

A High Altitude Chamber for Biological Studies

Take Your Pets to New Heights

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Way back in September of 1965, Scientific American's *The Amateur Scientist* column ran an interesting article on building and using a high altitude chamber. The device, designed by David E. Smucker, a high school student in Wheaton, Illinois, was fairly sophisticated. The chamber itself was made from a 30 gallon steel tank. Three pumps were used to produce and maintain environments simulating altitudes to 30,000 ft. above sea level. One pump, a piston-type refrigeration compressor, was used to evacuate the chamber. Another served to recirculate the air in the chamber through a bed of sodium hydroxide (to control the concentration of carbon dioxide) and calcium chloride (to control the water content). A third pump acted as an emergency backup to the recirculating pump.

The temperature in the chamber was controlled with a heat exchanger coil/fan assembly in the chamber. Water of the desired temperature was circulated through the heat exchanger. Pressure was measured with a mercury manometer and could be automatically controlled to an altitude of 15,000 ft. (400 Torr) using a modified bellows-type pressure control switch. Air was admitted constantly through a leak valve.

Smucker used the chamber to observe the effects of high altitude (10,000 ft.) exposure on the weight and red cell count of albino rats. The experiment ran for 96 days including observation periods. There were 2 control rats and 2 experimental rats. The article detailed the procedure and the results.

Thinking that a simple high altitude chamber might be of interest to some readers of this journal, I put together the simple system that is illustrated in Figure 1. The system could be used to study the effects of altitude on small animals and/or plants.

The chamber is made from two mixing bowls: the bottom bowl is of stainless steel (available from US Plastic Corp., 800-537-9724, as catalog number 84104) and the top bowl is a Pyrex 5 liter bowl, available from just about any homegoods or hardware store. The bowls are close enough in size that a rubber gasket (sheet stock available from the hardware store) will seal the two together quite effectively. The total cost for the bowls and gasket should be no more than \$30.

Holes can be cut in the stainless bowl to permit the incorporation of feedthroughs. I used 1/4" brass hose barbs, epoxied in place. I was a bit concerned about the ability of the steel bowl to withstand vacuum but the only effect was a very slight bowing of the flat bottom.

There are probably a lot of other applications where a simple chamber setup like this would be handy.

Vacuum is provided by a dry-vane vacuum pump, obtained as surplus from C&H Sales (800-325-9465) for about \$50.

Rather than have a pressure switch that maintains pressure by cycling the pump on and off, I used a simple vacuum regulator made by Control Devices and available through local Grainger outlets as catalog number 5Z763. The valve, model number VR25, costs about \$5. Details on this valve are shown in Figure 2. The valve is a proportional relief valve that must have air going through it to operate. Figure 2 has the guidelines, Figure 1 shows the proper position of the valve in the system. You will have to do a bit of juggling between the needle inlet leak valve and the pressure control valve but, once set, the control valve works quite nicely. You will notice that much more air goes through the control valve than through the leak.

I've shown the pressure monitor as a simple 0-30 in. Hg Bourdon gauge. Bear in mind that the gauge and control valve are both atmosphere referenced. If your atmospheric pressure changes due to meteorological conditions, the absolute pressure in the chamber will change accordingly. Also, if you are not at sea level, the reference will be whatever altitude (pressure) you are at. The following table gives a reasonable correspondence (i.e. as good as I could do in looking at a small graph) between altitude above sea level, absolute pressure, and the Bourdon gauge reading.

Altitude (ft.)	Absolute Pressure (Torr)	Bourdon Gauge (in. Hg)
0	760	0
5,000	625	5.4
10,000	525	9.4
15,000	425	13.4
20,000	350	16.4
25,000	275	19.4

The dry pump easily got the system up to Mt. Everest altitudes.

A good alternative to the Bourdon gauge would be a pocket altimeter. Edmund Scientific (800-728-6999) has a unit that goes to 15,000 ft. and has a zero adjustment. It is their catalog number Y34,544 and costs \$32.95.

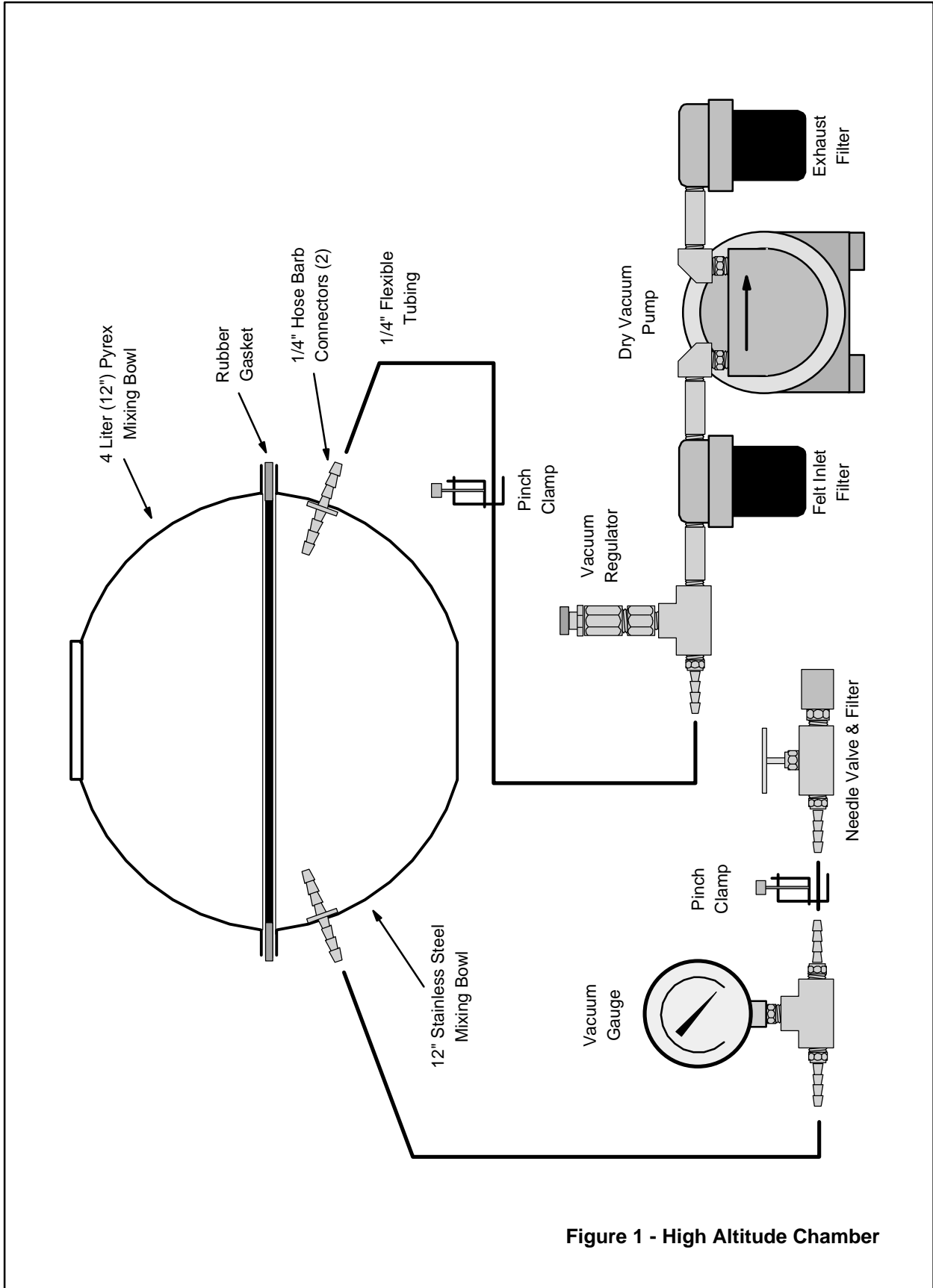


Figure 1 - High Altitude Chamber

As for regulating the temperature of the chamber to conditions other than ambient, heat lamps above the chamber or a reptile tank heater under it would be workable. If cooler temperatures are desired, the lower bowl could be placed in chilled water.

The incoming air quality can be changed by coupling an appropriate device between the ambient and the needle valve. Driers, bubblers, sources of toxic gases (kidding!), etc. can be placed in series. Liquid nutrients can also be introduced periodically by dipping the inlet into a water solution. This will draw the solution into the chamber.

I have shown a couple of pinch valves which can be used to isolate the chamber if it is desired to have a closed system.

A second, atmospheric pressure, chamber might be useful in some experiments. This chamber would be attached to the inlet of the needle valve. Air would first

pass through the atmospheric chamber and then through the needle valve into the low pressure chamber. The first chamber would act as a control: same atmosphere, same air flow (mass flow), similar air composition, but at normal pressure.

I'm no biologist so I am not sure what I'm going to do with this thing. If I can find an interested science teacher locally, I might loan it out for a class project.

For anyone doing high altitude biological studies, if the experiment involves animals please be reasonable and keep the simulated altitudes something less than what would render a Sherpa unconscious.

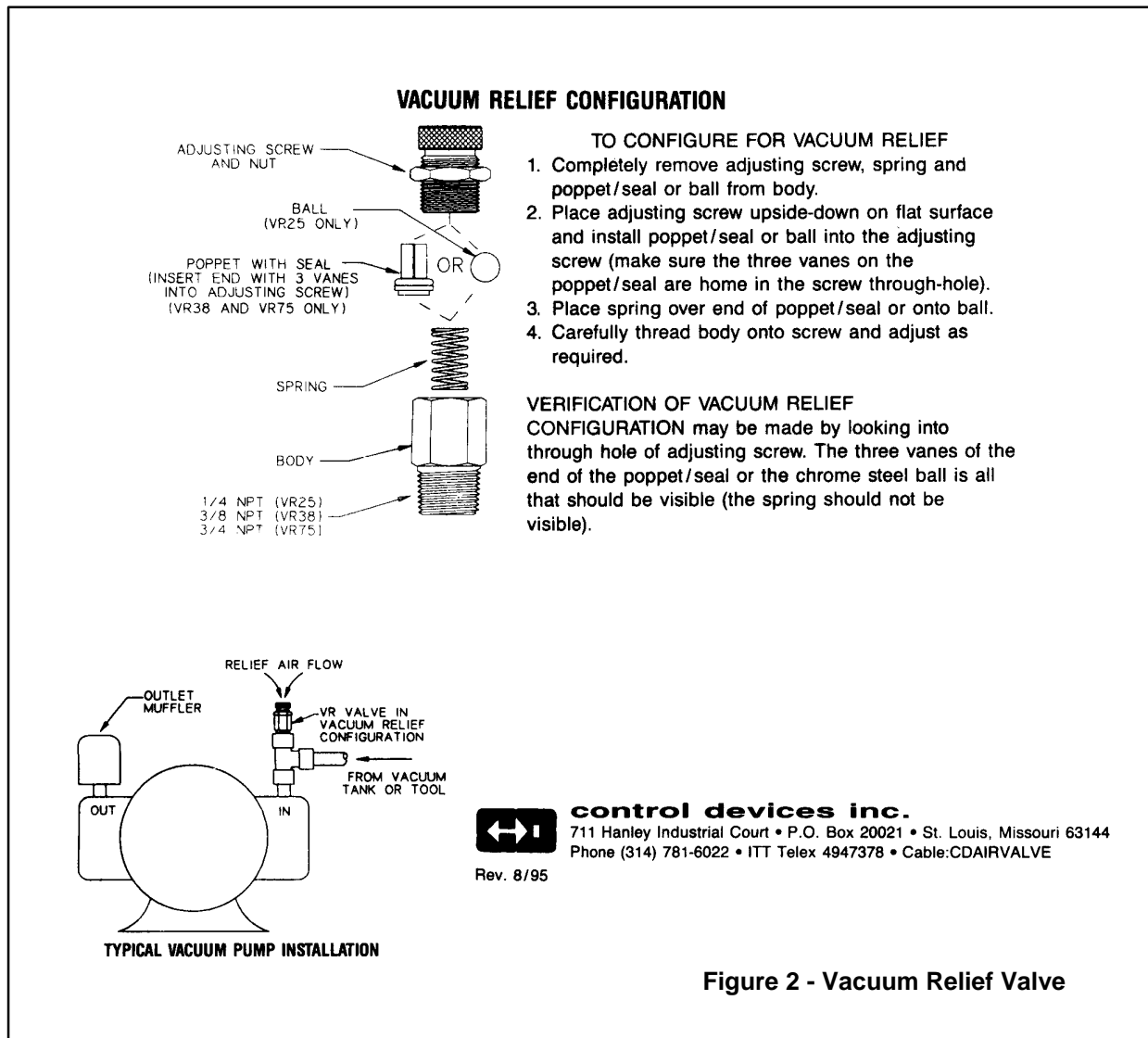


Figure 2 - Vacuum Relief Valve