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NASA TECH BRIEF

Langley Research Center

Remote Control Radioactive-Waste Removal System Uses Modulated Laser Transmitter

A laser-controlled laboratory model of a remote control cleaning device for removing radioactive debris and waste material from nuclear engine test sites has been designed, constructed and tested in order to study the feasibility of the optical control line approach. The model has five command channels, an automatic tracking capability, and an optical link operating range of 110 m.

There are other existing remote control systems. However, in the radio frequency system, the command signals interfere with engine control and monitoring devices, as well as other ancillary equipment; the acoustic systems suffer from range limitations and sensitivity to ambient noise; and the hard-wire systems are restricted by their cables.

The laser remote control system consists of the transmitter, the auto-tracker, and the receiver. The transmitter and tracker, packaged together and bore sighted, constitute the control station. The receiver serves as the slave station.

The transmitter uses a continuous wave He-Ne laser operating at 6328 Å as the source. The laser is amplitude modulated by six discrete-frequency sine-wave subcarrier oscillators for command and tracking functions. The subcarrier oscillators are coupled to the laser modulator through a mixer to insure proper modulator drive. The six widely separated frequencies in the 10 to 200 kHz range of the laser modulator allow sufficient band spacing and harmonic separation.

For azimuth control, the transmitter is mounted on a milling-machine turntable immediately below the auto-tracker. The tracker consists of a pair of photomultiplier tubes with optics which are bore sighted with the laser transmitter. Beam splitting optics are used to display half of a retro-reflected laser beam from the slave station onto each face of the phototube surfaces. The signal outputs of the phototubes are amplified, filtered, and rectified, and are then applied to a null circuit which compares them. Unbalanced outputs cause a dc motor to drive the turntable until the null position is reached. This action keeps the laser transmitter pointed at the slave station. A narrow band interference filter is used for background noise rejection.

The slave station consists of an optical antenna, a detector, demodulator and switching circuits, drive motors, and a retro-reflector for tracking. The incoming signal is collected by the optical antenna, a conical reflecting surface with a parabolic curvature. This "parabacone" allows the collection of transmitted energy from any azimuth. The lower support of the parabacone acts as an electronics housing and a background noise shield. It is also surfaced with the retro-reflective material (Scotchlite) which supplies the signal for the tracker.

The signal from the detector is amplified and fed to the demodulator, which consists of a parallel assembly of tuned circuits, one for each of the five command functions. When a tuned circuit responds to its respective frequency, this signal operates a field effect transistor which in turn energizes a switching circuit. The switching circuits control two dc motors which drive the slave unit. Both right and left drive motors may be commanded forward and backward simultaneously or independently. The slave unit is thus capable of moving forward or backward and making wide and sharp right and left turns. The fifth command turns a blower on and off, simulating a vacuum sweeper capability. All

(continued overleaf)

power for the drive motors is supplied by rechargeable batteries aboard the slave unit. The slave has an inherent "dead man" operation in that loss of command signal by beam obstruction or loss of tracking will terminate all activity of the slave.

After indoor tests were complete, the system was taken outside for long distance operational tests. A protective disc was added to the top of the slave unit to shield the detector from direct sunlight and to reduce the effect of skylight. The system was operated at a maximum range of 110 m. At this distance, the receiver signal-to-noise ratio was 10. The tracker signal-to-noise ratio proved more than adequate for its operation.

Note:

Requests for further information may be directed to:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

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