

Emerging Designs in Daylighting

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- Capture as much sunlight as possible for *controlled* distribution that is free of glare.
- Make aesthetically pleasing.
- Engineer for low maintenance.
- Manufacture and install as inexpensively as possible (given excellent quality).
- Integrate with controlled electric lighting.
- Ensure good view of external world.

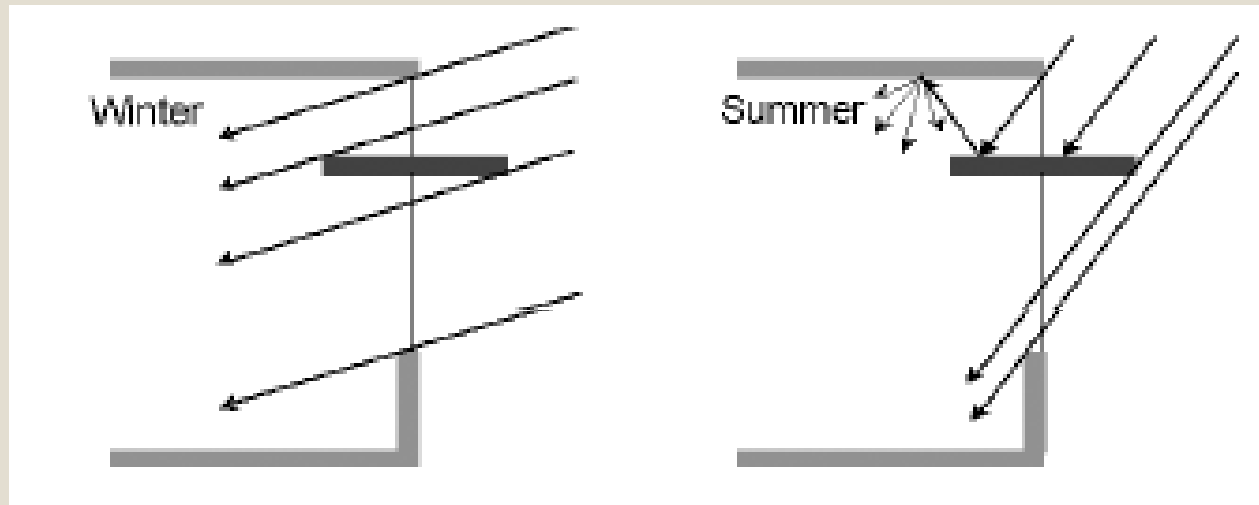
Designing a solar lighting system: technical challenges

- Direct-beam sunlight can cause unacceptable glare.
- Diffusers work, but ceilings alternate bright patches and dark areas. This problem is also common to tubular skylights and conventional 2 x 4 fluorescent lighting, even with diffusers.
- A more uniformly illuminated, light-colored ceiling works much better.

Skylighting glare



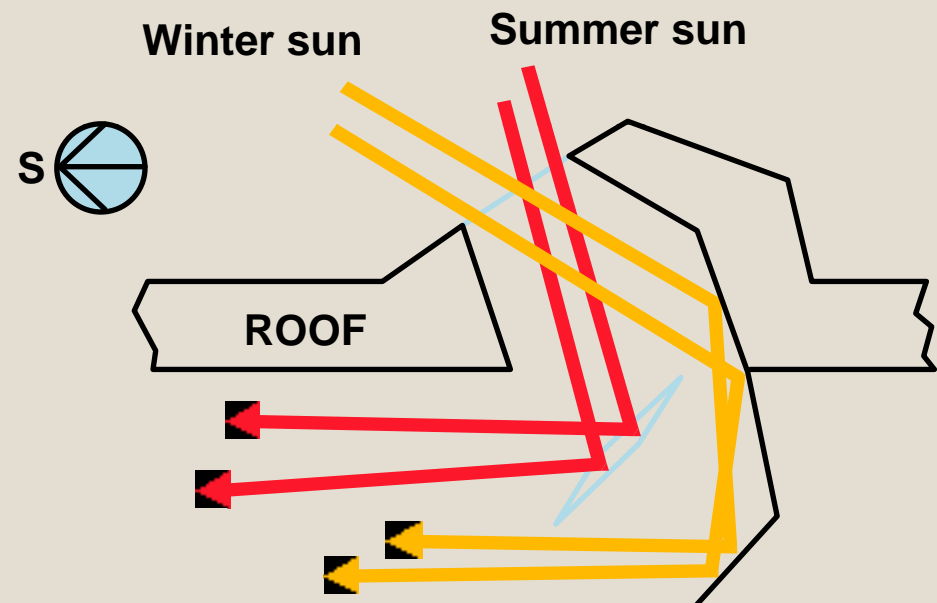
Light shelves



- Bounce light off light-colored ceiling.
- Perform shading function in summer.
- Don't solve azimuth problem very well (the sun persists in rising in the east and going down in the west in spite of two-dimensional drawings in architecture texts!)

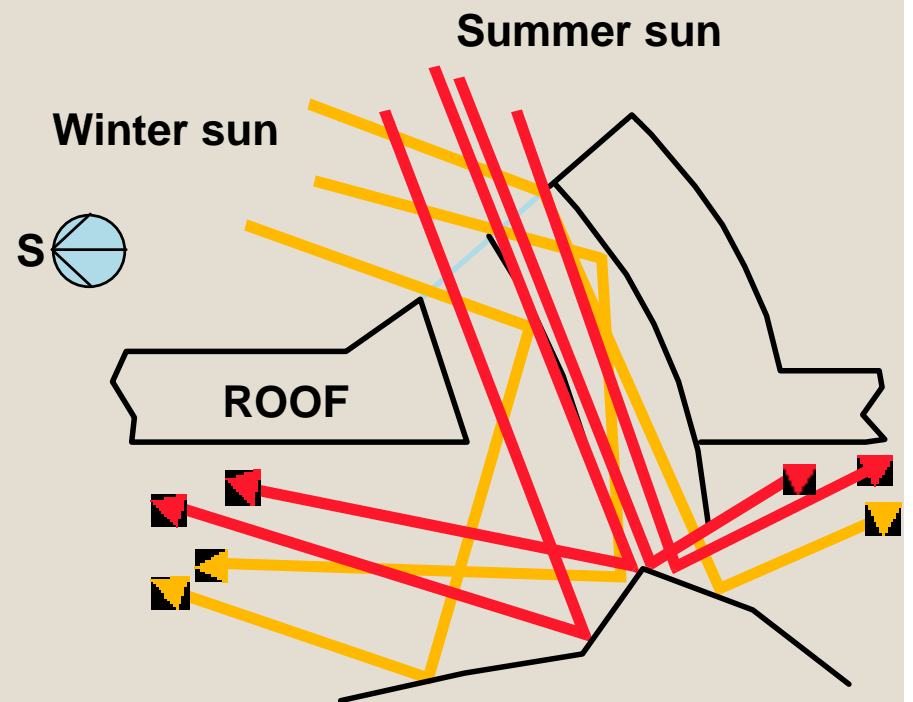
- Specular reflector on architectural surface directs beam sunshine across white ceiling
- No glare, simple natural light
- Backup from T5s or T8s integrated into fixtures
- Reflectors cleaned by compressed air
- Should work well on high ceilings, even if some equipment installed
- Insulating shutters to optimize, see next slide

Modern Monitor Design



- Variation on the theme gives two-way light
- specularly selective glazing in monitors gives excellent lm/W
- Modest air-conditioning load
- Inexpensive
- Recommend use with exterior insulating shutters for cold nights. These might enhance or modulate incoming light during day
- Option 2: interior shutter that slides over light well
- Option 3: interior shutter integrated with center mirror; may optimize light distribution during day
- Choice of glazing and shading important for good all season performance

Modern Monitor Design 2



- The design that follows uses the preceding two passive elements to control direct beam light and spread it across the ceiling. It's passive.
- But insulating shutters are employed as a solar and thermal control as well; these are active.
- Finally, the interior light shelf moves to optimize the spread of light as deep within the structure is possible while controlling for glare--so it is active.
- Shall we call such systems hybrid?

Passive plus Active Daylighting

SE and SW elevations

- The south façade has a set of windows for passive solar below the exterior fixed light shelf.
- Light shelf provides shading in summer, directs sun rays through daylighting windows all year around.
- All windows, including monitors, protected by exterior insulating shutters that are in “pockets” between glazing when not needed.
- Shutters raise insulating value of fenestration from approximately R-2.5 to R-18 when closed.
- In conjunction with excellent insulation, radiant heating and cooling, result is a very comfortable, low-energy-use building.



North and south elevations

- An interior light shelf is hinged at the window wall. It is adjusted via a simple gear motor to just keep direct beam sunlight from falling on the floor below; instead it spreads light across the white ceiling and the tops of walls. It is an *active* system!
- These surfaces become diffuse light reflectors, illuminating the space below with natural light that has minimal glare and shadowing.
- Sliding doors facilitate looking inside, adjusting light meters, and taking pix.



East elevation



- Illustrations show optical details within.
- Reflective surfaces are made of Alanod, first-surface mirror aluminum sheet stock that has a reflectivity in the visual spectrum of 98%.

Interior light shelf slopes downward when sun is high to optimize distribution. It is slightly curved to avoid hot spots on the ceiling. Photo when sun partially covered by clouds.





Looking SW from east side; no glare at working level

Active daylighting system design

- The trick is to intercept direct-beam sunlight, “process” it, move it to where it’s needed, and control the resulting light, even while the source (the sun) is moving.
- Thanks to the advent of inexpensive robotics, microprocessors, sensors, and reflector technologies, active systems can be remarkably inexpensive.
- Far superior performance over passive systems because light can be ***concentrated*** and controlled.

Active systems that concentrate

- If an intense beam composed of parallel rays can be formed cost-effectively, many exciting possibilities are opened

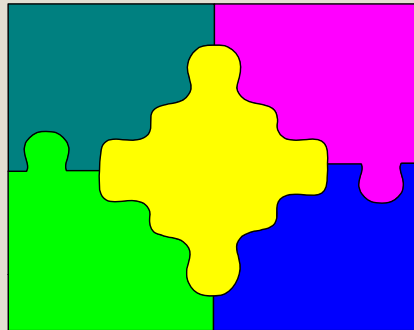


Daytracker system

- A new concept in gathering natural light, mixing it with efficient electric light as needed, controlling light, and distributing it via simple, cost-effective fixtures.



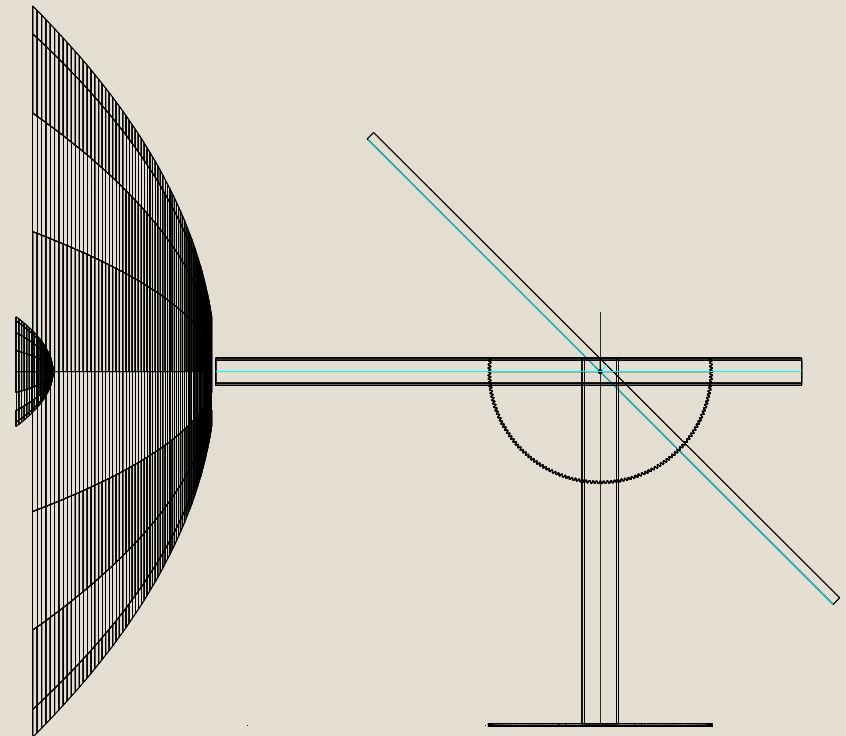
Three key elements of the Daytracker puzzle



- Collection
- Distribution
- Outlet
(Luminaires)

Daytracker collection and concentration scheme

- Uses a pair of mirrors to form a tight beam
- Secondary mirror directs beam back through center of primary mirror
- Flat tertiary mirror directs beam down a fixed light pipe
- Entire assembly rotates on a lazy susan-style bearing
- The sun, the daytracker, and the light pipe share the same plane. This simplifies *everything*.



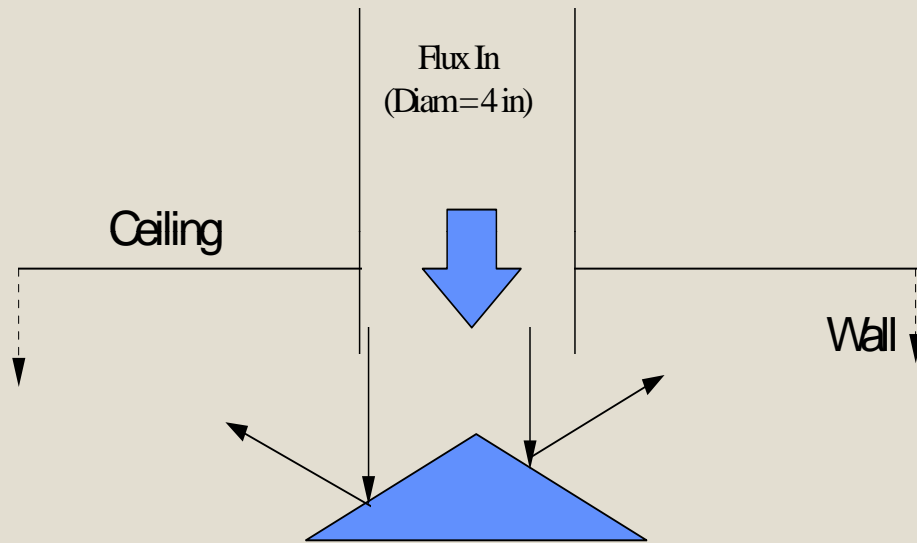
Distribution stage

- May be as simple as a light pipe
- Occupancy sensors or manual controls used to distribute light to where it's needed
- Unused portions of spectrum can heat DHW or provide supplemental space heating via inexpensive filters (because beam is small but intense)
- Supplemental high-efficiency electric lighting (e.g, T-5 florescent, metal halide) integrated into system; used when needed; very energy efficient

Outlet stage

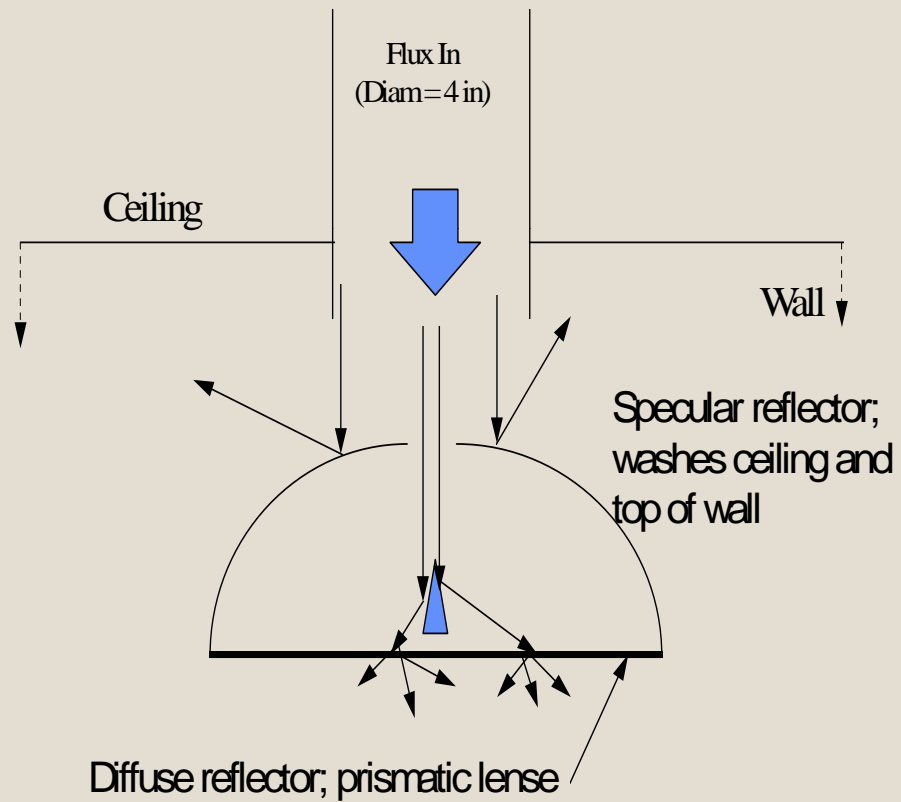
- High flux levels coming from small-diameter light pipes allow great flexibility of design--the illuminating equivalent of 35 100 watt bulbs
- Combinations of functions are easily achieved: diffuse, direct, soft, spot from a single fixture.
- Aesthetics can include metals, woods, fiberglass, fiber optics, etc.

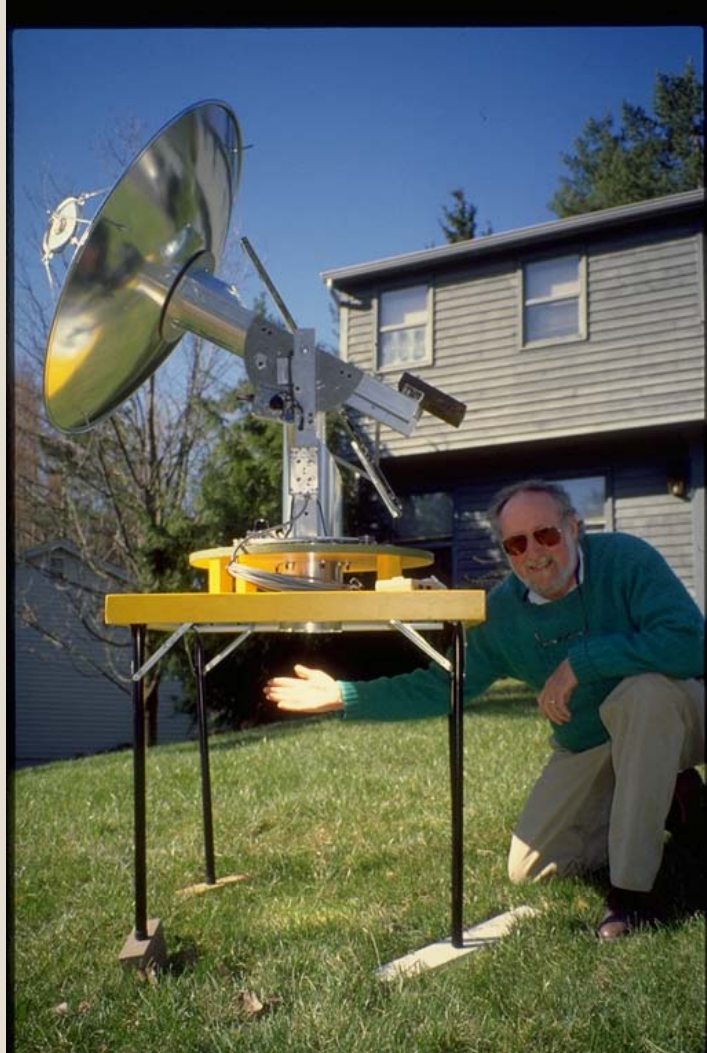
Ceiling washer



A pyramid shape produces beams in four directions; a cone produces a bright annulus on ceiling or top of wall depending on luminaire geometry and distance below light pipe. Slight positive curvature softens light.

Multifunction luminaire





It hurts so good!

Synertech

Tracking direct beam and concentrating the resulting beam has ups and downs.

- A great deal of flux can be transmitted efficiently over long distances using light pipe technology.
- If solar light is gathered outside of the envelope and concentrated before being brought in, the hole in the insulating envelope through which it passes can be small, resolving thermal problems mere windows cannot solve.
- Small filters cost much less than large ones!
- Too much concentration can be dangerous to retinas.
- Too much concentration requires much more precision in system optics, driving up costs.
- Too much concentration can result in striations in light patterns that may jiggle due to wind or other sources of vibration such as HVAC systems.

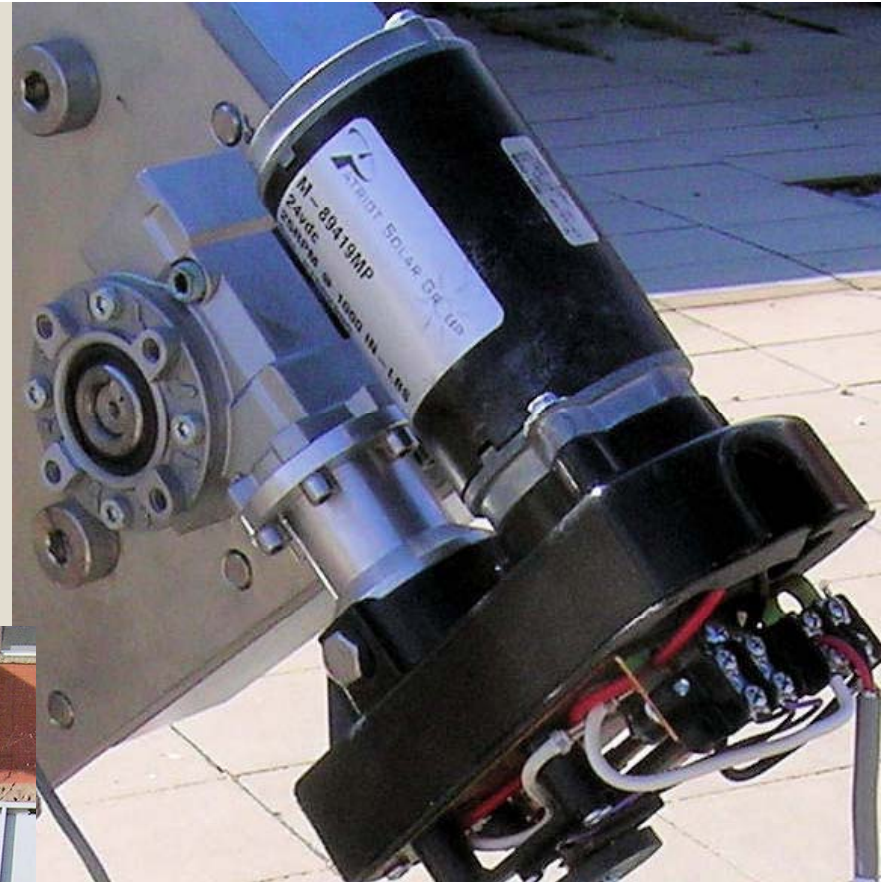
- Parabolic reflectors are somewhat expensive, costs vary directly with cross sectional area.
- Practical upper limit of system size owing to awkwardness of tracker, weather-related matters such as wind, snow, and ice.
- A simpler system that delivers more well-controlled flux/\$ is desirable.

Daytracker limitations

Sunflower's Sundolier two-axis tracker on Washington School



Sundolier drive mechanism





Instrumented classroom

Questions? Answers?

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