Air Pressure and Dent Pullers
von Guericke and the Magdeburg Hemispheres

The experiment shown in Figure 1 was done by Otto von Guericke in Magdeburg, Germany in the 1650's. Two hemispheres were placed together, forming a sphere, and the air was then evacuated from the sphere. Two teams of horses could not pull the hemispheres apart. The hemispheres are now known in the literature of science as the Magdeburg hemispheres.

A modern, low-cost version of the experiment can be done with suction cup dent pullers, shown in Figures 2a and 2b. Squeeze the two suction cups together, as shown in Figure 2b, and then have two people try to pull them apart. It should be very hard or impossible to pull them apart (but just in case they do release, it's a good idea to have a person standing behind each of the people pulling, to catch them if they suddenly fall backward).

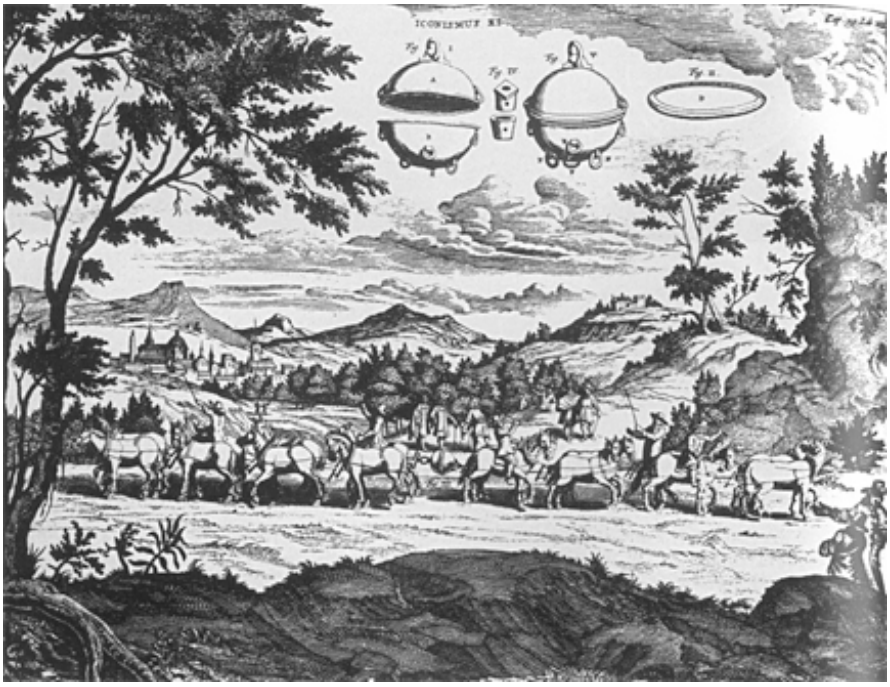

Figure 1

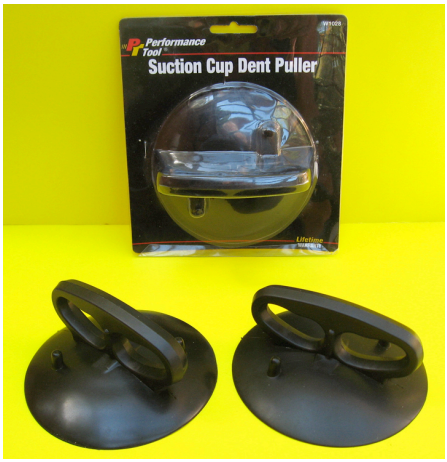

Figure 2a

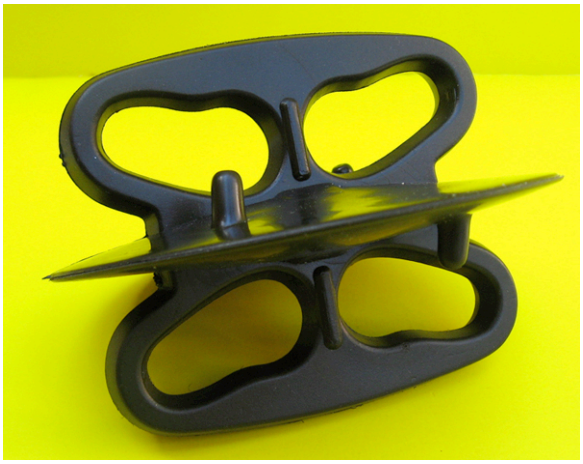

Figure 2b

To find the force holding the dent pullers together, multiply the atmospheric pressure times the area of a suction cup:

Pressure = Force/Area or P = F/A or **F = P x A**

Using 14.7 psi as atmospheric pressure and 5 in as the diameter of the suction cup (2.5 in radius), the force is calculated as follows:

$P = 14.7\ lb/in^2$ $A = \pi r^2 = 3.14 \times (2.5)^2\ in^2 = 3.14 \times 6.25\ in^2 = 19.6\ in^2$ $P \times A = 14.7\ lb/in^2 \times 19.6\ in^2 = 288\ lb$

This is a maximum theoretical value. The actual value would be less, since the vacuum is not perfect, and the effective working diameter of the suction cup is likely less than the actual diameter. But it does show the amazing amount of force involved when atmospheric pressure acts on a surface area, and gives an insight into why teams of horses were unable to pull apart von Guericke's Magdeburg hemispheres. Their diameter was around 20 in, and if you run the numbers as was done above, the force necessary to pull the hemispheres apart turns out to be more than 4500 lb!

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