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Mini-Laser Spirograph

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For around \$15, excluding the cost of a laser pointer, you can construct an extremely compact laser spirograph. Similar, much larger devices employing a He-Ne laser have been described previously.^{1,2} The essence of the device is two mirrors attached to small dc motors. A laser beam striking the rotating mirrors will produce a wide array of patterns. With one mirror rotating, the reflected beam “paints” an ellipse on a screen. When both mirrors are spinning, two elliptical patterns superimpose to produce more complex shapes. The pattern observed depends on the ratio of the speeds and direction of rotation of the mirrors. These parameters are controlled by a potentiometer and a reversing

Materials

(from RadioShack Catalog)

- 2 – dc motors (1.5 V-3 V), #273-223, \$2.29 ea.
- 2 – mirror pieces
- 2 – 1-cm length dowels (width depends on size of mirror piece)
- 1 – AA battery holder, #270-401, \$.99
- 1 – SPST switch, #275-406, \$2.49/2
- 1 – DPDT switch, #275-403, \$2.99/2
- 1 – 25- Ω , 3-W potentiometer, #271-265, \$3.99
- 1 – breadboard (any type), #276-1396, \$4.29
- wire
- soldering iron
- solder

switch connected to one mirror while the second mirror is allowed to spin

freely. A sample spirograph pattern is seen in Fig. 1.

The arrangement of the spirograph components is shown in Fig. 2. The placement of the switches, potentiometer, and battery is not critical. However, it is important to arrange the mirrors so that the laser beam forms a Z-shaped path. A schematic is given in Fig 3.

Two small mirrors are attached to 1.5-cm long pieces of 2.5-cm dowel rod. If first surface mirrors are not available, pieces of ordinary mirror produce very acceptable results. The pieces of dowel rod need not be cut with particular care since the mirrors need to be mounted at a slight angle in order to produce elliptical images. The mirrors may be attached



Fig. 1. Sample spirograph pattern.



Fig. 2. Spirograph close up.

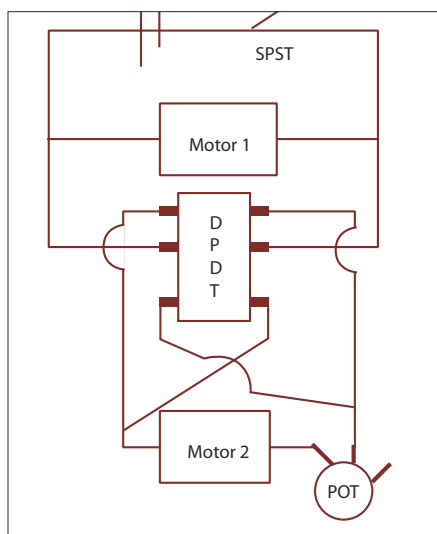


Fig. 3. Schematic of spirograph.

to the dowel rod with either Liquid Nails™ or hot glue. (Note: We have never had a mirror detach. However, it is always prudent to have students stand behind you while the device is in operation.) Friction will keep the dowel/mirror assemblies on the motor shafts if holes with slightly smaller diameters than the motor shafts are drilled in the center of the pieces of dowel rod.

Students are often surprised to learn that the patterns observed are all in their heads! Through the phenomenon of persistence of vision, the eye-brain system retains an image for

a fraction of a second. Hence, an entire pattern is observed even though at any instant there is only a point of light on the screen.

References

1. Herbert Gottlieb, "76. Applications, Lissajous patterns," *Metrologic Laser Workbook and Catalog* (Metrologic Instruments, Bellmawr, NJ, 1987), p. 39.
2. Christopher Chiaverina, "A laser spi-rograph for under \$3 (laser not included)," *Phys. Teach.* **28**, 606 (Dec. 1990).

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Technological Intuition

Steven Lubar of the National Museum of American History, writing in *Science*¹ said:

"I recently sat in on an undergraduate engineering design course. Twenty students, mostly seniors majoring in engineering, were to design and build a walking robot. Most of them found the project very difficult. They could use mathematical techniques and computer programs to determine the details of motion and structure, but they had a hard time coming up with the design, imagining how the machine would work. They knew how to analyse, but not how to synthesize.

"Eugene Ferguson, emeritus professor of the history of technology at the University of Delaware, explains why this is. Engineering education, he argues, has lost sight of the true nature of technological work. Engineering is not a scientific discipline. It is closer to an art than a science. It is non-verbal, creative, physical, and intuitive, based on experience of the real world, not on equations borrowed from the scientist.

"A good engineer must have an 'intimate, firsthand, internalized knowledge'—an 'intuitive sense'—of technology. The only way to get this, says Ferguson, is to gain a 'tactile and muscular knowledge' of moving machinery, materials, and fabrication processes. Students should visit factories and construction sites and get their hands dirty. But today, 'engineering schools teach contempt, not admiration' for people who actually build things."

1. Steven Lubar, *Sci.* **258**, 1504–1505 (Nov. 27, 1992). This is from a review of the book *Engineering in the Mind's Eye*, by Eugene S. Ferguson, MIT Press, Cambridge, MA (1992).