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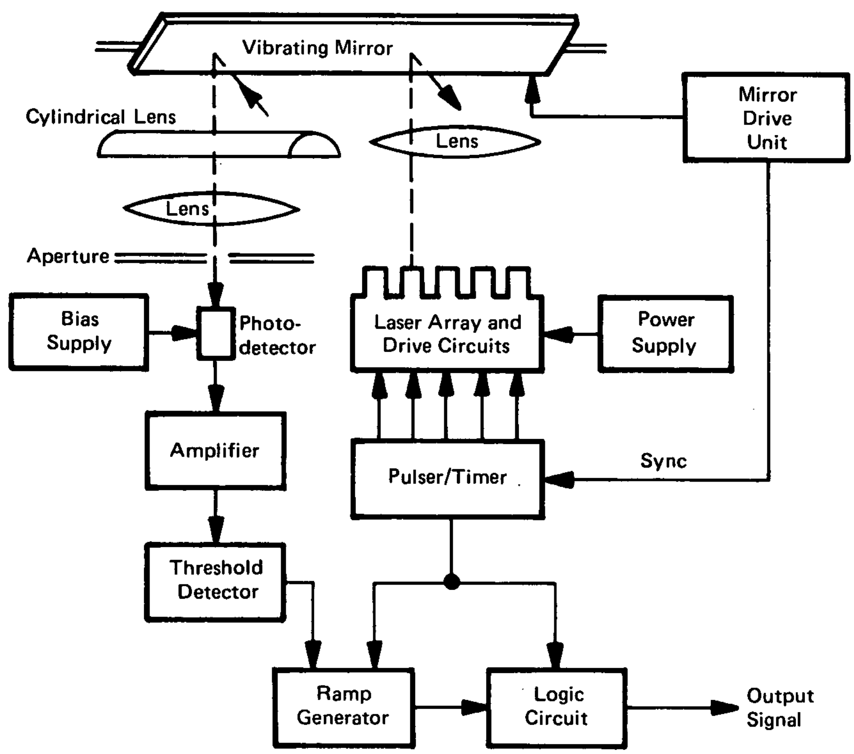
Short-Range Laser Obstacle Detector

Extensive safety measures incorporated into the modern automobile have demonstrated much progress in protecting both the car and the driver during collision. With all of this progress, however, no system, independent of the driver, is yet available that would prevent a vehicle from collision. Systems that would divert the vehicle automatically from an obstacle in its path are only concepts. To this date, the prevention of accidents by and large remains in the hands of the driver.

One step in preventing collisions is the development of a short-range laser obstacle detector. The detector designed for a slow-moving vehicle to explore the surface of Mars will automatically divert the vehicle from obstacles as small as 0.5 m in its path.

The detector comprises an injection laser operating in the pulse time-delay measurement, or radar, mode. It is capable of scanning an area extending from a few meters to approximately 30 m. In use as a Mars excursion controller, the detector will generate command signals to divert the vehicle from collision.



Obstacle Detection System

(continued overleaf)

The major components of the detector system are shown in the block diagram. The transmitter portion of the rangefinder consists of an array of five gallium-arsenide laser diodes, each equipped with its own driving circuit. Each diode has a typical output of 13 W and an emitting area on the order of 3 by 225 μm. The diffraction-limited beam spread for the laser itself is on the order of 0.3 rad. Since the target area is illuminated with a beam of the smallest possible diameter, to minimize target-induced pulse spreading and split returns, a collimating lens is incorporated.

The beam is swept by the vertical scan at an angular rate of 68.5 rad/s; so when a transmitter pulse repetition rate of 10 kHz is used, the terrain is sampled at 0.61-m intervals at the midrange distance of 13.3 m for the vehicle on a level terrain. Since only one laser diode is operated on each vertical scan, the entire field is scanned once each 0.2 second, a time which is sufficiently short so that vehicle pitching and rolling should only occasionally interfere with the scan.

A 25-mm f/3.2 simple lens is used to collimate at least 80 percent of the radiation emitted by any one of the five diodes and to project it onto a spot never larger than 0.1 m in diameter for ranges up to 30 m. The diodes are spaced at 6-mm intervals along the lens focal plane to achieve the required scan coverage. The pulser/timer sequentially operates one laser of the array on each elevation sweep and fires the laser diodes at a 10-kHz rate with a pulse duration of about 4 ns.

The receiver portion of the rangefinder contains collecting optics, a photodetector, an amplifier, and a threshold detector. The optics consist of a cylindrical lens followed by a 25-mm-diameter simple lens to produce a receiver beamwidth of 3 mrad in elevation and 0.4 rad in azimuth. This particular beam shape includes all of the azimuthal area in its field of view illuminated by the transmitter, but it is otherwise minimized to reduce the amount of background solar radiation intercepted.

The optical system also contains a 5.0-nm pass-band optical filter to discriminate further against background radiation. The optical bandwidth is made as narrow as laser characteristics permit. Room temperature gallium-arsenide injection lasers emit at a nominal wavelength of 902.0 nm, with an output wavelength spread on the order of angstroms caused by multimoding and by heating within the duration of a pulse.

The receiver aperture is selected to be small but comparable to the area required for the transmitter optics. Sensing is provided by avalanche photodiodes operated at a gain between 100 and 200 to yield an adequate signal-to-noise ratio at a range of up to 30 m.

At the nominal condition of level vehicle attitude, a vehicle traveling at a velocity of 0.139 m/s (0.5 km/h) will detect a given obstacle 900 times in the 5- to 30-m search range. This redundancy is somewhat reduced when the vehicle is pitching but is still sufficient to prevent false alarms; that is, an obstacle is detected several times in succession before the sensor signals its presence.

Notes:

1. This detector may be of interest to automobile, earthmoving equipment, and aircraft and ship navigation system manufacturers.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP74-10101

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,781,111). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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