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NASA TECH BRIEF

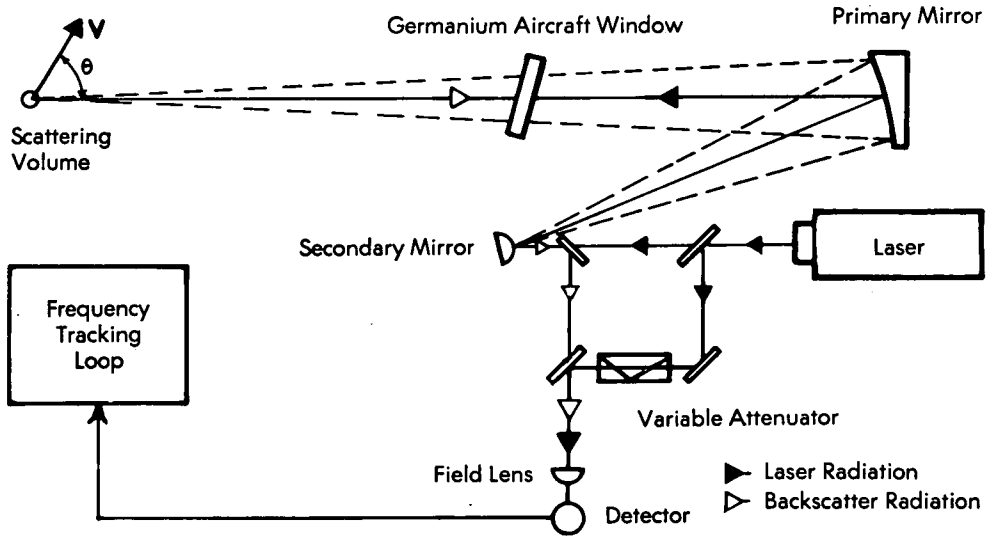
Ames Research Center

True Airspeed Measured by Airborne Laser Doppler Velocimeter

A Doppler detection velocimeter utilizing a carbon dioxide laser has been developed to measure the true airspeed of an aircraft. Results of flight tests indicate that clear-weather airspeeds can be measured with an accuracy better than 0.1% at altitudes up to 3000 meters; measurements can be made at much greater altitudes in cloudy or turbid air.

The optical system of the velocimeter consists of a colinear transmitting and receiving telescope, beam-combining optics for homodyne operation, and a large-aperture infrared window which replaces a glass window in the aircraft. The laser beam is focused at a point about 20 m in front of the aircraft, where the air is undisturbed by the bow wave. The system detects backscatter from aerosol particles and measures the apparent shift in frequency (Doppler effect), which is proportional to the plane's airspeed.

The laser optical system is folded for compactness and rigidity, and includes a true internal mirror system in order to eliminate frequency fluctuations which can arise from variations in cabin pressure; it operates in a sealed-off configuration and has an extremely high passive short-term stability of one part in 10^{10}. The cavity structure consists of a yoke assembly and two end pieces made of low-expansion quartz (thermal expansion coefficient of $2 \times 10^{-8}/°C$); one end piece is roof-shaped to fold the laser beam. An angular alignment transducer is attached on one side of the laser and a GaAs output coupler at the other. Two water-cooled, gold-coated silicon mirrors



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fold the laser beam by 180°. Two plasma tubes connected in series to form the laser are sealed by the two end pieces to provide an internal mirror system requiring no Brewster windows. Output characteristics of the laser feature a stable single-mode (TEM_{oo}) operation at a single frequency corresponding to the carbon dioxide rotational line (P20). The beam spread of the laser approaches the diffraction limit and is of the order of 2.5 mrad.

Referring to the diagram, the (Hg, Cd, Te) detector output is fed to a frequency tracking loop which consists of a mixer, voltage-controlled local oscillator, and a specially-developed zero-IF system that permits selection of the predetection bandwidth to provide optimum tracking sensitivity for a broadband signal. A triangular dither-waveform sweeps the voltage-controlled oscillator through a small range about its center frequency. When the difference between the local oscillator and signal frequencies is within the bandpass of the video amplifier, a voltage is developed at the output of the envelope detector. The phase of this voltage with respect to the dither signal depends on the relationship of the signal frequency and the VCO center frequency. Thus, a phase-sensitive detector is used to develop a voltage which swings positive or negative, depending upon whether the VCO center frequency is above or below the incoming signal frequency; the voltage is averaged and summed by the dither signal to lock the VCO to the signal frequency. The preamplifier has a frequency response from 2 to 32 MHz with a noise figure of 1.5 db.

Note:

Requests for further information may be directed to:

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Reference: TSP 73-10506

Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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