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Laser System Generates Single-Frequency Light

For many communications and radar applications the conventional free-running laser is more like a special kind of optical noise source than it is like an optical carrier. These uncontrolled lasers oscillate at a large number of optical frequencies simultaneously, and the oscillating modes have time-varying relative phases and amplitudes. The beats and competition between these modes are among the principal causes of noise in the output of the laser.

A program was initiated to eliminate these major sources of noise in the laser output, with minimum sacrifice of total laser output power. Additional objectives included the design and development of a CW laser system which would feature high power single-frequency output in the S-20 photocathode response region. The results of the program are summarized below:

1. *Ring discharge excitation with separate RF power supply.*

The one-watt ring-discharge argon laser used in the CW laser program is powered by an external 5 kw RF supply at 10 MHz. All other ring-discharge lasers have been designed to require the inclusion of the RF supply in the same package as the laser itself. This combination is considered detrimental to the best functioning of both components. The packaging of laser and power supply together increases the size, complexity and heat load of the laser, whereas separate packaging allows the optical alignment of the laser to be optimized without design compromises imposed by included RF circuitry. Also, the separate RF supply can be serviced without disturbing the laser or its optical system.

In this laser system, the RF exciter is connected to the laser by flexible coaxial cables and standard HN connectors. Considerable care in the design of this circuit prevents excessive RF voltages and currents from circulating in the cables and connectors. The resulting system has such an efficient transfer of energy from supply to laser that ordinary bidirectional power meters can be inserted at either end of the coaxial line to measure the forward and reflected RF power to the laser.

2. *Single frequency operation of an argon laser.*

By a unique combination of an argon laser and electro-optic elements, 350 mw of single frequency light in the visible region of the spectrum was obtained. This is the most single-frequency power yet obtained in this wavelength region suitable for detection with electron multiplier phototubes.

This single frequency power was obtained by first modifying a multimode argon laser to make it operate as an FM laser. When this modulator was driven at three times the laser's axial mode interval, the modes of the laser become locked in FM phases. The output of the laser is then an FM signal, with the same power as the free running laser, reduced only by the insertion loss of the modulator itself.

The FM output of the laser is then sent through an external phase modulator consisting of the electro-optic material $LiNbO_3$, heated to 180°C to prevent the incoming light from making it opaque. This modulator produces a modulation equal to that of the FM laser, but 180° out of phase. The result of this second modulation is to compress all the energy in the sidebands of the FM signal into the optical carrier, and thus give a single frequency output at the same power as the original laser.

Note:

Additional details are contained in: *CW Laser System for the Generation of Single-Frequency Light,* by

(continued overleaf)

Russell Targ, Sylvania Electronic Systems, 1 March 1967. Copies of this report are available from:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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