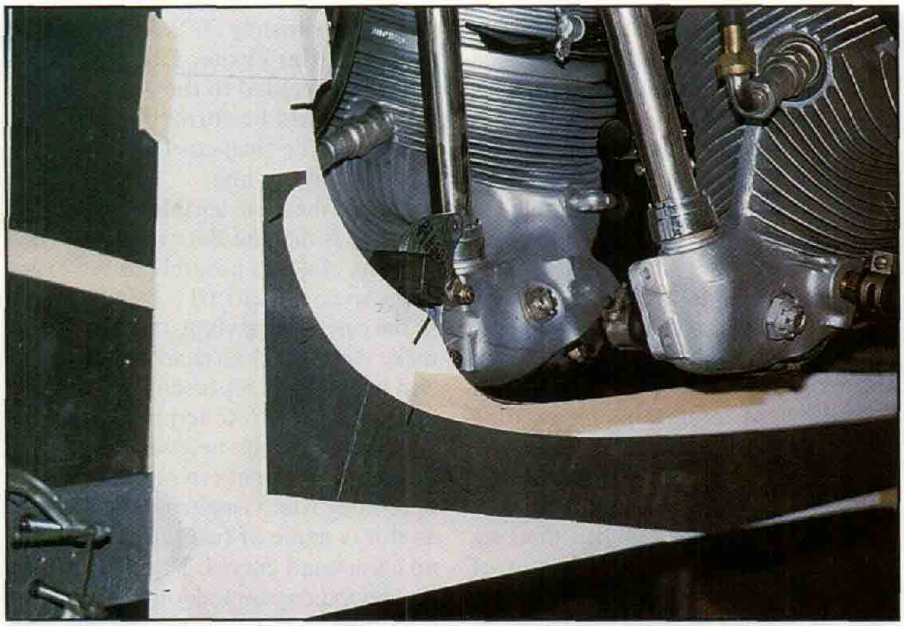
TECHNICAL FEATURE

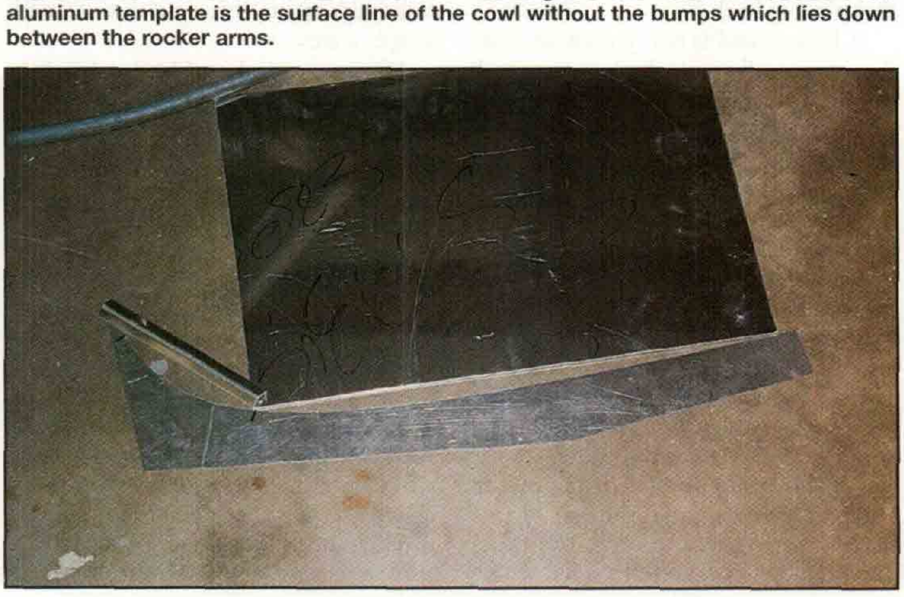
Radial Engine Cowling From Scratch?

Not an Impossibility!

BY BUDD DAVISSON



The white template represents the cowl outline with the bumps in it to clear the rocker arm boxes. The two black marks are the edges of the front cowl section. The aluminum template is the surface line of the cowl without the bumps which lies down between the rocker arms.



The full curve of the cowl will be done in two sections. The straight edges indicate the surfaces of the truncated cone patterns and show how much stretching has to be done.

With all the Russian and other radial engines beginning to show up on homebuilts and antiques a massive scavenger hunt for cowlings is underway. The guys with Chinese Yaks are afraid to park their airplanes in the wrong part of town for fear they'll come back and find some unscrupulous homebuilder has made off with his cowling.

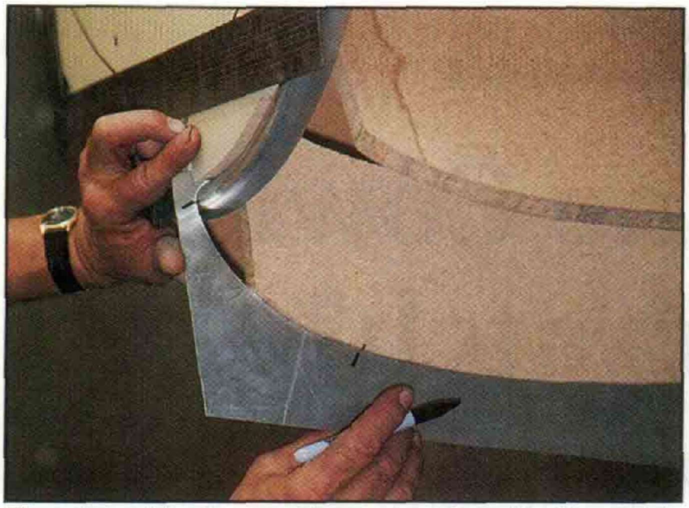
Okay, so that's an exaggeration. But it's not an exaggeration to say it is very seldom someone who is hanging a round motor on an airplane thinks about making the cowling as opposed to adapting one which already exists.

It is even more unusual they think about hammering the cowling from scratch, rather than using a spinning which is either designed for a roof top ventilator or is provided by someone like Historic Aviation which has round cowlings spun commercially.

At first, the concept of scratch building a round cowling sounds ludicrous. It's logical to ask how anyone could possibly hammer out a cowling and have it symmetrical as well as smooth. It doesn't seem possible.

After watching one going together down at Historic Aviation in Springdale, AR, I'm here to tell you it is not only possible, but it isn't as difficult as it first sounds.

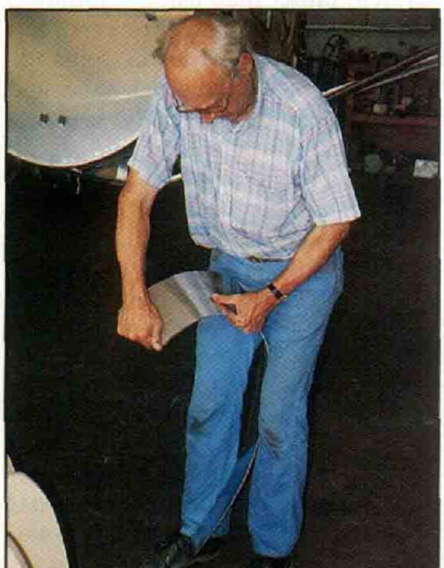
Besides understanding how to compound form aluminum, the most important skill for this project is un-



The edges of the front section are transferred to the particle board to be used in determining the radii necessary to develop the flat patterns.

Jim Younkin uses straight edges and a tape measure to layout the geometry necessary to determine the pattern radii.

The skirt radii were so long a giant compass was made from aluminum angle. If you look carefully you'll see Bob Bell under the Mulligan fuselage establishing the center point while Jim swings the arcs.



The first forming operation for the nose section is pretty rudimentary using tools most builders have in their shops.

derstanding the geometry of what is going on and building correct tooling ahead of time.

The cowling we were watching take form was a bump cowl Jim Younkin is going to use to cover the P&W R-985s on the Mullicoupes. He is very particular about his cowl lines and thought very seriously about modifying his existing spinning form and having the pros spin him the basic cowl shape. However, after thinking about the amount of work it would take to modify the huge form, he decided he could hand build all three cowls in the time it took to modify the spinning buck.

A bump cowl is really nothing more than a smooth cowl which is too small to clear the rocker arm covers so the bumps are necessary. The first thing Jim had to do was decide the shape and dimensions of the basic cowl. Once he had this laid out in two dimensions, he transformed those outlines to particle board and made a three-dimensional form. This form would be crucial to every part of the project. It would provide full sized measurements as well as give Jim something to try-fit the pieces against to see how the radii and compound curves were coming.

He was going to make the cowl in two basic pieces, the front four or five inches which would have the most compound curve, and the skirt, which was approximately 20" wide and had a much gentler curve. The nose bowl would be welded to the skirt and the bumps would be formed behind the weld line. The final cowl would split in half at the water line.

One of the basic tenants of aluminum forming is that the flat metal blank has to be as close as possible to the exact shape so no extra metal is being worked. In the case of a cowling, it is possible to make the patterns so exact that the front and back edges represent lines which are not to be stretched because they have the exact radii needed.

The way the pattern radii are developed is by first visualizing the cowling as if it is made of two flat-wraps with no compound curves. The pieces wrap around the engine and join at the chord line where the two pieces will be welded together. Each of those flat sections represent pieces cut out of much longer cones.

If one wanted and had infinitely large sheets of aluminum, two cones could be rolled and sections cut out of them where the radius is right to fit the engine. Since one of the cones would be around 20 feet long, that is clearly an insane idea.

The radii can be determined quite easily, however, with a few measuring tools and a hand calculator. Here's a chance to use that trigonometry you always hated.

First, a metal template showing the final cowling curve is cut. This template will determine everything you do from now on so make sure you're happy with it. Then the points where the nose section will end are marked on it. In

Younkin's case, he uses one inch aluminum conduit for the leading edge of his cowls so the front point is where the aluminum will weld to the conduit. The second point is further back.

This entire process could be chalked out on the shop floor, but since we had the particle board form we did the measurements on that. The edges of the front cowl piece were carefully transferred from the shape template to the board form. Then a straight edge was notched to clear the conduit so we could measure right from the point where the weld would be. The straight edge was laid across the two pieces and clamped in place. Then a framing square was stood up on the form and the distance to the centerline measured. This gave the hypotenuse of the angle and the vertical measurement. A little basic trig (remember Pythagoras?) gives the radius at the first mark. Then a little ratioing gives the radius at the back mark.

These dimensions represent the arcs which must be struck to give a flat pattern which, when rolled into a truncated cone, represent the nose section before the compound curves are pounded into it.

Many times Younkin actually rolls the flat piece and welds the ends together to form an actual truncated cone. In this case, however, he thought they would be easier to handle if cut in half.

A long straight edge was made out of angle lying around the shop and holes drilled the appropriate distance apart. Using a liquid marker, the radii were struck on .063 3003 H-14 sheet.

We attacked building the nose bowl first and Jim bent the flat pattern into a curve and fit it onto the particle board form just to make sure the radii were right. Satisfied, he began beating the heck out of the strip on the shot bag with a plastic mallet, being careful to stay away from the edges. Remember, the edges represent the right radii so they don't want to be disturbed.

Once the strip was suitably dimpled and ugly, he went right to the English Wheel to begin smoothing out the lumps and blending the stretched areas into one another. This could also be done with a plastic mallet on a piece of curved pipe but the wheel is much faster. Jim also has a gigantic power hammer and he prefers to use that because it moves metal faster and more smoothly. For the purpose of this exercise, however, we considered that cheating.

In rolling the narrow strip lengthwise, it rapidly curled too tight to fit on the form so Jim had to alternately roll across the piece to bring the radius back to the right dimension.

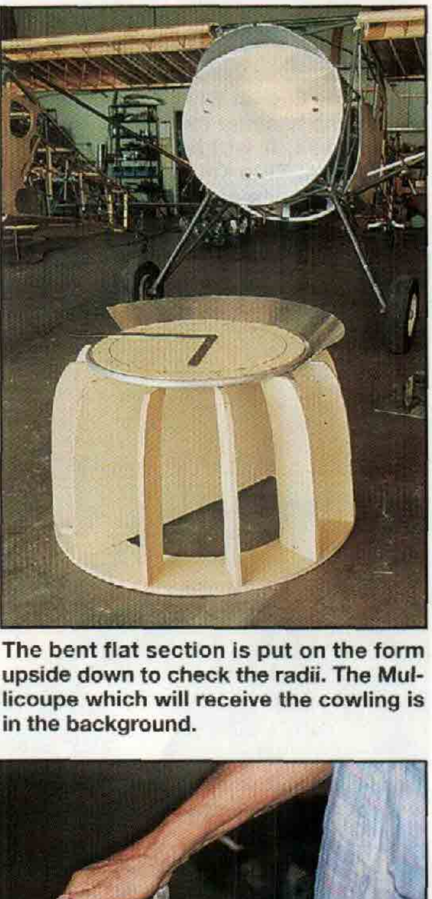
The curvature template was never far away and was continually used to see how the chordwise curve was coming. The radius was constantly checked against the particle board form.

It took less than a half hour at the English Wheel, with an occasional trip to the shot bag when serious stretching was deemed necessary, to get the curve and the radius right. Then it was time to smooth it out on the wheel. This involved seeking out low spots and concentrating the rolling in those areas to bring them up.

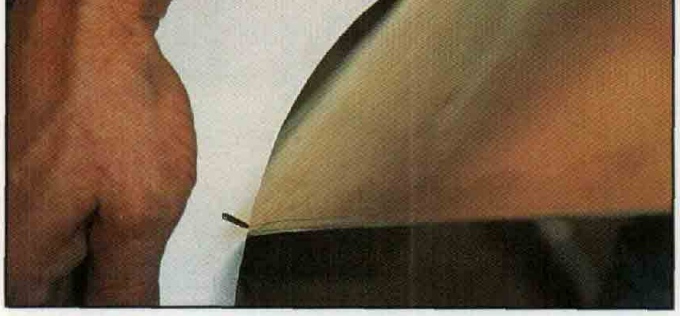
Start to finish for half the nose bowl was less than an hour.

Initially Jim wanted to work the much wider skirt section in just two pieces but it didn't take long at the wheel to realize the piece was entirely too long to easily handle. A measurement was taken off an engine to determine the right length so the cut and the resulting weld seam would fall between the cowl bumps.

The actual amount of compound curve needed for the skirt was quite small compared to that needed for the nose section. It was less than an inch over nearly two feet where the nose section had about the same amount over only five inches. The skirt, however, offers the challenge of making it



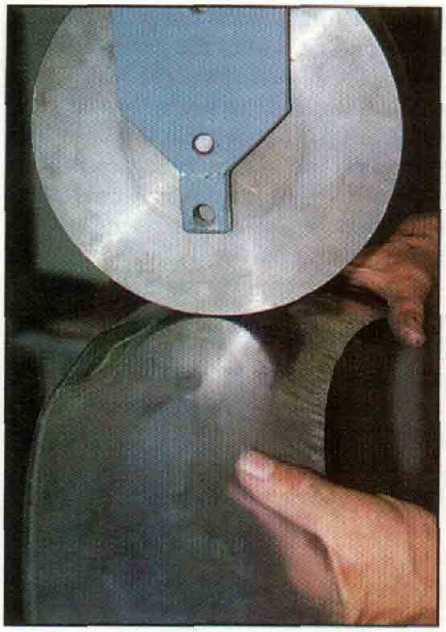
The bent flat section is put on the form upside down to check the radii. The Mullicoupe which will receive the cowling is in the background.



The template shows how much stretching must be done on the flat pattern.

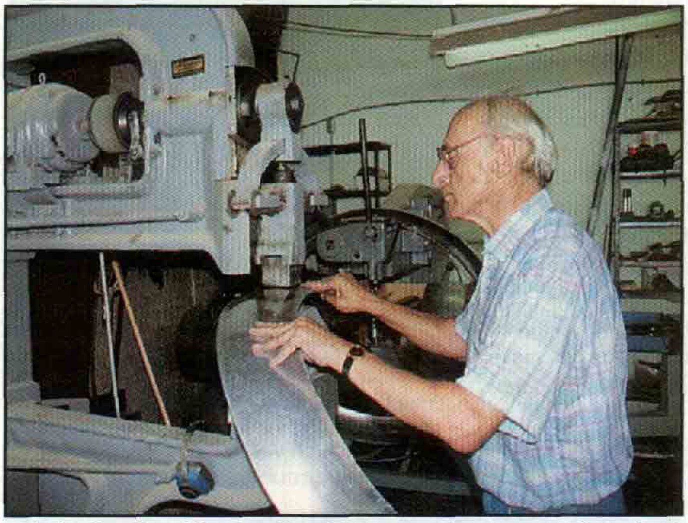
Because there is so much stretching on the nose section, it is first hammered down into the shot bag. No finesse is required since the goal is to stretch the metal, not form or shape it.

Initially the English Wheel is used to flatten out the hammer marks but, as work progresses, it will be doing its own stretching. This smoothing process could have been done by hand, but the wheel works much faster.



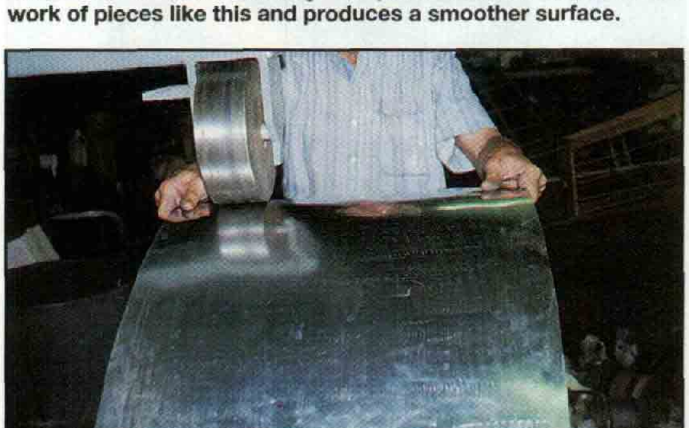
Only about 15 minutes separates this picture from the last one. The Wheel does its work very quickly. here it is being used crosswise to keep the radii of the part from shortening.

The template is used continuously all along the work piece continually looking for low spots. At the same time the cowlings radius has to be monitored and maintained.

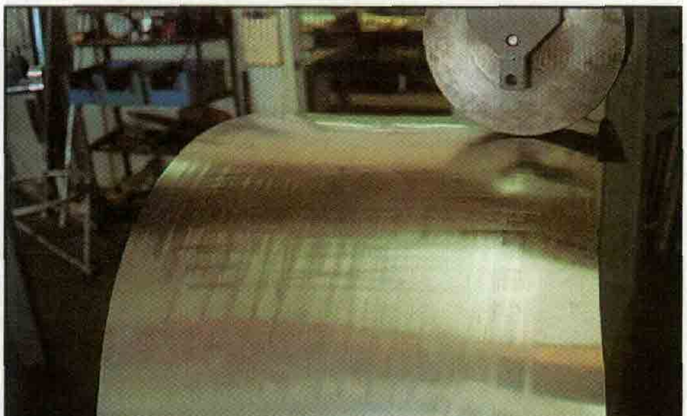


This is Jim Younkin cheating. The power hammer makes short work of pieces like this and produces a smoother surface.

Before and after. Total time invested is less than an hour. By the time all the rolling and hammering had been done, the relatively soft 3003 H-14 aluminum has work hardened considerably. The ends will be trimmed on assembly.



The skirt was so large and the curve so gentle it didn't require using the shot bag for the initial stretching. Stretching it on the wheel was much more gradual although Jim preferred using the power hammer.



The crisscross pattern of the roller marks show where Younkin has been dividing up his rolling so the compound curve develops without radically changing the radius of the skirt.

It fits! The pieces are tried on the form dozens of times as the curves and radii are developed. The entire process happens very quickly and the parts illustrated here represent less than three hours work. That doesn't count the 20 years leading up to them.

The leading edge of the cowling uses aluminum electrical conduit with a wall thickness of close to 1/8". They roll it in rolling dies they've developed for their Bridgeport.

smooth. Since stretching changes the radii, most of the major stretching has to be done while the radii area is still being adjusted. Then the smoothing actions won't change anything. The smoothing is a fairly logical process that can't begin until the radii are dead on and the compound curve is so close only the low spots need to be picked up.

As with the nose section, the front and back edges of the skirt are left alone because they represent accurate radii.

Because the amount of compound curve was so small, all of the stretching was done on the English Wheel, although Jim would sneak off to the power hammer when we had our backs turned. The shot bag wasn't used because major stretching wasn't required. If an English Wheel hadn't been available, the entire operation could have been done on the shot bag and anvils but the hammering for the initial stretching would have been of the tap-tap variety not the slam-bang type used on the nose section. Also the smoothing process would have been much more tedious.

Throughout the forming of both the nose and the skirt sections, a groove was worn in the floor walking back and forth to the particle board form. The aluminum was constantly being laid on the form to see how both the curve and radii were doing.

It took about 45 minutes per panel, each of which represented 1/4th of the total skirt. When each panel was finished it was carefully fine-tuned against the form and then prepped for welding together. However, before they are final trimmed and welded, Jim will form the cowl bumps in each using the special molds he has developed. He'll do that first because forming the bumps is bound to change the shape of the skirt slightly and it will be easier to straighten things out if the pieces aren't welded together yet. But, that's a story for another day. ◆