FREQUENCY STABILIZATION OF A GaAs *INJECTION LASER BY MEANS OF AN EXTERNAL FABRY-PEROT RESONATOR*

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The radiation frequency emitted by a continuously operating GaAs semiconducting injection laser was stabilized by means of the transmission resonance of an external Fabry-Perot interferometer, using the dependence of the frequency on the current. The relative stability during several minutes was not inferior to 10^{-7}.

THE investigation and improvement of the temporal coherence that is observed in the case of stimulated emission sources comprise an important direction of quantum electronics research that is significant for both physical and applied problems. Several ideas that have been discussed in[1] indicate how a laser frequency can be stabilized fairly simply by means of a nonlinearly absorbing cell. This technique has enabled the centering of a He-Ne laser frequency on a methane line with 10^{-11} accuracy.[2]

In the present work we have studied the possibility of frequency stabilization for a GaAs injection laser by means of an external Fabry-Perot resonator. This was a promising subject because semiconducting lasers can operate in a wide spectral range. Figure 1 is a block diagram of the apparatus. The diode 1 operated with a cold conductor in a nitrogen atmosphere; the current was supplied by the source 6. The voltage of a sinusoidal frequency generator 7 was also applied to the diode. The parallel laser beam (shaped by a lens) traversed the resonance element 2 and the filter 3 before being focused on the photocathode of the FÉU-2 photomultiplier. The signal from the latter passed through the narrow-band amplifier 4 and was then fed, together with a reference signal from the generator 7, to the synchronous detector (SD). Following the SD and the dc amplifier 5, the signal entered a feedback circuit. The external resonance element was a Fabry-Perot resonator with 3-cm mirror separation and 80% reflection coefficient. The DFS-12 spectrograph was used to discriminate single-mode laser operation and to determine the current range in the case of single-mode operation.

A preliminary investigation of the spectral characteristics showed that the laser wavelength depends strongly on the injection current. This effect enabled scanning of the laser frequency; for this purpose a sawtooth voltage was applied to the diode. The upper portion of Fig. 2 is a transmission oscillogram of the external Fabry-Perot resonator as a function of the injection current; the lower portion represents the variation of current amplitude through the laser. The equal spacing of the transmitted peaks indicates that the frequency ν is linearly dependent on the current I. From the separation between modes of the interferometer it was found that

$$d\nu / dI = -1.2 \text{ GHz/mA}.$$

From the transmitted half-width we obtained $Q \sim 5 \times 10^5$ for the interferometer. The observed current dependence of the frequency permitted current feedback. In the absence of feedback the laser frequency, during a period of 5–10 min (depending on the operating conditions and the diode quality), varied from a few hundred MHz to 10 GHz. With feedback the frequency varied only a few MHz during the same period of time; thus the relative stability of the laser was not inferior to 10^{-7}. The transmission band of the feedback circuit, as determined from the SD time constant, was a few Hz.

Frequency-stabilized semiconducting lasers can be used extensively in communications, in uhf resolution

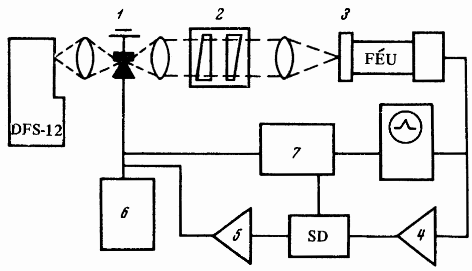

FIG. 1. Block diagram of the apparatus.

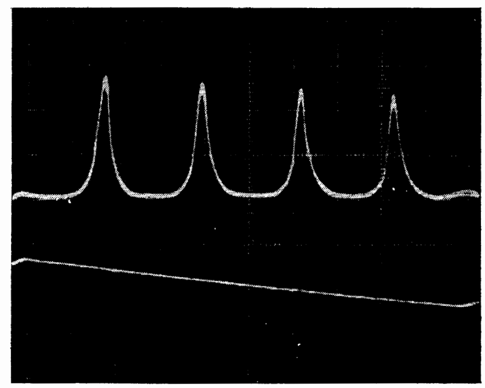
FIG. 2. Oscillogram representing transmission through the external interferometer vs. current through the diode. The amplitude of current variation is 20 mA.

spectroscopy, and as narrow-band sources for optical pumping.

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[1] N. G. Basov and V. S. Letokhov, Usp. Fiz. Nauk 96, 585 (1968) [Sov. Phys.-Uspekhi 11, 855 (1969)].
[2] R. L. Barger and J. L. Hall, Phys. Rev. Lett. 22, 4 (1969).

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