by Shawn Carlson

Sensing Subtle Tsunamis

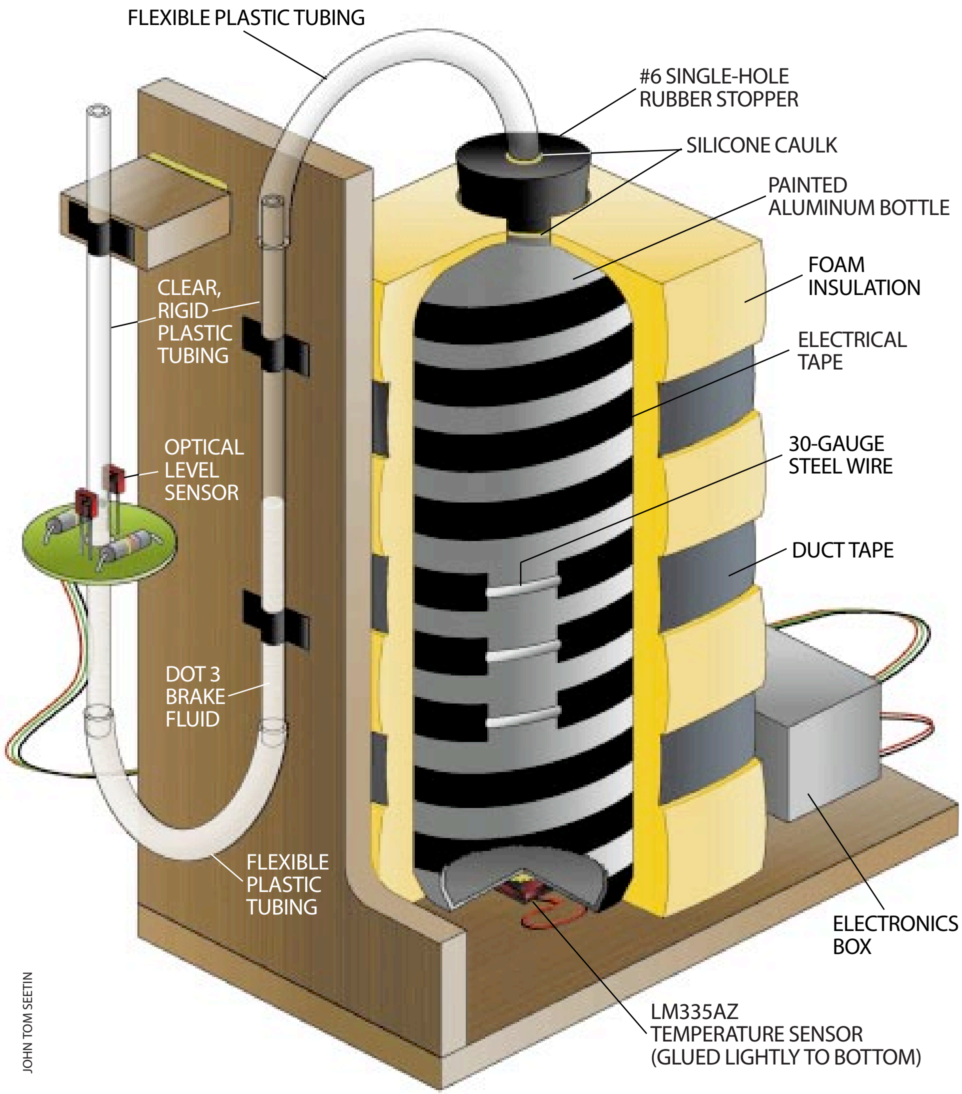
As I write this column, I am enjoying my regular Sunday morning bagel at a small café overlooking the ocean. It's raining, and storms at sea have whipped up unusually large waves. These ribbons of energy march thousands of miles in lockstep, finally breaking on Pacific beaches with spectacular effect. Watching these watery monsters roll up onto the nearby sand reminds me of another kind of wave passing by. The world's greatest ocean is the atmosphere, and it, too, contains extraordinarily powerful waves. Like their oceangoing counterparts, atmospheric waves are normally generated by energetic storms. But they can also arise and spread, like ripples on a quiet pond, when a meteor or volcanic explosion violently shocks the air.

Yet even the largest atmospheric tsunamis are quite difficult to detect. The pressure excursions that betray their passage are typically just a few millibars (thousandths of one atmosphere), and these tiny undulations often take tens of minutes, or even longer, to go by. Instruments that can monitor such subtle signals are called microbarographs, and professional units can cost thousands of dollars. But, thanks to Paul Neher, a gifted amateur scientist from Las Cruces, N.M., anyone can now observe these ephemeral waves for about $50.

Neher uses a manometer (in this case, a U-shaped tube and sensor) [*see illustration on this page*] to balance the barometric pressure against the air pressure trapped inside an aluminum bottle that is kept a bit warmer than the surrounding air. Because the pressure of an isolated gas varies with temperature, any shift in external pressure can be matched by changing the temperature of the air inside the bottle. Neher's instrument senses external pressure fluctuations by monitoring the height of a liquid in the manometer. A rise in external pressure presses the liquid down into the manometer and triggers a heating coil that warms the bottle. If the pressure drops, the level of the liquid rises, and the heater is kept off, thus allowing the bottle to cool a little to compensate. Monitoring the temperature changes with the circuit shown on the opposite page reveals minuscule shifts in air pressure.

For the aluminum container, Neher completely drained a tire inflator bottle of 32-ounce (about one-liter) size and then replaced the crimped-on cap with a single-hole rubber stopper. He fashioned his manometer from a piece of glass tubing, which he bent after heating with a propane torch. But you can link two clear, rigid plastic tubes with a short, flexible plastic hose. You'll need to fill this assembly about one-third full with a liquid that has a low viscosity and does not evaporate. Neher uses clear brake fluid in his device.

The instrument senses changes in the fluid level by using the transparent liquid to focus the light from an infrared light-emitting diode (LED) onto a phototransistor. When the liquid drops below the set point, the defocused light becomes too diffuse to detect. This change causes the circuit attached to the phototransistor to send an electric current through the heater. Neher employed



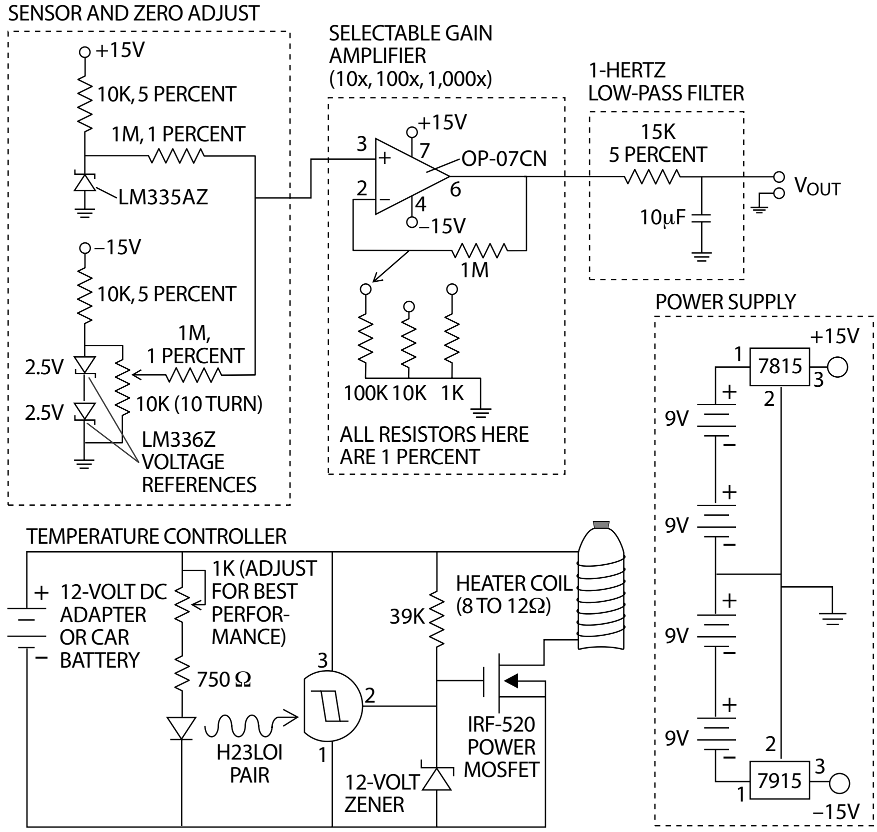
MICROBAROGRAPH
is easily constructed from an aluminum bottle, steel wire and plastic tubing.

"beading wire," which he obtained from a craft store, for the heating filament. Hobbyists use this 30-gauge (1/4-millimeter) steel wire to make necklaces, but it has a resistance of about one ohm per foot (about three ohms per meter), which is ideal for this application.

After electrically insulating the bottle with a layer of enamel paint, wrap 10 evenly spaced turns along the length of the bottle and secure them with electrical tape. Surround the wrapped bottle with a few inches (about 10 centimeters) of an insulating material such as foam rubber or a spray insulation (which you can purchase at a hardware store). When operating, the circuit heats the bottle slightly every 10 seconds or so, replacing the tiny amount of heat that leaches through the insulation, thereby keeping the level of the fluid stable. The LM335AZ chip is a sensitive solid-state thermometer that varies its output voltage by 10 millivolts for each degree Celsius change in temperature. This marvel can measure temperatures to about 0.01 degree C, which corresponds to an ultimate pressure resolution approaching 20 microbars—that's a scant 20 millionths of one atmosphere.

To begin your observations, disconnect the tube that links the manometer to the aluminum bottle, then heat the bottle about 10 degrees C (18 degrees Fahrenheit) above room temperature by blocking the light from reaching the phototransistor. Reconnect the tube and allow the circuit to stabilize the bottle at this elevated temperature. It's easy to see if your instrument is working: just lift it. It should register the 100-microbar drop in pressure that results when you raise it about one yard (one meter).

You will want to calibrate the microbarograph over a larger range than you can easily generate by shifting its height. The solution is quite simple: move the LED-phototransistor pair up or down a bit on the manometer column. The circuit will then adjust the temperature inside the bottle to raise or lower the liquid between the LED and phototransistor to match. This manipulation causes the fluid level to become uneven, with the weight of the unbalanced liquid being supported by the pressure difference between the atmosphere and the air inside the bottle. The specific gravity of DOT 3 brake fluid, which is widely available in the U.S., is 1.05. For this value, each inch (centimeter) difference in the level of the liquid corresponds to a pressure difference of 2.62 millibars (1.03 millibars).



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ELECTRONIC CIRCUITS FOR THIS PROJECT
can be built with components from Mouser Electronics (817-483-6848).

This fact allows you to set the device to a number of known pressure differences while measuring the corresponding output voltages. To make the LED-phototransistor pair easy to move, mount the assembly on a small piece of perforated circuit board with a hole in the middle that is large enough to let the manometer tube slip through.

You can read the output of the Neher microbarograph with a digital voltmeter or, better yet, record the data continuously using your computer and an analog-to-digital converter. These versatile devices, once too pricey for amateur budgets, are now quite affordable. Both Macintosh and PC aficionados should check out the Serial Box Interface, which is available for $99 from Vernier Software (8565 Southwest Beaverton Highway, Portland, OR 97225; www.vernier.com, 503-297-5317). PC users can also consider buying a similar unit for $100 from Radio Shack (part number 11910486). Either unit will turn your home computer into a sophisticated data-collection station. Then with your own sensitive microbarograph, you will be able to detect the endless train of subtle atmospheric tsunamis that is constantly rolling by. SA

For more information about this and other amateur science projects, check out the Forum section of the Society for Amateur Scientists's Web site at http://web2.thesphere.com/SAS/. You may also write the society at 4735 Clairemont Square, Suite 179, San Diego, CA 92117, or call them at (619) 239-8807.

Cautionary note: We urge readers building the centrifuge described in the January Amateur Scientist column not to neglect to use the protective housing included in that project. One reader ran his newly built centrifuge at high speed without this housing only to discover that the rotor was imbalanced enough to shatter, perilously sending pieces of plastic in all directions (see http://web2.thesphere.com/SAS/WebX.cgi).