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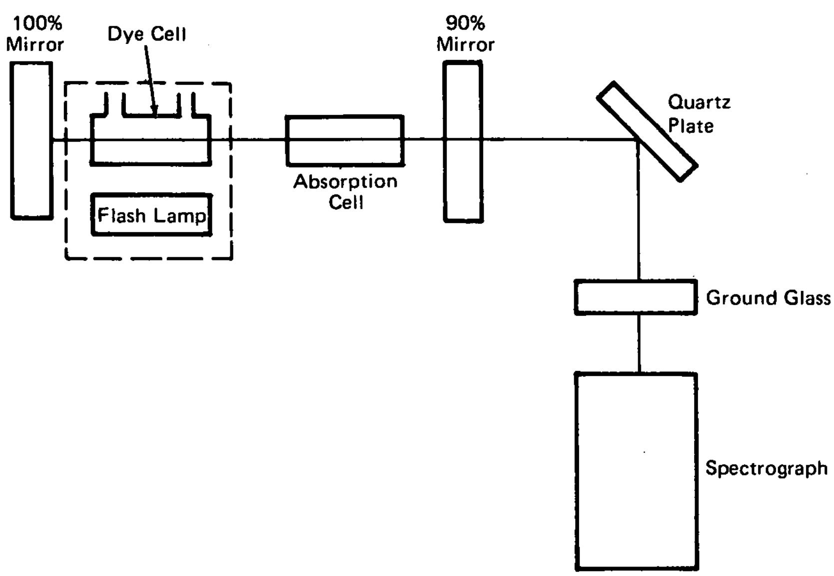
An Absorption Spectrum Amplifier for Determining Gas Composition



The problem:

Compositions of gas samples are frequently studied by laser absorption spectroscopy. In this method, an absorption cell containing the sample is placed outside the laser cavity. Laser radiation and spectroscopy are then used to determine the absorption spectra of gas and, hence, its composition. Although reasonably accurate, this technique is not sensitive to very low sample concentrations, e.g., below 10^{-5} Torr range for sodium.

The solution:

Sensitivity is improved by two orders of magnitude when the absorption cell is placed inside an organic-dye laser cavity.

How it's done:

The block diagram of the amplifier is shown in the figure. This system uses a xenon-flash-lamp-pumped rhodamine 6-G dye solution at 50 mg/*l* in absolute ethanol which is contained in a 7.5-cm dye cell. The cell has windows with anti-reflection coatings and is positioned between the 90 and 100% reflectance mirrors. A 10-cm long absorption cell which contains the gas sample is positioned in the cavity.

Absorption is measured with the laser beam which is partially reflected (2% of the beam) into the entrance slit of a spectrograph by reflection from an uncoated quartz disc positioned inside the cavity at 45° to the optical axis. The spectrograph has 25 μm slits with a grating of 600 lines/mm and uses a Polaroid 3000 ASA

(continued overleaf)

film to record the spectra. The flash-lamp pulse duration is 20 μs and that of the laser pulse about 2 μs. By a change in the concentration of the rhodamine 6-G, the laser can emit a continuous spectrum of a 2 to 10 nm bandwith.

Sodium and iodine samples were tested to compare this method with the conventional one. Laser emission was varied from 570 to 590 nm for sodium and 500 to 620 nm for iodine. The conventional method using the absorption cell outside the cavity resulted in detection of sodium down to 2×10^{-5} Torr (cell temperatures at 205°C), whereas the improved method with the cell inside the cavity detected sodium down to 3×10^{-7} Torr (cell temperature at 112°C). Tests on iodine revealed that the improved method showed the finer spectra structure more accurately.

Additional tests with the new method were performed on europium-nitrate dissolved in methyl alcohol. Results show that optical densities as small as 0.004 were detected.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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Patent status:

No patent action is contemplated by NASA.

Source: E. F. Zalewski, N. C. Peterson, M. J. Kurylo, A. M. Bass, W. Brown, and R. A. Keller of National Bureau of Standards, U.S. Department of Commerce under contract to NASA Headquarters (HQN-10752)