FATHER HIMALAYA SOLAR FURNACES:
OPTICAL PRINCIPLES, TECHNOLOGIES, AND LINEAGE

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" Les Amis du Padre Himalaya de Sorede"

Second International Conference
CONSOLFOOD2018
22-23-24 January 2018 - Faro, Portugal

FOURSOLAIRE SORÈDE

From Arcos de Valdevez to Coimbra

- **Manuel Antonio Gomes**
- 1868: Born in Cendufe (hamlet of Arcos de Valdevez)
- Seminary in Braga (nicknamed "Himalaya") → 1891
- College professor, rector in Coimbra
- College chaplain in Porto

Scientific goal

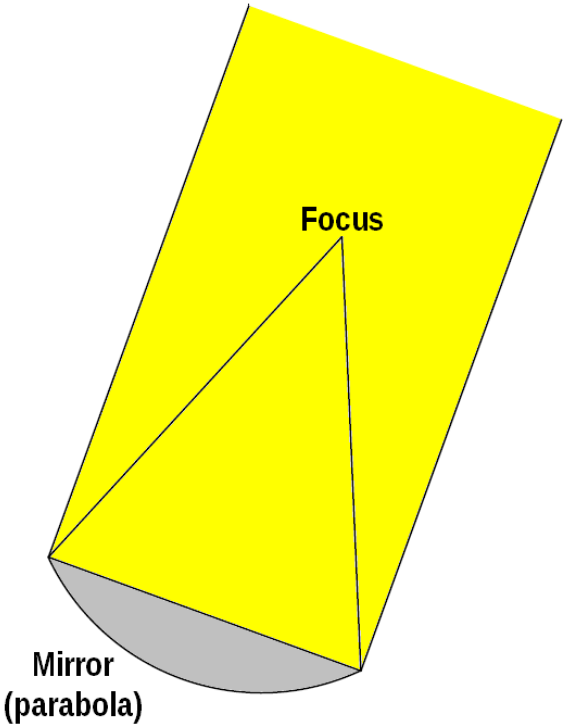
- **Farming yield increase**
- **Synthesis of nitrogenous fertilizing compounds from atmosphere components**

- **High temperature process**
  1. ~~**Electric arc**~~ (Crookes, 1892)
  2. **Solar concentration**

- **Travel to Paris**
- **Education at *Collège de France***
  (free higher education, but without diploma)

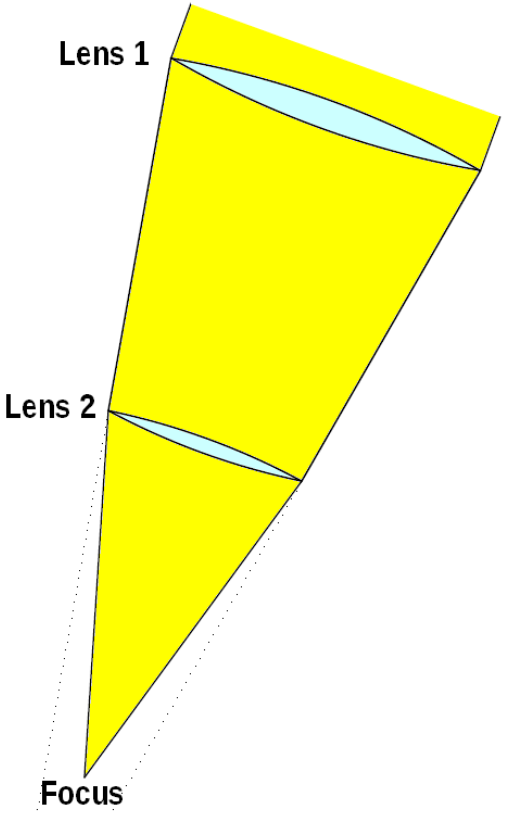
State of the art

- **Burning mirrors**



- Focus not easily accessible
- Risks of molten materials falling down on the mirror

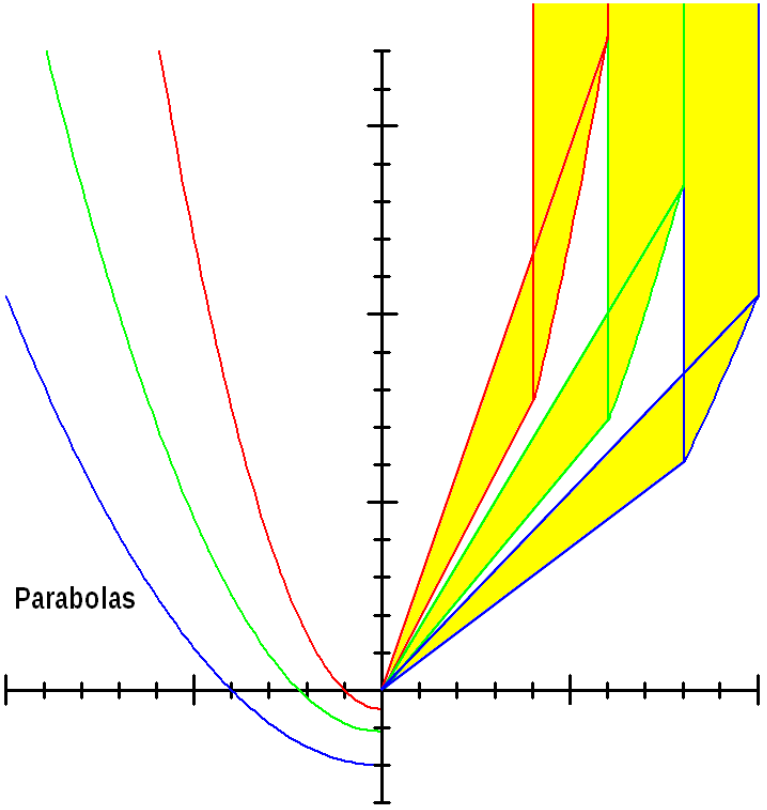
- **Burning lenses**



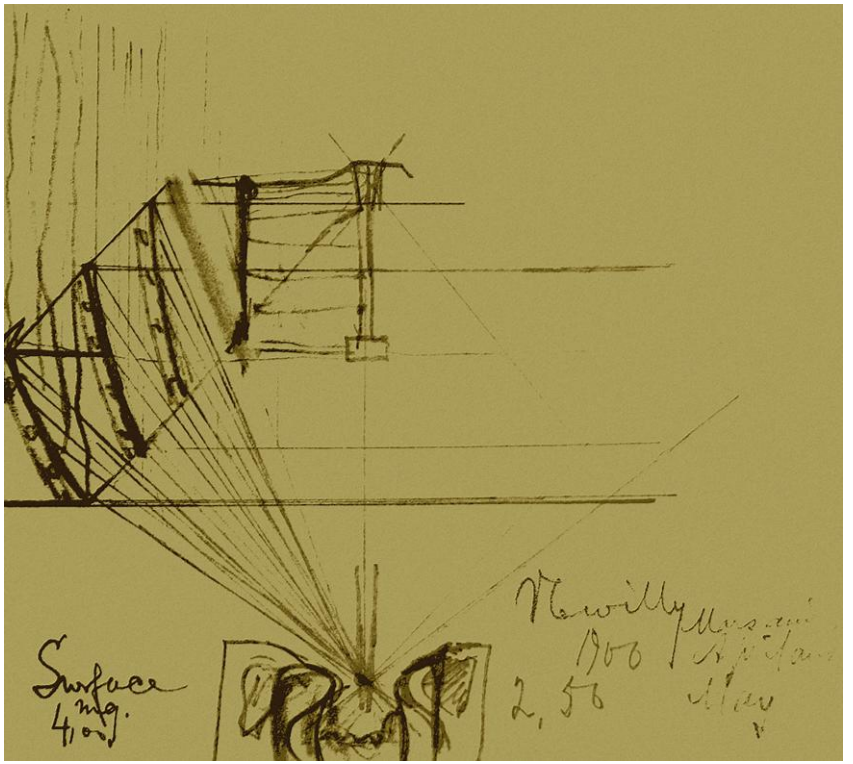
- High absorption on thick lenses
- MAG never mentions stepped lenses (Fresnel lenses)

First generation solar furnaces: Metallic lenses

- **Principle**



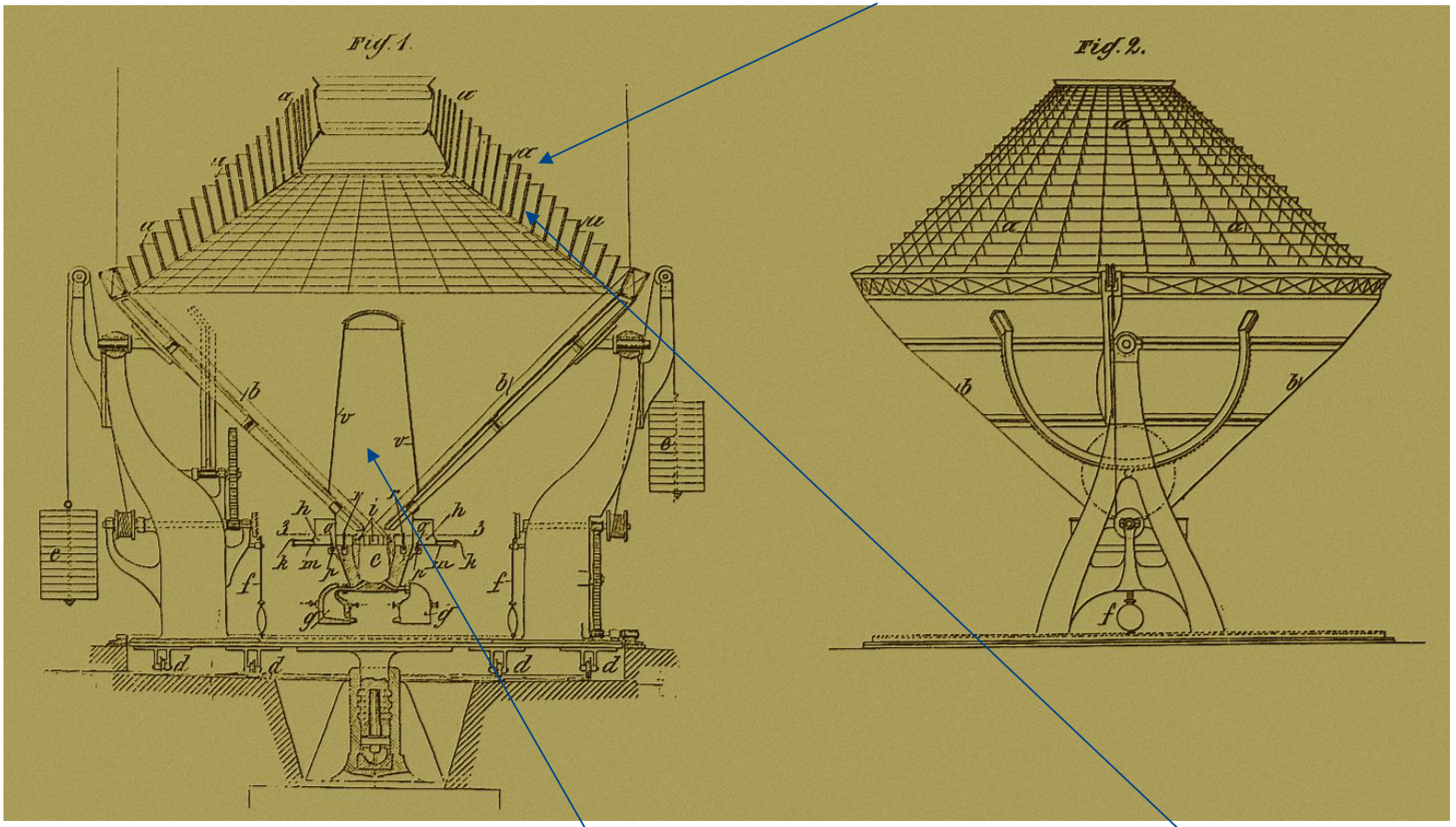
- **First prototype (1899)**



- Diameter≈2.5 m; Aperture≈4 m²
- Tested March-May 1900, Neuilly (49°N)
- Fusion of lead and zinc
- Estimated temperature≈500°C

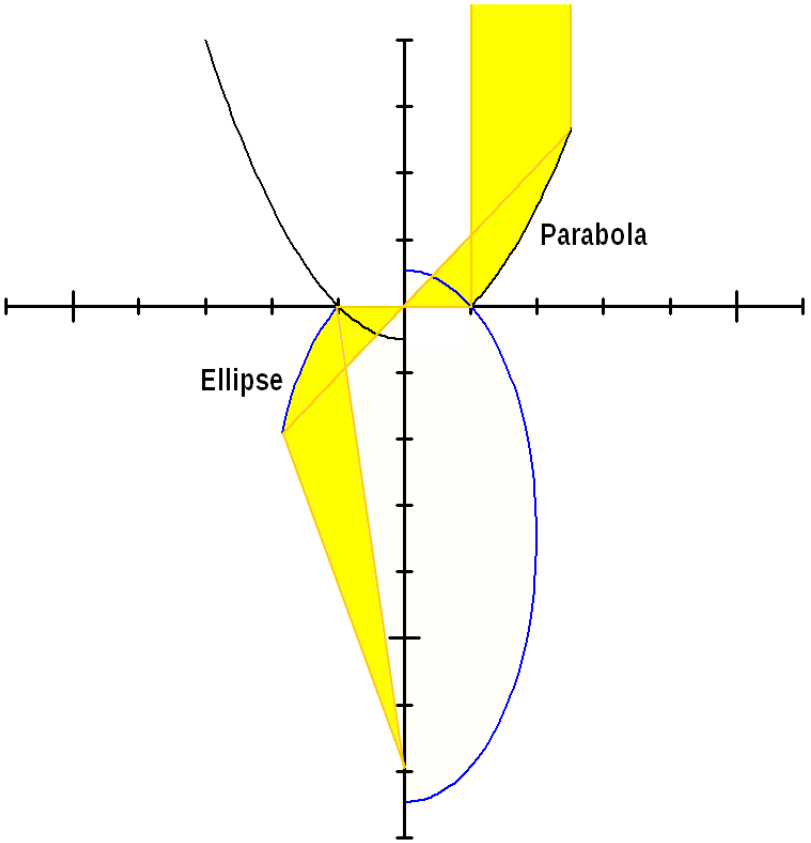
Patent n°292.360, 7th September 1899

Conical mirrors for manufacturing simplification

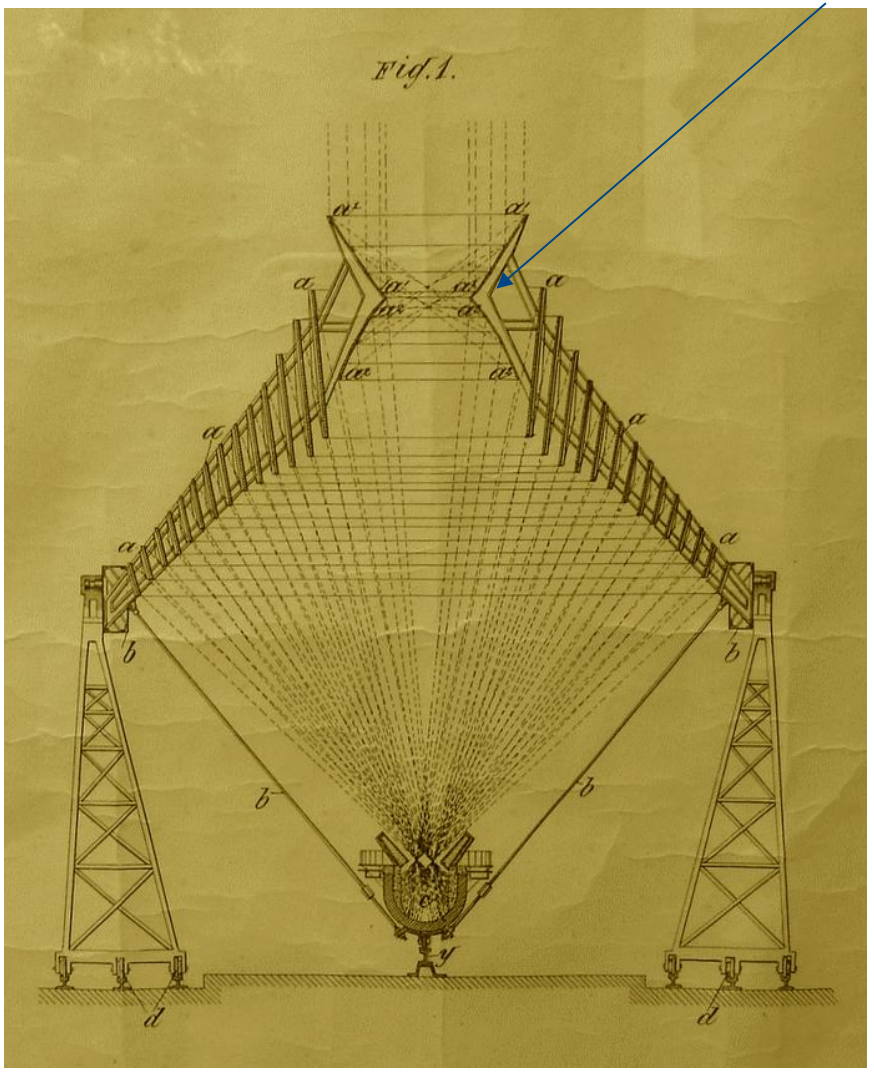


- Remark#1: Controlled atmosphere enclosure
- Remark#2: Variable step and/or length for conical mirrors

Diabolo-type concentrator



Conical mirrors for manufacturing simplification



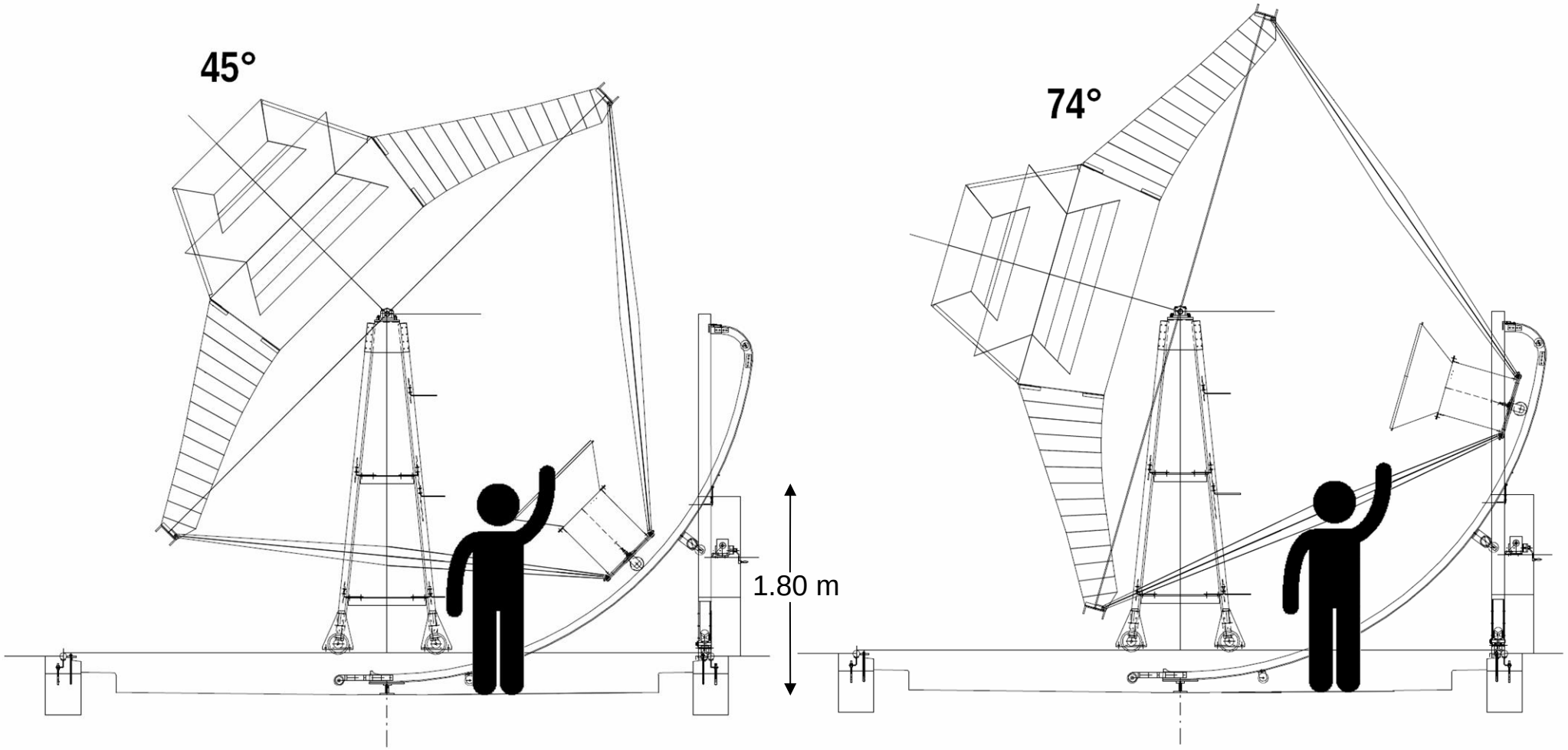
Industrial size solar furnace: Summer 1900

- Diameter≈5 m; Aperture≈20 m²
- 14 truncated cones + 2 "diabolos"
- Copper alloy faceted mirrors
- Azimutal mounting

- Controlled atmosphere enclosure (inert or vacuum)

- Tested July-September 1900, Sorède (42.5°N)
- Fusion of aluminum, not copper
- Estimated temperature≈900°C

Industrial size solar furnace: Summer 1900



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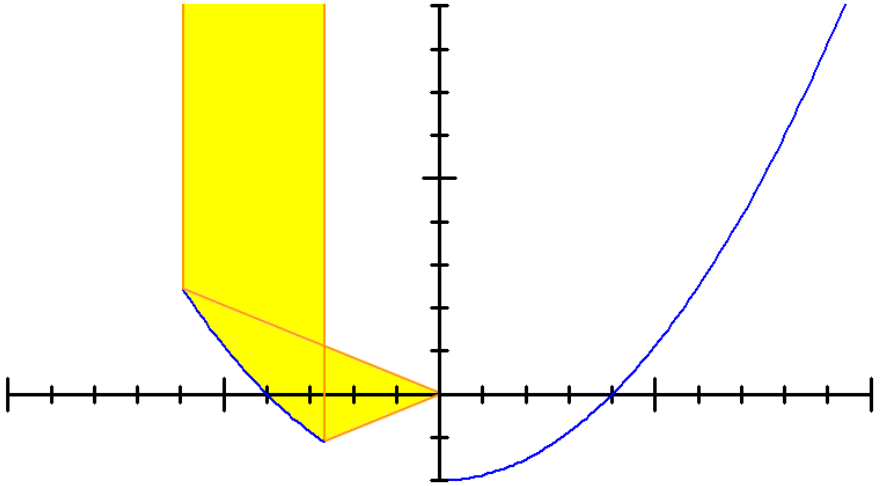
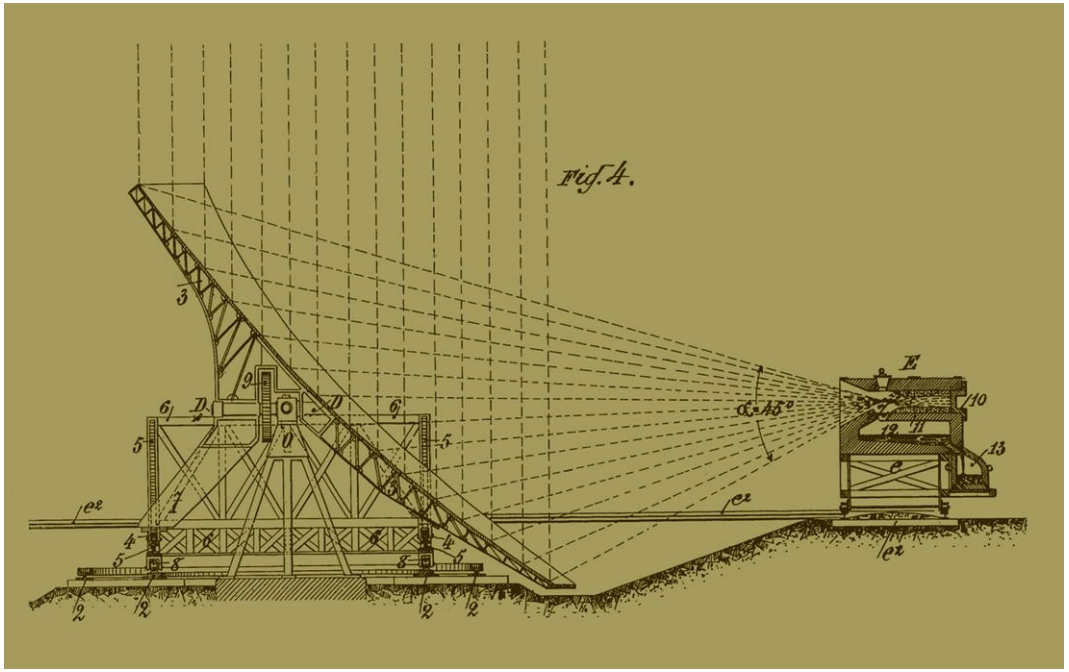
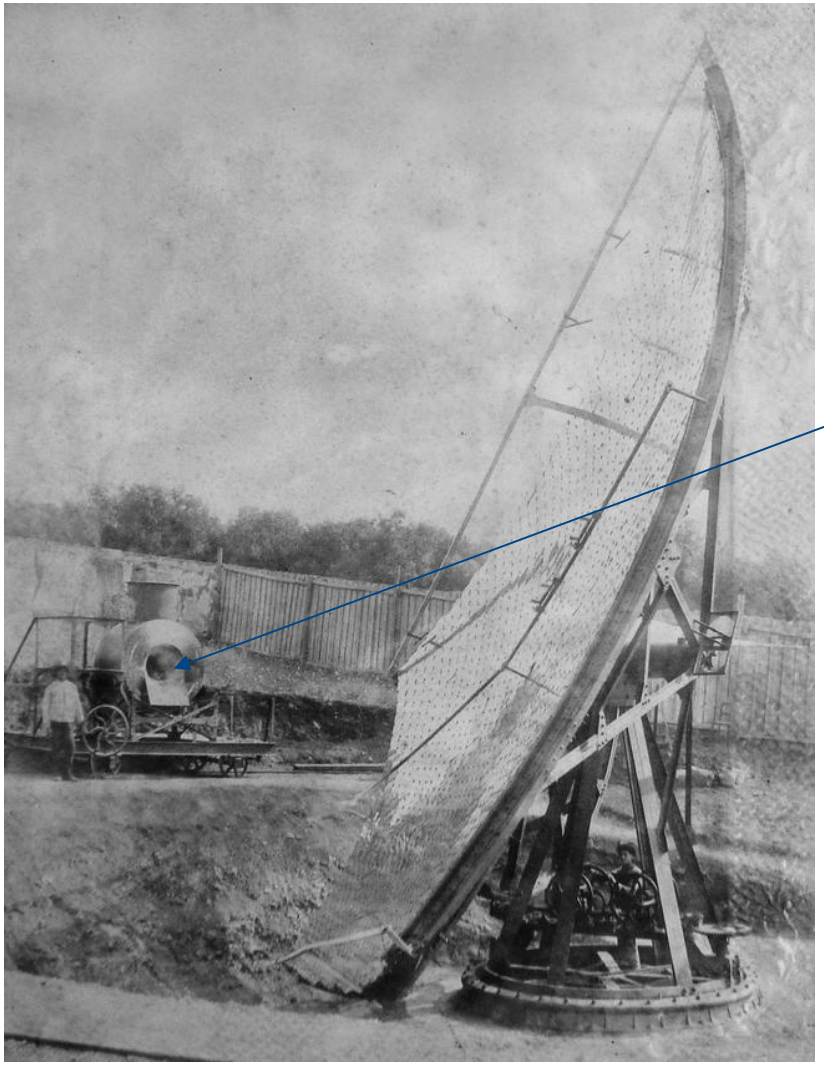
Second generation solar furnaces: Off-axis parabola

Patent n°307.699, 31st January, 1901
+ complement, 29th Januray, 1902





2nd generation, 1st version: Spring 1902



- Aperture≈60 m²
- Reflective area≈80 m²
- Copper alloy faceted mirrors
- Azimutal mounting

1) Inauguration: Lisbon (38°N)

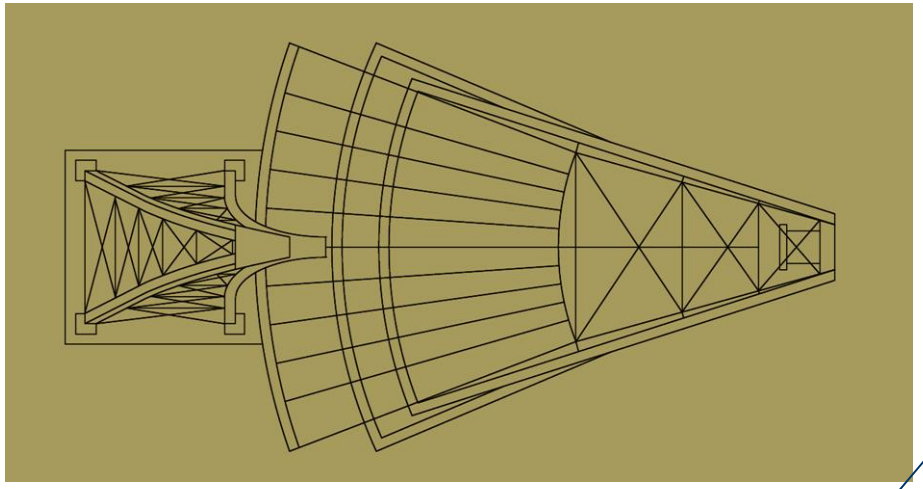
- Partial destruction, Crucible collapse

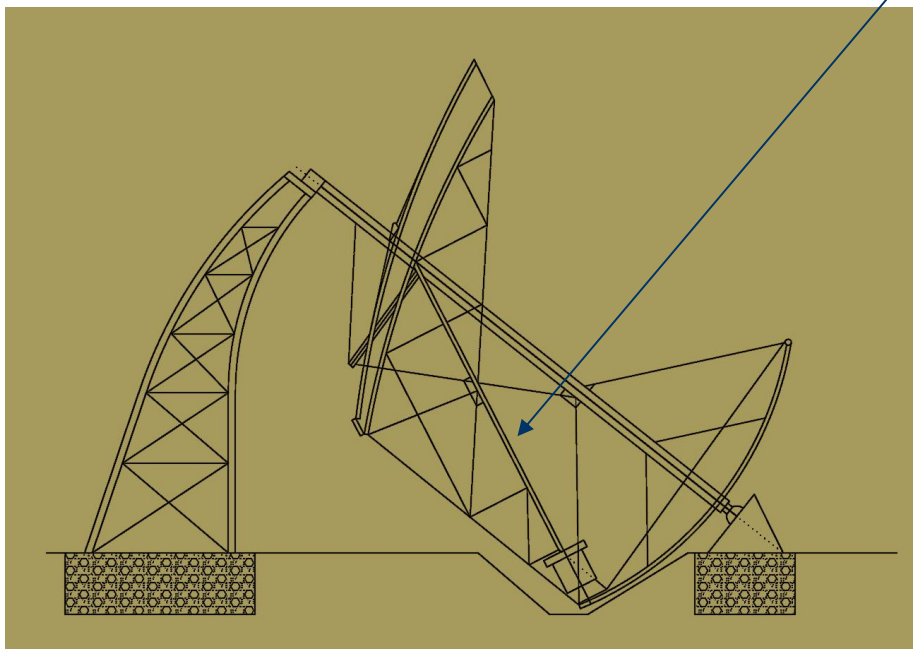
2) Main results

- Fusion of iron oxide, silica, quartz, basalt, granite, glass, firebrick [but not lime, chalk or magnesia]
- Estimated temperature≈2000°C

> Not only did Father Himalaya succeed in reducing oxide of iron, silica, quartz, basalt, granite, glass and firebrick to a liquid state, but the plumbago crucible which held the minerals yielded to the heat and mixed like water with the iron and silica. The melting of the plumbago crucible was beyond the cleric wizard's expectations. The 3,632 degrees of sun heat, however, were powerless to melt lime, chalk or magnesia.

2nd generation, 2nd version: Pyrheliophor

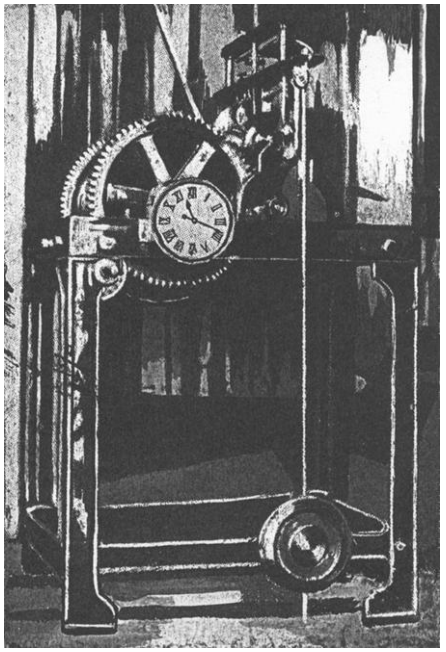




- Aperture≈60 m²
- Reflective area≈80 m²

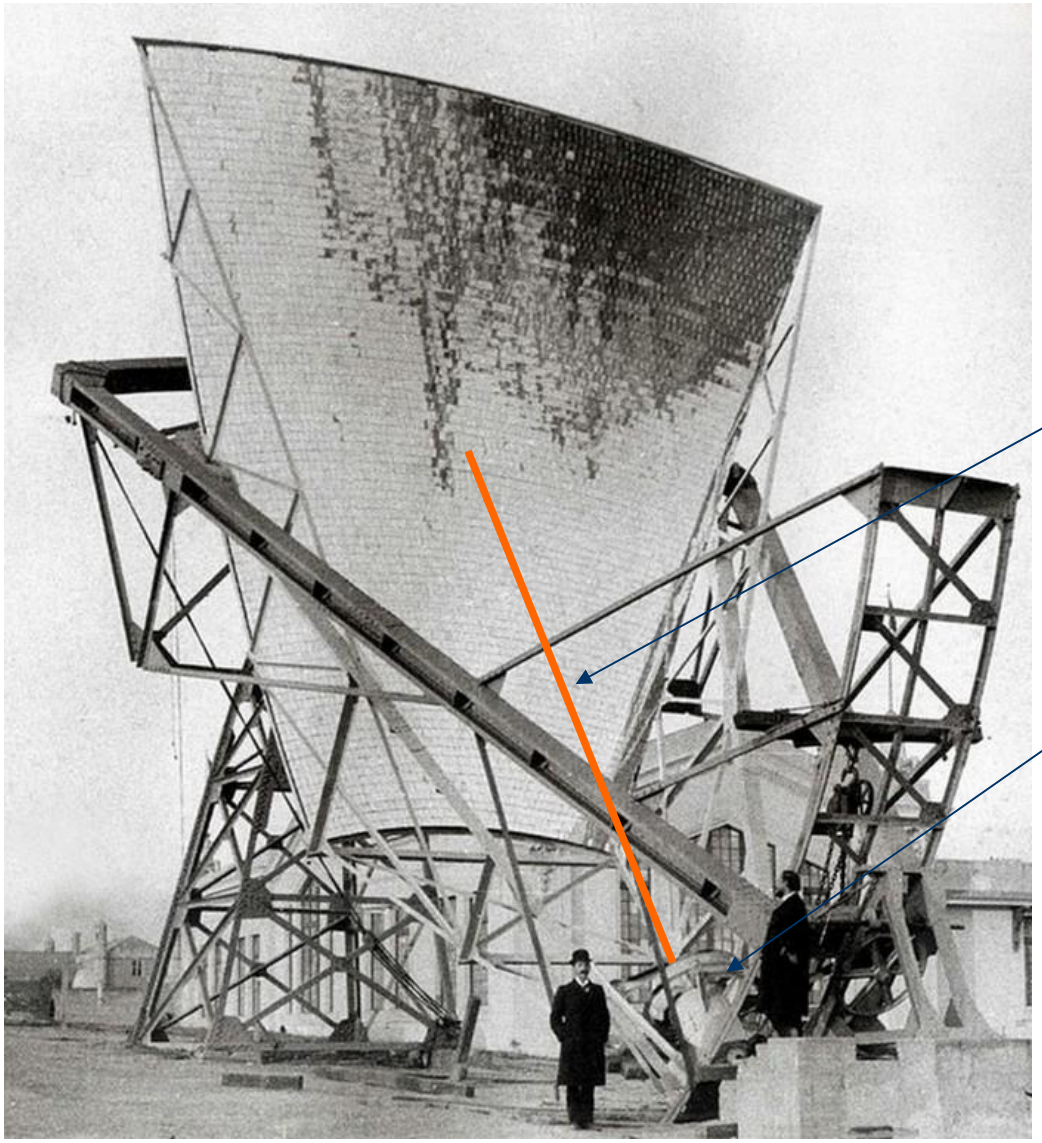
  Trapeze: 10.5 m (top) x 5.4 m (bottom)
  10.5 m (height)

- Equatorial mounting
- Sun tracking thanks to a clock



First solar furnace automatically orientated !

2nd generation, 2nd version: Pyrheliophor

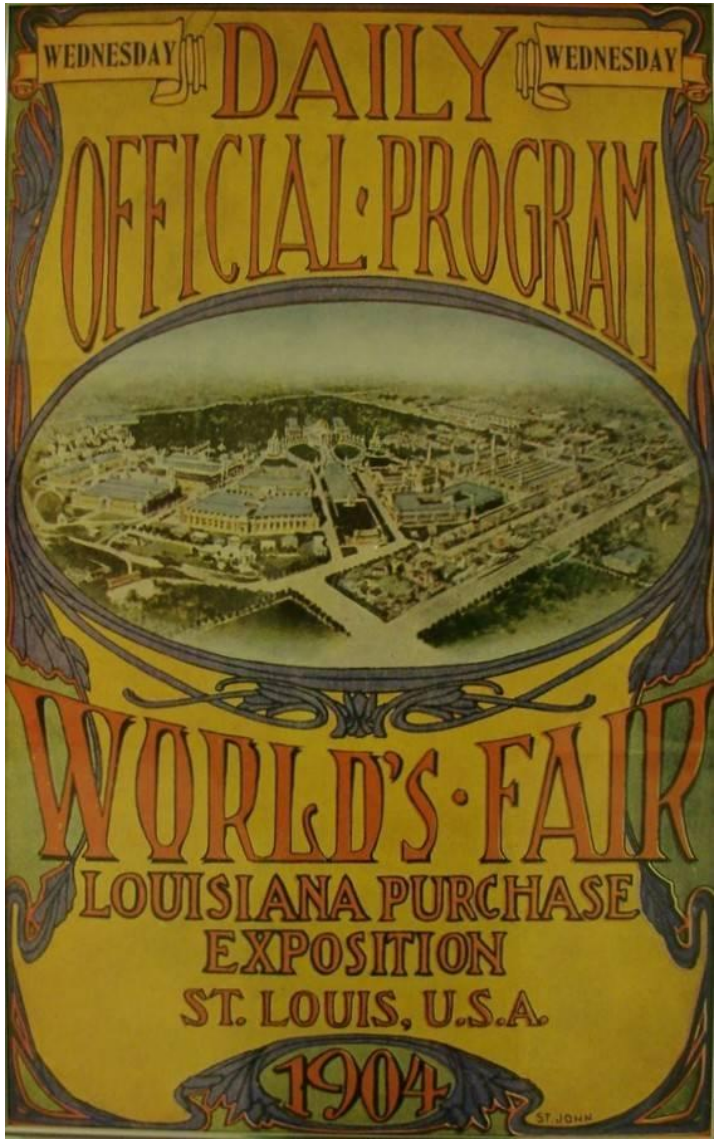


- Reflective area
  Large copper alloy mirrors
  replaced by 6117 small glass mirrors
  Size: 123 x 98 mm

- Mean focal length: ≈10 m
- Focus diameter: ≈15 cm

- Crucible: 45 cm in diameter, 60 cm deep
  Lined with magnesia

2nd generation, 2nd version: Pyrheliophor



- **World's Fair, St. Louis, April 30 - December 1st, 1904**
  - Construction & adjustment duration: 5 months
- Fusion: iron (<1 min), fire-clay (≈3 min), magnesia (≈20 min)
- Estimated temperature: 3800°C

ENCOURAGED by American scientists and the highest awards at the World's Fair—the grand prize, two gold and a silver medal—Father A. M. G. Himalaya, the inventor of the pyrheliophor or solar apparatus, has taken up his residence at Washington, D. C.

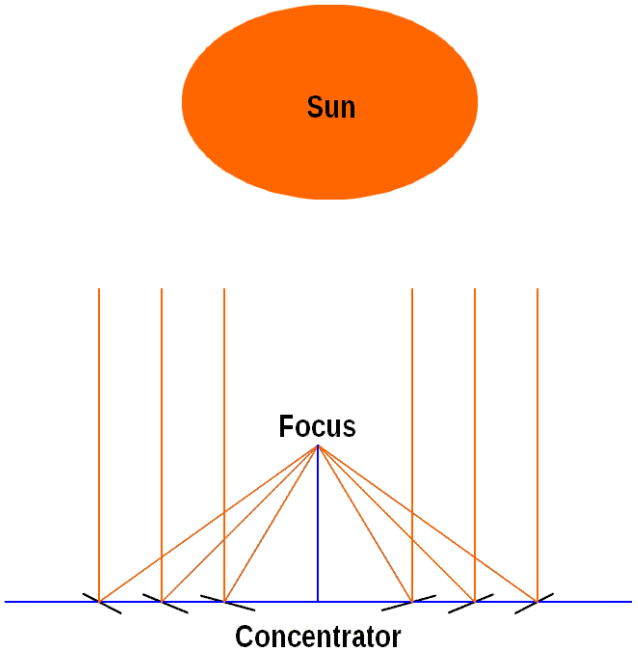
- **Pyrheliophor destroyed on St. Louis site, or during the return trip to Europe ?**

Summary of five years of solar research

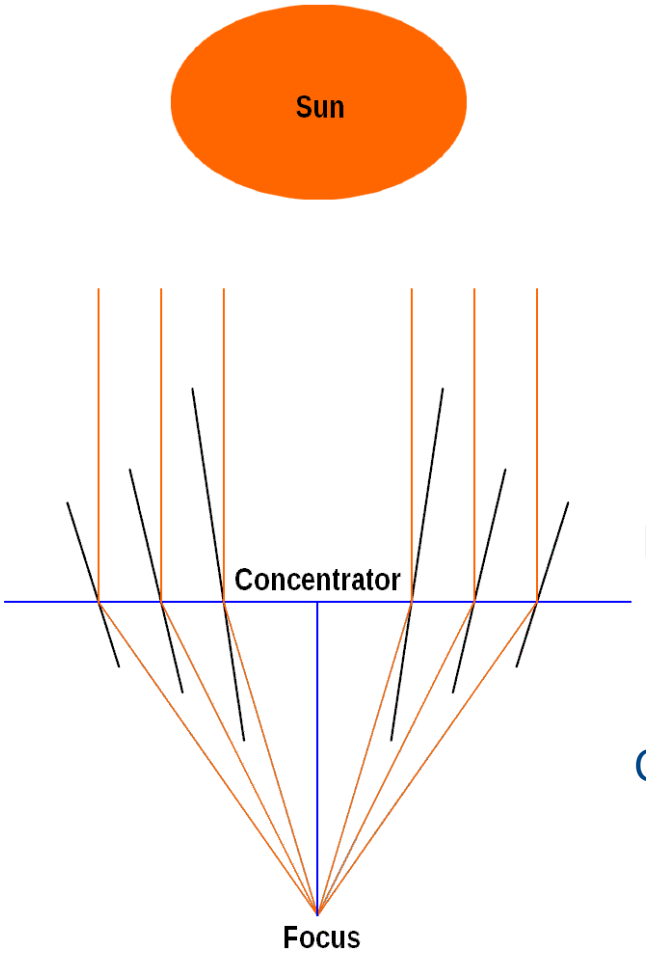
- **3 firsts in the field of concentrated solar energy**
  - **the "metallic lens", truncated cones array**
  - **the "pyrheliophor", off-axis paraboloïd**
  - **atmospheric nitrogen combustion**

Fresnel-like Reflecting Concentrators

SFC
Sun-Focus-Concentrator



SCF
Sun-Concentrator-Focus

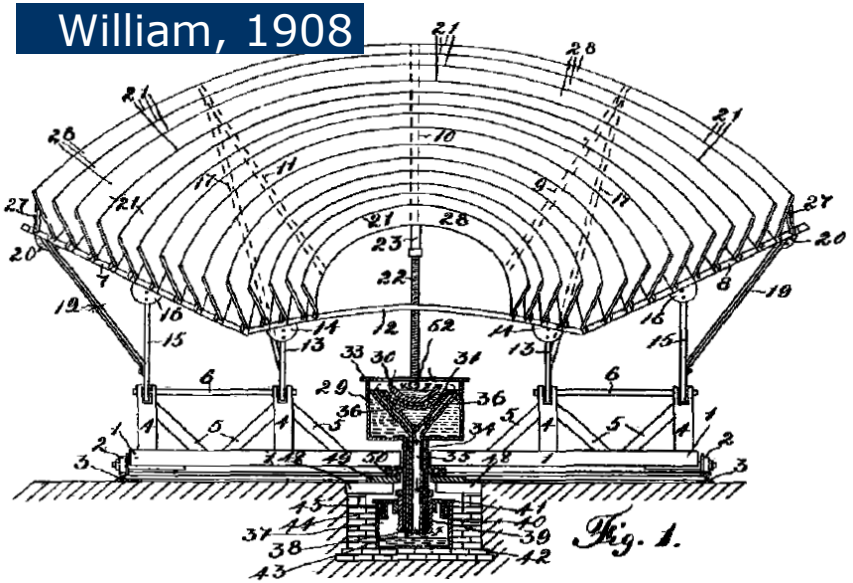


Metallic lens

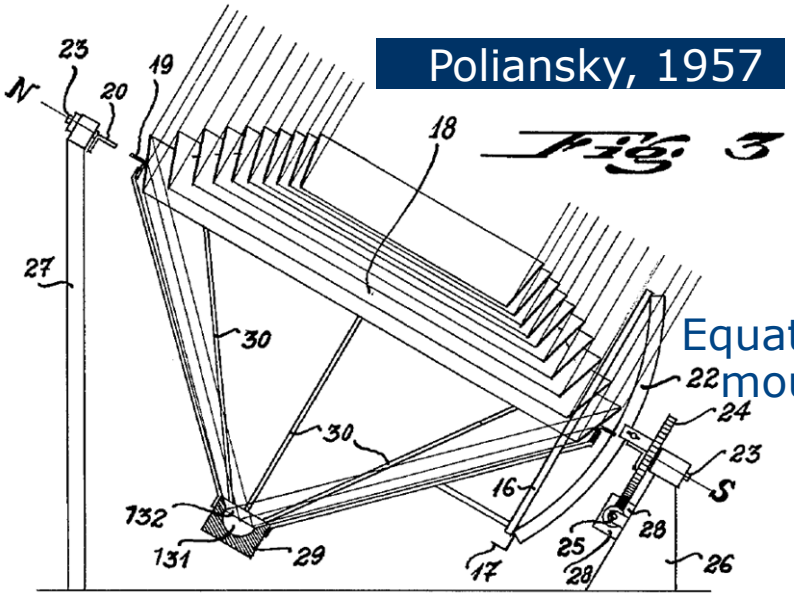
Grazing-incidence Concentrator

Grazing-incidence Concentrators

William, 1908

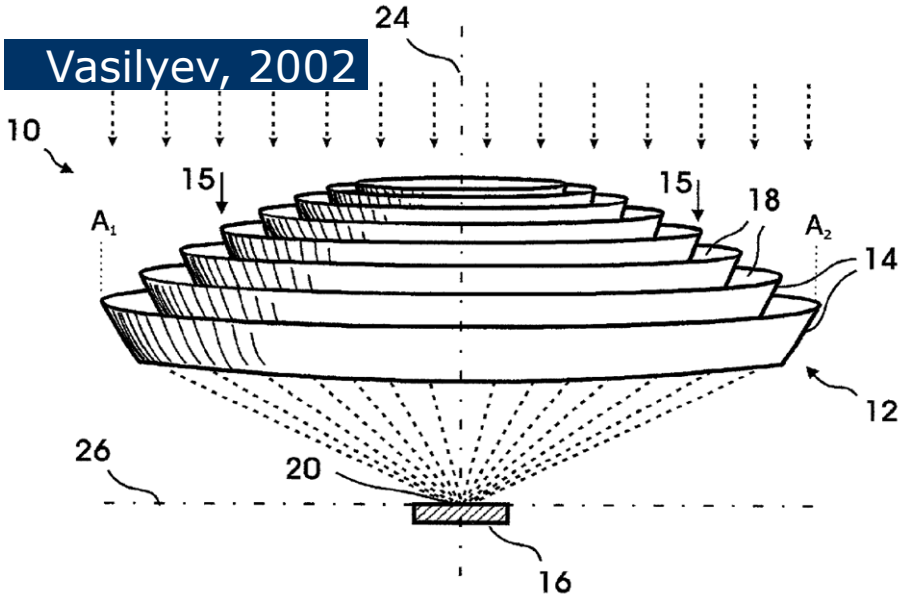


Poliansky, 1957

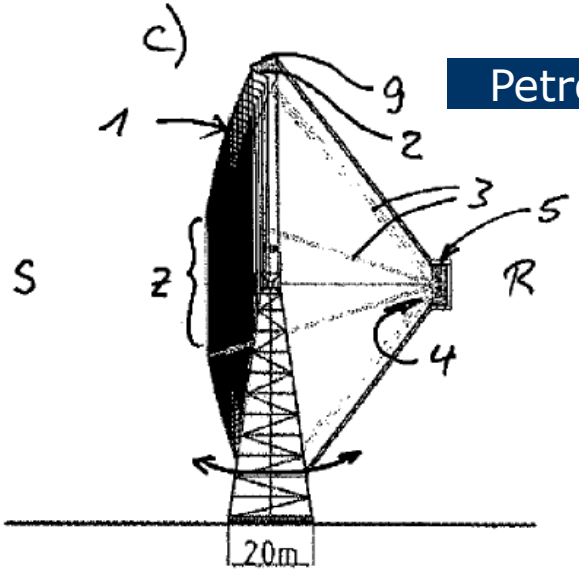


Equatorial mount

Vasilyev, 2002



Petrovic, 2012

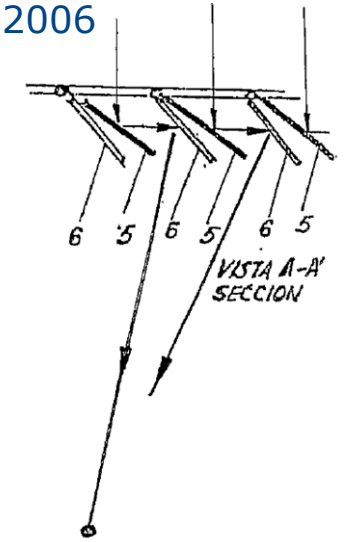


Grazing-incidence Concentrators

Petrovic, Serbia

Cruz, Spain

Granada, 2006



Not
Grazing-incidence
but
Double reflexion

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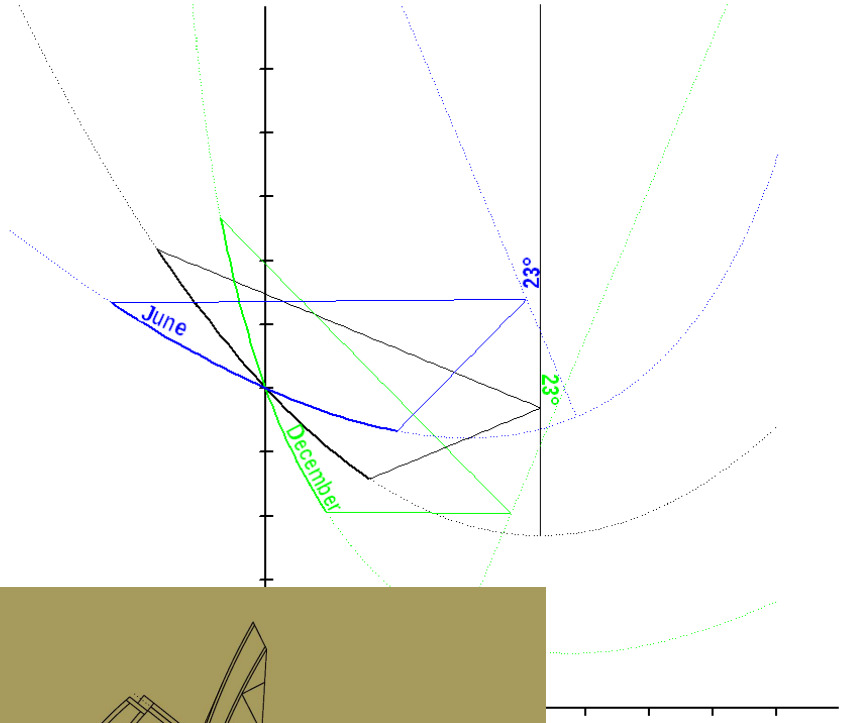
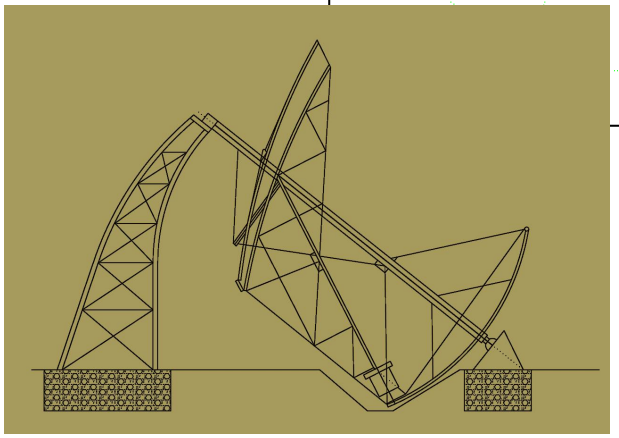
Off-axis Paraboloïd Concentrators

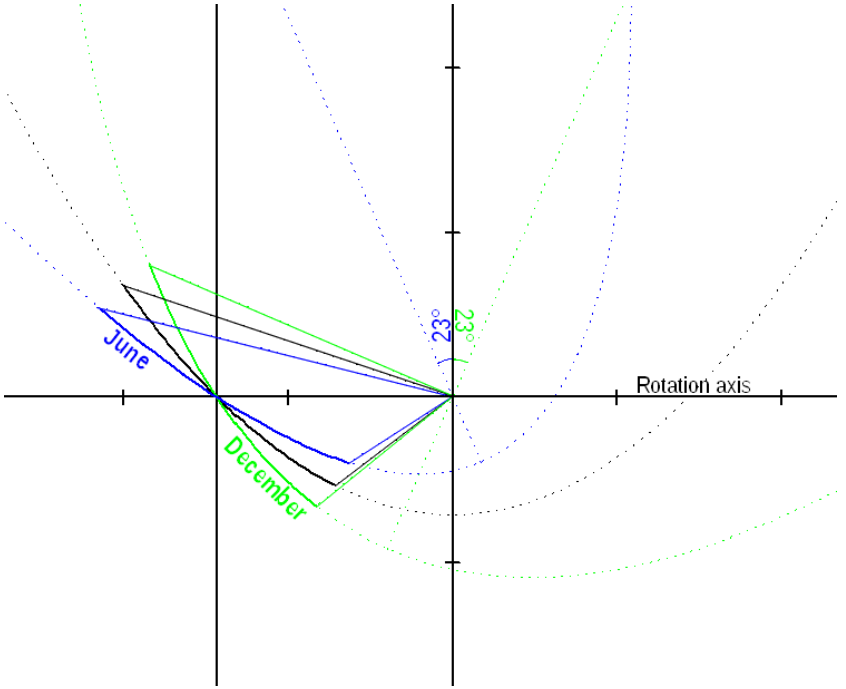
Himalaya system: Fixed paraboloïd
Seasonal focus shifting





Scheffler system: Fixed focus
Seasonal paraboloïd deformation

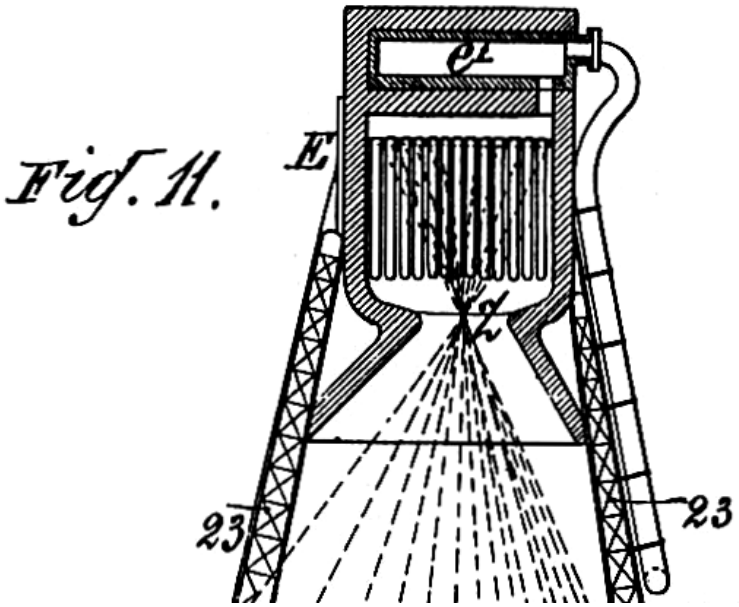
Fundamental improvement !



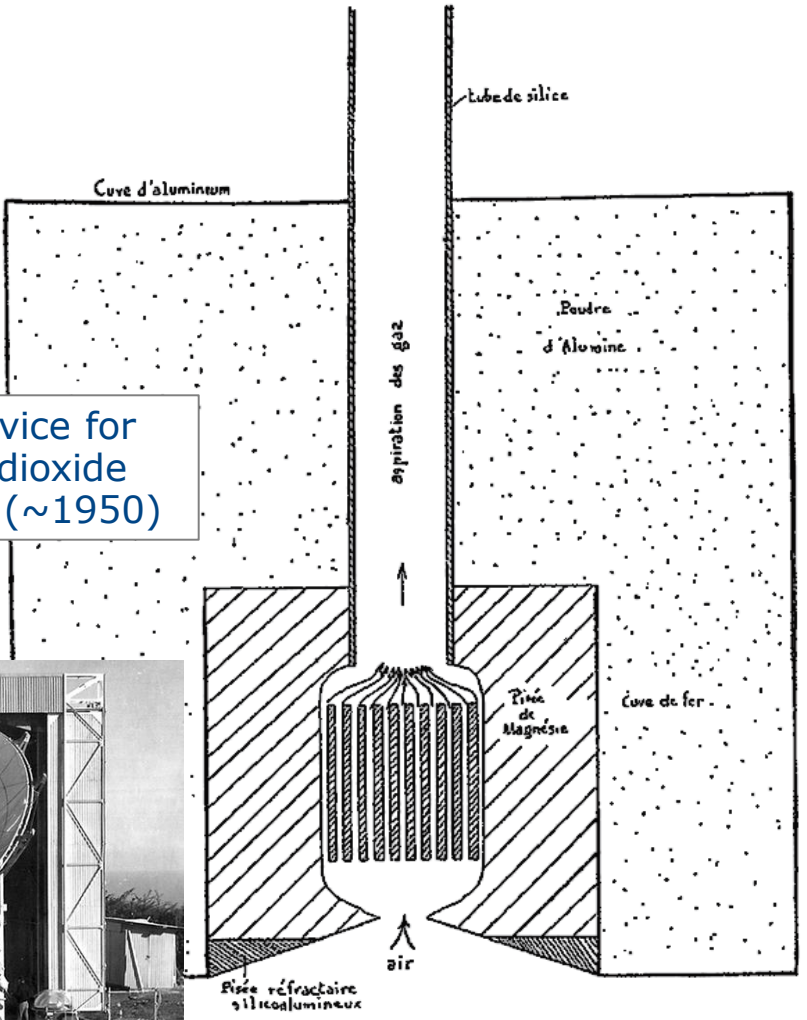
Thousands of Scheffler concentrators all around the world !

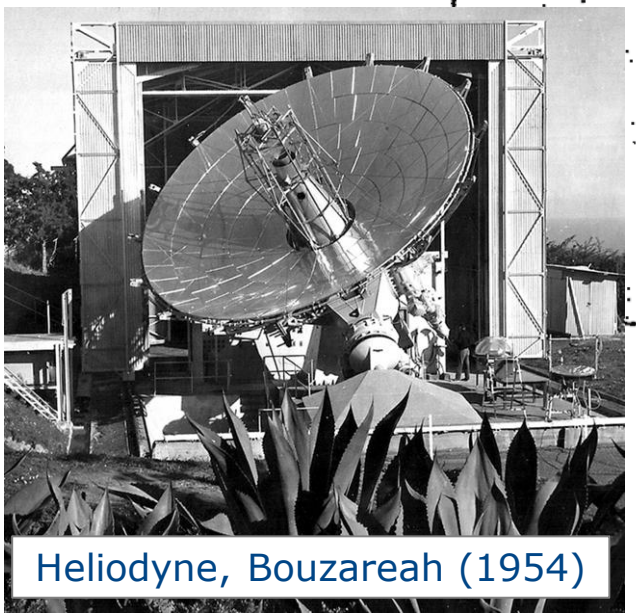
Nitrate Fertilizers Production

Himalaya device for "atmospheric nitrogen combustion"



Trombe device for "nitrogen dioxide production" (~1950)





Heliodyne, Bouzareah (1954)

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Conclusion

- **1899-1904: 5 years of research and development with the aim of obtaining ultra-high temperatures by means of concentrated solar energy**

◊ **industrial scale**

◊ **easy to use**

◊ **several innovative concepts**

◊ **In 1904, the "pyrheliophor" was the larger solar furnace in the world, the first to be automatically orientaded.**