



## Green Design

### Diffuse-Illumination Systems for Growing Plants

**Discrete sources produce spatially and spectrally mixed light.**

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Agriculture in both terrestrial and space-controlled environments relies heavily on artificial illumination for efficient photosynthesis. Plant-growth illumination systems require high photon flux in the spectral range corresponding with plant photosynthetic active radiation (PAR) (400–700 nm), high spatial uniformity to promote uniform growth, and high energy efficiency to minimize electricity usage. The proposed plant-growth system takes advantage of the highly diffuse reflective surfaces on the interior of a sphere, hemisphere, or other nearly enclosed structure that is coated with highly reflective materials. This type of surface and structure uniformly mixes discrete light sources to produce highly uniform illumination. Multiple reflections from within the domelike structures are exploited to obtain diffuse illumination, which promotes the efficient reuse of photons that have not yet been absorbed by plants. The highly reflective surfaces encourage only the plant tissue (placed inside the sphere or enclosure) to absorb the light. Discrete light sources, such as light emitting diodes (LEDs), are typically used because of their high efficiency, wavelength selection, and electronically dimmable properties. The light sources are arranged to minimize shadowing and to improve uniformity. Different wavelengths of LEDs (typically blue, green, and red) are used for photosynthesis. Wavelengths outside the PAR range can be added for plant diagnostics or for growth regulation (see figure).

The advantage of this approach over previous artificial illumination methods is that it facilitates the use of a few discrete point light sources to illuminate an extended plant volume/surface area while minimizing canopy shadow effects and providing nearly perfect uniform illumination. The lighting system method efficiently mixes light, recycles photons, and enables nearly 100 percent spatial mixing of various colors. This system also makes it possible to conduct plant-

growth research in diffuse light fields with various spectral distributions. In theory, this efficient mixing of different light sources, as well as the spatial uniformity enabled by the dome/hemisphere environment, should minimize plant-growth variability and optimize growth.

*This work was done by George May of the Institute for Technology Development and Robert Ryan of Science Systems and Applications, Inc. for Stennis Space Center.*

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

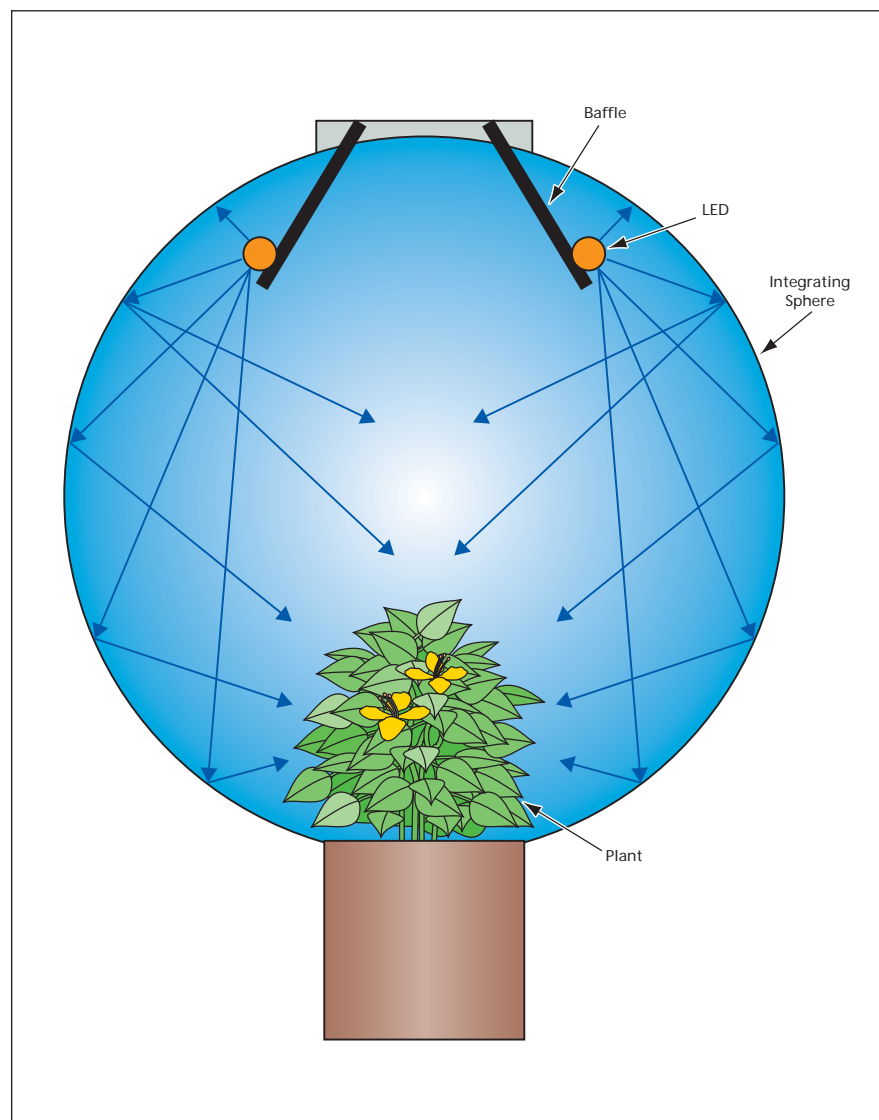
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Multiple Diffuse Reflections mix light from several LEDs to illuminate plants diffusely at several wavelengths.