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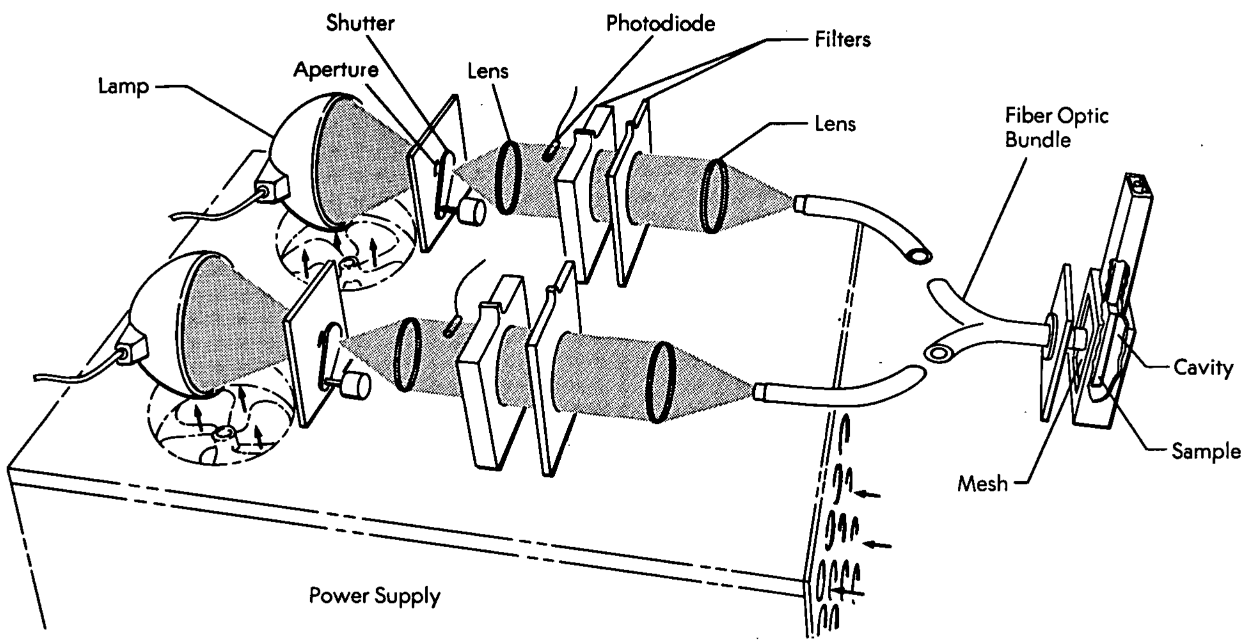
A Dual-Beam Actinic Light Source for Photosynthesis Research



The problem:

The overall photosynthetic process in plants consists of two photosystems, each of which is driven preferentially by different wavelengths of visible light. In order to study electron flow resulting from illumination of low forms of plant life, it was necessary to provide light of two wavelengths for a photosynthetic experiment in which the test sample is located entirely within a microwave cavity and must be illuminated from one side. Electrical integrity of the cavity must be maintained. For flexibility in choice of experimental parameters, the system should provide either continuous or periodic light of each wavelength, with the light and dark periods adjustable over several decades of time. Light sequencing should be automatic and include provision for automatic data acquisition. Additionally, it was considered necessary to provide a high intensity of sample illumination, to minimize heating of the sample, and to vary the wavelengths and their intensities independently.

The solution:

Two separate and identical optical channels that provide independently adjustable wavelengths (filters), shutter sequencing, and control intensity of illumination. The outputs of the two channels are blended in a bifurcated fiber-optic bundle. The signal end of the bundle is flange-mounted to the microwave cavity at the optical window. Heating of the

(continued overleaf)

sample is minimized by using a light source with low heat content, and inserting appropriate filters into each channel.

How it's done:

The source of light for each channel is a metallic arc lamp with forced air cooling and power supply; an integral glass reflector focuses light through an aperture, and the dichroic coating of the reflector provides the desired 5000 K color temperature light and transmits the unwanted thermal energy at wavelengths beginning at 700 nm. This type of lamp was selected because it has a smooth spectrum in the area of interest and does not emit strongly in the near infrared.

Behind the aperture of each channel is a single-leaf shutter, driven by a rotary solenoid. The shutter control system provides for independent variation of width and time of the light pulse derived from each channel. Timing control is accomplished by means of motor-driven adjustable cams and changes in gear ratios. Shutter duration ranges from continuously open or closed, to 10 msec; shutter action can be monitored by contacts incorporated in the timing mechanism.

Beyond the shutter, two $f/1.6$, 25-mm lenses collimate the light and then refocus it onto the end of one branch of the optic bundle. An iris is located in the collimated beam, where it can uniformly attenuate the light over a range from 1 to 60 without altering the illuminated area. Interference and neutral density filters in the collimated region provide monochromatic light, eliminate residual thermal energy, and extend the limits of attenuation control. A silicon photodiode located in the lens mount before the filters monitors the light output from the channel.

In the single end of the fiber optic bundle, strands from the two branches are mingled so that illumination of the sample is uniform when either channel is used alone.

Illumination of the microwave cavity takes place either through a metal plate having milled slots or through a hole screened by a fine gold wire mesh; selection of these alternatives for a particular experiment is a tradeoff between the superior electrical performance of the slots or the better light transmission of the screen.

The useful wavelength range of the system extends from 460 to 770 nm, corresponding to the optical bandpass of the system. Power density of light from one channel illuminating the sample varies from 210 mW/cm^2 for white light without filters to as low as 0.55 mW/cm^2, depending on the choice of filters and wavelength.

Reference:

Margozzi, A. P.; Henderson, M; and Weaver, E. C.: A Dual-Beam Source of Actinic Light for Photosynthesis Research. Photochemistry and Photobiology, vol. 9, p. 549, 1969.

Notes:

1. In addition to experiments using electron paramagnetic resonance spectroscopy, this system may be applicable to other types of research in the photosynthetic field.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP 72-10205

Patent status:

No patent action is contemplated by NASA.

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