DAVID BUSHNELL AND HIS TURTLE

by

June Swanson

David Bushnell was a Connecticut farmer who finally had an opportunity to attend Yale College at the age of twenty-seven. The year he matriculated was 1771, and war was being discussed everywhere! David became interested in gunpowder and how it could be exploded underwater. He tested his theory with success and sought to find a way to use his findings.

He began drawing plans for a "sub-marine mine", and then a "sub-marine vessel" that could be used to attach his mine to enemy ships. The *Turtle* was ready for testing by the fall of 1775; David called his boat a turtle because it "looked like two turtle shells set on end and glued together". The *Turtle* was the first working submarine and the first submarine that was used during a war. Many of David's ideas have been changed slightly and are being used in submarines today.

Students can study some of the concepts that David Bushnell used in his invention by making a Cartesian diver in a two-liter soda bottle. The instructions are for a modern version of an old but exciting toy that can be built by students in class or at home. It can also be made by an adult and set in a science corner for great hands-on experimenting!

MATERIALS: 1 plastic pipet, 1 brass nut, 1 one or two liter soda bottle

ACTIVITY: See attached sheet.

SOURCE: *Activities for a Science Table* Workshop, SMART Center, Sacred Heart University, Fairfield, CT, 1990. Until 1984, Cartesian divers had been constructed by using glass droppers. Bob Becker, a teacher at Greenwich High School, showed teachers how to make these divers from plastic pipets. He has continued to invent ways to use the pipets in 2-liter plastic soda bottles to play basketball and dive for buried treasure. Materials for the divers and his

Cartesian Diversion, a DVD #CD-900 DVD, can be purchased from Educational Innovations, Inc.: 1-888-912-7474. Online: www.teachersource.com The DVD contains worksheets which can be printed for classroom use.

STANDARDS:
BSL: 1.1, 1.2. 1.3, 1.5, 6.2, 11.2, 11.4, 12.1, 12.6, 12.10
NCTM: 4d, 10a
SCS: A1, B1, B2, D1, E2, G1, H2, H3, H4, H5

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Cartesian Divers

Instructions

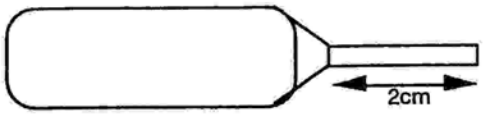
Materials:

- 3 Plastic Pipets
- 3 Brass Nuts
- Plastic Soda Bottle

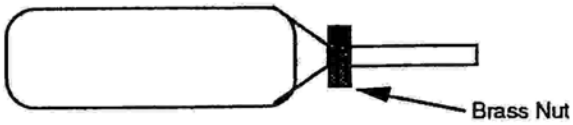
(other materials)
- Fizz-Keeper® Pump Cap (optional, available from Educational Innovations)
- Scissors
- Plastic Cup
- Food Coloring (optional)
- Candle (optional)
- Pliers (any type, optional)
- Aluminum Foil (optional)

Cartesian divers are one of the oldest and most interesting toys you can build at home. While they are easy to construct, however, there is a lot of science behind the workings of this deceivingly simple toy. A Cartesian diver is an object whose density changes with pressure! In fact, most Cartesian divers become more dense as pressure is increased. By constructing a Cartesian diver carefully, it is possible to make a diver which floats in water, at atmospheric pressure, and sinks when the pressure is increased. Wate has a density of about 1 gram/ml. Objects which have a density of less then 1 gram/ml float, while objects with a density greater than 1 gram/ml sink. As pressure is increased, a Cartesian diver's density might increase from about .8 grams/ml to 1.2 grams/ml. When this happens, the diver sinks in water. Cartesian divers often change their density by changing the amount of water they displace (i.e. changing their volume). When the pressure is increased the air inside the diver is compressed. This compressed air takes up less space and, thus, displaces less water. As less water is displaced, the density of the diver appears to increase and the diver sinks.

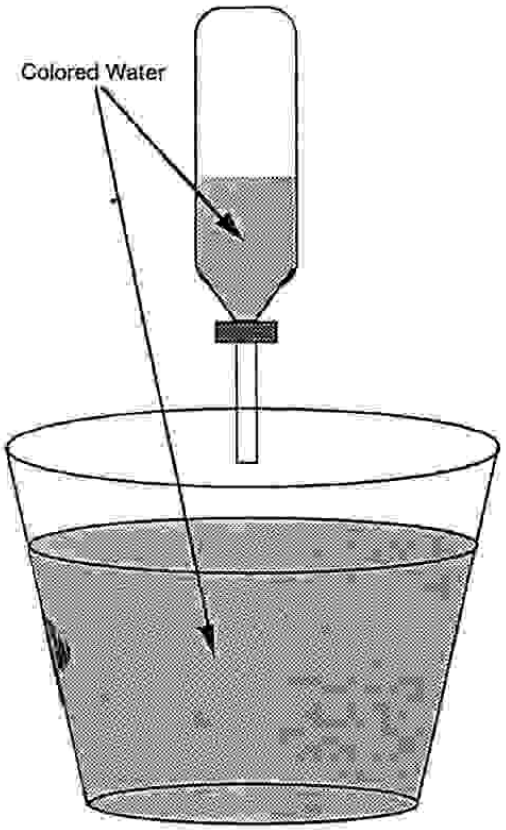
1. With a scissors, snip off all but 2cm of the neck of each pipet.



2. Screw one brass nut onto the remaining 2cm neck of each pipet.



3. Fill each pipet bulb with colored water. Note that the bulbs must float when placed in a cup of water. Experiment with different amounts of water, making sure each time that the bulbs still float. Bulbs which float higher in a cup of water will make divers which are more difficult to sink. You might use different colors of water in each of your 3 bulbs. Try one bulb which just floats and one with no water at all!



4. Your Cartesian divers are ready! Fill a 1 or 2 liter plastic soda bottle almost to the top with water. Place your divers in the bottle and screw on the Fizz-Keeper pump cap. Try squeezing the bottle. Can you make your divers sink? Now pump the Fizz-Keeper and watch as your divers sink right to the bottom. Can you figure out how to get them back up to the top?

5. Remove the pump cap, pour out your divers and try varying their buoyancy. Try filling them with different amounts of water. Put them back in the bottle, replace the pump cap and try sinking them again.

There are literally hundreds of experiments you can try! For instance, try crumpling up a piece of aluminum foil into a small ball. Place this in your bottle. See if you can sink it by squeezing the bottle... how about pumping it? Try numbering your divers and see if you can make them sink in order. Note that your divers are not yet sealed and so they may be adjusted as many times as you like (colored water will leak out of them until they are sealed).

6. When you are satisfied with your divers and would like to make them permanent, you can seal them by sealing the open end of the bulb. This can be done with any waterproof glue or the neck can be sealed by melting the plastic slightly and squeezing it gently with a small pliers. To seal the bulb by melting, first make sure your bulb floats properly. ONCE IT IS SEALED, ITS STARTING BUOYANCY CANNOT BE CHANGED! Make sure there is no water in the neck by holding it upside down and tapping or squeezing it slightly. Hold the neck about 1-2 inches above a candle flame until it becomes completely transparent (the change is very subtle). Immediately remove the neck from above the flame and squeeze the end gently with a pliers to seal. Let cool. Return your divers to the bottle with clean water and they will last for many years.

GOOD LUCK and GOOD EXPERIMENTING!

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