A new infra-red gas analyser and portable photosynthesis meter

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Abstract: The new infra-red gas analyser for measurement of CO₂ concentration described uses a focussed, dual optical path. The 2 W radiation source is a heated alumina bead and a cooled lead selenide photoconductive detector measures the difference in radiation absorption at 4.26 μm by the gas in sample and reference tubes. Radiation is chopped alternately between these tubes at 120 Hz. The signal from the detector is processed through an a.c. coupled amplifier, phase sensitive detector and low pass filter. Incorporated into the photosynthesis meter, the sample tube of the analyser is connected to a leaf chamber and circulating pump forming a closed gas circuit. As a leaf in the chamber removes carbon dioxide from the air in the closed circuit, the decrease in its concentration is sensed by the analyser. The time taken for the concentration to decrease by a predetermined amount (typically 30 ppm) is displayed and rate of net photosynthesis can be calculated from this and the volume of the closed circuit. A measurement of the light-saturated rate of net photosynthesis of a healthy flag leaf of wheat can be made in 10–15 seconds. The system is fully portable and has been used intensively in the field for two summers.

Introduction

Commercially available infra-red gas analysers used for photosynthesis and respiration measurements generally use the Luft detection system [5]. The impedance of the Luft detector is typically 10⁹ ohms and so requires a high input impedance amplifier and measures to reduce the effects of extraneous noise. The detector is, however, inherently highly selective. The Luft detector also functions as a capacitor microphone and hence is sensitive to mechanical vibration. To minimise vibration effects the analysers are heavy and normally used in a fixed position. Semi-conductor infra-red detectors do not have the disadvantages of the Luft detector but lack its selectivity. However, the desired selectivity can be achieved with optical filters and so it is now possible to build portable analysers for the accurate measurement of small differences in carbon dioxide concentration in air. An analyser of this kind was required for measuring net photosynthetic rates in the flag leaves of wheat and related species [1]. This paper describes the instrument built for making these measurements.
The instrument

The photosynthesis meter compares the carbon dioxide concentration of air in a reference tube with that in a sample tube. The sample tube holds gas that is part of a larger volume in a closed circuit containing an illuminated leaf. The time taken for a given decrease (typically 30 parts per million by volume) in carbon dioxide concentration to occur as a result of photosynthesis is measured and is inversely proportional to the rate of photosynthesis of the leaf.