Optoelectronic Tool Adds Scale Marks to Photographic Images

Scale marks are optically projected into any desired scene.

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A simple, easy-to-use optoelectronic tool projects scale marks that become incorporated into photographic images (including film and electronic images). The sizes of objects depicted in the images can readily be measured by reference to the scale marks. The role played by the scale marks projected by this tool is the same as that of the scale marks on a ruler placed in a scene for the purpose of establishing a length scale. However, this tool offers the advantage that it can put scale marks quickly and safely in any visible location, including a location in which placement of a ruler would be difficult, unsafe, or time-consuming.

The tool (see Figure 1) includes an aluminum housing, within which are mounted four laser diodes that operate at a wavelength of 670 nm. The laser diodes are spaced 1 in. (2.54 cm) apart along a baseline. The laser diodes are mounted with setscrews, which are used to adjust their beams to make them all parallel to each other and perpendicular to the baseline. During the adjustment process, the effect of the adjustments is observed by measuring the positions of the laser-beam spots on a target 80 ft (≈24 m) away. Once the adjustments have been completed, the laser beams define three 1-in. (2.54-cm) intervals and the location of each beam is defined to within 1/16 in. (≈1.6 mm) at any target distance out to about 80 ft (≈24 m).

The distance between the laser-beam spots as seen in an image is strictly defined only along an axis parallel to the baseline and perpendicular to the laser beam (also perpendicular to the line of sight of the camera, assuming that the camera-to-target distance is much greater than the distance between the tool and the camera lens). If a flat target surface illuminated by the laser beams is tilted with respect to the aforesaid axis, then the distance along the target surface between scale marks is proportional to the secant of the tilt angle. If one knows the tilt angle, one can correct for it. Even if one does not know the tilt angle precisely, it may not matter: For example, at a tilt of 10°, the secant is approximately 1.0154, so that the tilt error is only about 1.54 percent, which is negligibly small for a typical application in which only approximate measurements are needed.

Each diode laser generates a light beam having a power of 3 mW and consumes an input power of 150 mW. The laser diodes
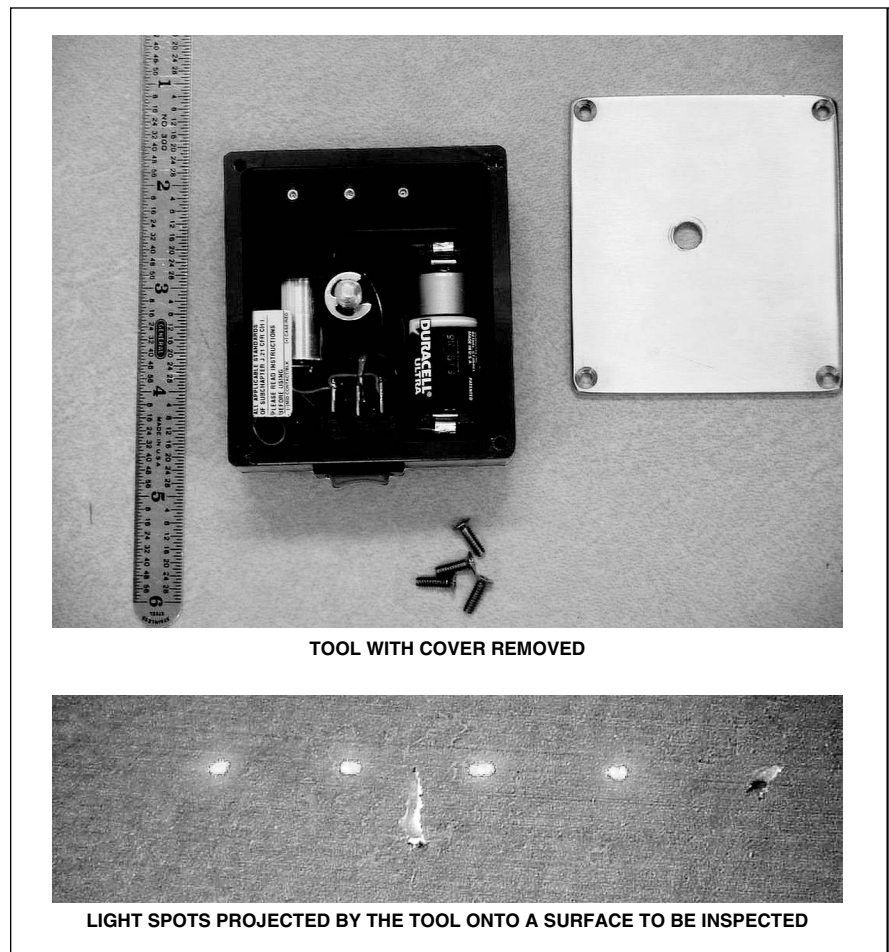

TOOL WITH COVER REMOVED

LIGHT SPOTS PROJECTED BY THE TOOL ONTO A SURFACE TO BE INSPECTED

Figure 1. The **Tool Contains Four Laser Diodes** that generate evenly spaced parallel beams that project light spots onto an object to be photographed for inspection. The laser diodes are located in the curved tubes that protrude from the rest of the housing.
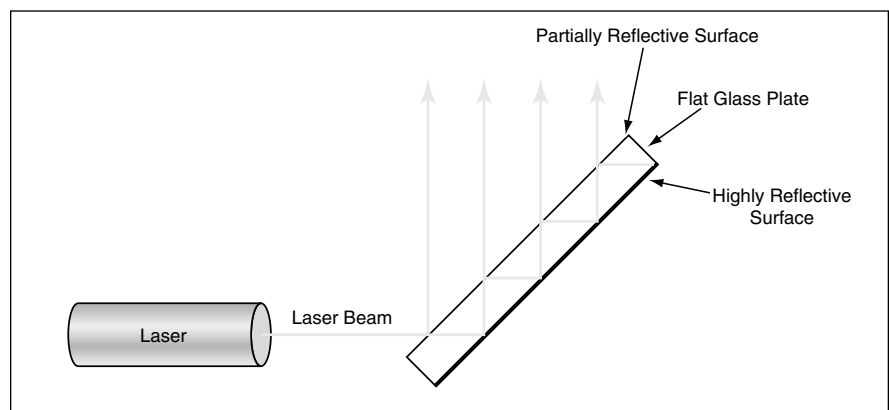

Figure 2. A **Laser Beam Would Be Split** into four parallel beams in this simple optical assembly. The four beams would not be of equal power, but in many applications, this inequality would not be a great disadvantage.

are powered by a lithium cell that can sustain operation for an interval of an hour or more. Because the optical performances of the laser diodes are equivalent to those of most laser-based auditorium pointers, the use of the tool should not pose a major con-

cern for eye safety — provided, of course, that one observes the usual precaution of not looking directly into the laser beams.

The tool can readily be attached to almost any camera by use of the standard tripod nut on the underside of the camera. Once the tool is thus attached and properly aligned, it projects the laser scale marks wherever the camera is aimed.

The basic principle of operation of this tool is amenable to a number of potential variations of its design. For example, the number of laser beams could be different from four. For another example, one of the laser beams could be aimed at a known angle relative to the others so that the different dis-

tances between laser-beam spots in an image can be used to estimate the distance between the camera/tool combination and the target.

For yet another example, one could reduce the cost of the tool by using a single laser in conjunction with a non-optimum inexpensive simple beam-splitting device to generate all four beams. In this case (see Figure 2), the beam-splitting device would be a flat glass plate coated to be partially reflective on one surface and highly reflective on the other surface. Because the parallelism of the output laser beams would depend only on the parallelism of the glass surfaces and the dis-

tance between successive beams would depend only the thickness of the glass surfaces and would vary uncritically with the tilt of the plate, this design would offer the advantage of simplification of alignment. The one shortcoming of this design is that the four laser beams would not be of equal power.

Compact Interconnection Networks Based on Quantum Dots

These networks would exploit the crossing of coplanar signal paths.

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Architectures that would exploit the distinct characteristics of quantum-dot cellular automata (QCA) have been proposed for digital communication networks that connect advanced digital computing circuits. In comparison with networks of wires in conventional very-large-scale integrated (VLSI) circuitry, the networks according to the proposed architectures would be more compact. The proposed architectures would make it possible to implement complex interconnection schemes that are required for some advanced parallel-computing algorithms and that are difficult (and in many cases impractical) to implement in VLSI circuitry.

The difficulty of implementation in VLSI and the major potential advantage afforded by QCA were described previously in "Implementing Permutation Matrices by Use of Quantum Dots" (NPO-20801), *NASA Tech Briefs*, Vol. 25, No. 10 (October 2001), page 42. To recapitulate: Wherever two wires in a conventional VLSI circuit cross each other and are required not to be in electrical contact with each other, there must be a layer of electrical insulation between them. This, in turn, makes it necessary to resort to a noncoplanar and possibly a multilayer design, which can be complex, expensive, and even impractical. As a result, much of the cost of designing VLSI circuits is associated with minimization of data routing and assignment of layers to minimize crossing of wires. Heretofore, these considerations have impeded the development of VLSI circuitry to implement complex, advanced interconnection schemes.
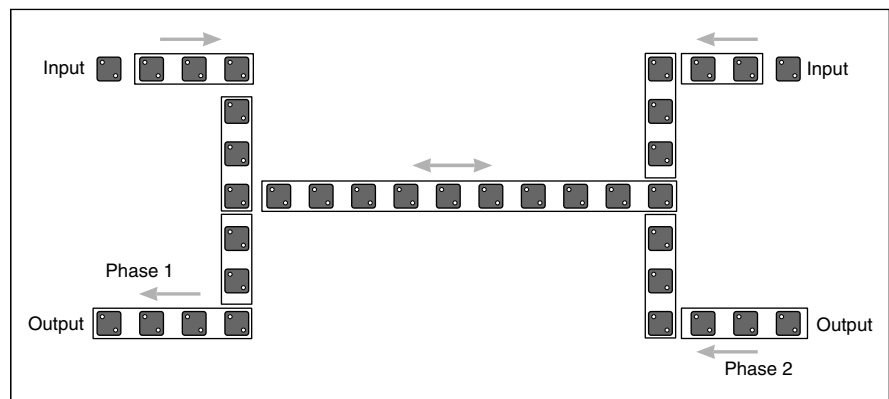

Figure 1. A **QCA-Based Wire for Bidirectional Communication** would be terminated in input and output branches at both ends.

On the other hand, with suitable design and under suitable operating conditions, QCA-based signal paths can be allowed to cross each other in the same plane without adverse effect. In principle, this characteristic could be exploited to design compact, coplanar, simple (relative to VLSI) QCA-based networks to implement complex, advanced interconnection schemes.

The proposed architectures require two advances in QCA-based circuitry beyond basic QCA-based binary-signal wires described in the cited prior article. One of these advances would be the development of QCA-based wires capable of bidirectional transmission of signals. The other advance would be the development of QCA circuits capable of high-impedance state outputs. The high-impedance states would be utilized along with the 0- and 1-state outputs of QCA.

A QCA-based wire for bidirectional

communication (see Figure 1) would be terminated in two branches at each end — one branch for input, the other for output. To enable binary signals to propagate both from the left input to the right output terminal and from the right input to the left output terminal, it would be necessary to apply suitably phased clock signals (bias voltages) to QCA subarrays at various positions along the main wire and the end branches. (For complex reasons that must be omitted from this article for lack of space, such clocking is needed in any event to prevent spurious outputs. Here, the clocking would be exploited for the additional purpose of bidirectional communication.)

One especially useful interconnection network is an $N \times N$ crossbar network. A QCA circuit capable of a high-impedance output state would be needed to implement a crosspoint switch in a crossbar network. This is because while all N input