Non Imaging Optics for the production of clean water with energy from the Sun

by

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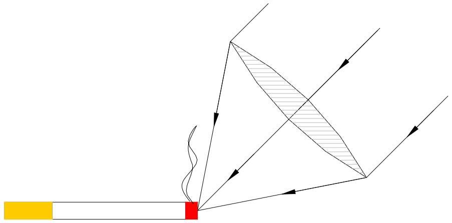
What is concentration? Why so important?

- Thermal losses from large absorbers are large:losses are proportional to absorber area
- If we reduce the absorber area ,in comparison with the collection area....
- Concentration → Aabs<Acol

C=Acol/Aabs



Classical Concentrators and imaging or focussing optics

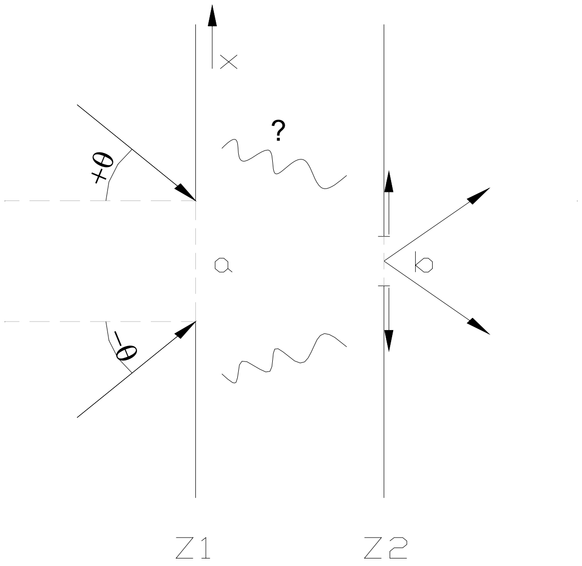
Fig. 1.6 Solar-1 pilot plant (10 MW_e) under test in Barstow, Calif. (U.S.A.)

- they only collect beam(direct)
- they must track the sun!

Is there an alternative (better) solution ?

The problem is: given radiation incident on an aperture **a** within a certain angular range (±θ) , how much can it be concentrated- Cmax?

- the solution calls for a new type optics: non -imaging optics; *give up the imaging part*, i.e. the optics must "*scramble*" the incident radiation, and then it can concentrate the energy to the *limit* - Cmax(θ)-established by first principles in physics



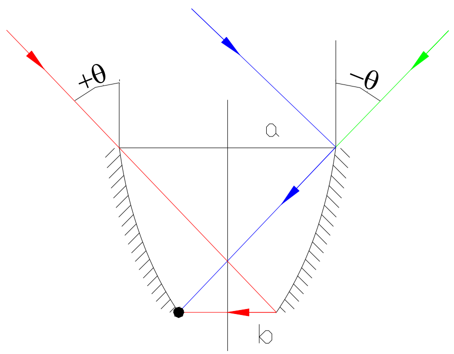
C=a/b

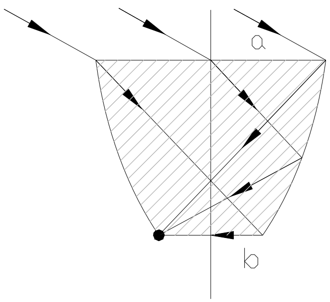
- Focussing optics, for any given angle θ, is a large factor away from the limit, normally a factor larger than 3…

N.I.O solution : CPCs, Winston collectors…

dielectric CPC
n=1 ← air

CPC with mirrors





n>1
dielectric

CPC with mirrors

•2 parabolic mirrors with Foci at the edges of segment b , with each axis paralel to the edge rays from (±θ)

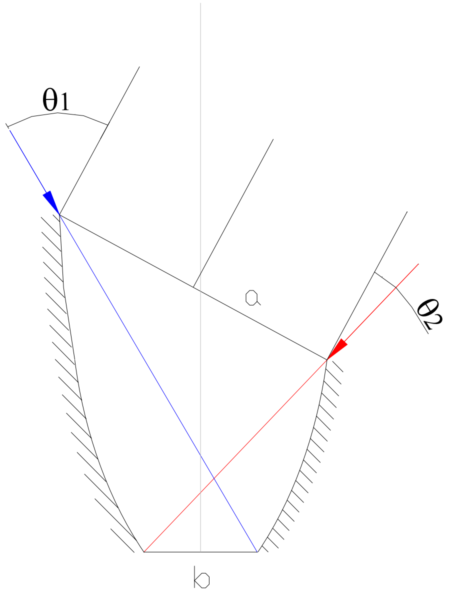
Dielectric CPC

•same geometry, but now taking into account total internal reflection

C=Cmax=a/b= 1/sin(θ)

C=Cmax=a/b=n/sin(θ)

Assymetric CPCs



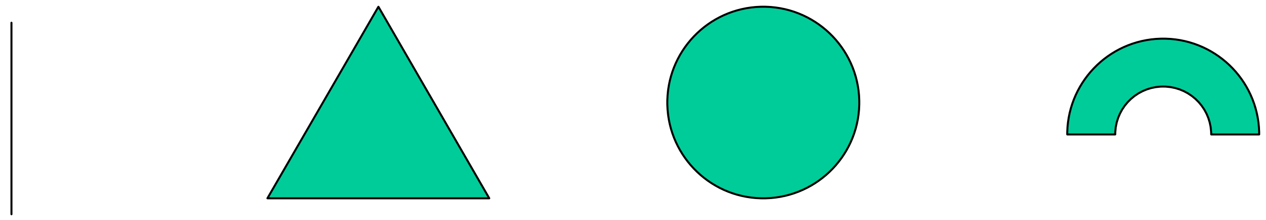
- Cmax=a/b= 2/ (sin(θ1) +sin(θ2))

Other features of Non Imaging or Anidolic Optics

- 2D; also 3D solutions

  in 3D $C_{max} = (n/\sin(\theta))^2$

- other absorber shapes (tubes, shaped fins, cavities, etc.)

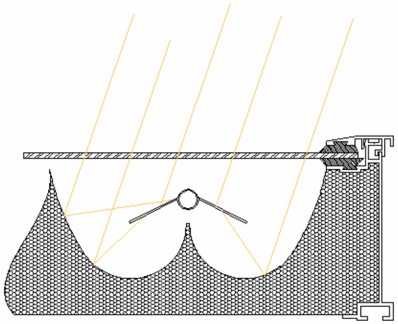


Application:Low and intermediate temperatures for water heating, heating and cooling, process heat, etc.

- collectors are concentrators with large θ; this means higher temperatures, but also
- 1) they are stationary (or require few adjustments through the year...)

  2) they collect diffuse radiation

  3) i.e they retain the potential for simplicity and low cost of flat plate collectors



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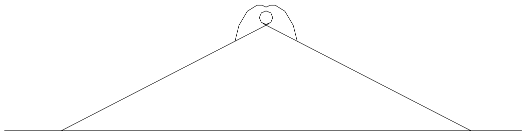
Other applications

- Electricity, via PV conversion

•illumination: interior lighting, car lights, etc.



•radiation collection/detection : defense , astronomy, particle physics,etc.

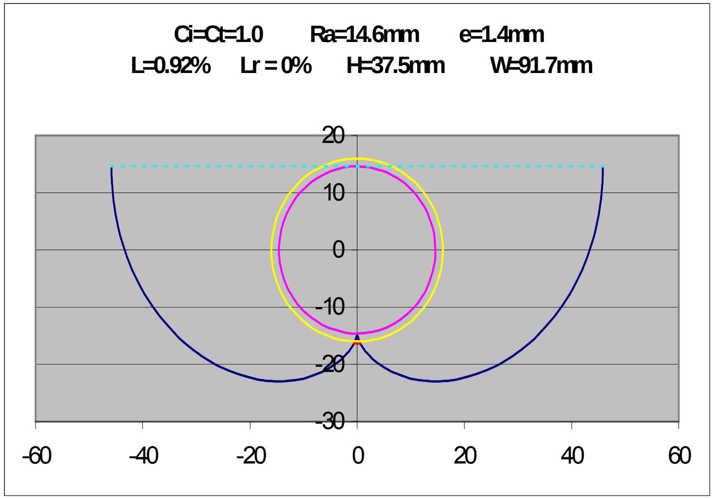
In general : N.I.O. achieves the best possible match between any source of light/radiation and any target where light is to be directed to

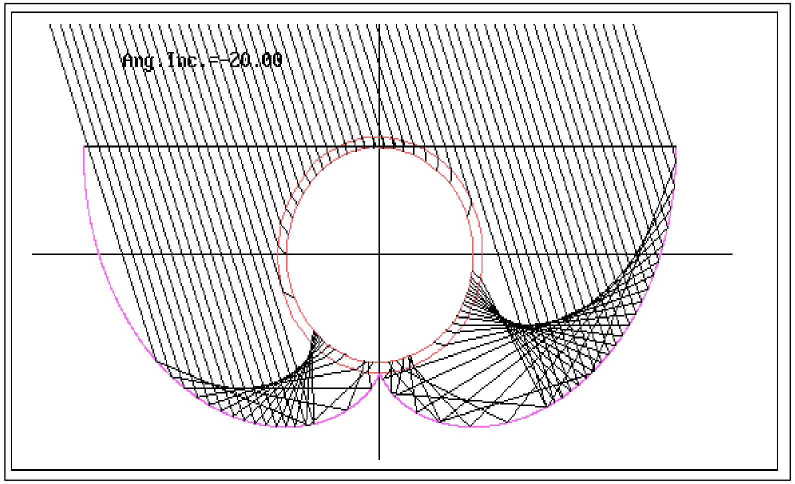
Non Imaging Optics and Photocatalysis (Photo Fenton, etc): Efficiency

- Collection efficiency and efficient solar UV energy delivery to an absorber, usually a tube; (direct and diffuse UV)
- diffuse UV implies very large acceptance angle, ($\pm\pi/2$)
- Low cost means: minimal number of tubes and connections
- N.I.O. does the job in the limits; concentrates solar radiation by a factor of **n**

One example-catalyst in suspension

- detoxification of contaminated wastes, with UV and a catalyst- TiO2(...) added to the waste water circulating in tubes





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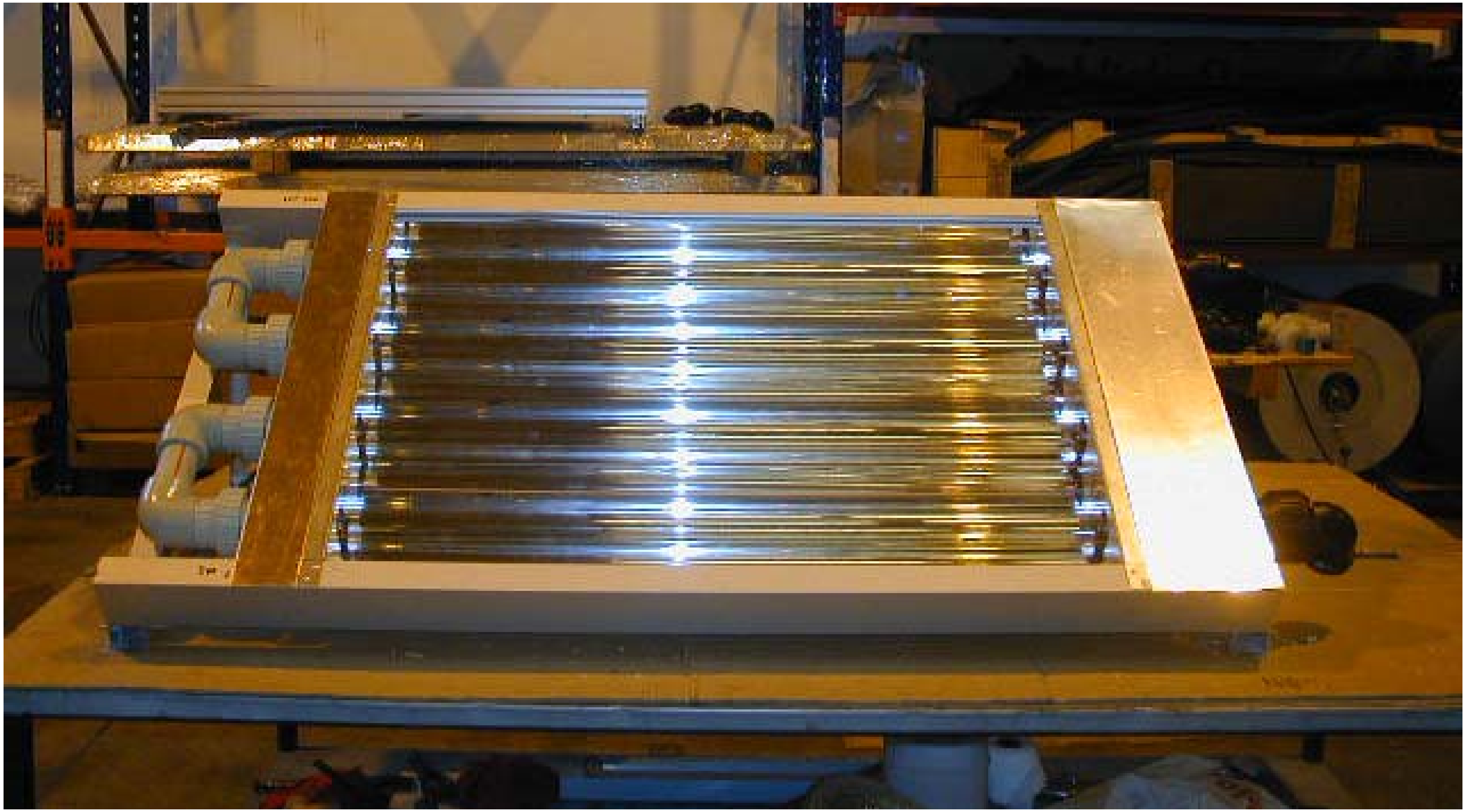

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