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APPARATUS for Teaching Physics



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Herb Gottlieb, who has been our Apparatus Editor for 15 years, and who has made this section the most-appreciated single feature in *The Physics Teacher* has now passed the baton to new editors. Rae Carpenter and Dick Minnix from Virginia Military Institute have agreed to take

on the job together. With their background in preparing and teaching about lecture demonstrations [see *Phys. Teach.* **20**, 167 (1982)], they are well equipped to analyze and judge manuscripts about apparatus. Send notes for this column directly to them.

A LASER SPIROGRAPH

In addition to myriad other applications, the laser is very useful for demonstrating ray optics, especially in large classrooms where a well defined, easily viewed ray is essential. This note describes a simple device that converts any laser to a projection oscilloscope¹ or what we call a laser spirograph.² This is a modern version of an oscil-

loscope spirograph described by J. G. Anderson.³

The key ingredients are two scanning mirrors mounted on mutually perpendicular axes as shown in Fig. 1. A small mirror (7 x 7 mm) is mounted so that its plane is parallel to the axle of the scanner (Fig. 2). Each scanner⁴ is a simple galvanometer with an angular deflection of the mirror which is roughly proportional to the input signal voltage. These scanners have a

usable frequency response in the low frequency range from dc to 700 Hz. Over this frequency range the scanners have a maximum angular amplitude of 12° which gives an optical deflection of 24°. They can be driven at higher frequencies, but the amplitude is attenuated. At low frequencies even nonsinusoidal signals such as a sawtooth can be used, but unwanted oscillations may occur in transient response unless they are damped with

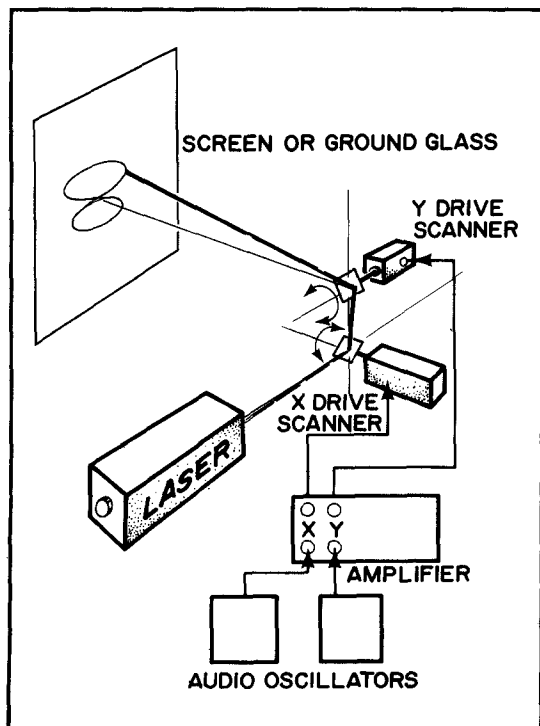
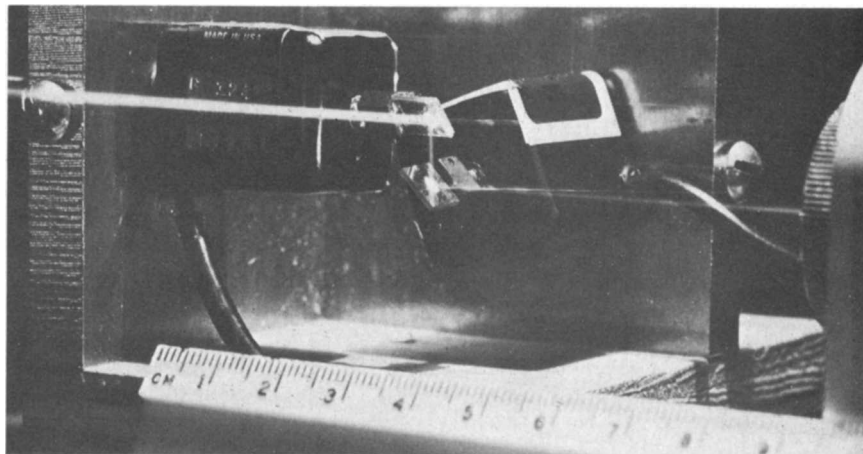


Fig. 1. Schematic diagram for a laser spirograph.

Fig. 2. Photograph of the scanners in their mount. The introduction of smoke makes the beam visible. One segment of the beam appears brighter because of the dominance of forward scattering of the laser beam.



a feedback circuit correcting for the back-emf produced in the scanner.

The scanners may be driven by two audio oscillators and a stereo amplifier. A greater variety of patterns can be generated by mixing the two input signals.³ We have found the circuitry described by Kirschman⁵ in *Popular Electronics* to be very satisfactory and easily assembled from inexpensive parts. It features circular sweep and has various controls, such as for phasing of the x and y sweep signals and independent amplitude regulation of the two input signals, making available an endless variety of patterns. The phasing control allows one to stretch the output pattern along a line from the upper left to the lower right. The sweep frequency input can be used to modulate the overall amplitude of the pattern.

Since the signals applied to the scanners are usually in the audio frequency range, one can use an ordinary stereo tape deck to record the signals for later playback. In doing this, it is advantageous to use a "three-head" recorder, so the signals can be monitored with the third set of heads and routed to the laser scanners during the actual recording. A medium quality cassette tape deck produced slight phase shifts between channels (which can severely spoil the appearance of many laser patterns), but using the tape monitor function as it was recorded allowed at least partial compensation for this at the signal-generating circuitry. A higher quality reel-to-reel deck produced no apparent phase shift between channels, but it was still advantageous to have the tape monitor function to insure exact equality of amplitude recording on the two channels.

The uses for the laser spirograph are probably limited only by one's imagination. In this note we describe three of our favorites: a spirograph, a device for displaying Lissajous figures and conic sections, and a dynamic optical display to accompany music.

At MSU we have an extensive holography show⁶ that includes several kinds of optical displays in addition to holograms. As most of the displays are static, the dynamic spirograph is a welcome addition. In this case the spirograph patterns are traced out on a wall (Fig. 3). We find it very popular to let people play with the controls and generate their own pictures. In this case one must be careful

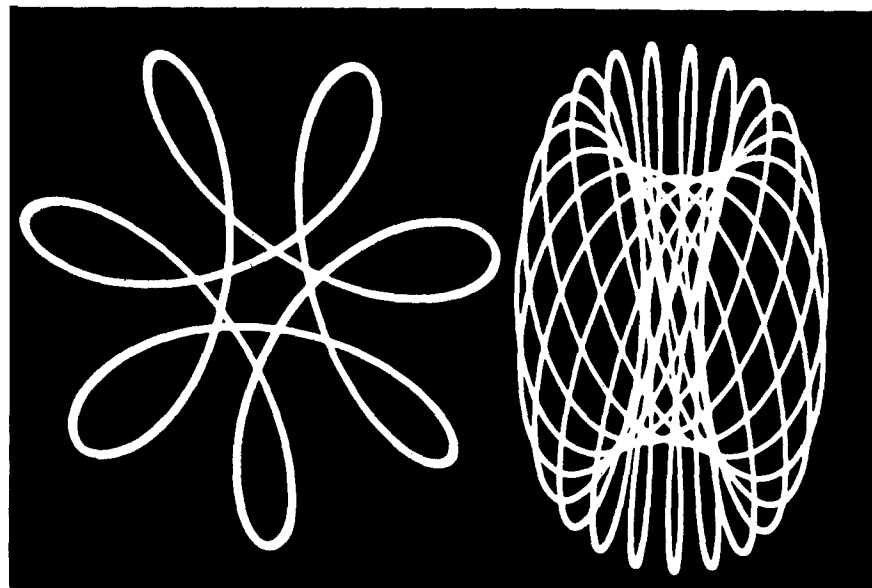


Fig. 3. Two laser patterns generated by circuitry similar to that of Ref. 1.

to protect the optical scanners so that curious hands don't damage them. We usually do this by placing the spirograph in an inaccessible location and connecting it by a long cable to the electronics. This also eliminates the potential hazard of students looking into the laser beam.⁷⁻¹⁰ To prevent the scanners from being driven too hard, we draw a square on the wall and request that they keep the pattern within this square. So far we have had no problems with damage to the scanners.

For large classrooms we have used the laser scanner to demonstrate Lissajous figures and conic sections. To show conic sections we project a circle on the screen and show that the laser beam is actually sweeping out a cone in space. The effect can be made dramatic by using the well known technique of darkening the room and clapping erasers together above the beam.¹¹ The conic sections can be explicitly displayed by intercepting light cone with a piece of white posterboard held at the appropriate angles. The beam can be projected onto virtually any background desired although an ordinary projector screen works nicely. With appropriate care that the beam doesn't stray directly into the eyes of the audience, a large piece of ground glass can be used as the screen so that the audience is on the other side of the display. In this case the spirograph acts like a large projection oscilloscope.

The art and music departments expressed interest when they learned that they could generate optical

patterns to accompany music. One can then watch music as well as hear it. The simplest mode is to use the audio input from the music to modulate the radius of a circular pattern. Various effects can be created by varying the types of patterns, the frequency of these patterns, and the type of music. This lends itself to a new type of composition and an interface between art and music.

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1. A laser device which has a sweep like an oscilloscope has been described by Albert A. Bartlett, Harry Clark, and Robert Stoller, "An Apparatus to Demonstrate Voltage and Current Waves in an LRC Circuit," *Am. J. Phys.* 39, 1133 (1971).
2. Less expensive devices are described in "101 Ways to Use a Laser," #74 and #76, available from Metrologic, 143 Harding Ave., Bellmawr, NJ 08031. See also Metrologic's ad on the back cover of *The Physics Teacher* for October 1979 and 1980.
3. J. Gerard Anderson, "An electronic spirograph," *Phys. Teach.* 12, 89 (1974).
4. General Scanning, Inc., 150 Coolidge Ave., P.O. Box 307, Watertown, MA 02172. Each scanner requires the following parts: 000-G124, scanner; 000-M110707, 1.0-thk x 7-mm mirror; 000-MT10A, mount assembly; and 000-EPOXYP, mirror mtg parallel.

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- Current price is about \$245 per scanner. Other scanners are available.
5. R. K. Kirschman, *Popular Electronics*, p. 41, March 1978.
 6. Larry D. Kirkpatrick and Mac Rugheimer, "A holographic road show," *Phys. Teach.* 17, 25 (1979).
 7. Debrah Van Brunt, *Laser Light Show* Safety. Available from the Bureau of Radiological Health, U.S. Dept. of Health and Human Services, Rockville, MD 20857.
 8. *Teaching Physics Safely*, AAPT Committee on Apparatus, 1980.
 9. H. Weichel, W. A. Dunne and L. S. Pedrotti, "Laser Safety in the Labora-

- tory," *Am. J. Phys.* 42, 1006 (1974).
10. Robert Tinker, "The safe use of lasers," *Phys. Teach.* 11, 455 (1973).
 11. The lecture halls we use have very intimidating NO SMOKING signs, otherwise pipe or cigar smoke would serve well and avoid some cleanup later.

Good reading from other journals

Continued from page 414.

to new construction, e.g., a sun space, but existing buildings can be modified.

The present article concerns itself with the amount of thermal mass appropriate to the square footage of south-facing glazing. Climatically far-flung cities are investigated via computer simulation such parameters as aperture area, per cent solar, cost and mass.

Previous principles covered (in decreasing order beginning with the January issue) are window options, passive systems, shading, aperture size, and conservation first.

Converters and inverters

Don Best, "What you should know about phase-change Water Heaters," and Charles H. Cox III, "Making the Utility Connection," *Solar Age*, December, 1981, pp. 22-25; 39-47.

The first article discusses a passive system similar to a solar collector for hot water, yet promises an end to pumps and controls, corrosion, freezing, and toxicity while yielding a 30% increase in efficiency. Employing basic thermal principles, one is able to follow the refrigerant around the loop of a system that has many advantages, e.g., no electricity needed.

The second article concerns itself with a potential problem of the future, i.e., the meshing of many small wind and photovoltaic systems with the utility power grid. The heart of the interface — the inverter is discussed in general terms. Problems in transmission from the utilities point of view are covered along with ac circuit theory.

Frederick J. Wolf
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Laboratory computer — BASIC programs

Peter Spencer, "Using the PET/CBM in the High School Physics Lab," *Computel*, April 1982, p. 100.

How can you use a small computer in your lab? Here is an article with BASIC programs to measure time in microseconds, using only inexpensive phototransistors and your computer. Spencer used a PET/CBM, I converted some of his programs — in BASIC (using a call in BASIC to machine language) to use on my VIC-20. The phototransistor can be Radio Shack. The author's style is easy and conversational. If you are looking for quick and easy lab or demonstration uses for a computer, Spencer's article is for you.

Kenneth E. Knox
Labette (KS) Community College
(Retired)

Calendars, old and new

Geoffrey Thomas, "Making a firm date," *New Scientist*, March 25, 1982, pp. 770-772.

We base time on the earth's motions, but because the year is not an integral multiple of the day, the seasons drifted on early calendars. To compensate, leap years were introduced by Julius Caesar, and a finer adjustment was proposed by Pope Gregory, although this calendar was not immediately adopted worldwide. England finally accepted the new calendar in 1752, with understandable confusion over the missing eleven days; Russia did not switch until the 1917 revolution. A World Calendar with 364 days logically organized into equal three-month quarters plus one or two "free days" was discussed by the UN in 1956, yet we appear to remain content with the present, familiar but confusing, system.

K. R. Evans
Kingston (NY) High School

The star that made its catalog famous

Bruce Margon, "Relativistic Jets in SS 433," *Science*, 15 January 1982, pp. 247-252.

Ejecting jets of material a quarter as fast as light with a 164-day cycle, SS 433 is a member of a binary system loaded with exciting examples for teaching introductory physics. Teachers who value a picture as much as a thousand words, however, will want to supplement the updated information in this article with the diagrams in the same author's article in the October 1980 *Scientific American*.

A new way to see atoms

F. P. Ottensmeyer, "Scattered Electrons in Microscopy and Microanalysis," *Science*, 29 January 1982, pp. 461-466.

A new approach to electron microscopy produces images with improved contrast. The key is the use of scattered electrons. The excellent pictures of atoms and molecules obtained with this technique should be of interest to everyone.

John L. Roeder
The Calhoun School (New York)

Progress in timekeeping accuracy

Brenda Ralph Lewis, "The Search for Longitude," *Oceans*, Jan./Feb. 1982, pp. 18-23.

This is an interesting account of the development of the chronometer, from Huyghen's first pendulum clock of 1656 to the atomic clocks of today. The story centers on John Harrison's lifetime quest for the 20 000-£ prize established by Parliament as a "public reward for such person or persons as shall discover longitude." Although he qualified for the prize after sea trials of his Number 4 chronometer in January 1762, the Board of Longitude withheld full payment until 1773, when Harrison was 80 years old and nearly blind. There is some interesting background material for your time lectures here, along with photos of the devices.

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