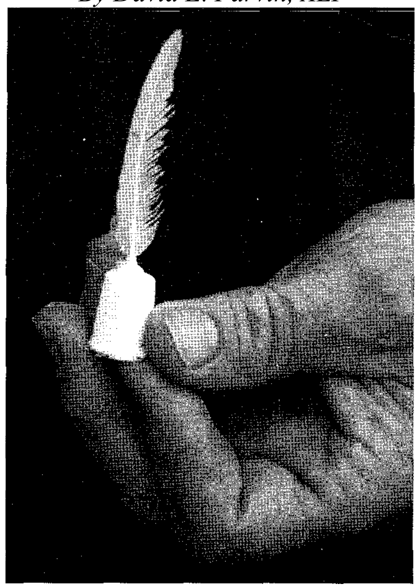
Using Vacuums and Pressure in Casting

By David E. Parvin, ALI



While castings of any size can benefit from using differential pressure, some would not be possible without it. Photo by Elliot Summons

This is the first in a series of articles. This one will explain just what vacuuming and pressurizing can do to improve casting quality. In the following months, I will describe in detail how to construct very functional vacuum and pressure chambers for less than $200.00 each and how to use them to improve quality and save time.

It's all about the bubbles. Those of us who are old and lucky enough to have been to Hawaii and heard Don Ho sing will remember how happy and fine the tiny bubbles in wine made him feel. But for those of us who strive for casting perfection, bubbles tiny or otherwise are the bane of our existence. Bubbles are there in every stage of the sculpting process from sculpting the model (i.e. the "original" object sculpted and not the person whose likeness we are duplicating) to making the mold, pouring the waxes, building the shells, casting the bronze, and welding the pieces together. And if one is not using the lost wax method but is casting in resin, plaster, Forton MG, etc., bubbles can be an even bigger problem.

Some years ago, I had sculpted a figure about 12 inches tall which convinced me at that time to avoid small pieces in the future. It was simply too time consuming to chase the waxes. The little 1 inch hands were especially troublesome; the fingertips were almost always missing and had to be reconstructed. Later, bubbles again got in my way when I began experimenting with casting in clear urethane. Clear materials present an even greater challenge since it's not only surface bubbles that must be eliminated but also those throughout the mixture. (Those of you who are "Sculpture Journal" junkies may recall that I discussed the elimination of bubbles in "It's Very Clear," Jan., 2002). The solution was differential pressure, reducing with a vacuum, increasing with pressure, or both. Now I can easily make flawless castings in wax, resins, plaster, Forton MG etc. that usually require no chasing which has saved me both time and money. In addition, the same technique will allow the construction of longer lasting rubber molds that more accurately capture detail with far less imperfections.

I have found that there is a general misunderstanding about what can be accomplished by casting in a vacuum. Some people think that if one could surround a mold within a vacuum and then pour in the casting material while maintaining the vacuum, one would get a perfect casting because there would be no pockets of air to prevent filling every nook and cranny of the mold. And they are right as long as the only bubbles present are pockets of air trapped in the mold. Jewelers use vacuum casting of precious metals with exquisite detail. Also, there are a few foundries that can vacuum cast bronze with the same results. The key with both of these is that molten metals do not have a problem with the two other sources of bubbles.

In my previous article on casting in clear materials, I pointed out that there are at least three sources of bubbles: air trapped due to agitation such as mixing, and air dissolved in solution. The first of these is the easiest to control. Major pockets of air can be vented to allow the air to escape. Carefully tipping the mold while filling it can also help. The second source, the bubbles trapped from mixing, may rise to the surface and escape if the material has a long enough working time or "pot life." Very carefully pouring into the mold will minimize additional bubbles. The dissolved air presents a greater challenge. The good news is that the solution to this final problem completely eliminates any remaining bubbles from the first two sources as well.

Liquids are capable of dissolving other materials including gasses. This takes place on a molecular level, i.e. and the gas molecules are dissolved within the liquid and are not in bubble form. The amount of gas that can be dissolved in solution increases with pressure and decreases with temperature (Charles's Law)> Releasing the pressure from a can of soda causes fizzing, the bends results from nitrogen bubbles during rapid decompression, and bubbles will appear on the sides of a glass of water as it warms up. Let's see how this affects us.

Imagine a container of some liquid substance that will set up. It could be rubber, resin, Forton MG, plaster, etc. Since it will set up, we can assume that at least two ingredients have been mixed together. There is air in this liquid from two sources: air that was in solution prior to mixing and additionally bubbles that were trapped as it was mixed. If we place the liquid in a vacuum chamber and reduce the pressure, two things happen. The bubbles enlarge (Boyle's Law states that the volume of a gas is inversely proportional to the pressure) and some are able to rise to the surface and escape. In addition, air comes out of solution, forms additional bubbles which may also rise to the surface. By reducing the pressure, we will have de-aired the liquid. Here comes the good part. If we then bring the liquid back to atmospheric pressure we have a mixture that has less air in solution than it could hold at this pressure. Given enough time, it would re-absorb all the air and we would find ourselves back where we started. However, it will likely have set up long before that would happen. This means that when this de-aired liquid is poured into a mold, not only will those original bubbles have departed but any new bubble trapped as the liquid is poured into the mold will be absorbed into solution along with any small amounts of air trapped in the mold and the set up material should be bubble free.

Curiously enough, pressurizing gives the same results. Let's imagine the same substance prior to being de-aired. If we were to pour it into a mold, then place the mold into a pressure chamber and increase the pressure, this is what happens. There is no effect on the air already in solution. But because a liquid can hold more air in solution with increasing pressure, the air bubbles will not only reduce in size but may be absorbed into solution and disappear resulting in a bubble free casting. I have pressure chambers that will take from 50 to 110 p.s.i.: 50 is usually sufficient. Often for insurance, I will both de-air and pressurize a particular material. The deciding factor is usually time. Some resins, particularly, set up to quickly to do both.

If you recall, I mentioned another source of bubbles which is caused by air coming out of solution as a liquid warms up. Unfortunately for many materials, setting up is an exothermic reaction and bubbles can be an unfortunate by product. However, bubbles likely will not come out of solution if the material has been de-aired or pressurized or both.

I realize that with careful handling of materials, most people can achieve excellent results without using a vacuum and/or pressure and may see no reason to make things more complicated. However, if you were to mix a sample of silicone rubber (or any other kind) and pour it into three plastic cups, you can easily see the difference if you have the equipment. Allow one to cure at atmosphere pressure. De-air another and then allow it to cure at atmospheric pressure. Pressurize the third. After all three have set-up, slice each in half. The first will look like a sponge, i.e. be full of bubbles. The other two will be bubble free. The feather in the photograph accompanying this article was cast in an unvented mold using a very fast setting urethane (Polytek EasyFlo 60). This would not have been possible to cast without both pressure and vacuum vessels. Stay tuned because in following articles, I will not only explain exactly how I did this but show you how to make your own equipment at very low cost which will save time, improve quality, and reduce frustration in your casting.

Dave Parvin is a Colorado sculptor whose primary subject is the human form in a variety of materials. He may be reached at (303) 321-1074