provide the maximum detector limited SNR performance through increased responsivity and specific detectivity.

Although application of this device in the IR is probably the most significant, it can easily be extended to other spectral regions.

OBJECTS OF INVENTION

An object of the present invention, accordingly, is to provide a new and improved combined concentrator system, preferably embodying tandem CPC concentration and inverted CEC concentration.

Other and further objects will be explained hereinafter and are more particularly delineated in the appended claims.

SUMMARY OF INVENTION

To summarize:

Cone CPC concentrators have been used in the past to improve collection efficiency, at the expense of angular response. Cone CEC concentrators have been used (usually "inverted") to tailor angular response, at the expense of efficiency.

The invention described herein combines the two techniques, achieving the advantages of both without the disadvantages of either.

The crux of the invention is using two compound concentrators, back to back, to accomplish both high collection efficiency and hemispherical angular response.

From one viewpoint, the invention embraces a three-dimensional hollow composite conical light concentrator enclosure of substantially egg shape having mirror-like inner walls and opposing end apertures for respectively receiving incident light at one end and for directing light concentrated and collected from the inner walls within the enclosure for detection at the aperture at the other end. Preferred embodiments and best mode designs are later presented.

DRAWINGS

The invention will now be described with reference to the accompanying drawings,

FIG. **1** of which is a longitudinal cross section of the system of the invention in dual-cone egg-shaped preferred form; and

FIG. **2** is a modification showing an example of light ray concentration and collection for infra red applications.

DESCRIPTION OF PREFERRED EMBODIMENT OF INVENTION

As before discussed, underlying the present invention is the finding that CPC and CEC type non-imaging optical concentrators can provide a photodetector with both uniform angular responsivity and high radiometric efficiency.

The separate concentrators, as earlier explained, either improve collection efficiency at the expense of angular response or tailor angular response at the expense of efficiency. Among prior devices of this character are those disclosed, for example, in Winston U.S. Pat. Nos. 3,923,381; 3,957,031; 4,003,638 and 4,002,499; and, also, Ploke German patent application 14722679 (1969).

The novel tandem collector combination of the invention is shown in FIG. **1**, applied for use with an integrating spectophotometric hollow sphere **1**, the light-ray integrating reflections and scatter within which emerge at aperture A and are to be detected by a photodetector D. Interposed between the aperture A and the photodetector D is the dual composite cone concentrator system of the invention comprising, at the left-hand section, an inverted symmetrical hollow cone **3** embodying the opening A (typically compound parabolic curvalinear configuration), and, at the right-hand section, a symmetrical hollow collecting cone **5** (typically compound elliptical configuration), abutting at the break **2**, and with the same cone cross-sectional dimensions thereat and preferably the same symmetrical axial lengths to permit a continuous hollow symmetrical egg-like three-dimensional enclosure. The inner walls of the egg-shaped cone combination **3–5** are mirror or mirror-like surfaces **3'** and **5'**, and the right-hand terminal opening of the collecting cone **5** receives or is directed upon the detector D.

In accordance with this construction a substantially hemispherical 180° light-ray field of view is provided by the inverted cone portion **3**, with the collecting cone portion directing the light onto the relatively small recessed detector at the right-hand aperture, which may be similar to aperture A. The light entering from end aperture A enters the larger cross-section of the cone **3** and is concentrated by cone **5** onto the small detector aperture at D, at the opposite end. These two back-to-back compound concentrators most advantageously accomplish both high collection efficiency and hemispherical angular response.

Typical light ray tracings are shown in FIG. **2** for infra red applications, wherein a liquid nitrogen or other suitable dewar N is interposed in the enclosure in advance of the detector D.

While shown in preferred respective inverted paraboloidal and ellipsoidal tandem surface sections, the advantageous features of the technique of the invention can also be obtained, in various degrees, with other curvalinear surface shapes, as well. In some instances, non-symmetrical length-cone sections may be desired; and further modifications will also occur to those skilled in this art, being considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An optical light collection system, having, in combination, a three-dimensional hollow composite light concentrator enclosure formed by dual-compound abutting back-to-back conical inner and outer wall sections together defining a substantially egg shape open at opposite ends, the inner walls being mirror-like and the enclosure having opposing light-receiving and light detecting end apertures at said opposite ends for respectively receiving incident light at one end and for directing light concentrated and collected from the inner walls within the enclosure for detection at the aperture at the other end and in which the system is connected at said one end to an aperture of a hollow light-integrating sphere, and at said other end to photodetector means.

2. A system as claimed in claim **1** and in which the egg-shaped enclosure comprises an inverted curvilinear concentrating cone section abutting a substantially symmetrical curvilinear collecting cone section.

3. A system as claimed in claim **2** and in which the concentrating cone section is of substantially parabolic shape and the collecting cone section is of substantially elliptical shape.

4. An optical light collection system having, in combination, a three-dimensional hollow composite light concentrator enclosure formed by dual-compound abutting back-to-