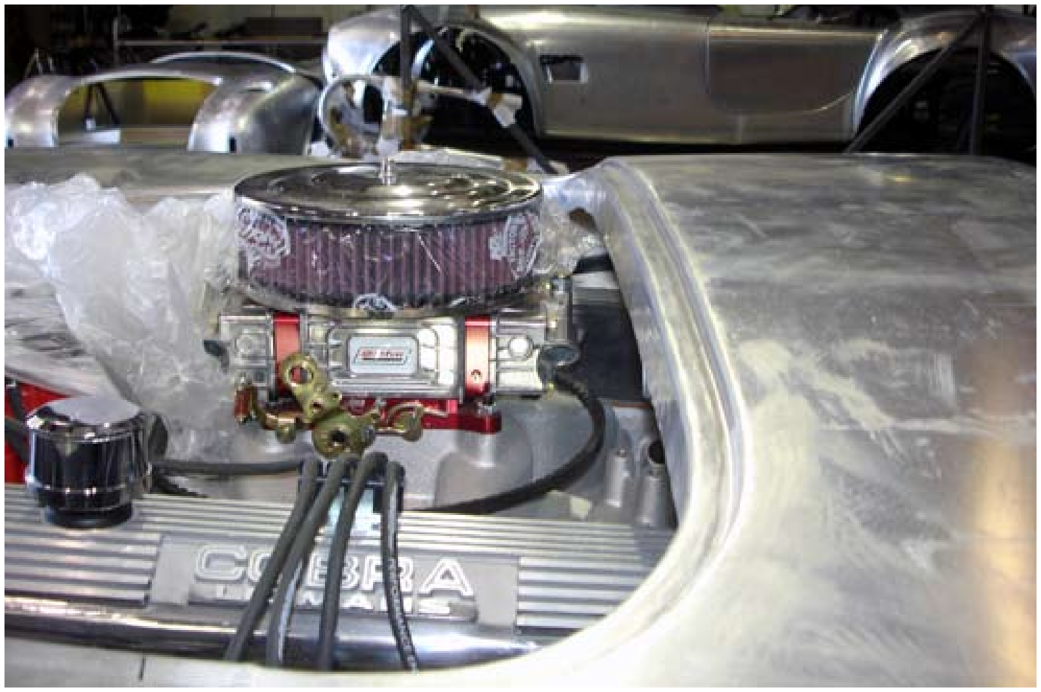
When everything fit, we bolted it to the billet chassis. (This is the prototype car.)

Here is the finished substructure—ready for the final fitting of the body.

We fit the front body clip on first.

Checking clearances.

We made sure the dash fit.

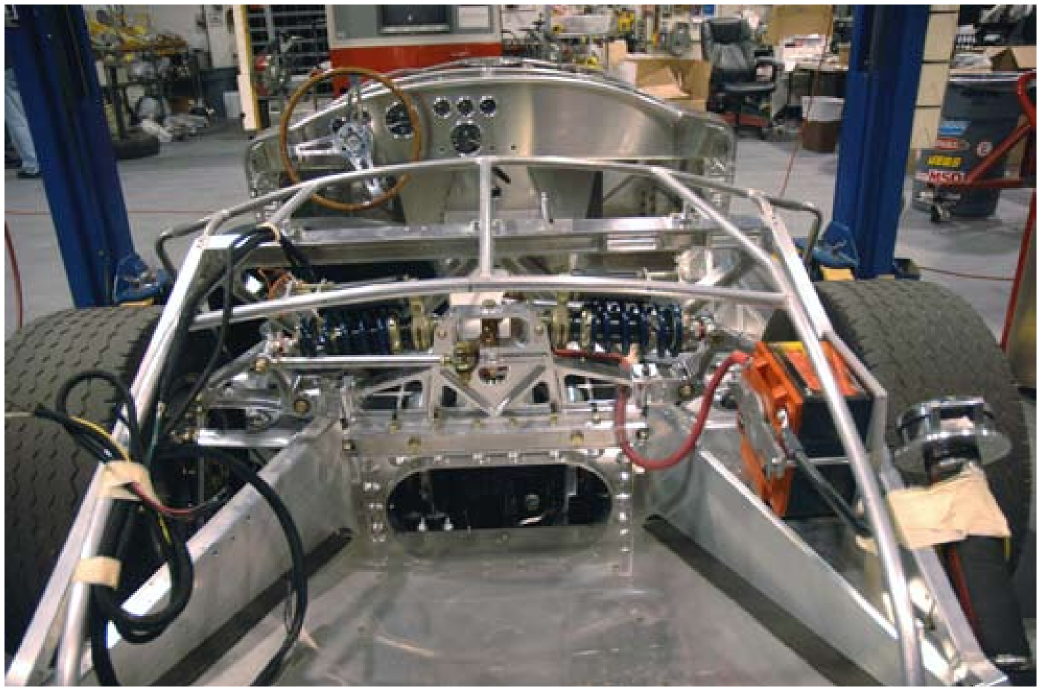


Checking engine clearances.

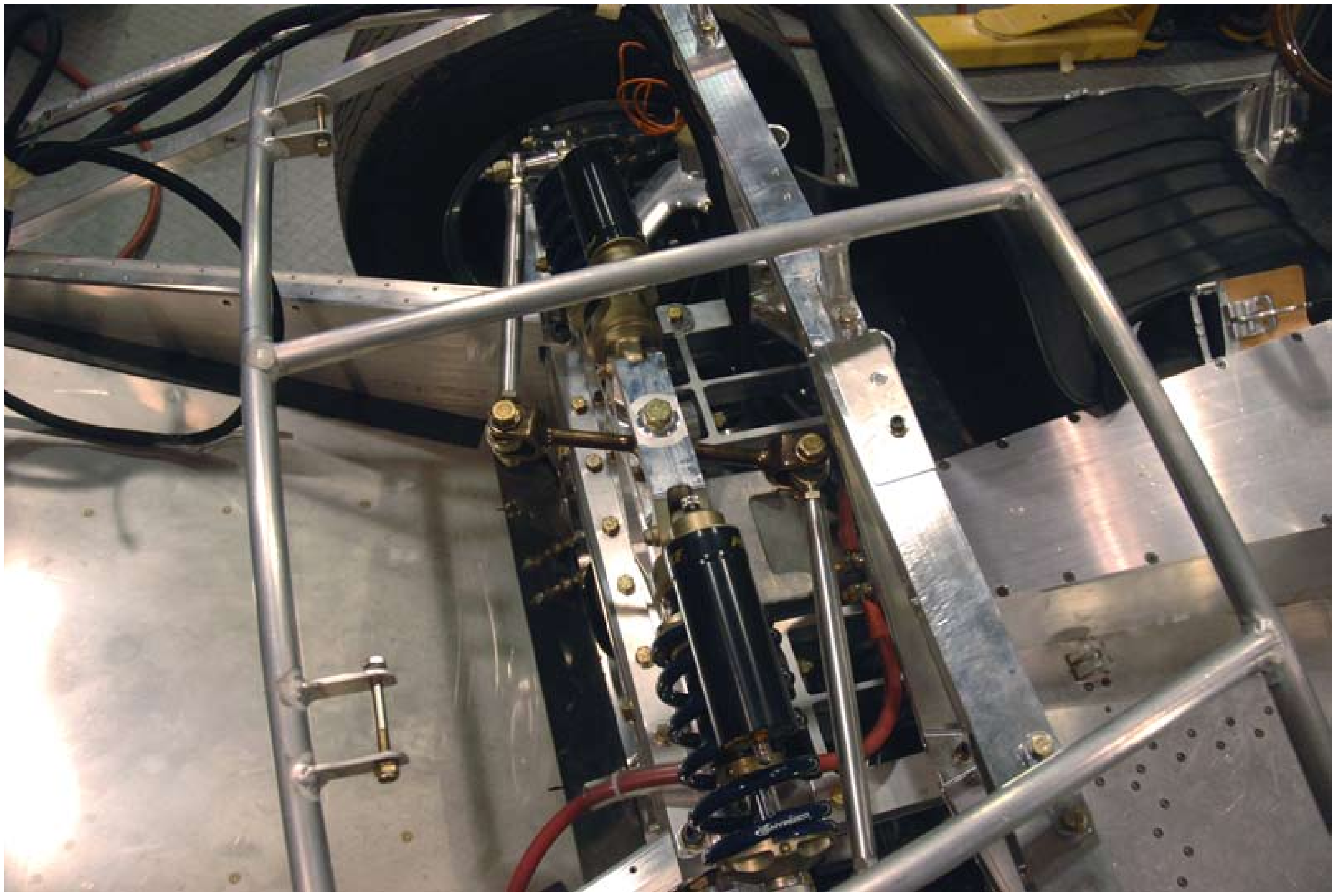
Checking foot pedal clearances.

Once everything fit, the final welds were made.

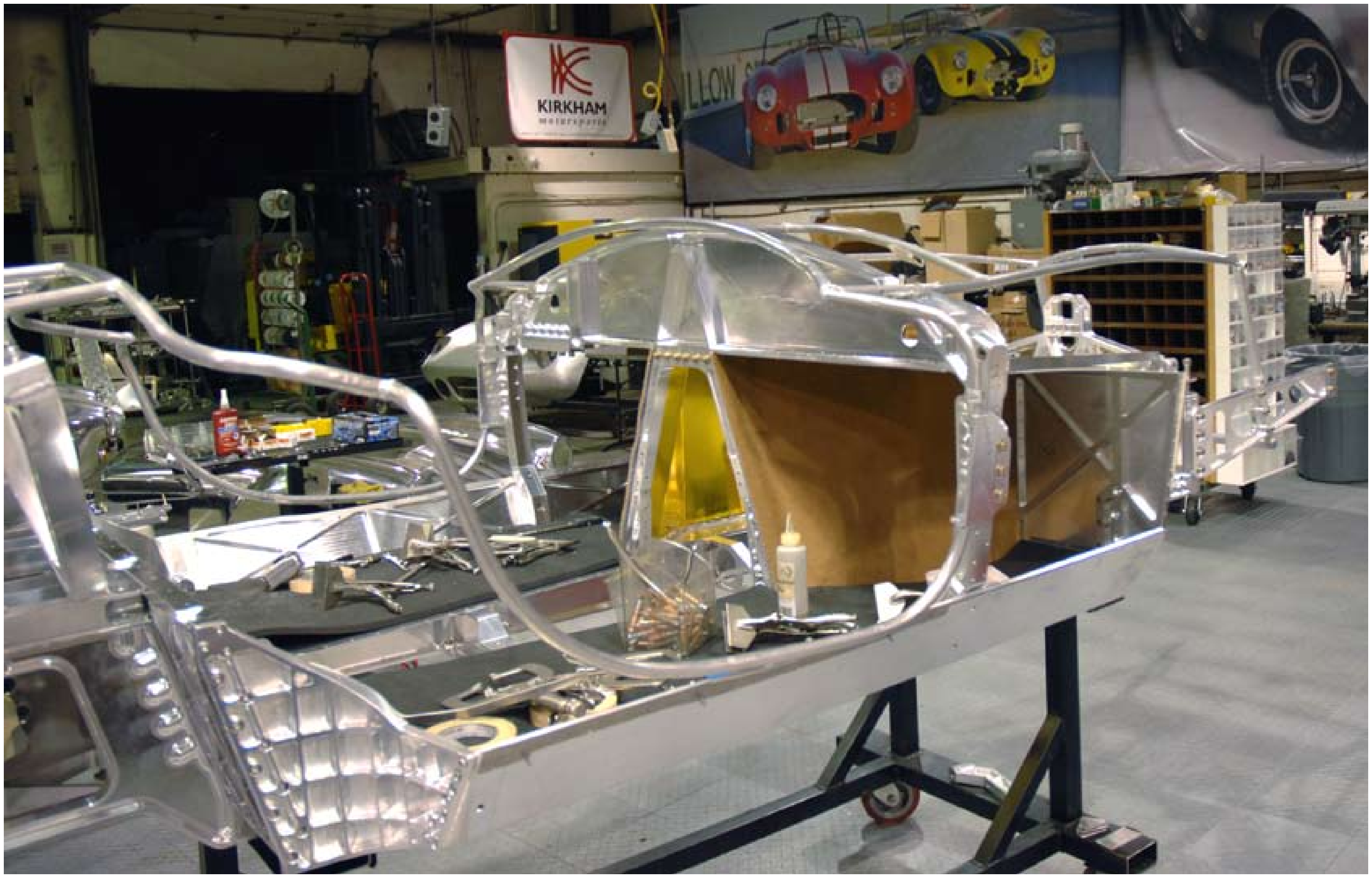
We repeated the same process with the rear body clip.



Here is the finished rear body substructure.



Once the body was fit, the trunk hinge tabs were welded to the body.



The final substructure tubing work was done with the doors.

Every one of those little dings in the metal was put there by hand when the body was made. Every one of them was removed.

All welds were straightened by hand.

Jozef places a straight edge on a panel to check it for straightness. Light shows under the edges where the panel is not straight.

He then rubs his hand over the surface of the metal. An experienced craftsman can tell the subtle differences between high spots and low spots. A hammer is typically used to do the gross straightening of the panel. His left hand is holding a "dolly" or a heavy piece of metal that generally conforms to the shape of the panel to back up the hammer blows and help straighten the metal.

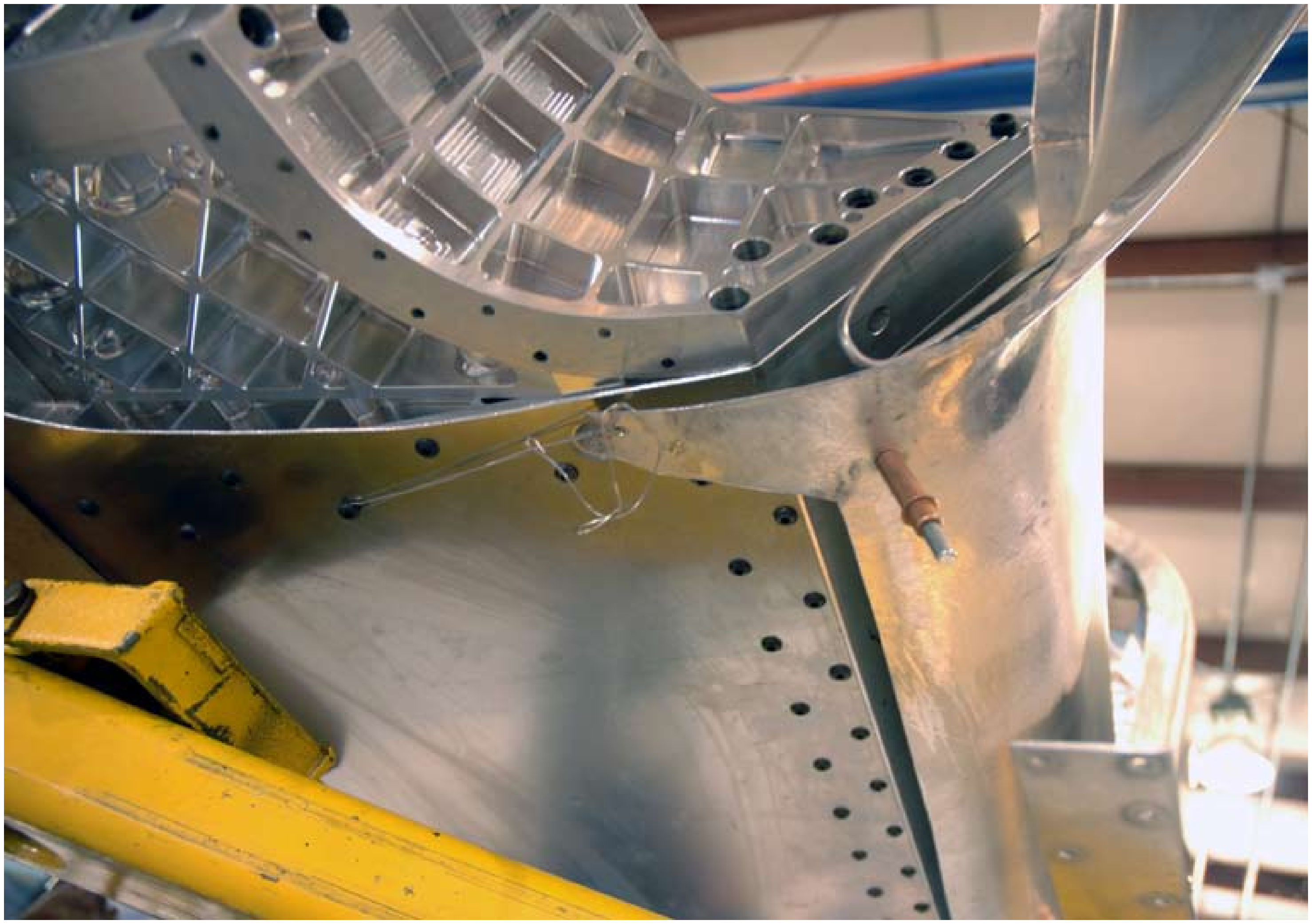
Once the panel is roughly straight, a "slapper" is used. It has a large, broad face to spread the blows over the surface of the panel. Again, he is using a dolly to back up the panel.

For delicate straightening, we use a "bull's-eye" pic. The long leg under the fender is gently tapped to "pick up" small areas of low metal.

Once everything is straight, we spray some black paint over the panel. When a panel is filed, the black paint comes off the slightly high areas first. This shows which areas are low and need to be picked up. This is where the term "pick and file" comes from.

Expert craftsmen can straighten the roughest of panels. If you look closely, you can see the reflection of his arm in the panel. Some panel beaters wear gloves to reduce drag, allowing their hands to easily slide over a panel. Drag makes it more difficult to feel the highs and lows in the metal.

It is much easier to work on the bottom of the body when it is upside down. All the preliminary straightening work was done with the loose body on one of our standard frames. This allowed for greater access to the body.

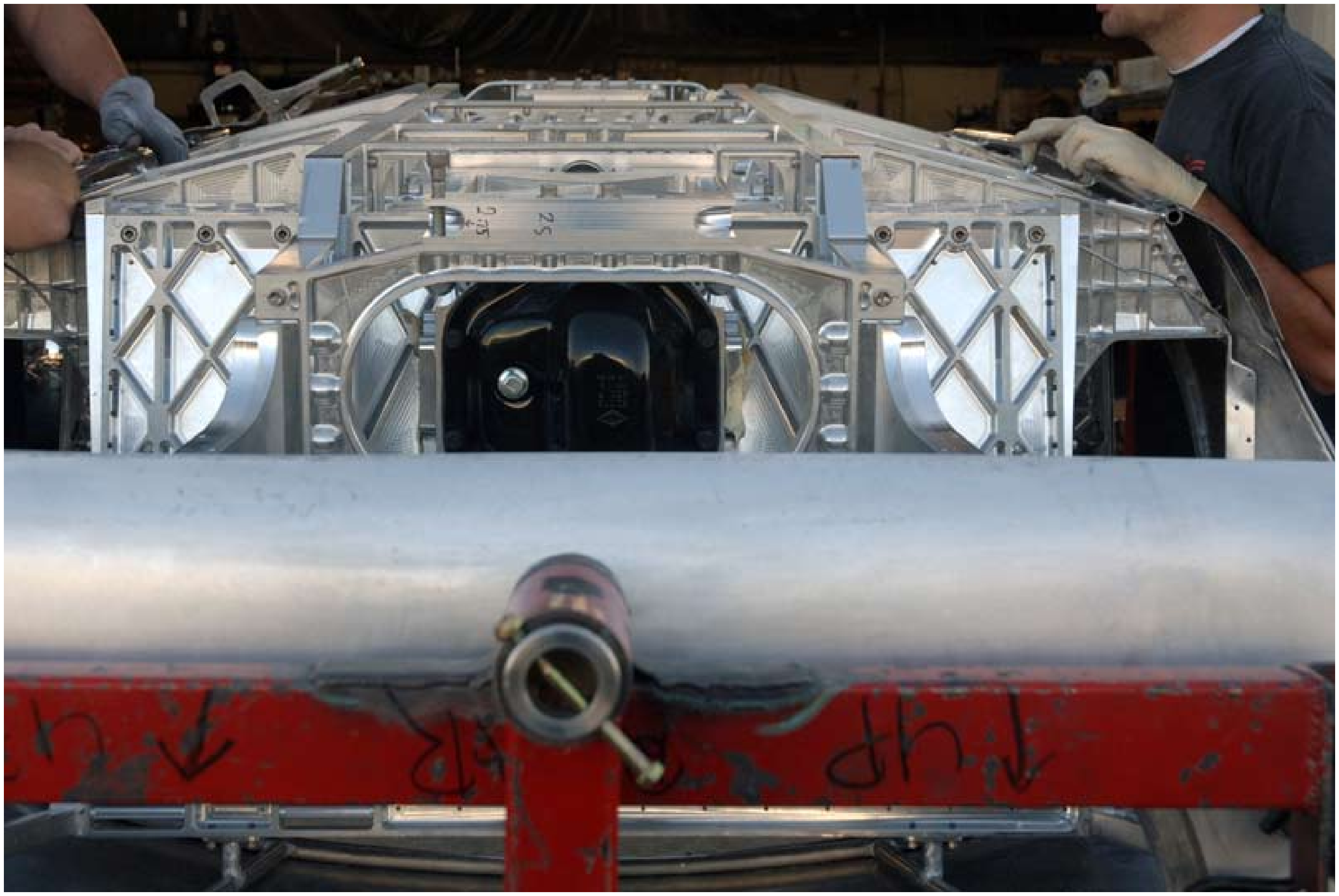


When we were finished with most of the straightening and filing, the body was ready for transferring to the billet chassis for final mounting. Here we left a tab on the body that we could wire to a bolt in the chassis. By twisting the wire, we could shorten it and finely tune the position of the body on the chassis. This is the prototype chassis.

Once the body was positioned, Jozef began to wrap the aluminum over the substructure tubes. Here he is using an aluminum "U" channel as a very large dolly to back up the body as it is wrapped around the tubes.

Once the hood and trunk were wrapped, we put the car on a rotisserie so we could turn it upside down for easier access to the bottom of the wrap. You can tell this is the final car by the gold foil on the footboxes.

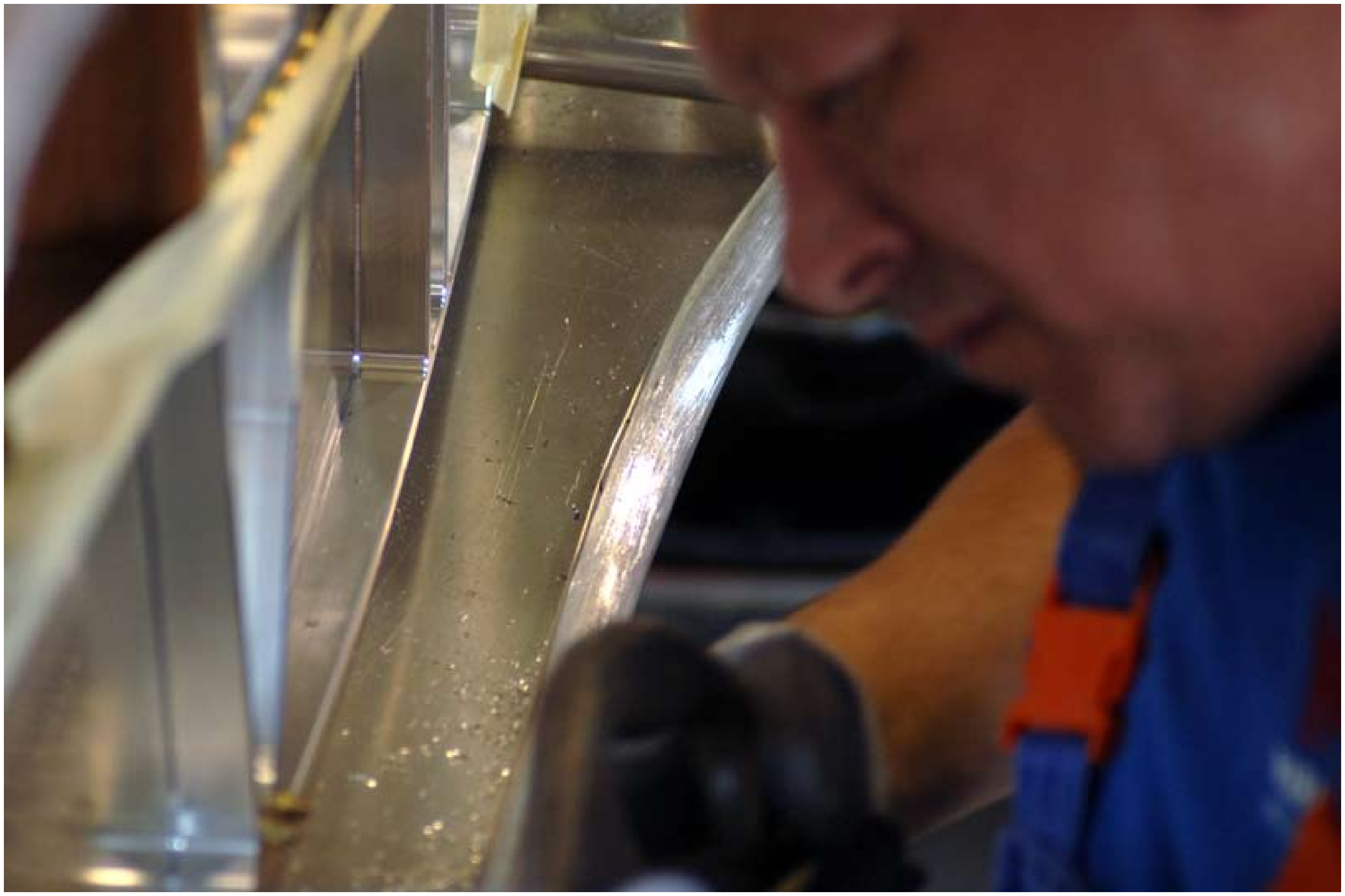
The final part of the body to wrap is the area under the doors, or the rocker panels.



Wrapping the aluminum around the rocker tubes.

Once the rockers were wrapped, they were riveted to the body tube.

The rockers were "pick and filed" smooth once they were riveted down.



While the car was upside down, we sanded the dash tube smooth.

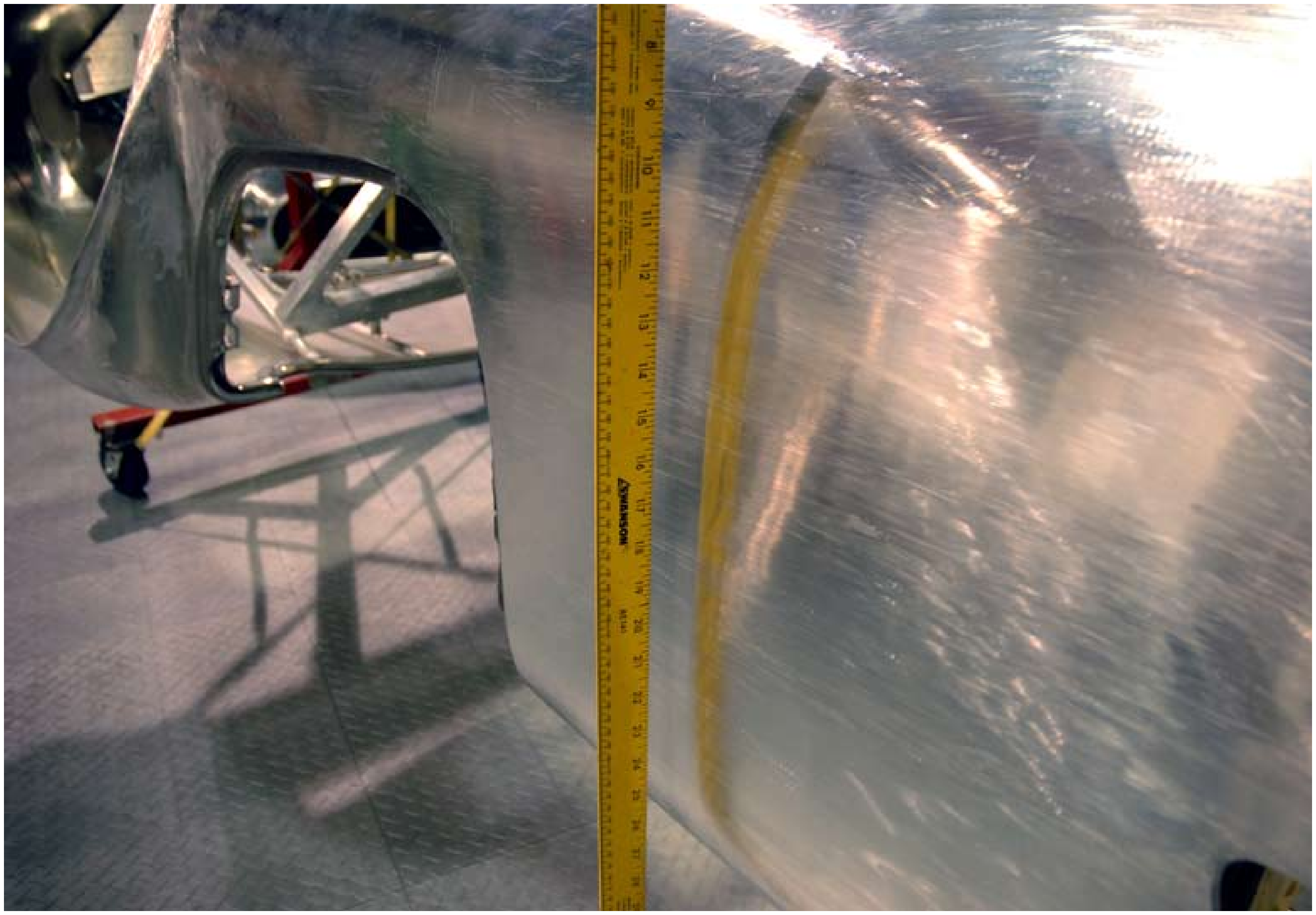
Polishing under the hood jam tube.

Once all the undersides of the tubes were polished, we riveted the aluminum down permanently.

We had a difficult problem with the driver's side of the car. It had slightly too much shape in it by about 1/8 inch. So I took a torch and heated up small spots in the fender. As they heated up, they expanded. While they were hot, I smashed them with a hammer and literally shrunk the panel (tricks I learned from the old Rolls Royce panel beater, Dennis Balchin).

Once the panel was shrunk below the size we needed it, we began to coax it back out to shape.

Aluminum is an amazing material. Notice Jozef's reflection in the panel after he pulled the panel back into shape.

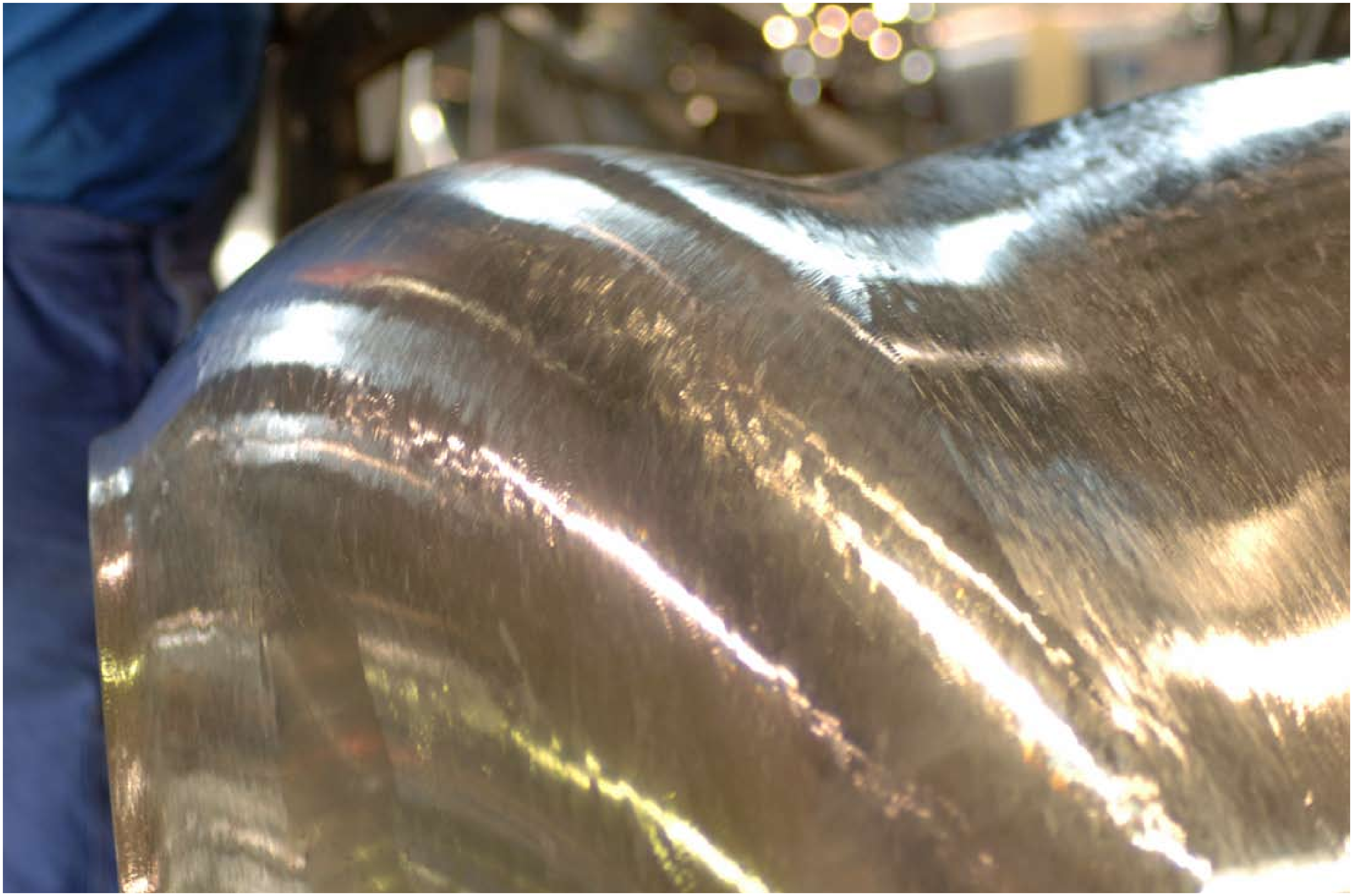


You can see by the reflection of the yard stick in the panel it is straight again.

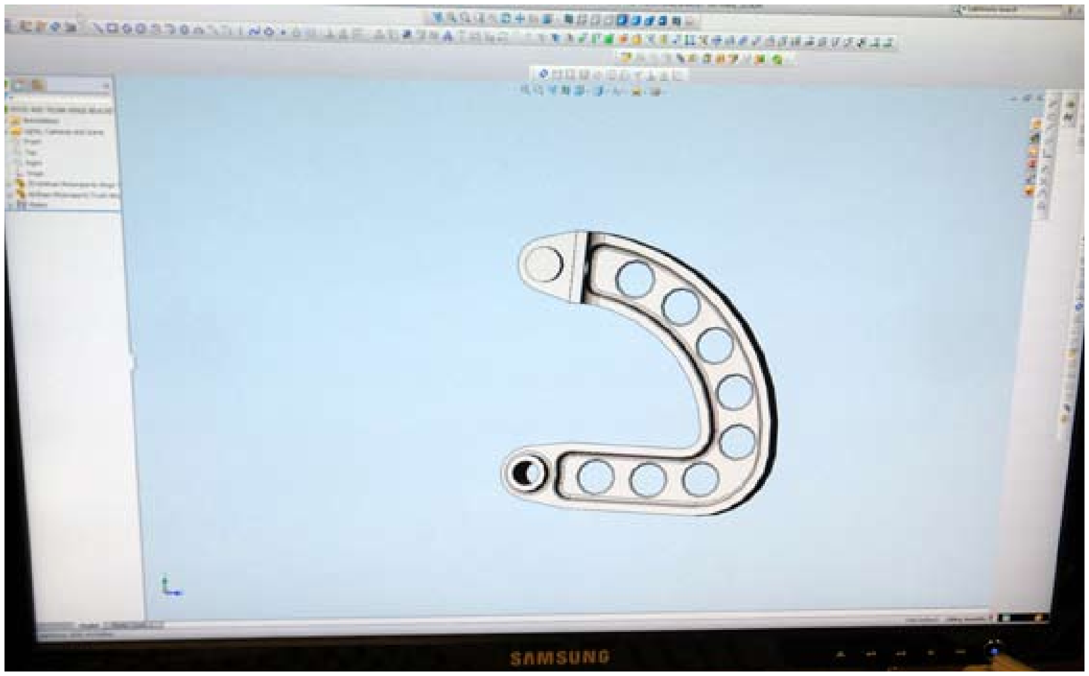
Jeremy and Sandwich welding the body.

Passenger fender completely filed out.

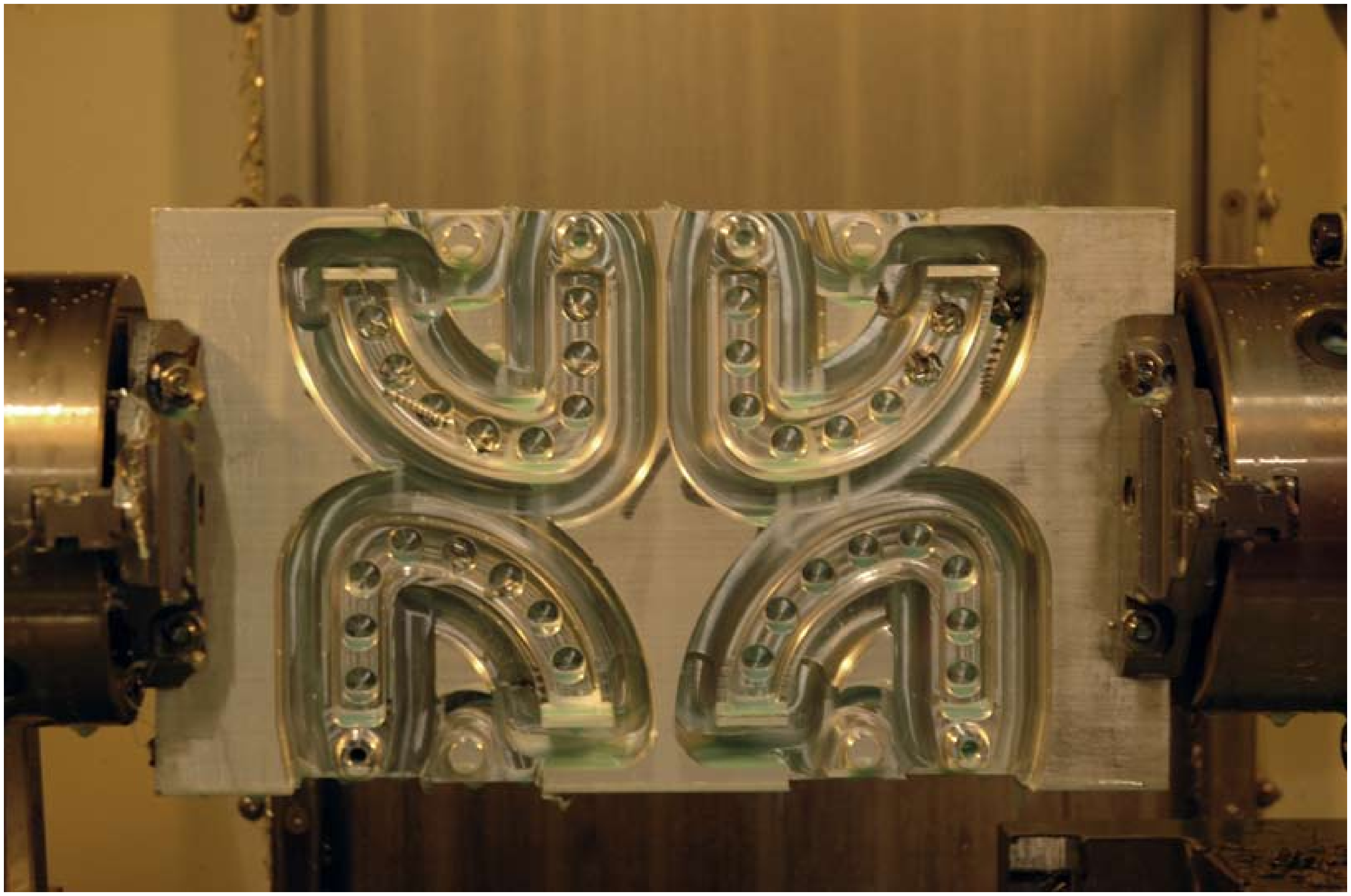
The bottom of the oil cooler scoop was straightened and filed.



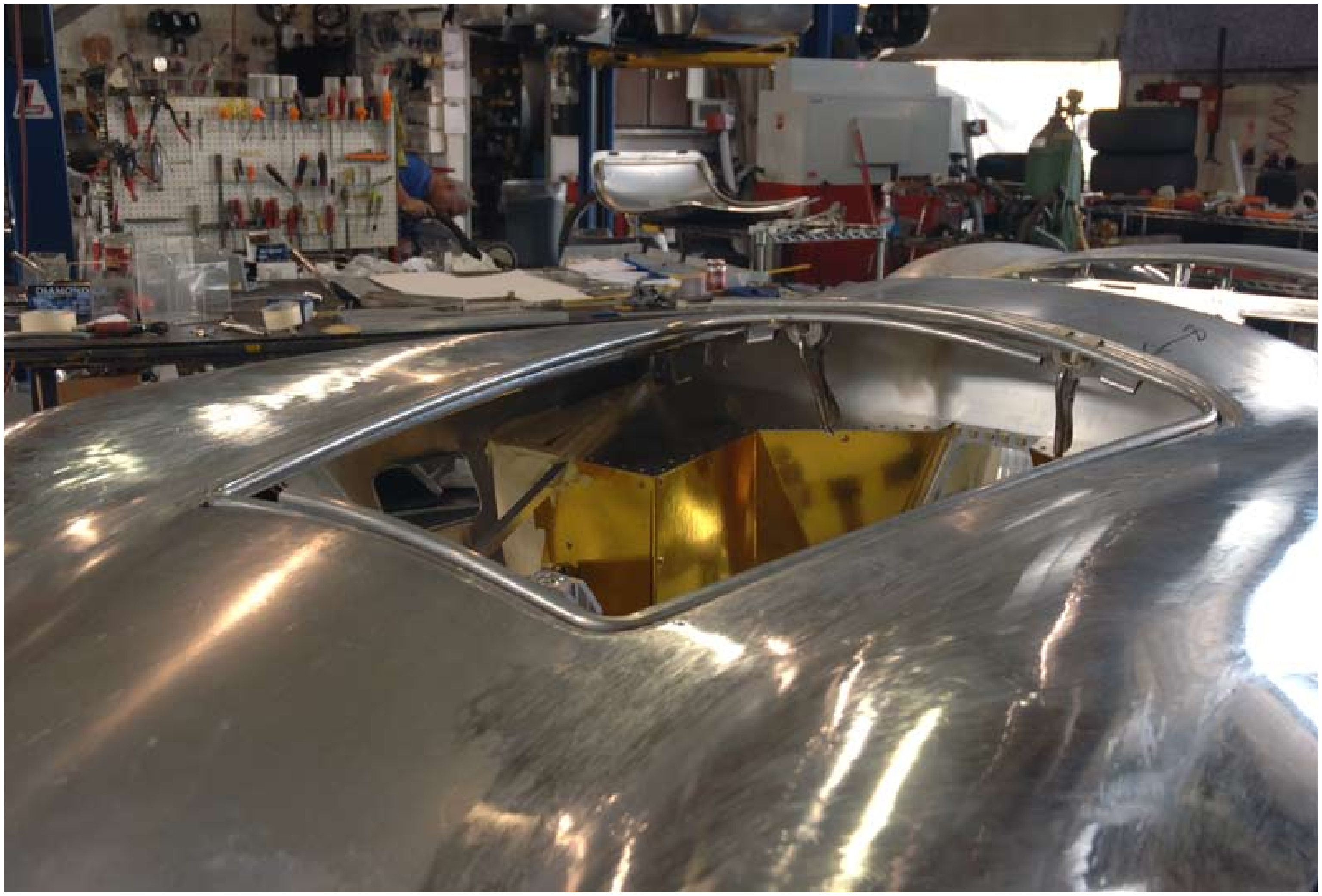
Driver's fender completely filed out.



We needed to design and make the hood hinges before we could make the hood.



The hood and trunk hinges are identical; we machined them from the same plate.



Once the body was wrapped, we were able to make the hood. Here is the initial lay out of substructure tubing for the hood.

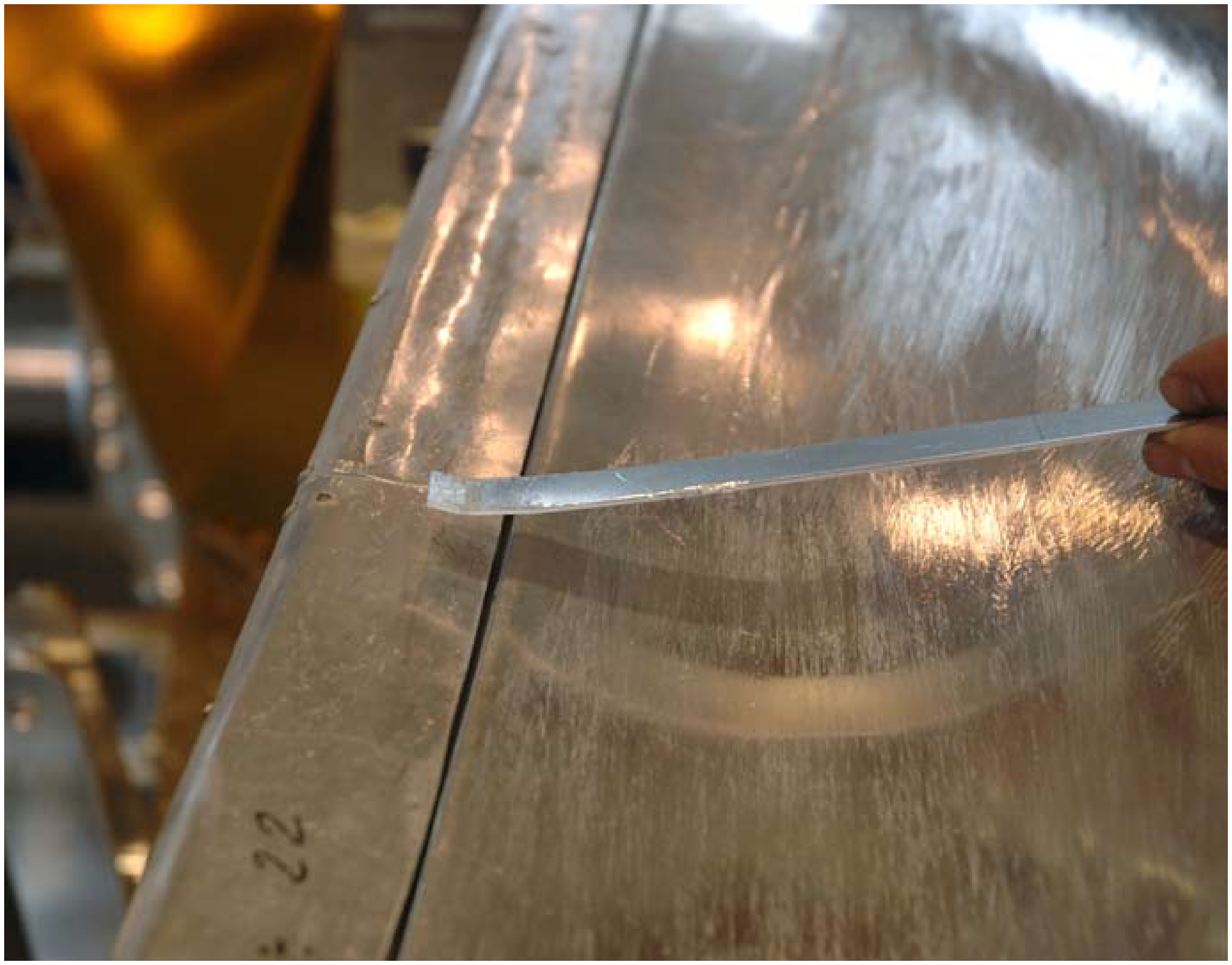
The hood hinges need to be mounted to get the hood tubing in the right place.

To support the rear of the hood in the right place, we drilled and tapped a hook into some Vise-Grip pliers then placed the tubes on the pliers. The hood tubes were then cut to length and welded together.

The correct height of the tube is set by this simple tool. The tubes needed to be at least 2 thicknesses of aluminum below the surface of the body—one for the hood skin itself and one for the hood flange.

After the tubes were adjusted to the right height, the hood skin flange was cut out and Cleco'd to the hood skin. Clecos are the copper-colored, spring-loaded, temporary rivet you see in the hood.

The flange is then wrapped around the hood tube with a nylon mallet. The nylon doesn't stretch the aluminum out of shape like a steel hammer does. Also, the nylon hammer doesn't mar the aluminum surface. Notice Jozef is holding a dolly in his left hand to support the tubes. Jeremy is holding another dolly on the flange to hold it down as well.



The hood flange is then raised up with a hooked tool.

We hook the lever under the edge of the hood flange and pry against the stiff edge of the hood jam while tapping down on the tube—this lifts the edge of the flange up.

The edge of the flange is tapped up until it is one thickness of aluminum from the body.

The finished hood flange.

A custom scribe marks a line into the hood flange. One leg of the scribe is longer than the other so it can easily ride against the hood jam. The distance of the scribed line is 3/16 of an inch for the desired gap plus 1/16 of an inch for the thickness of the hood skin.

The flange is then trimmed along the scribed line.

Straightening the hood flange with a hammer tapping on a slapper. The hinges and hood latches are mounted to the frame to make sure the hood opens and closes properly.

The hood substructure is then put back on the car to make sure everything is correct.

Cleaning the hood skin to prevent dirt scratches while upside down.

The hood frame is placed on the upside down hood skin and adjusted to fit.

The flange is then clamped to the hood skin.

Marking the distance of the hem with a tool similar to the flange scribe.

Scribed lines.

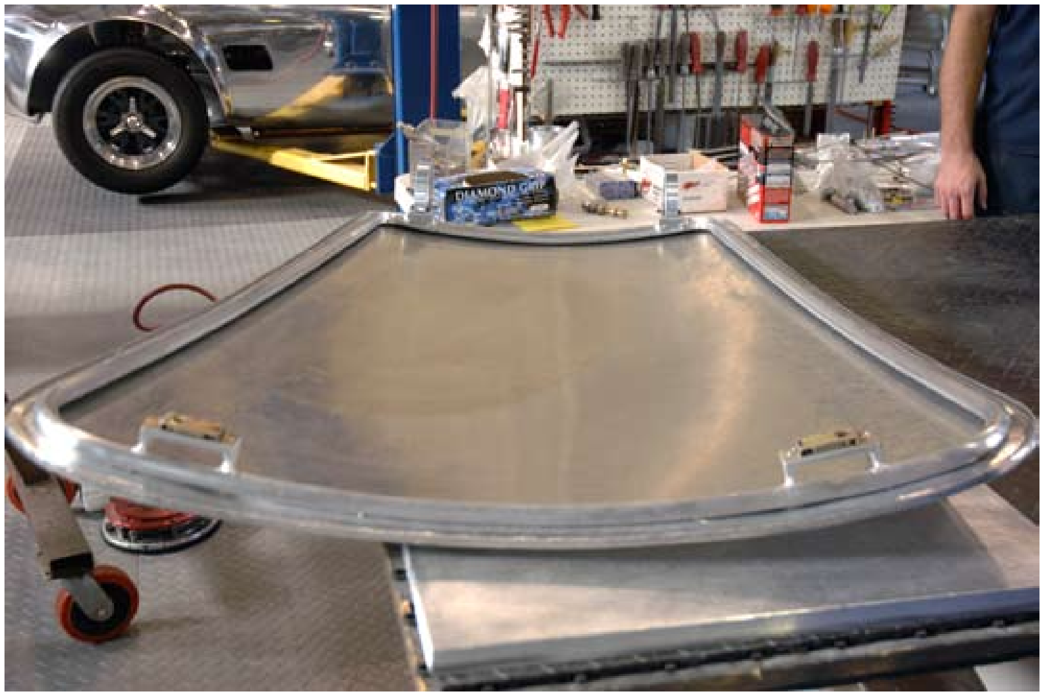
The hood skin is then carefully trimmed on the outer line.

We use this simple tool to make the hem. The slot is just wider than the thickness of the hood skin.

The depth of the slot is exactly the distance required to make the hem. We then bend the hood skin up 90 degrees. We work the bend in gradually to minimize stretching the hood skin.

Next the hem is flattened with a hammer and dolly.

The half moon dolly is shaped to fit into the radius of the hood skin.



Once the hem is straightened out, we take a hammer and strike the edge of the hem to tighten up the radius.

Then we place the hood skin with the hem bent up at 90 degrees into the hood frame.

A steel hammer is used to close the hem 180 degrees and to fold it flat.

Jozef checks the hood jam gaps.

Areas in the jam that need adjusting are marked.

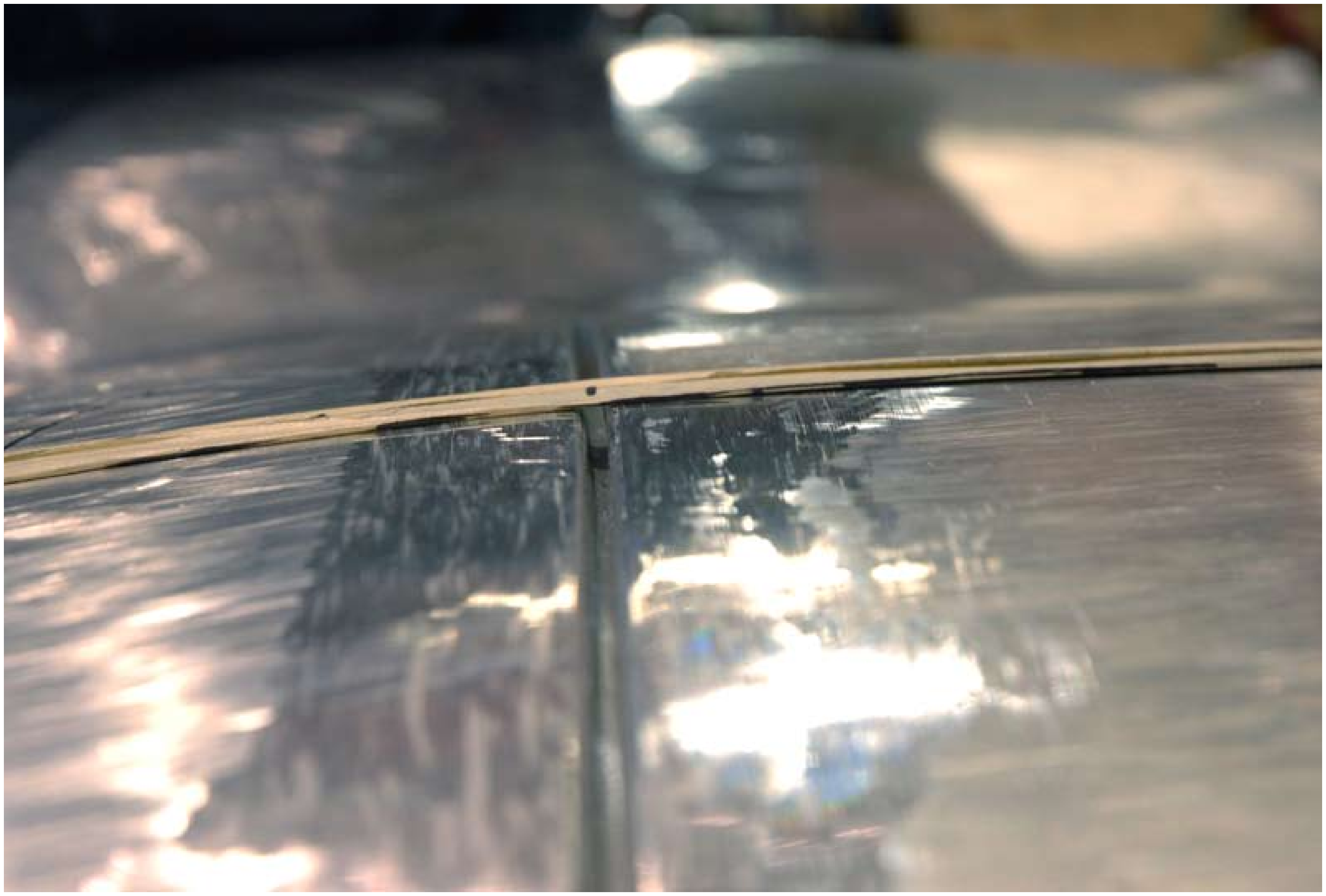
With a steel hammer, we move the hood lines until they fit just right.

The hood and the nose do not yet make a perfectly smooth arc on an original car. The nose needs to be raised by about 1/8 of an inch to make a really clean sweep. This is barely visible and would be almost impossible to see once there are stripes on the car. Building a car body by hand truly needs the touch and eye of a master.

So we took a hammer and finessed the nose and hood until they made a clean, sweeping arc.

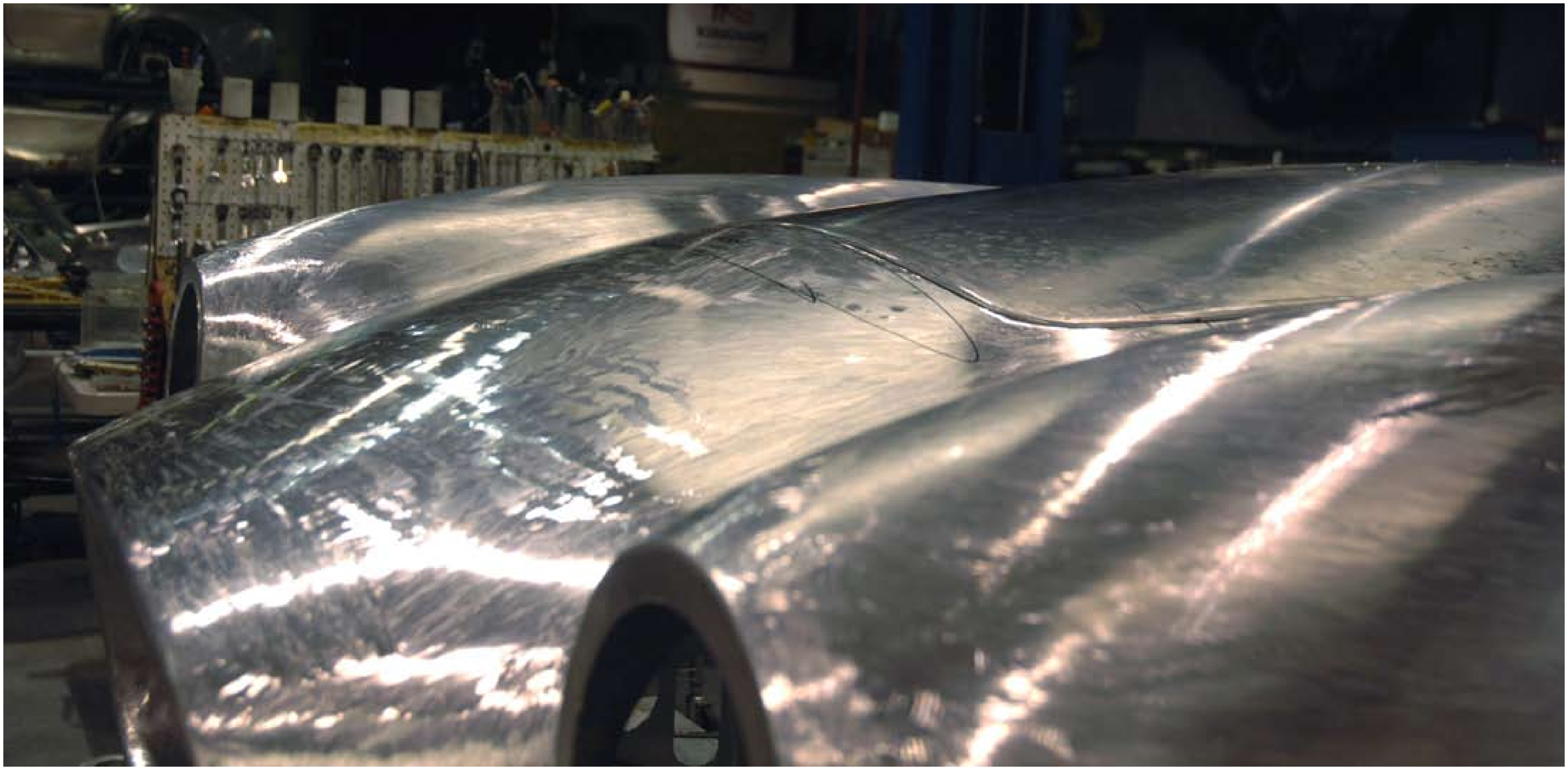
The new arc needed to be blended back into the hood quite a distance.

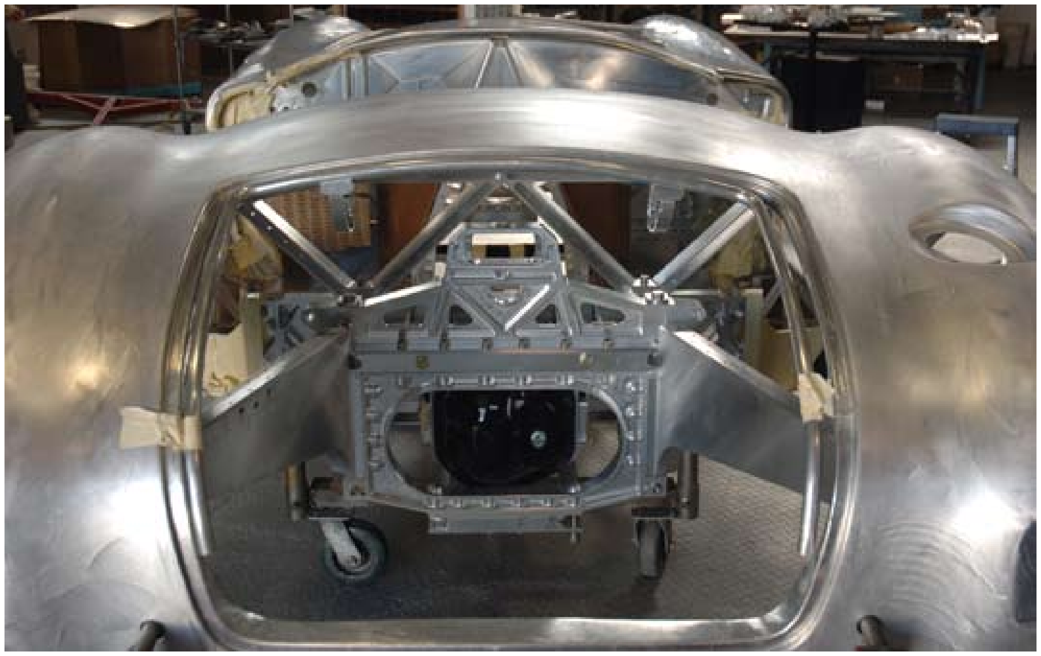
This was done with a hammer and then feathered out with a file.



Here you can see a flexible steel rule (covered in tape so it doesn't scratch our polished cars) lies flat on the arc across the hood jam.

The new nose shape. Now, it is quite graceful.





The trunk substructure tubes are done the same way as the hood—except the trunk is a bit more difficult to do because of the large arc.

Cleaning the trunk frame getting it ready to skin.

Billet trunk latch bracket.

Skinning finished.

Original cars do not have a beautiful transitional sweep from the trunk latch area to the body area below. The transition needed a little bit of surgery to make it right. Aluminum must be annealed to move it very far. First, I coated it with soot...

Then I burned the soot off. The soot burns off at exactly the right temperature to anneal the aluminum. Notice the piece of channel we clamped to the frame so the body wouldn't move around while we were annealing it.

Because we changed the body shape, the trunk gaps moved and had to be corrected. We had to move the trunk line down about 1/8 of an inch. The dark line in the jam is the original 90 bend. We unfolded it then made a new bend 1/8 of an inch farther down.

In the above picture, you can see the edge of the jam is quite round and full of hammer dings. Here we sharpened up the jam and cleaned out all the hammer marks. The white wavy marks are soap. The soap reduces file clogging.

Here I am tapping on a slapper with a hammer, spreading the blows out to do the final tuning of the trunk lines.

When we finished, the trunk body sweeps were as nice as the hood sweeps. You can see the flexible steel rule lies nicely across the jam.

The sides of the trunk jam still needed to be tuned up. You can see they are quite round and not very sharp.

We annealed the side of the trunk jam.

In this closeup, you can see how rounded the edges of the jams were.

After hammering them with a special dolly, we were able to square up the jams quite nicely. Again, the steel rule lies flat across the jam.

This is the custom dolly we made to square up the trunk jam. We got the radius of the body from our CAD file, and then CNC machined the dolly from a block of aluminum.

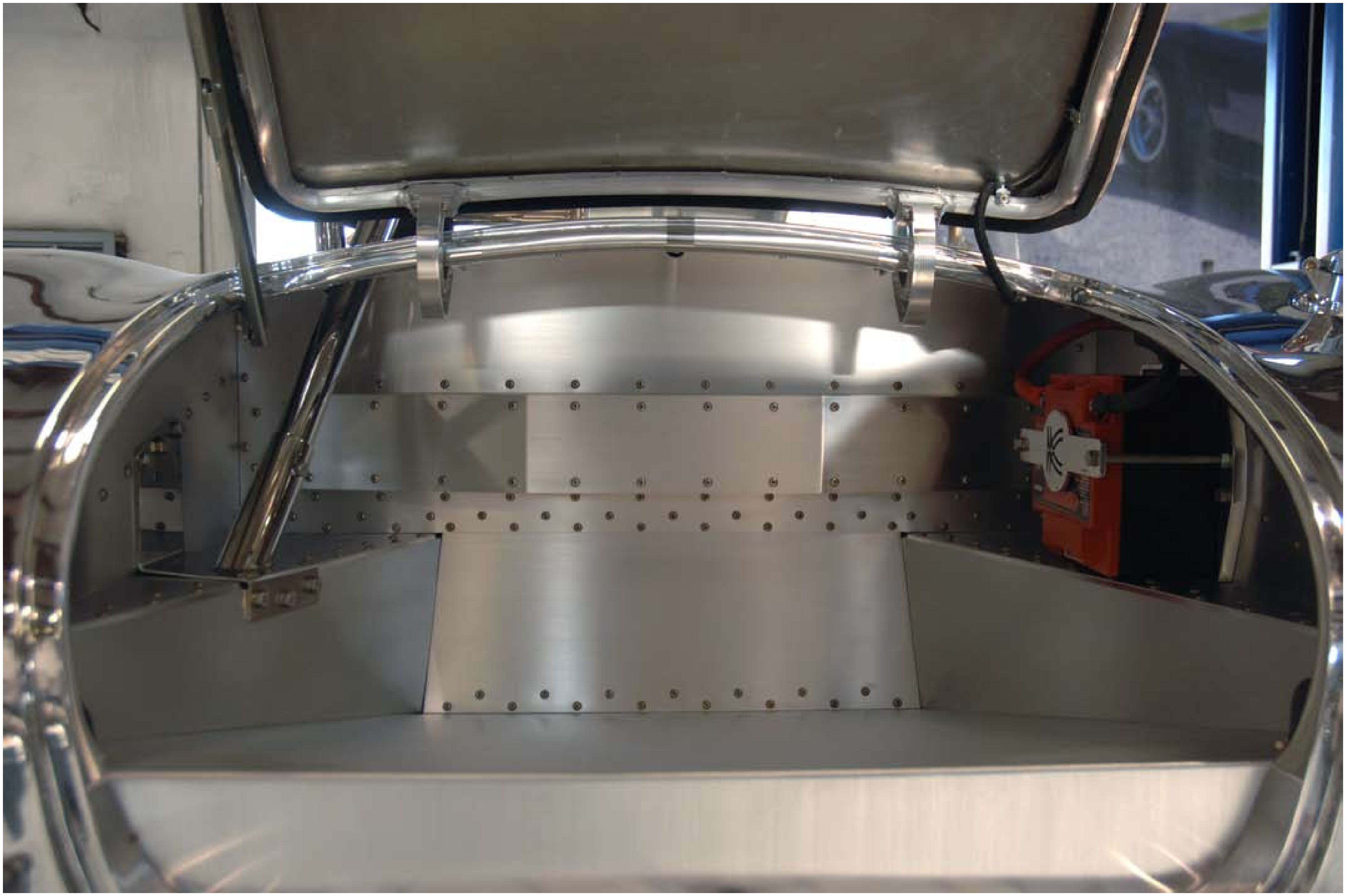
Tools of the trade. Almost all of them are handmade. The big black rubber slapper (third from right) is from our factory in Poland.

Jeremy filing out the trunk jam to remove any errors.

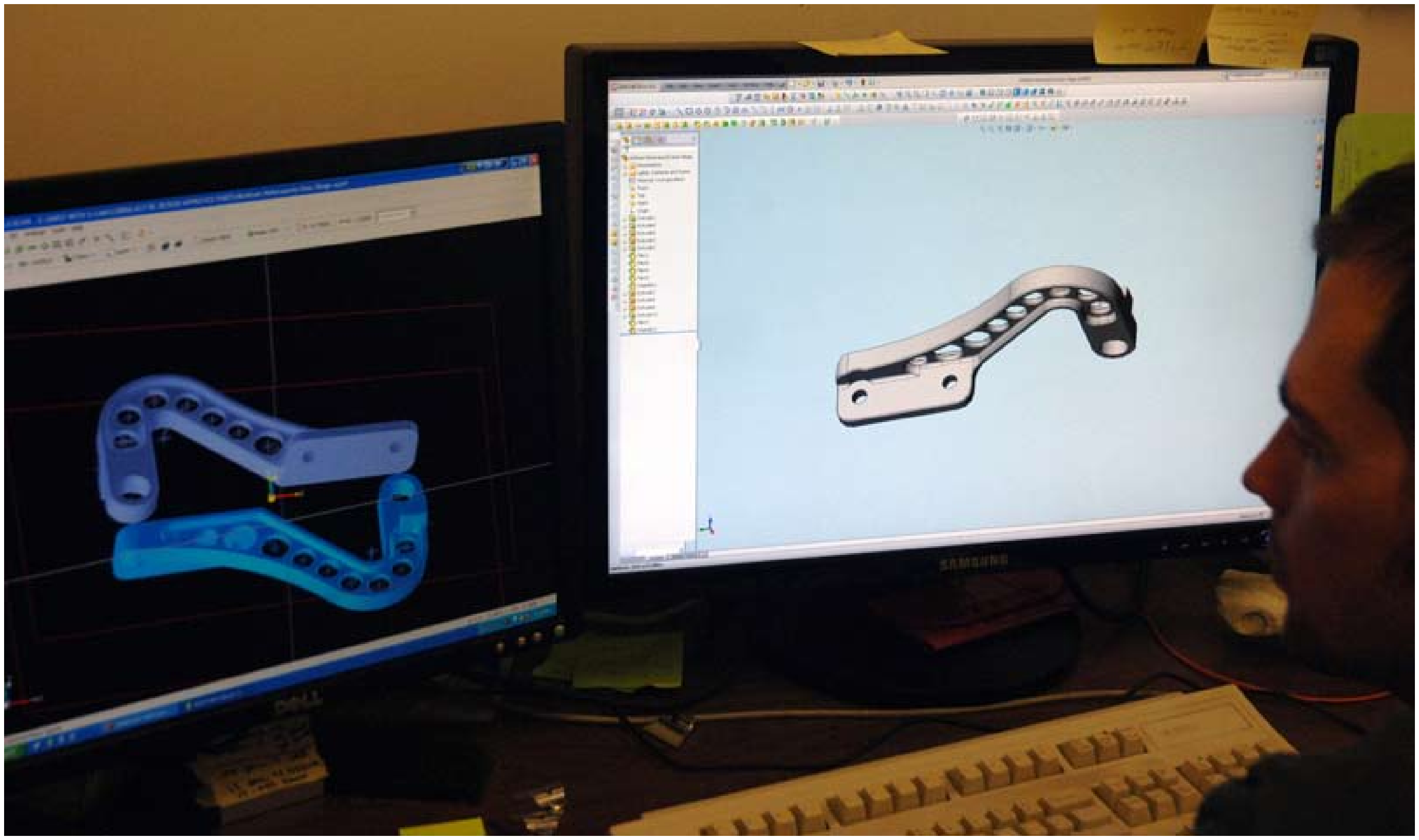
Once the jams and body shape were right, the trunk lid was filed completely smooth.

Sandwich fitting the trunk support.

The finished trunk. All the mounting screws are button-head, stainless screws.

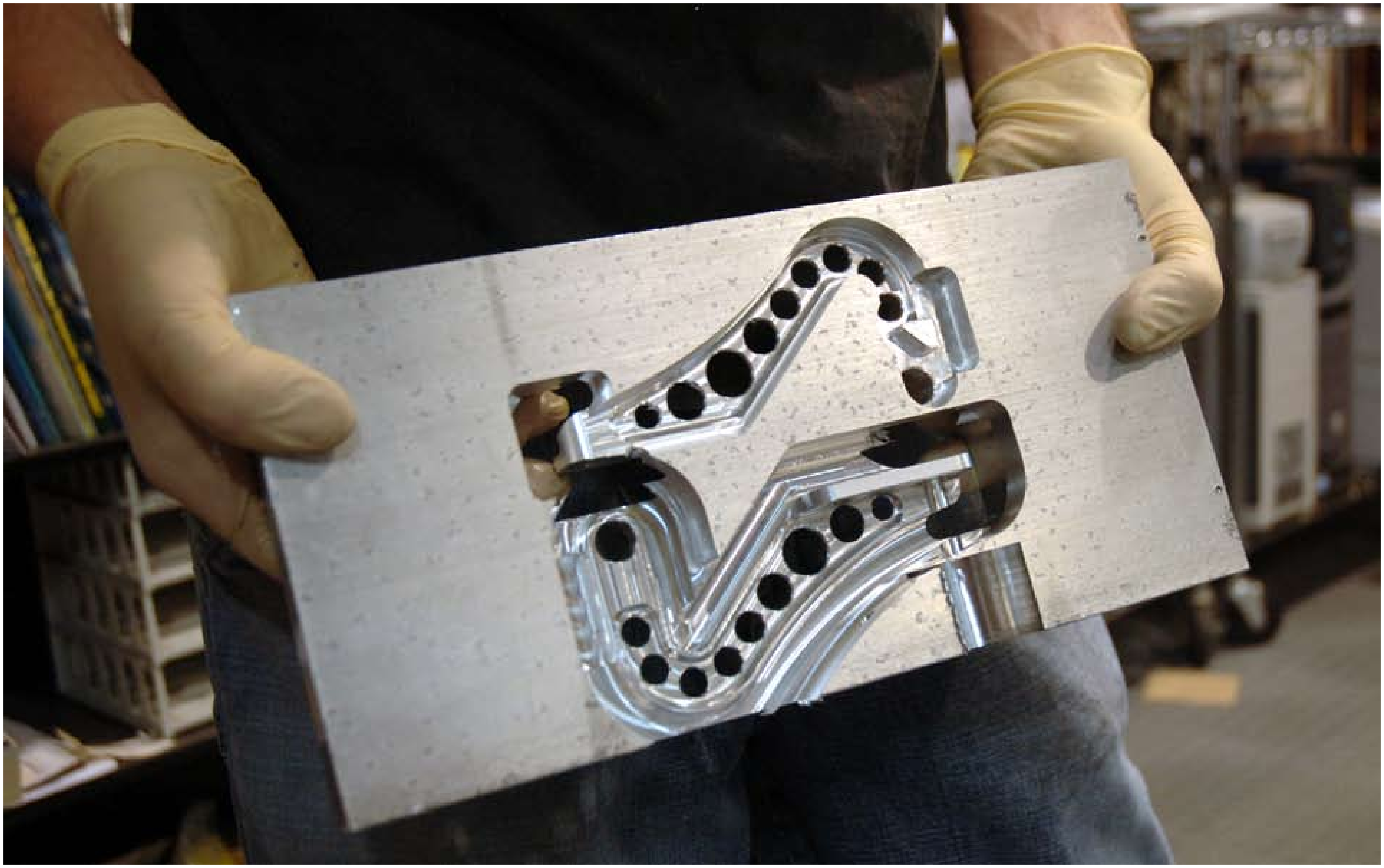


Closeup of the lightweight trunk hinges.

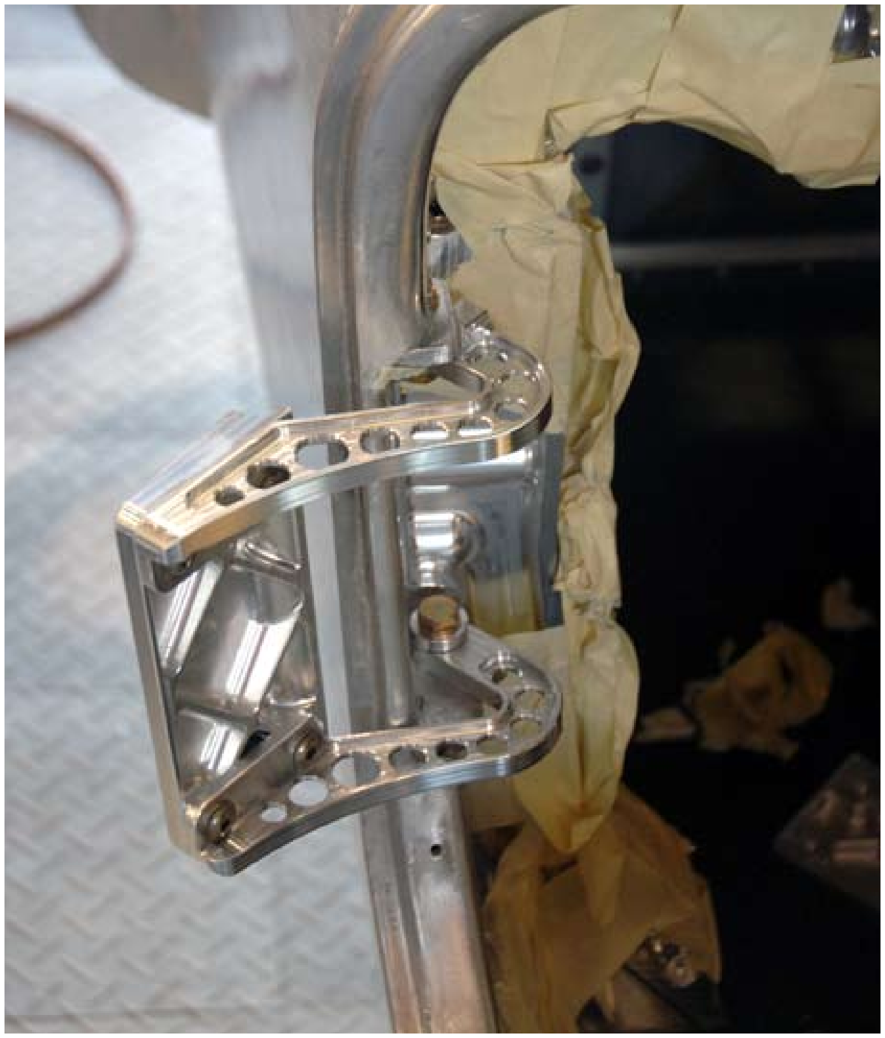


Sandwich designed some beautiful door hinges for Larry's car.

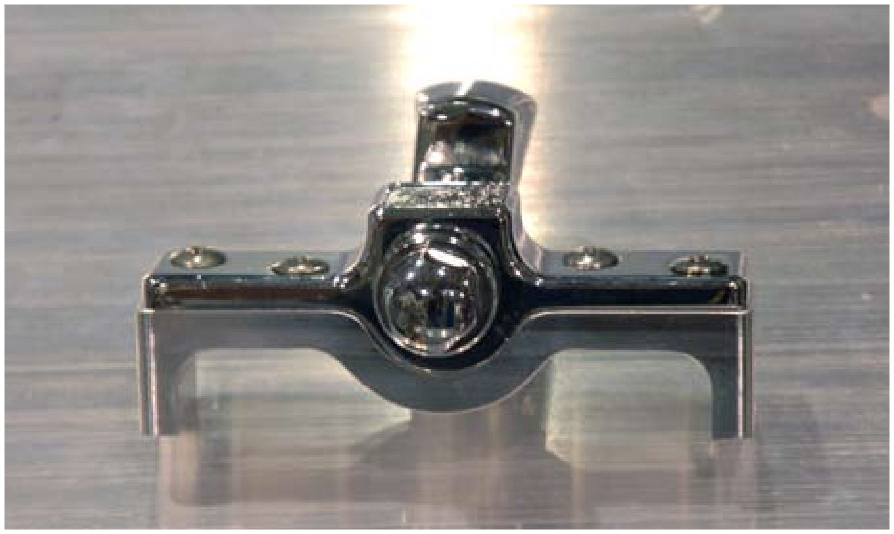
Door hinges coming out of the mill.



The door hinges had to be bolted onto the car before we could build the door.



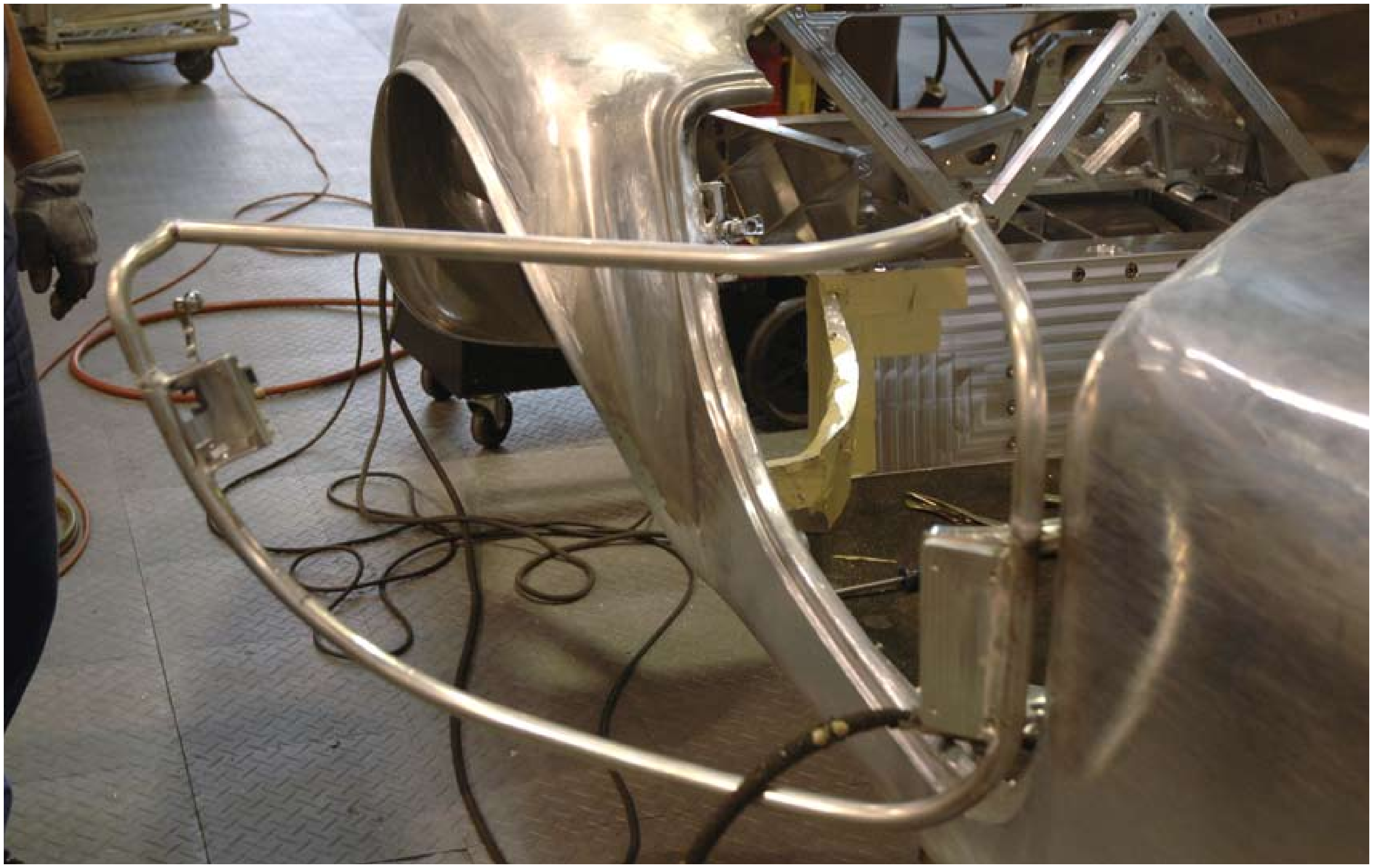
The door latches below were then bolted to the door frame latch brackets. Sandwich machined these out of billet aluminium as well.



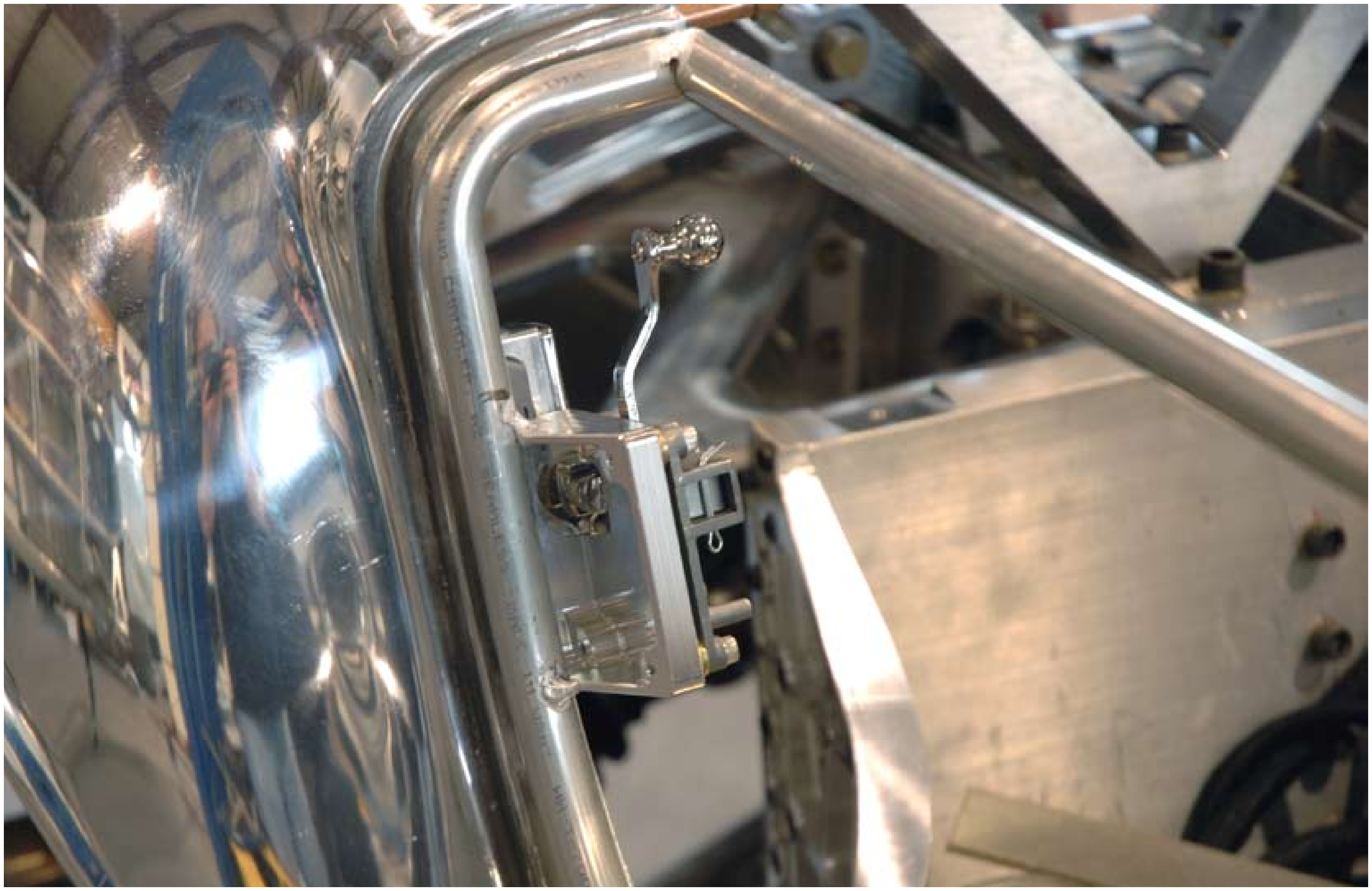
The door striker was bolted to a billet striker bracket and then tack welded to the frame.

Beginning work on the door frame tubes. The hinge, striker, and latch are functional at all times to make sure the door works.

The door frame sweeps have to line up perfectly with the body.



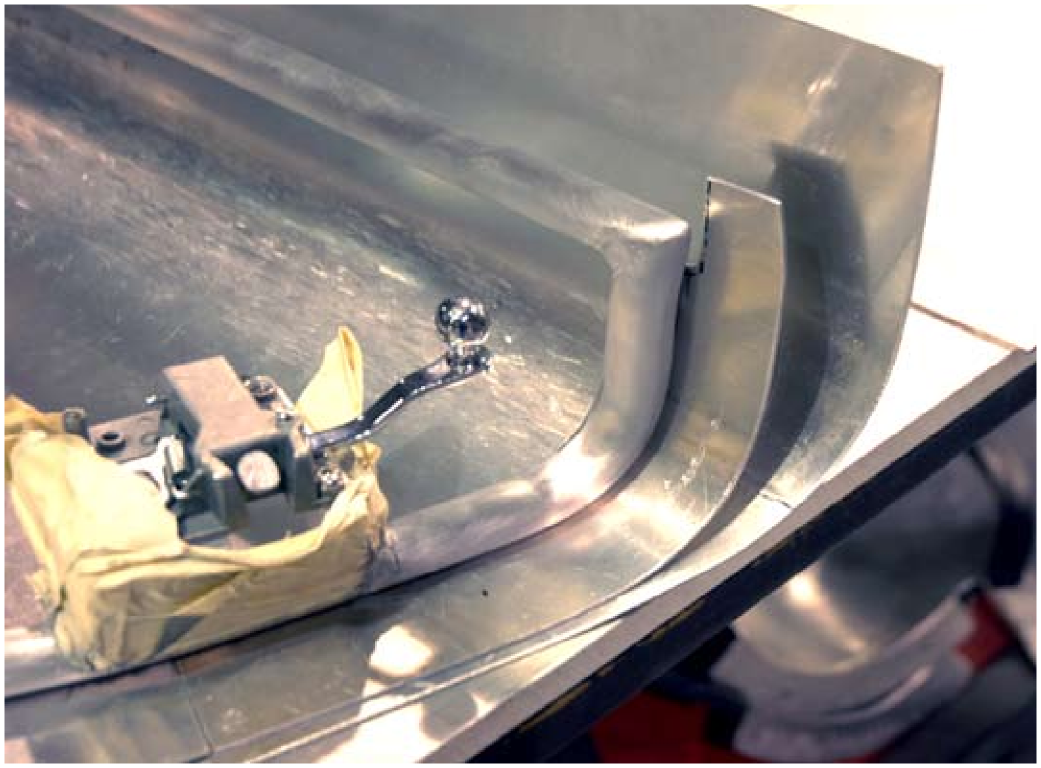
The doors are a complicated three-dimensional shape.



The door latch is tack welded in place as the door is being made.

The door frame flanges being fit to the door.

The large curve of the door is made by bending a sheet of aluminum over a 4-inch pipe.

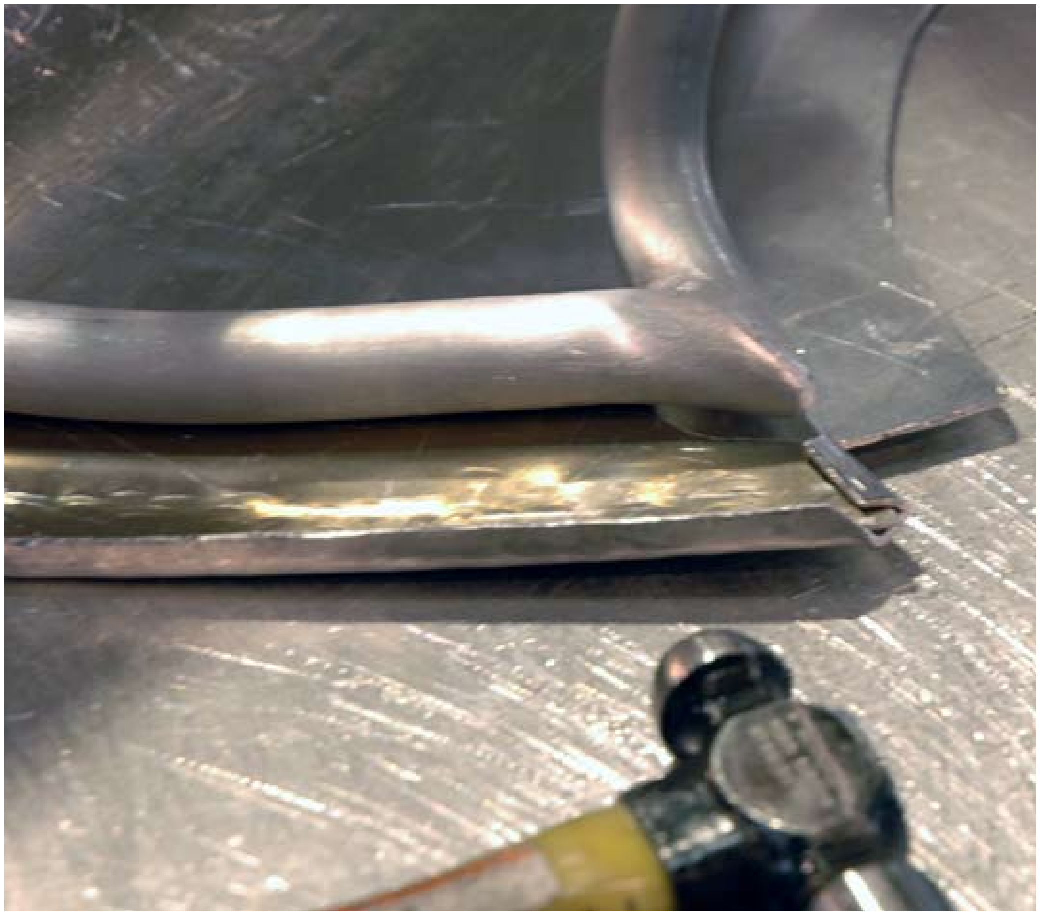


Fitting the door skin to the door frame for tracing.

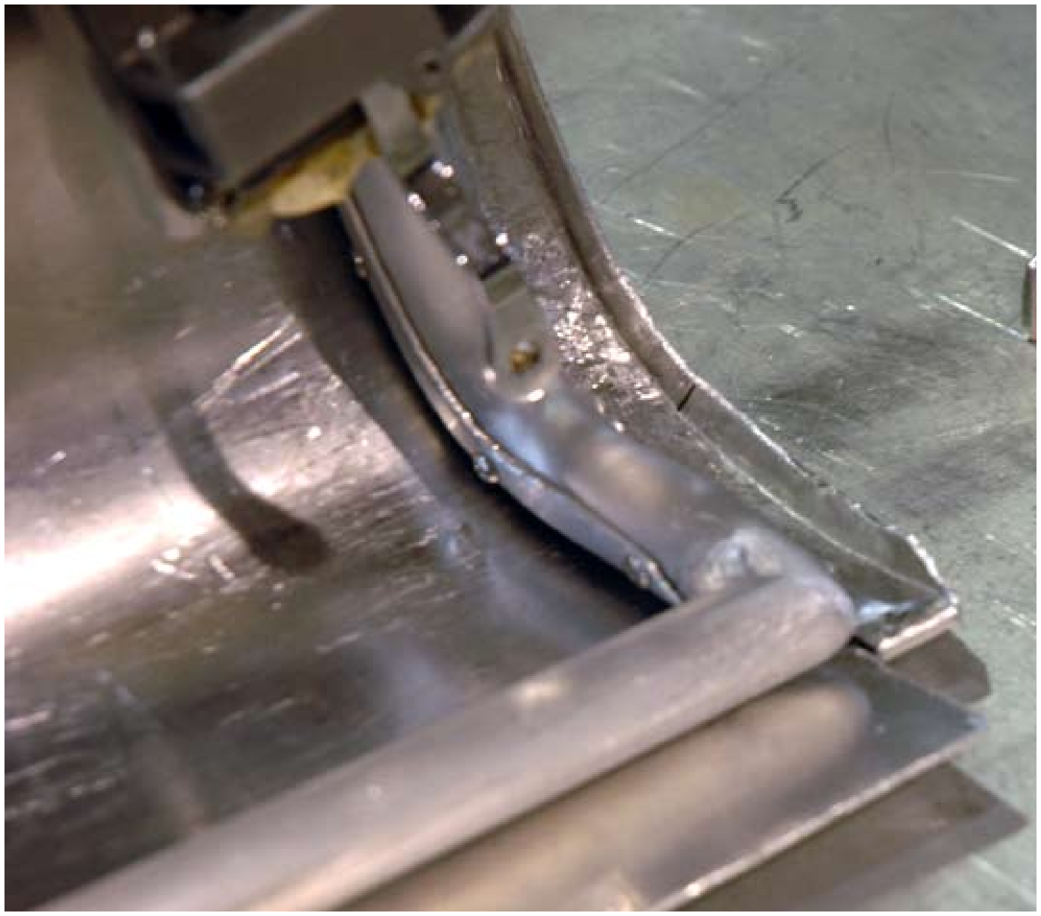
Bending the 90 degree hem into the door skin.

Squaring up the radius. We work on a flat sheet of aluminum to keep everything as square and flat as possible.

Fitting the door frame into the door skin.

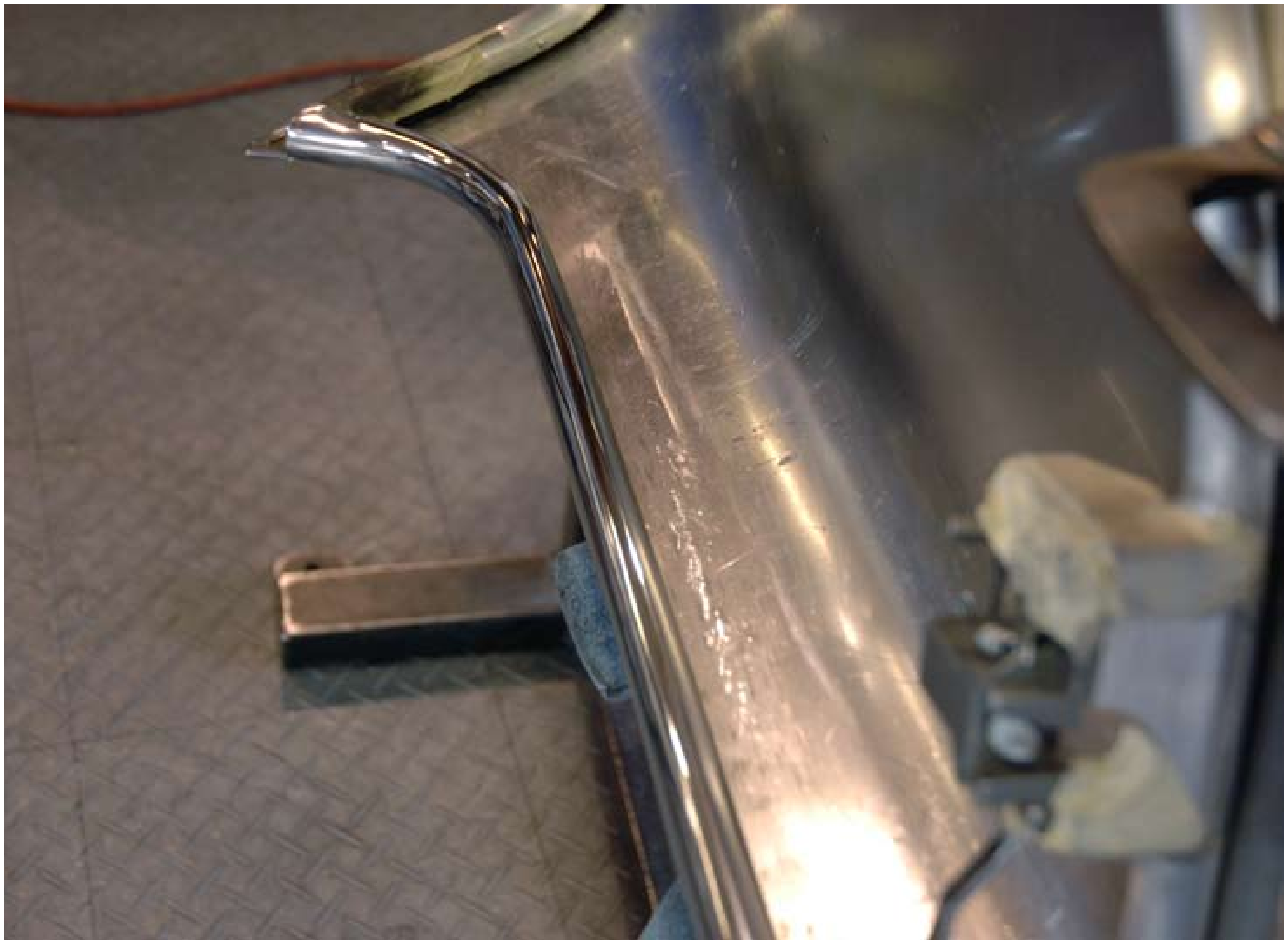


Once the door frame is in the door skin, a small tab at the front and rear of the door is bent over to lock the skin into place. Then, the rest of the door can be easily hemmed.



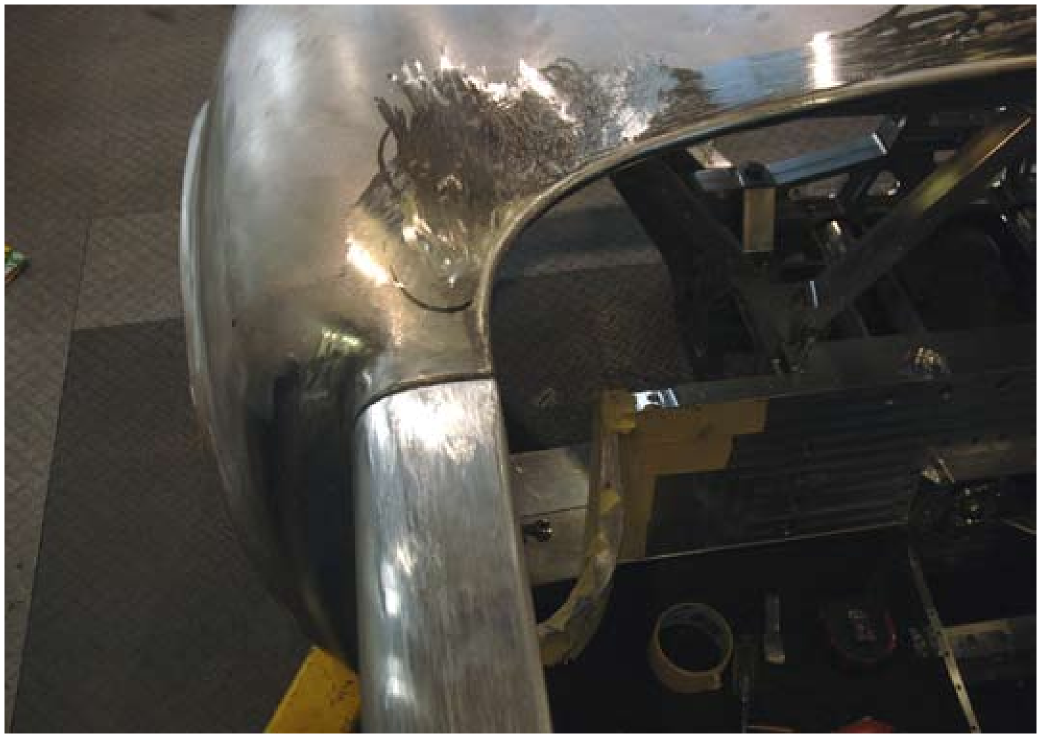
We checked the door gaps one final time before wrapping the cockpit edge of the door.

We made some wooden plates to protect the top of the door while wrapping. The door skin must be held firmly in place to get a nice, tight wrap on the door frame. We use a nylon mallet to minimize marring the door. Any marks will have to be polished out.



We polished the underside of the wrap—just in case anyone ever looks.

After the door is wrapped, it has to be straightened. The wrapping and hemming put a strain on the door, and bow it inward. We use a long, straight piece of an aluminum "U" channel as a dolly to coax the door straight again.



The door is then filed smooth. When we are finished, all door lines must line up with the body.

Yes, Jozef is filing on a mirror-polished door. Why? Some waves in the metal don't show up until the panel is polished. We didn't let them slide by—we filed them out.

You can see the slight wave in the door manifesting if you look at the reflection of our building (right on the dark trim line beside the window).

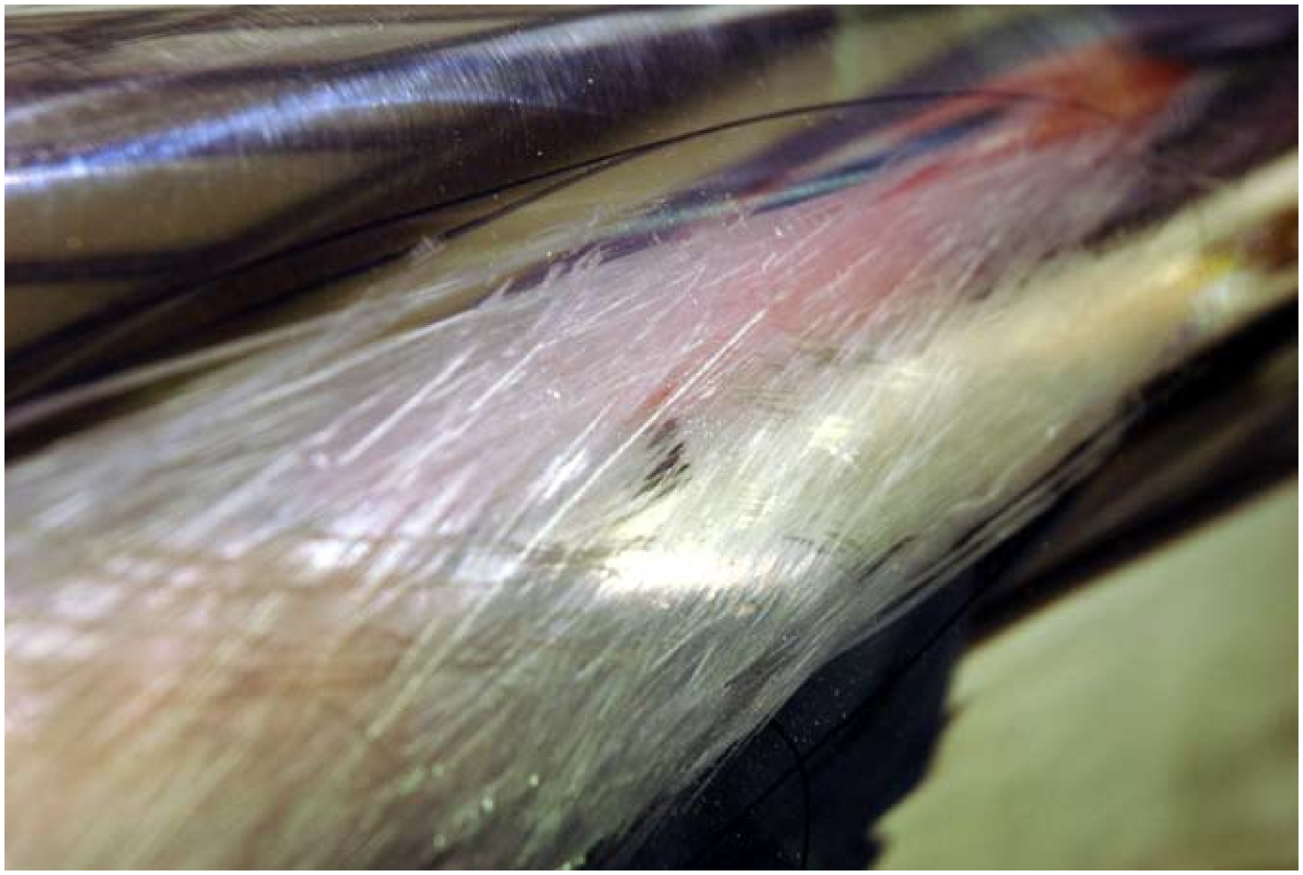
We use a laser to position the hood scoop correctly on the hood. If you look closely at the center cleco in the hood scoop, you can see a vertical laser line and a faint laser mark on the rear cowl tube right by the roll-bar hole.

We use a dual action sander to sand all the file marks out of the car. We start with 120 grit sand paper and finish with 800 grit. We then polish the 800 grit sand paper marks out with Nuvite polish.

Polishing the body.

Right: Sandwich found a few waves even after the body was polished.

Opposite: We polished out the hood, trunk, and door jams until all visible aluminum had a mirror finish.



You can see the slight wave that needed to be smoothed. It is marked by a black circle.

The final inspection.

Final polishing and striping on the body. The car is completely polished first. Then, the stripes are laid out on the body and sanded into the polished finish with 220 grit sand paper.

Reflections of Autoweek in the door.