BY CARL J. BERGQUIST

Experiments with your laser

Detect earthquakes and other vibrations, build an optical seismometer, and experiment with a laser listening device.

NOW YOU CAN PUT YOUR LASER TO USE AND TRY A COUPLE OF EXPERIMENTS. THE FIRST ONE WILL MEASURE GROUND MOVEMENT. THE BEST KNOWN DEVICE FOR DOING THIS IS CALLED A SEISMOMETER.

You can build a laser-based seismometer that is simple, yet remarkably sensitive and accurate.

Seismometers are best known for their use in measuring the intensity of earthquakes. However, they can also detect other vibrations, such as

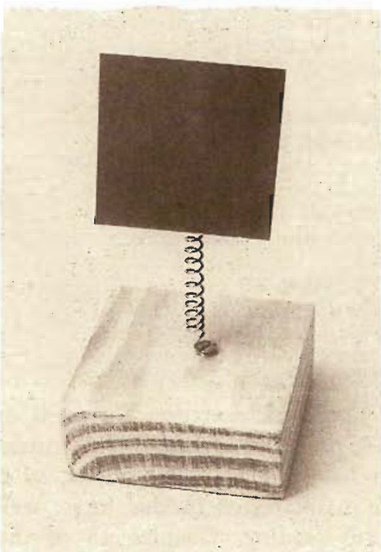

FIG. 1—SIMPLE VIBRATION SENSOR has only three parts — a small square of mylar, a spring, and a block of wood.

those from highway traffic, trains, explosions, lightning bolts, or any other source that causes earth movement. Even if such movements occur some distance away, you will still be able to detect them. The heart of the seismometer device is the sensor unit. It incorporates a variation of the speaker modulator described in the last column (*Electronics Now, June 1996, page 51).*

Figure 1 shows all three parts of the sensor unit. It is simply a 1½-inch square of rigid, aluminized mylar attached to one end of a 2-inch length of medium tension spring. Epoxy, silicon, or hot-melt glue will do the job. Fasten the other end of the spring to a 2-inch square block of 1×2 pine. This assembly, when mounted to a very stable foundation, will vibrate in response to any shock waves traveling through the earth.

For an indoor location, use an upright stud or pillar that is sunk into your home's foundation. Such a spot in your garage or basement will work well. Outdoors, a 6- to 8-foot fence post, or an antenna ground rod that has been driven 4 to 6 feet into the earth, will provide the needed stability and coupling to the earth.

Once you have determined the location, mount the sensor assembly firmly. If you select an outdoor spot, place a small box around the sensor to protect it from air currents and wind. Leave a 1- or 2-inch opening in the box for the laser beam. With the sensor in place, aim the laser at the mylar square. Adjust the laser beam angle so the reflected beam shines into the detector described in the previous column. Adjust the volume and gain of the receiver until you are able to obtain a uniform sound signal.

Your unit is now in its monitor mode, and the signal will remain unchanged until it detects vibrations. Strike the foundation gently and notice the change in the audio output. Drop a heavy object near your detector and again note the change in the audio output. Experiment with a variety of different objects and actions that causes the sensor to react. You will soon see a pattern develop that will let you estimate shock intensity by hearing the change in the sound.

If you have a frequency meter, you'll be able to draw some interesting graphs based on a plot of the

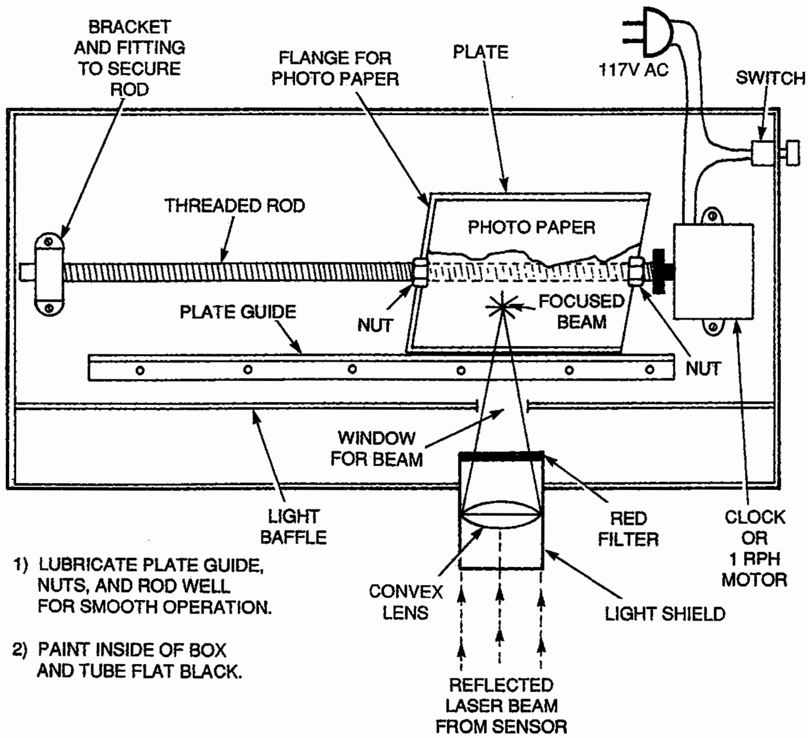

FIG. 2—FOLLOW THIS PLAN TO BUILD YOUR OWN photographic recorder. It makes a permanent record of vibrations and other earth movements over a 24-hour period.

actual frequency readings. If you connect a peak meter, an LED bargraph, an analog meter, or even a lamp and relay, you will be able to obtain all kinds of different data. If you want an alarm, use a relay to trigger a lamp or some other alarm device based on the sensor's output frequency.

Building a seismograph

While all of these demonstrations are interesting and informative they do not produce any record of the result. So for a more ambitious effort, you can build the simple seismograph based on the photographic recorder shown in Fig. 2. This device will receive the modulated laser beam, collimate it to a pinpoint of light, and record it on ordinary photographic print paper (the kind used to make black and white copy prints or enlargements).

In the prototype a threaded rod is coupled to a clock motor, which rotates the rod. Nuts that match the thread of the rod are cemented to a plate that holds a strip of photographic paper. This plate assembly is then threaded onto the rod, through the nuts. As the motor rotates, the plate moves from right to left. A metal guide is positioned at the bottom to keep the plate from spinning around the rod; a Teflon strip attached to the metal guide reduces friction. As the plate moves, it passes through the laser beam. This exposes the paper to whatever pattern is present.

With normal activity, the beam will create a rather straight line with a little background noise. But when the sensor detects significant movement, the line will break, and peaks will be displayed on both sides of the center line. This movement will be in direct proportion to the intensity of the vibration.

The project is not as simple as it sounds. Your detector will have to housed in a light-tight box as shown. Note the baffle that runs the length of the box, to further reduce stray light. The way it is set up, only laser light enters the lens and is sharply focused on the photo paper. The window in the light baffle must be kept as small as possible—mine measures only 3 inches by 1/2 inch. Notice the medium-red filter on the inside end of the collimator (lens tube). It helps keep ambient white light out of the box.

The rate at which the plate carrying the photographic paper moves is determined by the number of threads per inch that the rod has. The greater the number of threads per inch the slower the plate will move. If you use a rod with 20 threads per inch, the plate will move about 1-1/4 inches in a 24-hour period.

The unit is shown set up to record vertical (up-down) movements. To detect horizontal (side-to-side) movements, simply set the recorder on its end. Either way you'll have an accurate and permanent copy of the movements you monitor.

When your unit is complete, load it with a piece of photographic paper (in total darkness or under a red photographic safe light). Then seal the box and you are almost ready to go. Line up the laser and the recorder and turn on the motor. Come back the following day and retrieve and develop your photographic paper. It's simpler than it sounds and you should have a lot of fun with this simple device.

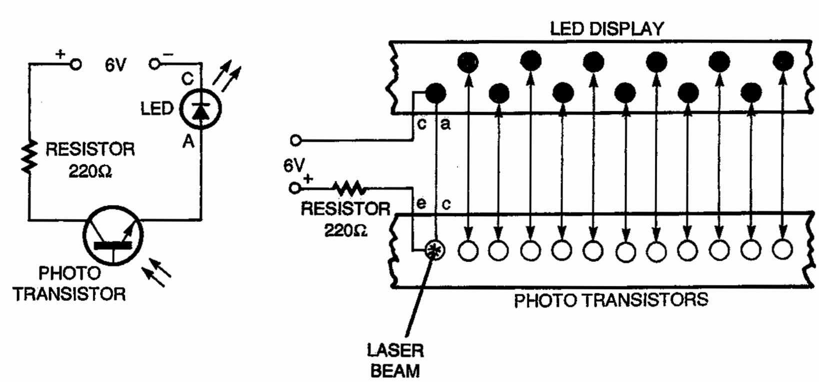

FIG. 3—PHOTOTRANSISTOR SENSING STRIP is easy to make and can be coupled to an LED display panel. Complete details are in the text.

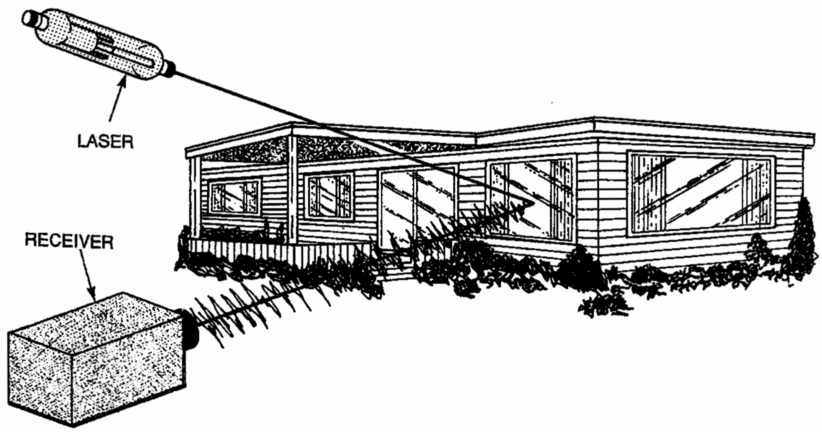

FIG. 4—BOUNCE A LASER BEAM OFF A GLASS WINDOW and pick up the reflections with your receiver. You can convert the vibrations in the glass to hear what is being said on the other side on that window.

Detecting small or slow movements

You can also put lasers to work to detect an object's small or slow movements that might otherwise escape the naked eye—the growth of a plant, for example, or the settling of a new building's foundation. This kind of study requires long-term monitoring.

One method to try is to attach a small piece of reflective mylar to the object being observed, and to reflect a laser beam off the mylar at a slight angle. The position of the return beam can be marked on a scale. As the object moves, the angle of the reflected beam will change and the spot will appear at a new location on the scale. Note these changes at regular intervals and you can chart the movement.

Let's use a clock's hour hand as a specific example—it will provide results quickly. As the hand moves around the dial, mark the reflections on a piece of graph paper. Then draw a curve using the points you have plotted. Remember, this is only an example to let you see results quickly. If you come up with an interesting test procedure, let us know.

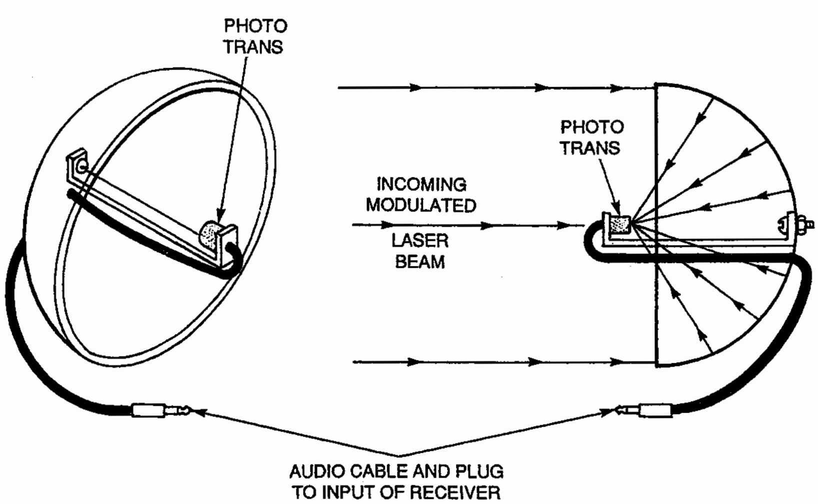

FIG. 5—A SIMPLE PARABOLIC DETECTOR noticeably increases the sensitivity of the detector.

To perform this kind of measurement you will need a collimator, a convex lens, to concentrate the laser beam into a small spot to make the markings more accurate. If an electronic display is needed, take a look at Fig. 3. On a strip of plastic or some other mounting material, set up a row of phototransistors edge to edge, keeping them as close together as possible. The miniature plastic types will let you squeeze in about 10 to the inch. Connect a 220-ohm resistor to each phototransistor's collector. Then tie the anode of a standard LED to each phototransistor's emitter. Make sure that the LED cathodes are all connected to the negative side of a 6-volt DC power source. The free end of each resistor connects to the positive side of the supply. Whenever the laser beam hits one of the phototransistors, the corresponding LED lights.

Reflected sound modulation

The last experiment in this section uses the high-gain amplifier described in the laser column in the June 1996 issue of *Electronics Now*, as a receiver. It demonstrates how sounds can create vibrations in solid materials. The degree of movement depends upon the volume of the sound present and is usually unnoticeable to the human eye. Yet it is there, and the receiver is sensitive enough to detect it. To illustrate this principle, aim your laser at a surface on a nearby building and align your receiver so it can pick up the reflected beam as shown in the diagram of Fig. 4.

Glass or metal surfaces are best, as both tend to vibrate better than more solid materials. When you bounce the beam of a pane of glass, only part of the light comes back, while the rest passes on through to strike whatever surface it finds. For more detailed information about the process see the article *Laser Listener* by Richard Pearson, in the October 1987 issue of Radio-Electronics magazine.

Adjust the receiver's gain and volume and you should be able to hear sounds within or around the building. Scan the beam around the structure to find the points of best reception. This type of system has been employed for clandestine eavesdropping, and such use is illegal.

It is interesting to note the sensitivity of the equipment and the variety of sounds received. For the best possible reception, try using a metallic parabolic dish to increase the concentration the incoming light and maximize the strength of the incoming audio signal (see Fig. 5) at the dish's focal point. EN