Natasha Stamler, Lakhsmi Chatterjee, Ann Garbowski, Jessica Wang

Experiment Name: A Simple Device to Measure CO_2 in the Atmosphere
Unique Identifier: CO_2 Indicator Cube

Purpose of Payload

The payload is designed to determine whether a small, simple device would be able to measure CO_2 in the upper atmosphere, without being contaminated by CO_2 from lower altitudes. Currently, most methods of measuring CO_2 are complicated and expensive. One popular method of measuring CO_2 is the Carbon Tracker, which collects data from all over the globe to compile information on the levels of CO_2 in the atmosphere (Andrews et al., 2007). There are measurers located throughout most of the world. However, this method, while quite accurate, is expensive and complex. There are other less complex methods to measure CO_2, such as portable detectors, but these are often very expensive. They can cost anywhere from $130-500. Our goal with this research is to find a simple and inexpensive method of measuring CO_2 so that more thorough research can be done with less funding, hopefully encouraging research by more people in poorer regions. The more research is done, the better we can understand global warming, allowing us to solve it better.

The CO_2 indicator strips we plan on testing are capable of detecting CO_2 at air pressure levels higher than 1 bar (Mill and Skinner, 2002). Since the pressure in the atmosphere is greater than 1 bar, they should be successful. The strips contain indicator ions, dyes which change colors, and a lipophilic organic quaternary cation, a positively charged polyatomic ion, creating a CO_2 sensitive material (Bengtsson and Ohlsson, 2002). When the strips come into contact with CO_2 , they react and change color, indicating a presence of CO_2.

Experimental Design

CO_2 indicator strips, PVC pipe, brass, rubber, and a mini barometer will be purchased from a commercial source. The bell jar and all necessary tools will be provided by our school, The Bronx High School of Science. The bellows and spring will be taken from this barometer. The brass will be formed into two 1.75 cm by 0.25 cm by 0.15 cm blocks whose edges will then be covered in the rubber to make the two seals.

Our experiment will be composed of two major components: the experimental cube that will go up into space and the controls that will stay on the ground.

Four CO_2 indicator strips will be placed inside the experimental cube. A ½ cm radius hole will be drilled into one side of the cube. The bellows and spring from the barometer will be installed in a pole made of hollow PVC pipe under the hole. When the spring expands, it will contract the bellows, pushing the brass blocks towards each other to block CO_2 from entering the cube. The edges of the brass blocks will be covered in rubber to minimize the amount of air entering the cube. Conversely, when the spring contracts, it will expand the bellows, pulling the brass blocks apart, allowing CO_2 to enter the cube. At ground pressure, the bellows will fully cover the hole, not letting any CO_2 enter the cube. We hypothesize that if cube is brought up into the low pressure of the atmosphere, the blocks will separate and allow the CO_2 indicator strips to accurately measure CO_2 in the atmosphere, and if the cube is brought back down to the higher pressure earth, the blocks push together and seal the cube from detecting CO_2. This way, we would only get the results of how much CO_2 is present in the atmosphere and not on the surface. We formed this hypothesis based on what we know about the bellows and springs in a Bellow Pressure Gauge. As is seen in the diagram below, the springs and bellows are able to expand and contract based on changes in pressure.

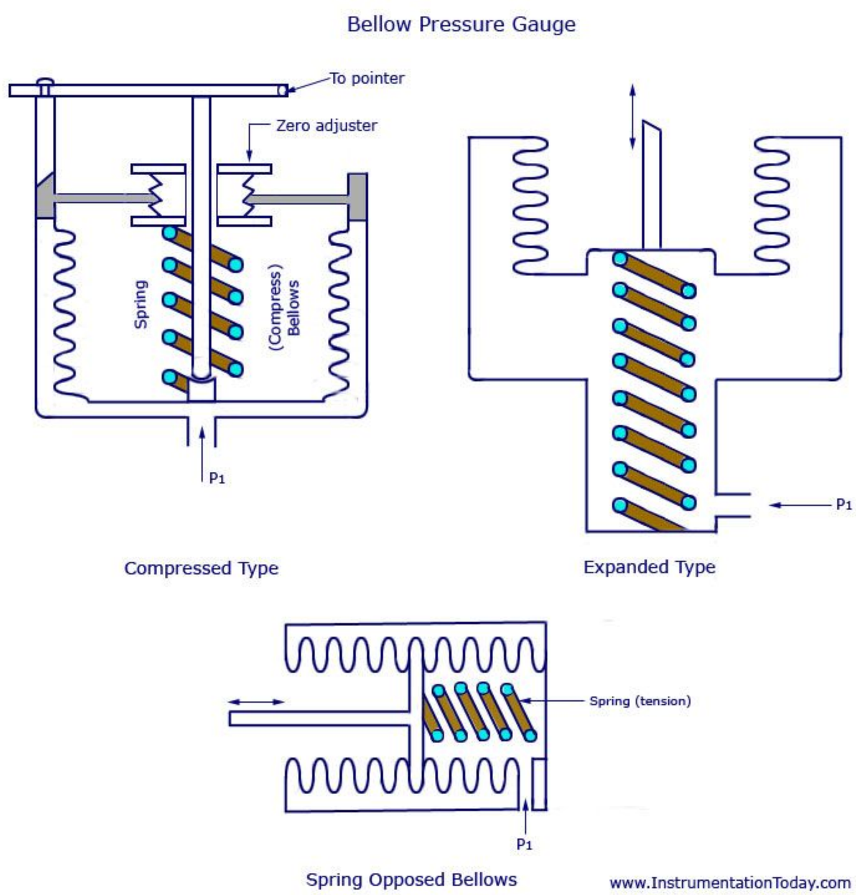

Fig. 1. Diagram of a Bellow Pressure Gauge[1]

[1] Webnesters Pvt.Ltd. Bellows. Instrumentation Today. 2011. http://www.instrumentationtoday.com/bellows/2011/09/.

In addition to the experimental cube, we would have two control cubes down on Earth. One, the sealed control, would remain sealed by the seals, the brass blocks coated in rubber, for the entire experiment to determine CO_2 leakage, and the other, the unsealed control, would remain unsealed for the entire experiment to measure just the CO_2 on Earth the have a comparison point for the experimental cube.

Prior to sending our cube up to space, we will test our experiment on earth to make sure all the components work as expected. We will leave a few CO_2 strips in a CO_2 heavy area to test and make sure they react with the gas. We will set up the bellows in a bell jar to make sure they contract at higher pressure. This will help ensure our experiment goes smoothly.

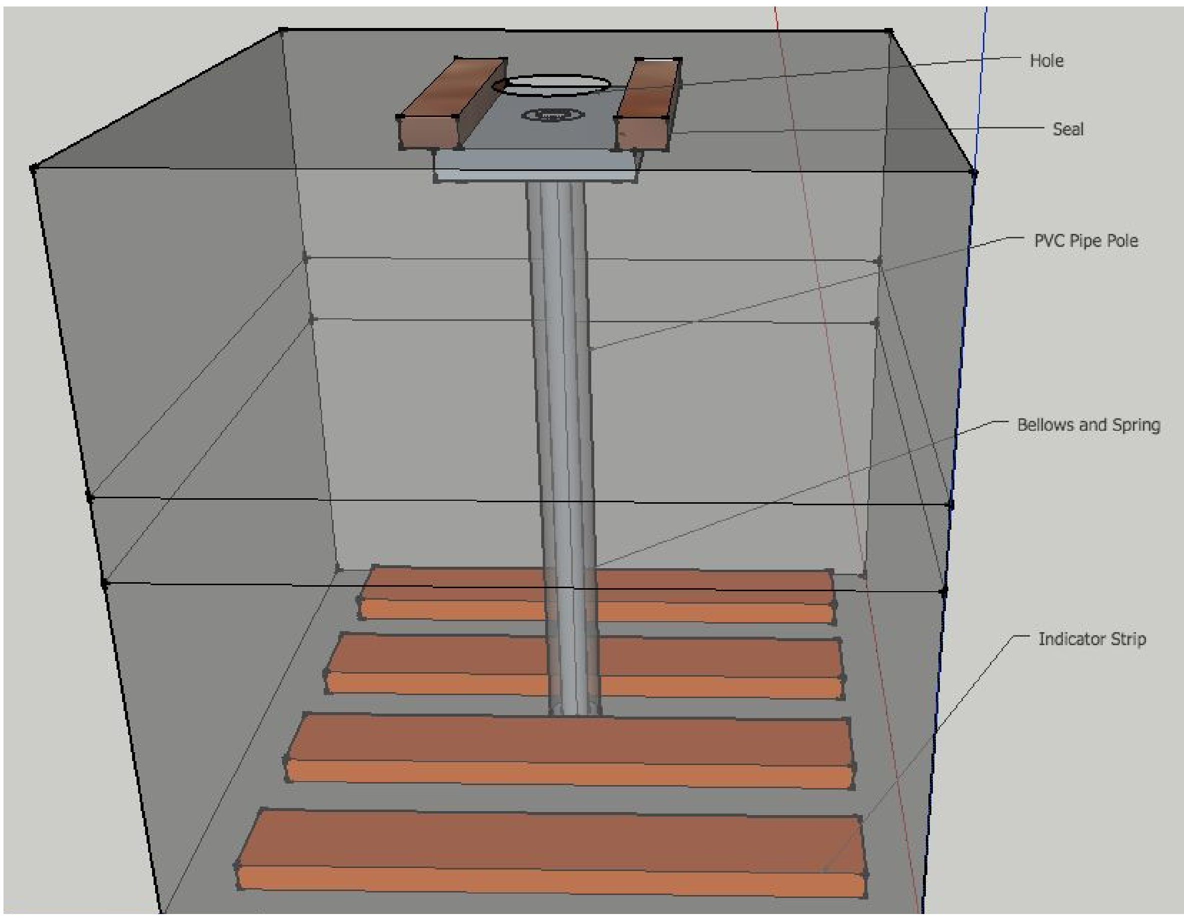

Fig. 2. Three-Dimensional Model of Experimental Cube

Payload Analysis Plan

Following the return of the experimental payload from space, the colors of the strips will be observed without adjusting the brass or rubber so that if even a partial seal was formed, it would be preserved. We will compare the color of these strips to the color of the strips from the unsealed control cube on Earth.

If the colors of the experimental and control CO_2 strips are very similar, the hypothesis would be refuted because the brass and rubber did not successfully seal the cube so the CO_2 strips in the experimental cube absorbed the CO_2 from lower altitudes. If the colors of the CO_2 strips are different, the hypothesis would be supported because the brass and rubber successfully sealed the cube, so the CO_2 strips in the experimental cube only absorbed CO_2 from the upper atmosphere and not from lower altitudes.

Communication Plan

A tri-fold board conveying our results will be presented at the annual Bronx Science Research and Engineering Expo in May where over 3,000 students will attend in addition to families, faculty, community members, and local scientists.

An article about our research will be published in our school's bi-weekly newspaper, *The Science Survey*.

A segment on our school's weekly news program, *Wolverine TV*, will feature our results and experiment to convey their significance to the rest of the student body.

A large poster article describing what we have done will be put up in the main hallway of our school, where thousands pass by every day.

Our project will be mentioned in our school's weekly news email sent to students and parents, *Next Week In Preview*.

Works Cited

Arlyn E. Andrews, Lori, M. P. Bruhwiler, Thomas J. Conway, Adam I. Hirsch, Andrew R. Jacobson, Maarten C. Krol, Kenneth Masarie, John B. Miller, Wouter Peters, Gabrielle Petron, James T. Randerson, Colm Sweeney, Pieter P. Tans, Paul O. Wennberg, Guido R. van der Werf, Douglas E. J. Worthy. 2007, "An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker", PNAS, November 27, 2007 , vol. 104, no. 48, 18925-18930.

Nils Bengtsson and Thomas Ohlsson. Minimal Processing Technologies in the Food Industries, 5.19 Oxygen and Carbon Dioxide Indicators, p.108-110. Boca Raton: CRC, 2002.

Andrew Mill and Graham Skinner. University of Strathclyde. Patent EP2591335A1 - Co2 Indicator. Google Patents. 2013. http://www.google.com/patents/EP2591335A1?cl=en.