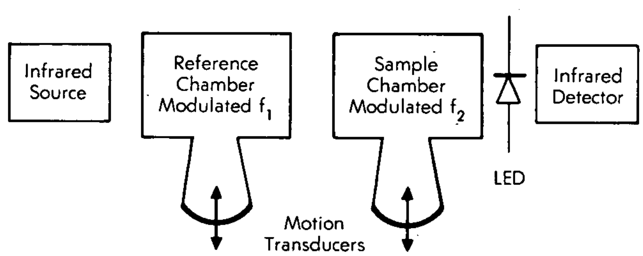
NASA TECH BRIEF
Ames Research Center

Carrier Suppression Device for a Heterodyne Gas Analyzer

A heterodyne gas analyzer (see Note 1) operates with broadband light from a blackbody infrared source; the light is passed sequentially through two gas-filled chambers to a suitable infrared detector while the pressures in the gas-filled chambers are modulated in a sinusoidal manner around a mean pressure of 1 atm. The first chamber contains a reference gas, for example, carbon dioxide, while the second is filled with a sample gas in which the concentration of carbon dioxide is to be measured; the gas pressures are modulated at two different frequencies, f_1 and f_2. Because the pressure, and hence density, of infrared-absorbing gases in the chambers is modulated, the total amount of infrared light absorbed by the gases is also modulated; the infrared detector thus receives two signals, at frequencies f_1 and f_2, which are proportional in amplitude to the concentrations of infrared-active gases present in the two chambers.

Absorption by infrared-active gases is a nonlinear process, i.e., the total absorption is not linearly proportional to the total gas concentration in the absorption path. Thus, if the *same* gas is present in both chambers, modulation of the nonlinear absorption signals at f_1 and f_2 also gives rise to signals at the sideband frequencies $f_1 \pm f_2$. The amplitude of the signals at frequencies $f_1 \pm f_2$ as seen by the infrared detector is proportional to the product of the concentrations of the same gas in the reference and sample chambers; the $f_1 \pm f_2$ signals are present only when the same gas is present in both chambers.

It is evident that if there are nonlinearities in the measurement system, apart from the gas infrared absorption process, severe errors can be incurred. In practice, most infrared detectors do not exhibit truly linear response; thus, when two different infrared-active gases are actually present in the chambers and signals at frequencies f_1 and f_2 are generated, $f_1 \pm f_2$ signals will also be generated in the infrared detector and will lead to the false conclusion that both chambers contain the same gas. However, a heterodyne gas analyzer is improved by interposing a light emitting



diode (LED) between the sample chamber and the infrared detector, as indicated in the diagram; the performance of the analyzer is improved because errors introduced by nonlinearities in the infrared detector and electronic circuits are reduced.

The LED is driven by a reference signal, at frequency f_2, which is 180° out of phase with the gas absorption-modulated f_2 signal. In addition, a null servo circuit is used to adjust the amplitude of the LED signal at frequency f_2 so that it cancels out the gas-absorption f_2 signal. Thus, the infrared detector receives two sources of modulated energy at frequency f_2, equal in amplitude but of opposite phase, and so no signal at f_2 is seen by the detector. The false $f_1 \pm f_2$ sideband signal produced by nonlinear detector response (or subsequent electronics such as

(continued overleaf)

amplifiers) is effectively eliminated by f_2 carrier suppression. However, the true $f_1 \pm f_2$ signal due to the gas-absorption process is already impressed and present in the infrared energy leaving the second chamber, and so is not affected by the carrier suppression device.

Notes:

1. Details of the prototype nondispersive infrared analyzer (for specific gases in complex mixtures) are summarized in NASA Tech Brief B72-10198; see also U.S. Patent No. 3,679,899 (John Dimeff).
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP 73-10381

Patent status:

NASA has decided not to apply for a patent.

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