PARIS HELIOS CIRCUS

PART I

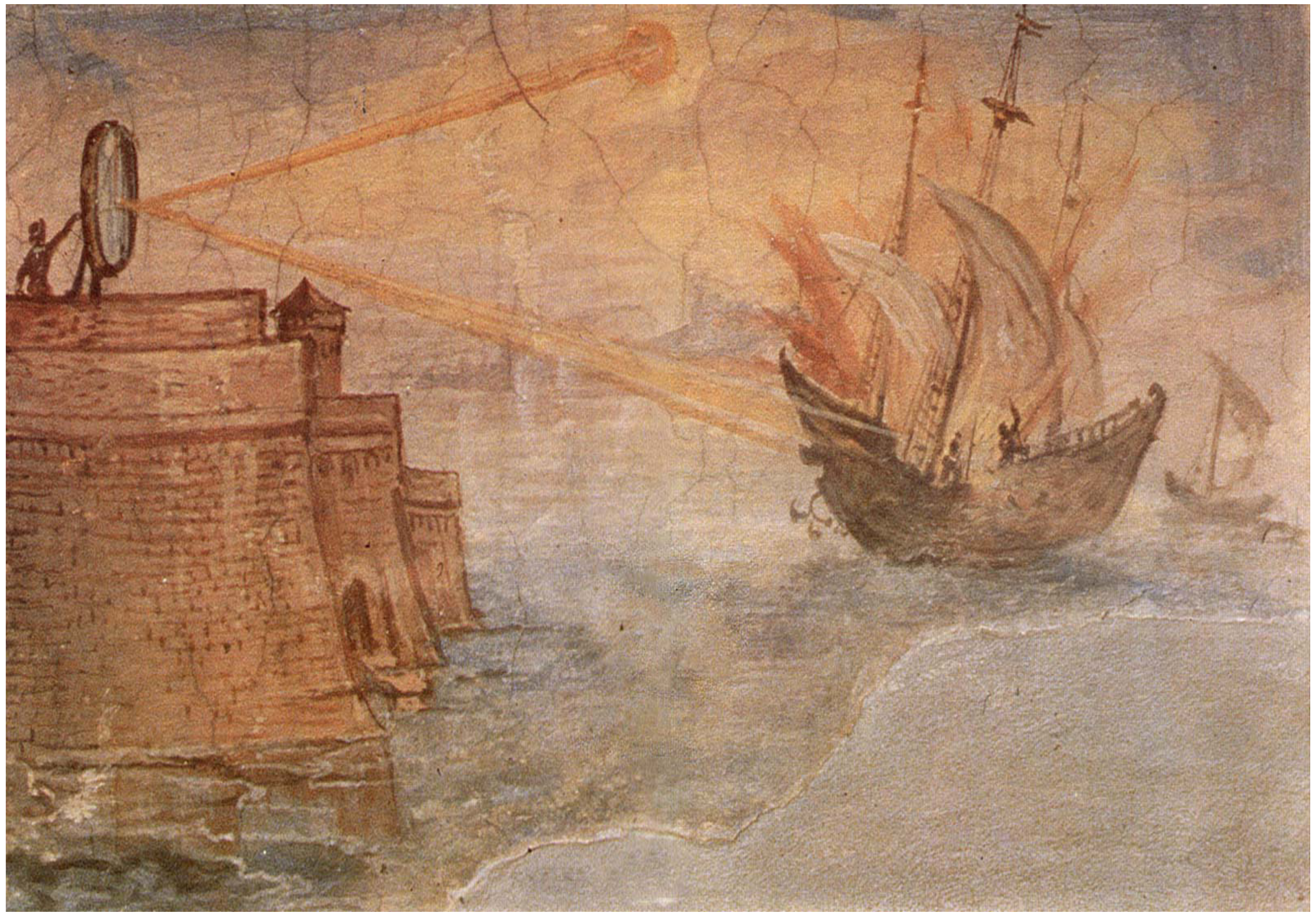
MAUDE VOUTAT

Master Thesis HS21

VOLUPTAS   Chair Charbonnet / Heiz   ETHZ

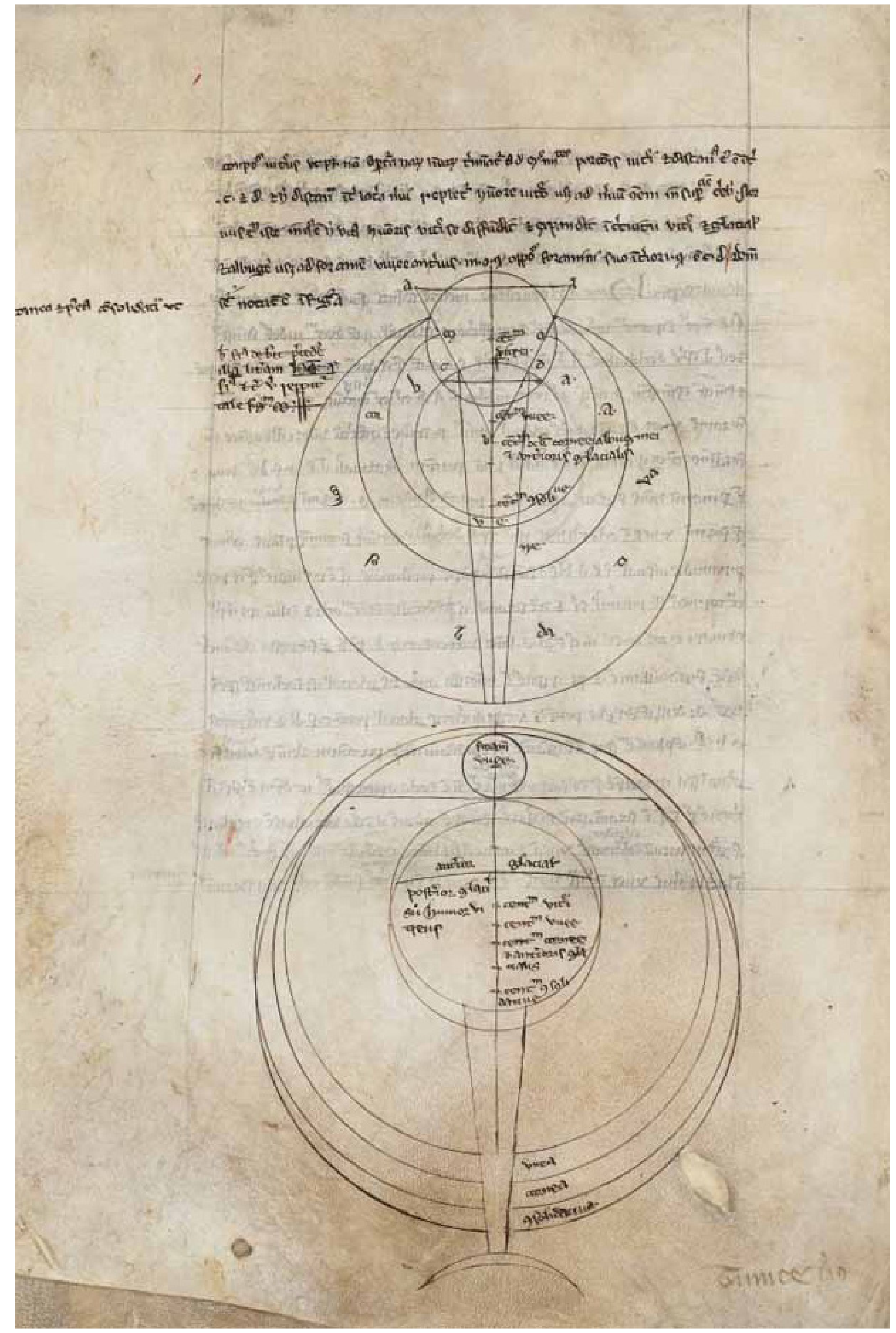
PROLOGUE
ARCHIMEDES' BURNING MIRROR

1



212 BC
GIULIO PARIGI (1599)
ARCHIMEDES' MIRROR USED TO BURN ROMAN SHIPS

2

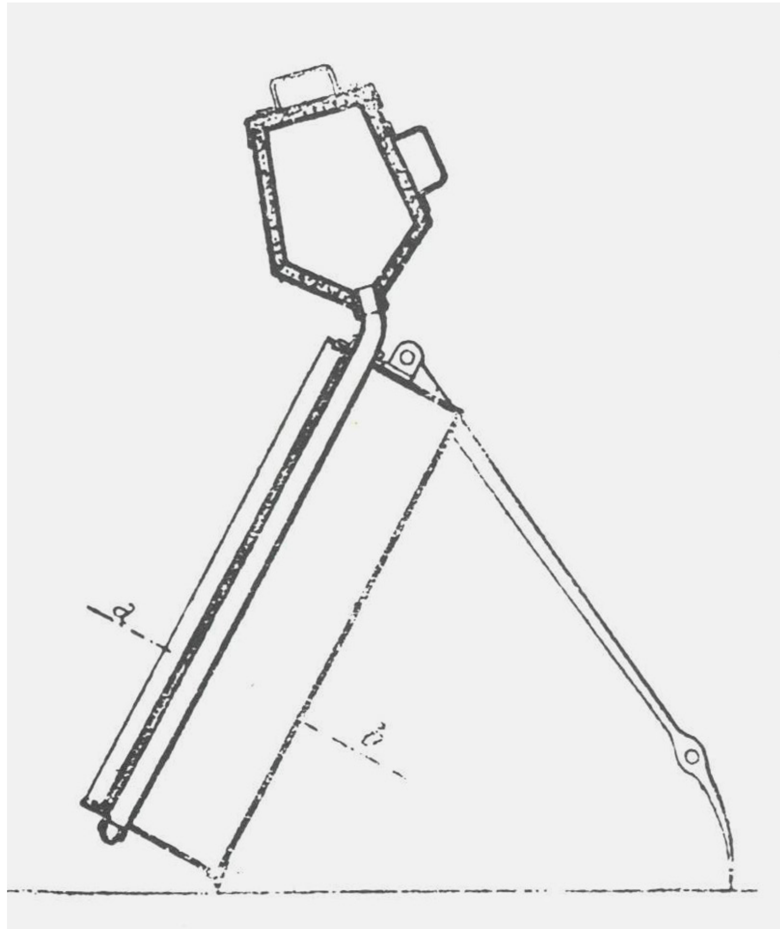


CA. 1250
ROGER BACON
EXCERPTS FROM HIS STUDY ON OPTICS

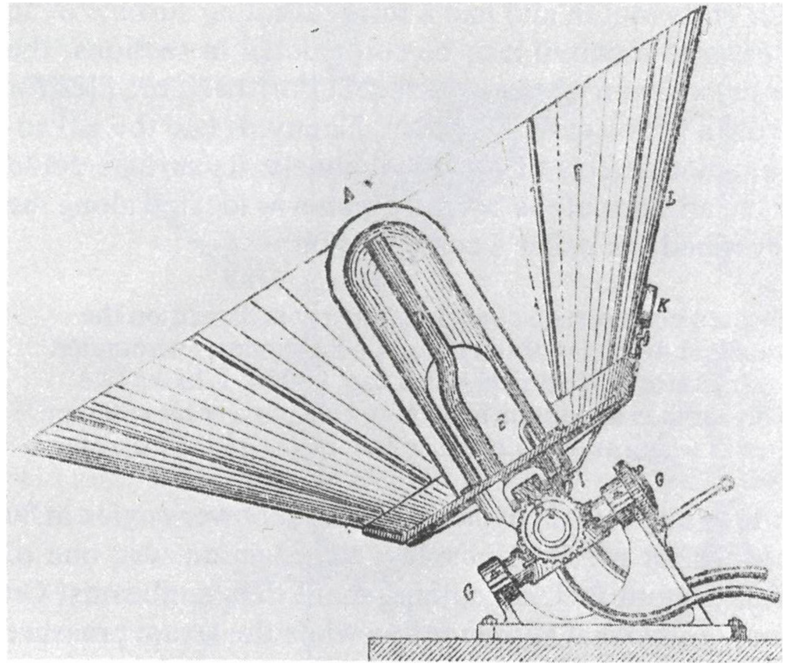
212 BC Legend has it that during the Siege of Syracuse, Archimedes had used, among other exotic weapons, burning mirrors to ignite the invading Roman fleet. He had supposedly developed giant mirrors which reflect and concentrate the sun rays onto the sails of the ships and set them on fire.

Experimentations with curved surfaces to focus sunlight grew as the understanding of geometry matured. Diocles, in the second century BC, gave the first formal geometrical proof of the focal property of the parabola : all rays reflected on a parabolic surface converge into one point, making it more effective than a spherical or elliptical surface. The studies on optics and the converging properties of lenses throughout the following centuries, maintained the fantasies of solar weaponry alive. Just like other sources of energy, such as nuclear power, the interest for solar power found its origin in military purposes.

1
A. MOUCHOT’S SOLAR MOTORS



1866
AUGUSTIN MOUCHOT
FIRST SOLAR MOTOR : A PARABOLIC MIRROR CONCENTRATES SUN RAYS ONTO A COPPER TUBE



1874
AUGUSTIN MOUCHOT
IMPROVED SOLAR MOTOR

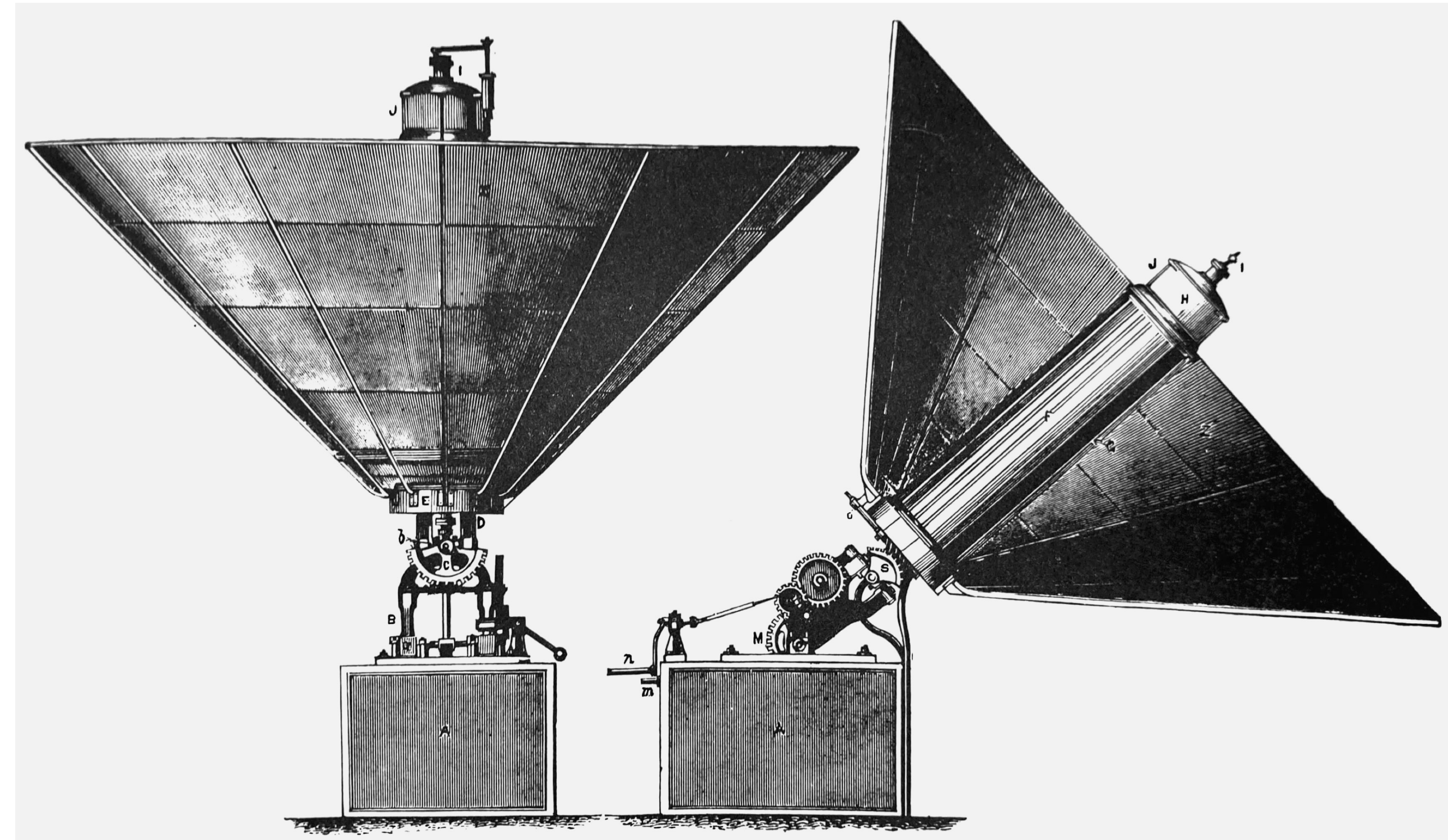
Over the 19th century, the industrialization of France demanded large amounts of coal, of which she had too scarce indigenous resources. On the one hand, coal was required to fuel the mechanized steam engines and on the other hand, mechanization relied on iron, and the production of one ton of iron required seven to ten tons of coal. France entered the industrial competition between nations disadvantaged, lagging behind coal-rich and rapidly industrialized Great-Britain.

Augustin Mouchot, French engineer and mathematics professor, concerned about the speed at which France was exhausting her coal resources and a general coal crisis, cautioned : « Eventually industry will no longer find in Europe the resources to satisfy its prodigious expansion. Coal will undoubtedly be used up. What will industry do then ? » Concerns about the durability of coal were further raised by British economist William Jevons. He exposed, in 1965, the paradox in which technological progress, enabling a more efficient use of a resource, lead to an increase of consumption of the resource, rather than a decrease.

Mouchot's answer was to turn towards the sun. Not only is the sun inexhaustible, but is the absolute energy, the energy behind all other energies. He argued : « It is the sun's rays that give birth to the winds, it is also the sun's rays that force the waters of the sea to circulate in steam, to water the continents and to produce springs and rivers, it is finally by their vivifying action that are elaborated amidst inorganic matter the plants that feed the animals and the man, and constitute the coal strata where one knew how to find an immense deposit of living force. The human industry is only a matter of the sun. »

1860 He started a two decade research to harness the sun, with the dream of driving the steam engines of the industrial age with solar energy. His experiments aimed to bring water to steam, by concentrating the sun's rays onto a glass boiler - a combination of the burning mirror and the use of glass as a heat trap.

1866 His research had proved successful and the first solar steam engine was built. Napoleon III enthusiastically offered Mouchot the financial backing to construct an industrial-scale solar engine. Yet, the invasion of Prussia in 1970 annulled the funding and further research.



1878
AUGUSTIN MOUCHOT
SOLAR MOTOR FOR THE UNIVERSAL EXHIBITION IN PARIS

The french colonies in North Africa and Asia, with constant sunshine and abundant open space were Mouchot's new target to prove the economical viability of solar power. He adapted his discourse to the imperial ambitions of colonial expansion and re-empowerment of the nation. The colonies, precisely, lacked combustible. Algeria, was at that time, importing 85% of coal from England. The authorities granted him a
scientific mission in Algeria.

1878 After a year of experimenting, he presented his findings to the impressed authorities of Algiers, who then commissioned him to build the largest sun machine in the world to represent Algeria in the upcoming Universal Exposition in Paris. After which, it were to be shipped back to Algeria for commercial use. This solar engine was able to pump 200 liters of water per hour, as well as distill alcohol, cook food or make ice if connected to heat-powered refrigeration device as the one invented by Ferdinand Carré in the 1850's.

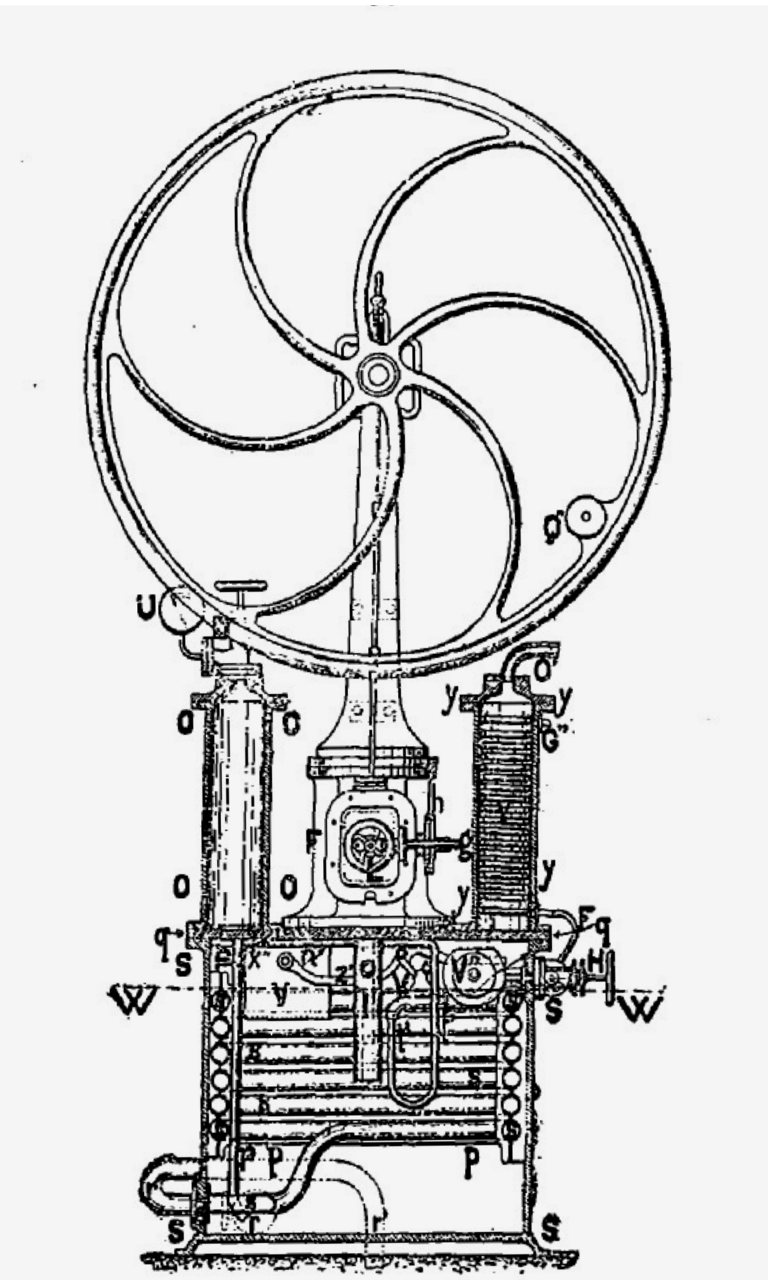


FIGURE 5.

1885
CHARLES TELLIER
LOW TEMPERATURE SOLAR MOTOR USING PRESSURIZED AMMONIA GAS IN 'LA CONQUÊTE PACIFIQUE DE L'AFRIQUE OCCIDENTALE PAR LE SOLEIL'

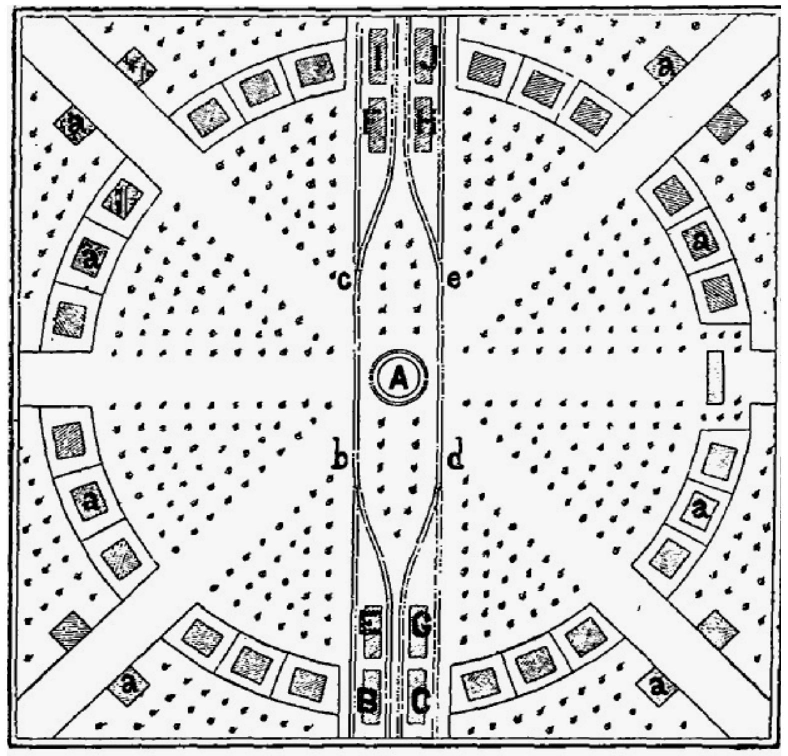


FIGURE 8.

1890
CHARLES TELLIER
PLAN OF A STATION FOR THE TRANSAFRICICAN RAILWAY IN 'LA CONQUÊTE PACIFIQUE DE L'AFRIQUE OCCIDENTALE PAR LE SOLEIL'

1890 Charles Tellier further pushed the colonial discourse in « La Conquête pacifique de l'Afrique Occidentale par le soleil », in which he imagined the colonies' agriculture, industry and economy to thrive thanks to the sun. Moreover, he developed low-temperature motors using fluids, such as ammonia, with boiling temperatures much lower than that of water. A step with the potential of extending the use of solar power in locations with unoptimal sunshine.

1870-1940
UNKNOWN (1920)
NATIONAL ASSEMBLY UNDER THE 3RD REPUBLIC

1860 The Cobden–Chevalier Treaty a free-trade agreement between France and Great-Britain ended border taxes on the main items trade : coal and iron from Great-Britain and wine, brandy and silk goods from France - luxury commodities destined to the victorian upper-class.

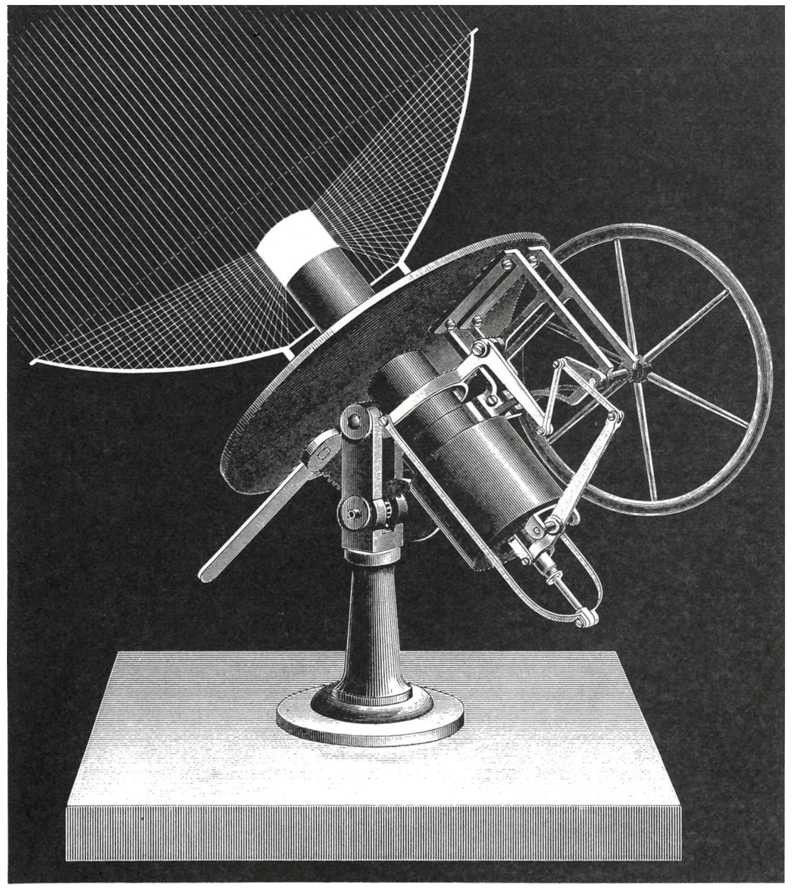
By 1880, free-trade had facilitating coal importation, and more efficient coal mining techniques reducing the extraction costs and an improved railroad system reducing the transportation costs, had contributed to a general decline of the price of coal. The costs of construction solar engines and their efficiency weren't comparable to coal, and the french government stopped funding Mouchot's research.

WHAT IF the free-trade agreement between France and Great-Britain had not been signed and had not rendered imported coal a worthwhile energy source ? The funding for solar research in the colonies would have been renewed in 1880, as it was a direct consequence of the decline of the price of coal. Solar energy would have been a means embraced by the colonial expansion initiated the same year.

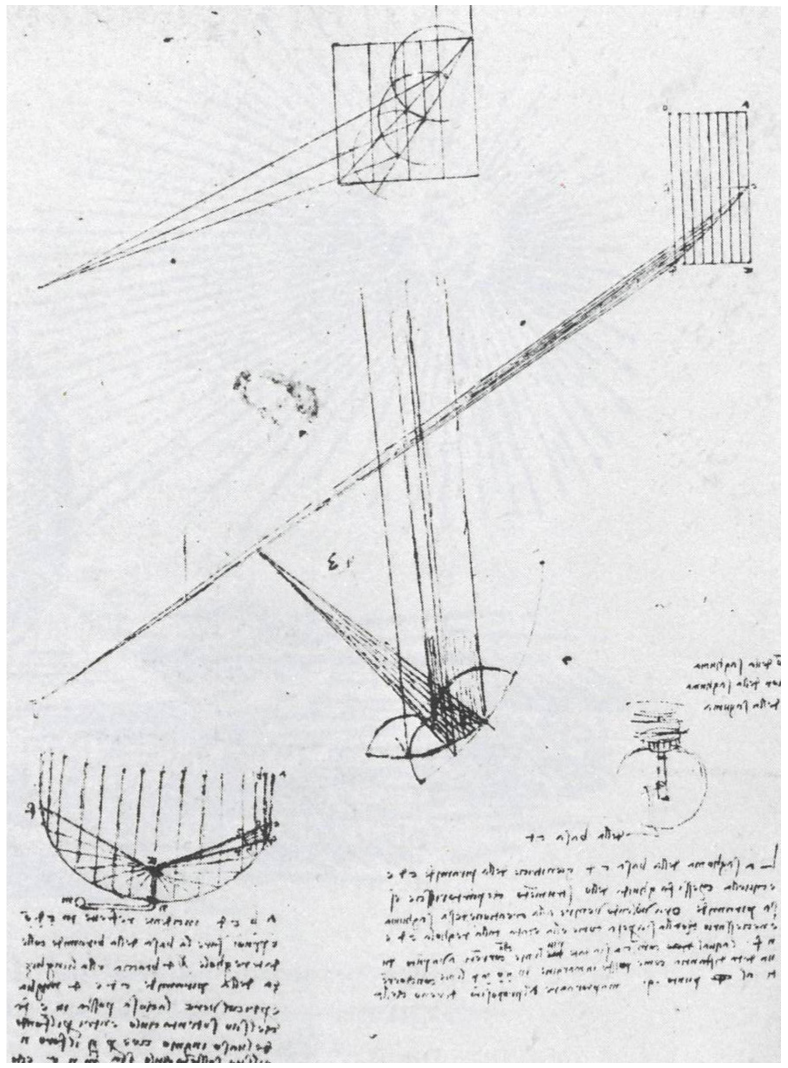
The warnings of solar-enthusiast engineers against the unreliability of coal and the discourses in favor of an alternative energy would have also have been reinforced. In 1881, Abel Pifre, Mouchot's assistant taking over the promotion of solar engines for domestic and industrial use France, and seeking for the next step of rendering solar engines cost efficient, affirmed : « The testing phase is over; it is already being used; it is being sold, it is in demand, the exploitation has started, now it only has to be developed ». With the step already made in the colonies, **WHAT IF** A. Pifre had managed to revive the interest of solar technologies for industrial and domestic application in France ? The third republic was also a moment re-empowerment - or of « redressement national ». Solar power could have been adopted as a means to energetic independence.

La Belle Epoque, a period of political stability, of scientific optimism and flourishing innovations, of ambitions and dreams of modernity, would have been an optimal frame for the improvements of solar technologies. Solar motors would run alongside other new inventions such as, cinema and the automobile, which shaped a new daily life.

2
F. SHUMAN'S PARABOLIC SOLAR STATION

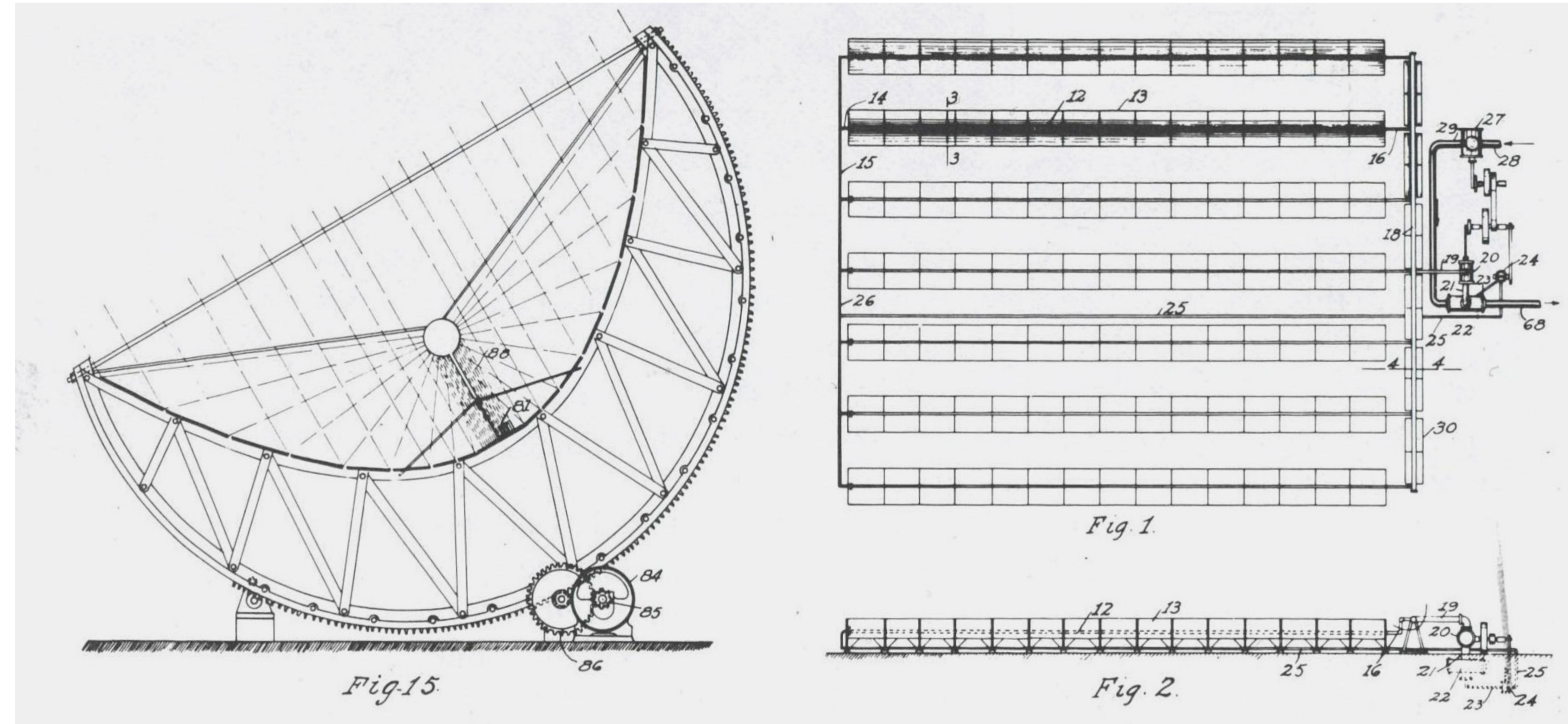


1884
JOHN ERICSSON
PARABOLIC SOLAR MOTOR, U.S



CA. 1515
LEONARDO DA VINCI
SKETCHES FOR THE CONSTRUCTION OF A GIANT PARABOLIC BURNING MIRROR

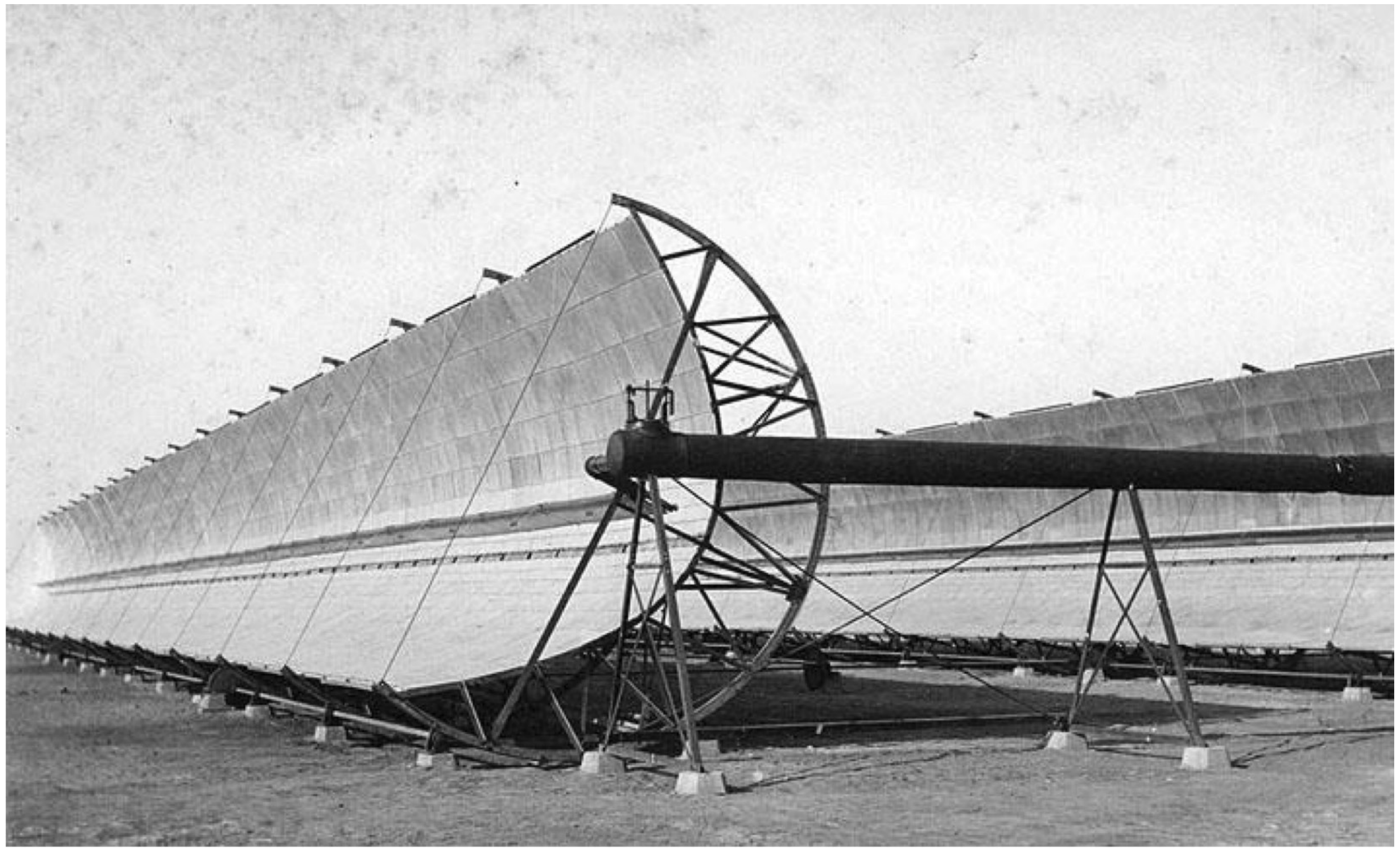
1884 American engineer John Ericsson, also voicing the hope that someday solar energy would fuel the steam engines of the industrial age, further developed Mouchot's solar motor, replacing Mouchot's conical mirror by a parabolic mirror, making the concentration of the sun rays more precise.

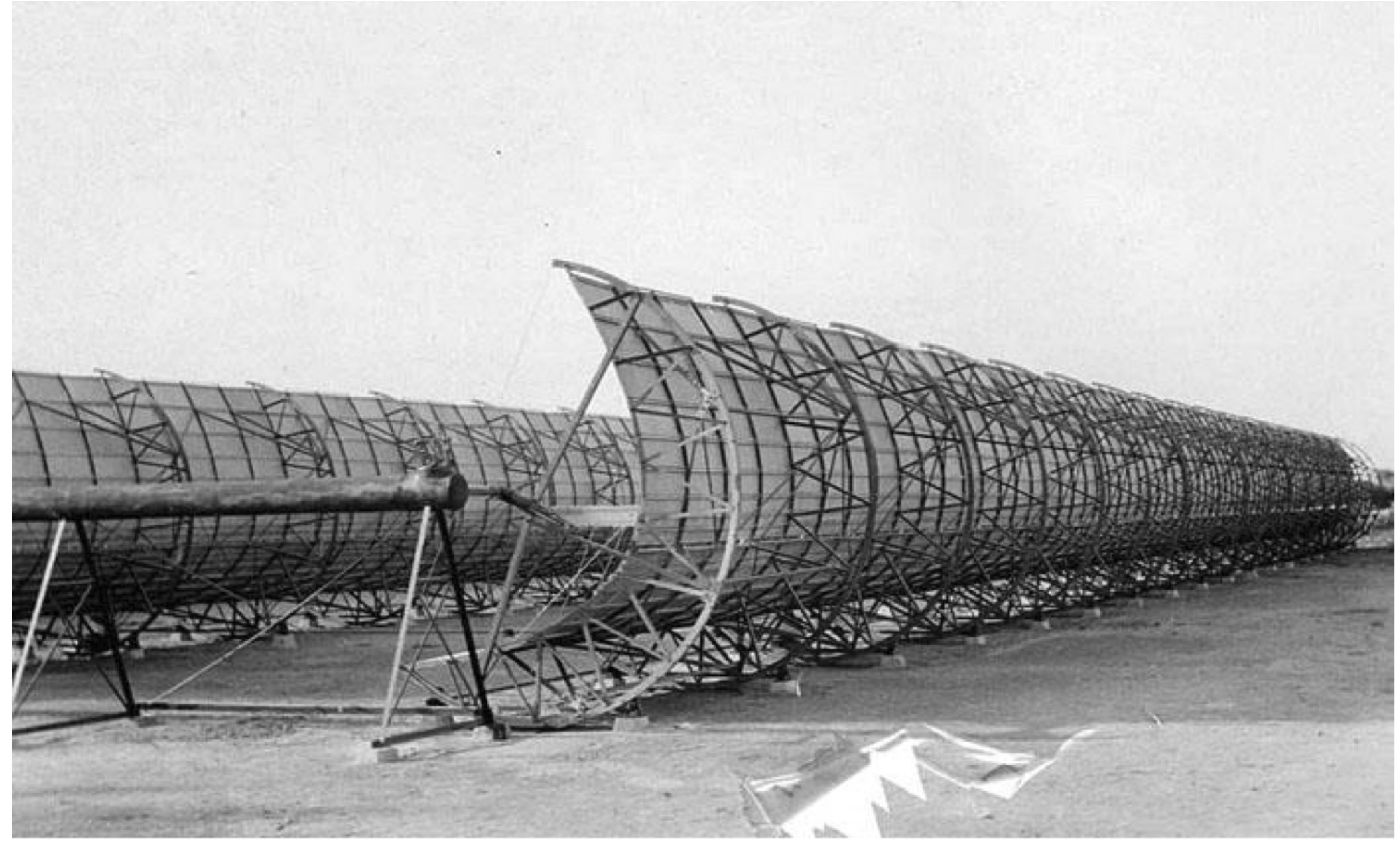


1913
FRANK SHUMAN
PATENT DRAWING FOR THE SOLAR PLANT IN MAADI, EGYPT

1907 The American inventor Frank Shuman of Tacony, Philadelphia, entered the field of solar energy with the main goal of making solar energy simple, practical and cost efficient - the step which had been dismissed to Mouchot's works. He had managed to convince wealthy investors about solar power and together they founded the Sun Power Company, with which he receives enough financial backing to pursue his experiments.

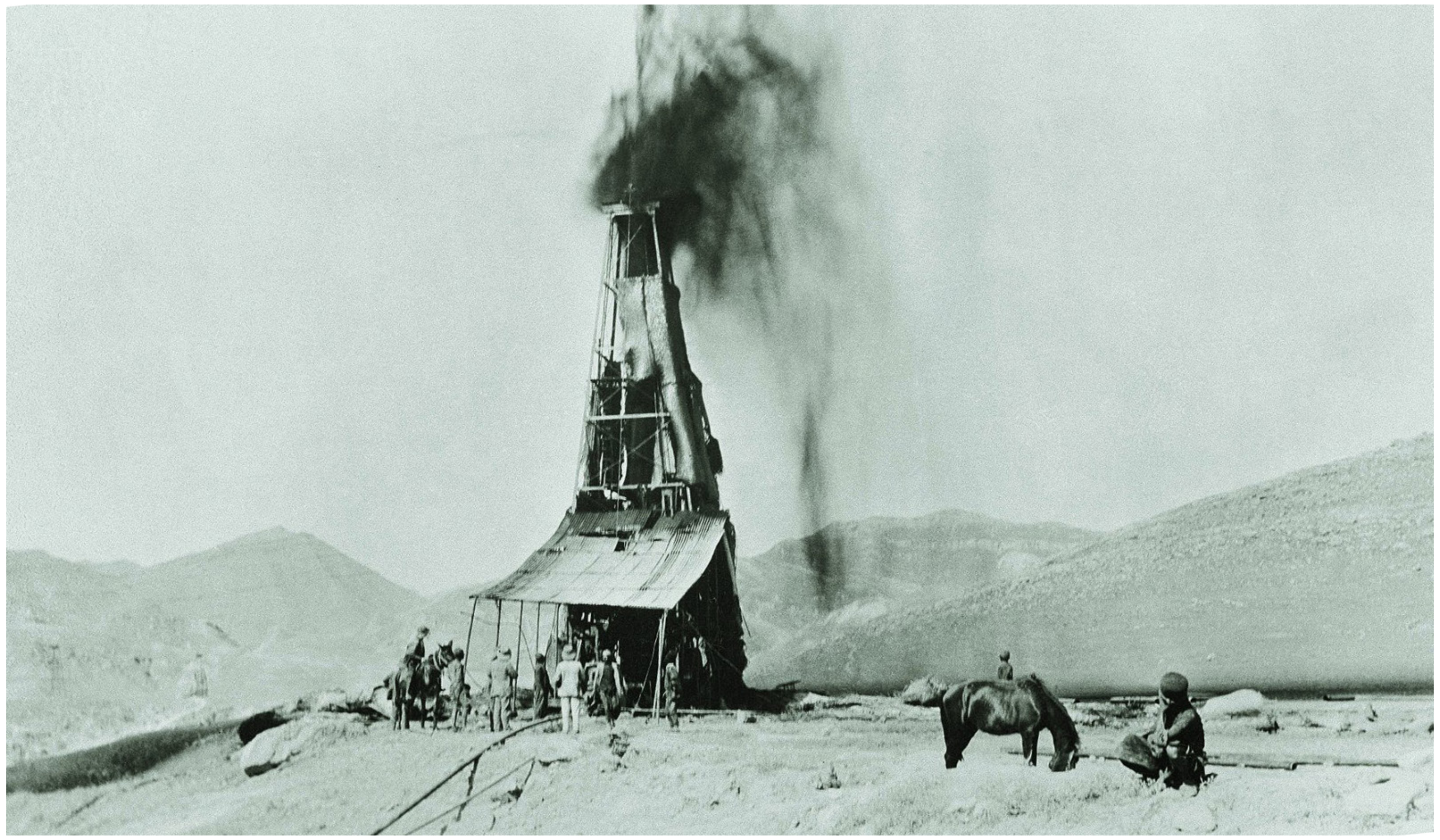
1910 Shuman found further investors abroad. With a group of British businessmen, they founded the Sun Power Company - Eastern Hemisphere. They planned the first large-scale solar plant in Egypt, then a British protectorate, where the agriculture depended entirely on irrigation.





1913
FRANK SHUMAN
SOLAR PUMPING STATION MAADI, EGYPT

1913 The final project, with inputs of British engineer Charles Vernon Boys, consisted in five 62 meter long and 4 meter wide parabolic concentrating reflectors, kept in alignment with the sun via thermostat-controlled motors. It was able to pump over 2’000 liters of water per minute, which made it surpass the performance of any previous solar engine. Plus, the costs of running the plant were so much lower than the operating costs of coal-fueled plants, that the high construction costs of the plant would have been paid off in a couple of years. This plant had proved itself to be economically viable and Shuman himself described it as an « actual record in sun power ». The outlook of solar power seemed extremely bright. The British authorities in Anglo-Egyptian Sudan commissioned Shuman a 12’000 acre cotton plant in Sudan to be irrigated by the sun. And, after an invitation to the Reichstag in Berlin, the German government commissioned a further solar plant for German Southwest Africa (today Namibia).



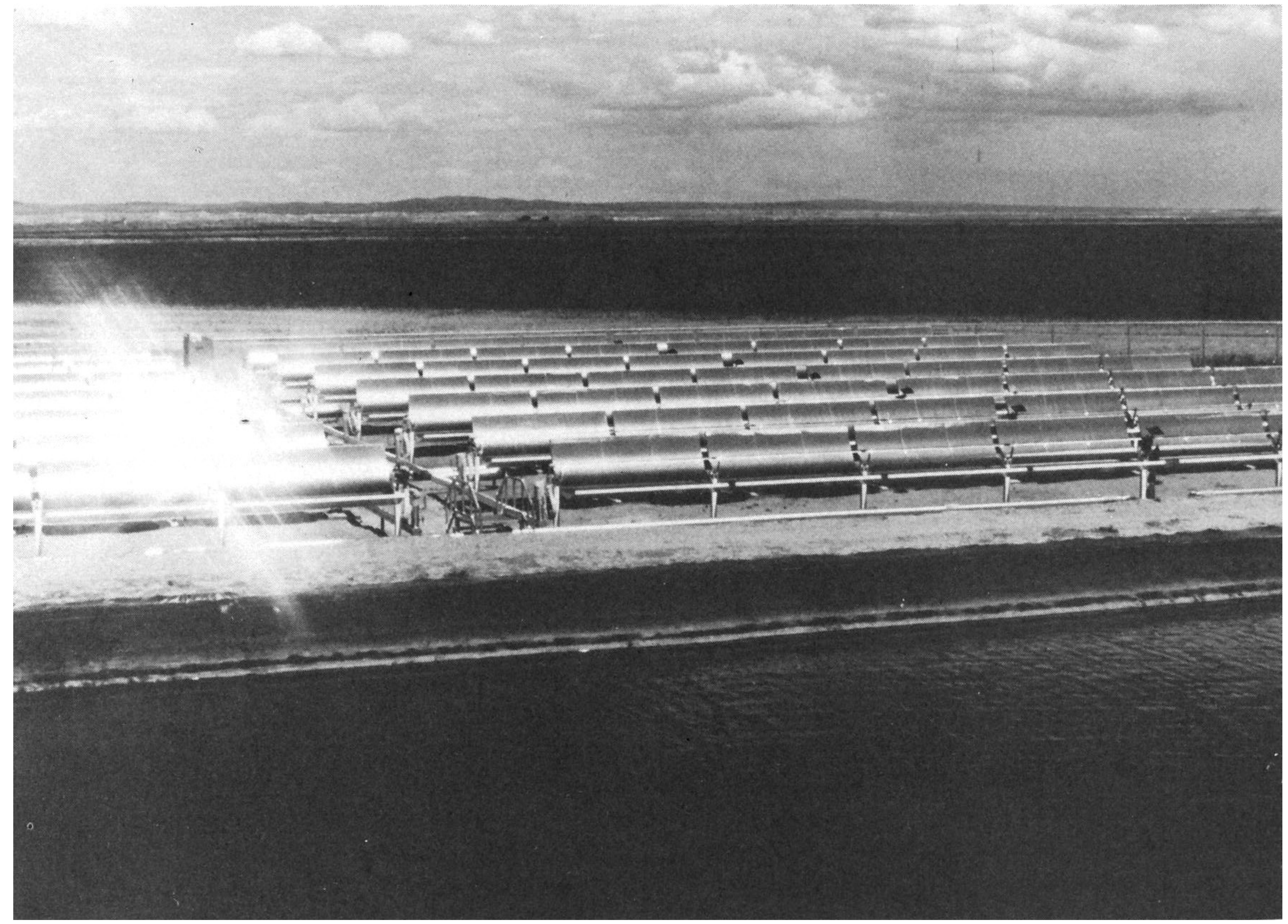
1908
BP p.l.c
DISCOVERY OF OIL FIELD IN PERSIA

However, Great-Britain also had views on other energy sources.

1901 An agreement between British businessman William Knox D'Arcy and Shah of Persia Mozzafar al-Din, settled Great Britain's power over Persia's potential oil resources. D'Arcy was allowed exclusive rights to prospect for petroleum, natural gas, and asphalt in Persia (today Iran) for 60 years. In exchange, the Shah received £20,000 (£2.2 million today) and a promise of 16% of future profits.

1908 After seven years of fruitless prospect, the first oil field in the Middle-East was discovered in Masjed Soleiman, Iran. This led to the foundation of the Anglo-Persian Oil Company, today known as BP and currently the 6th biggest oil company in the world.

1914 With the outbreak of the World War, the British government partly nationalized the company.



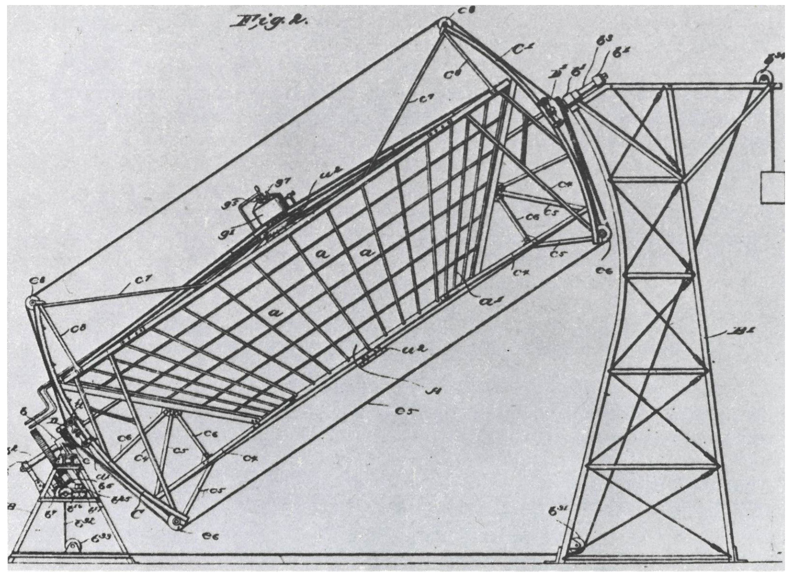
1977
SOLAR PUMPING STATION IN NEW MEXICO, USA

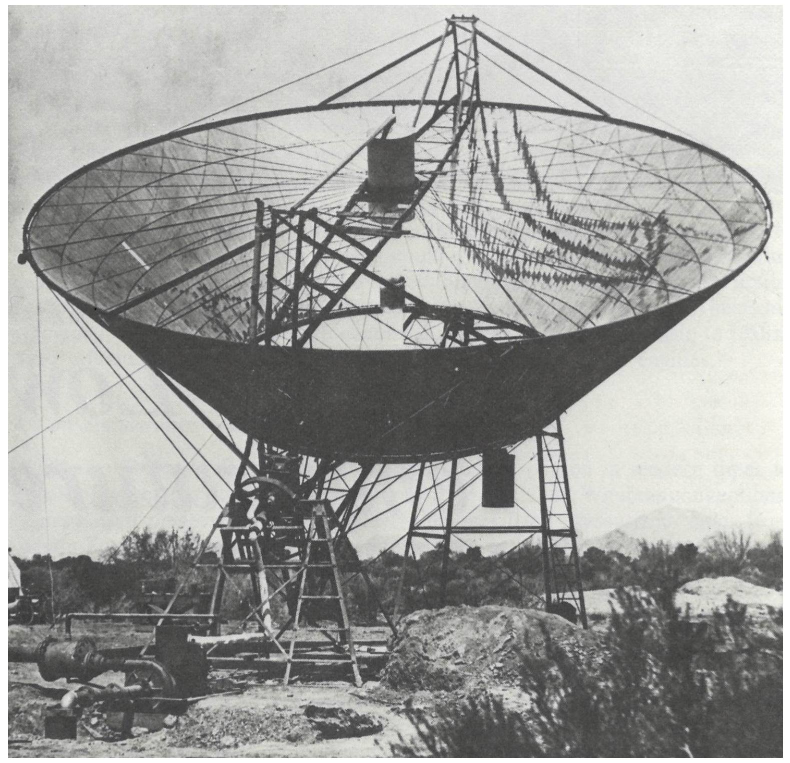
The war also paused Shuman's projects, and eventually dissolved them. By the end of the war, the British had discovered their oil to replace coal and had lost interest for solar energy. Germany had lost her colonies to the allies. Shuman had died before the end of the war, and with that the ambitions of the Sun Power Company.

Nevertheless, Shuman had established the basic design for future solar power plants. After a short revival of solar technologies in the late 70's with the oil crisis, and again 2000's with the rise of renewable energies, the parabolic trough collector system is today the most widespread form of solar power plants.

WHAT IF Shuman had found investors in France - in our alternative history already in a process of solarizing her colonies ? The investor's interest for solar energy would not have been affected by the war or the oil discovery. Projects of solar plants would have been realized, and their economic success would have accelerated the improvements of solar technologies.

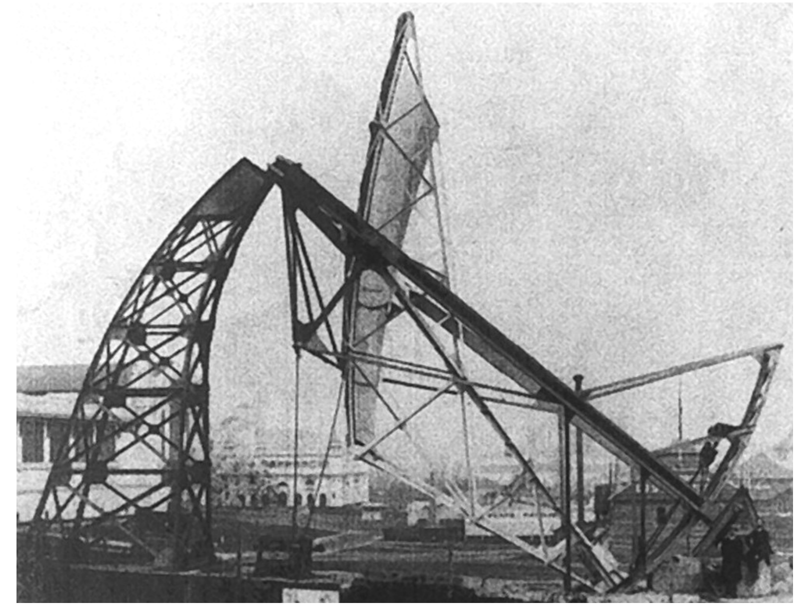
3
F. TROMBE’S SOLAR FURNACE



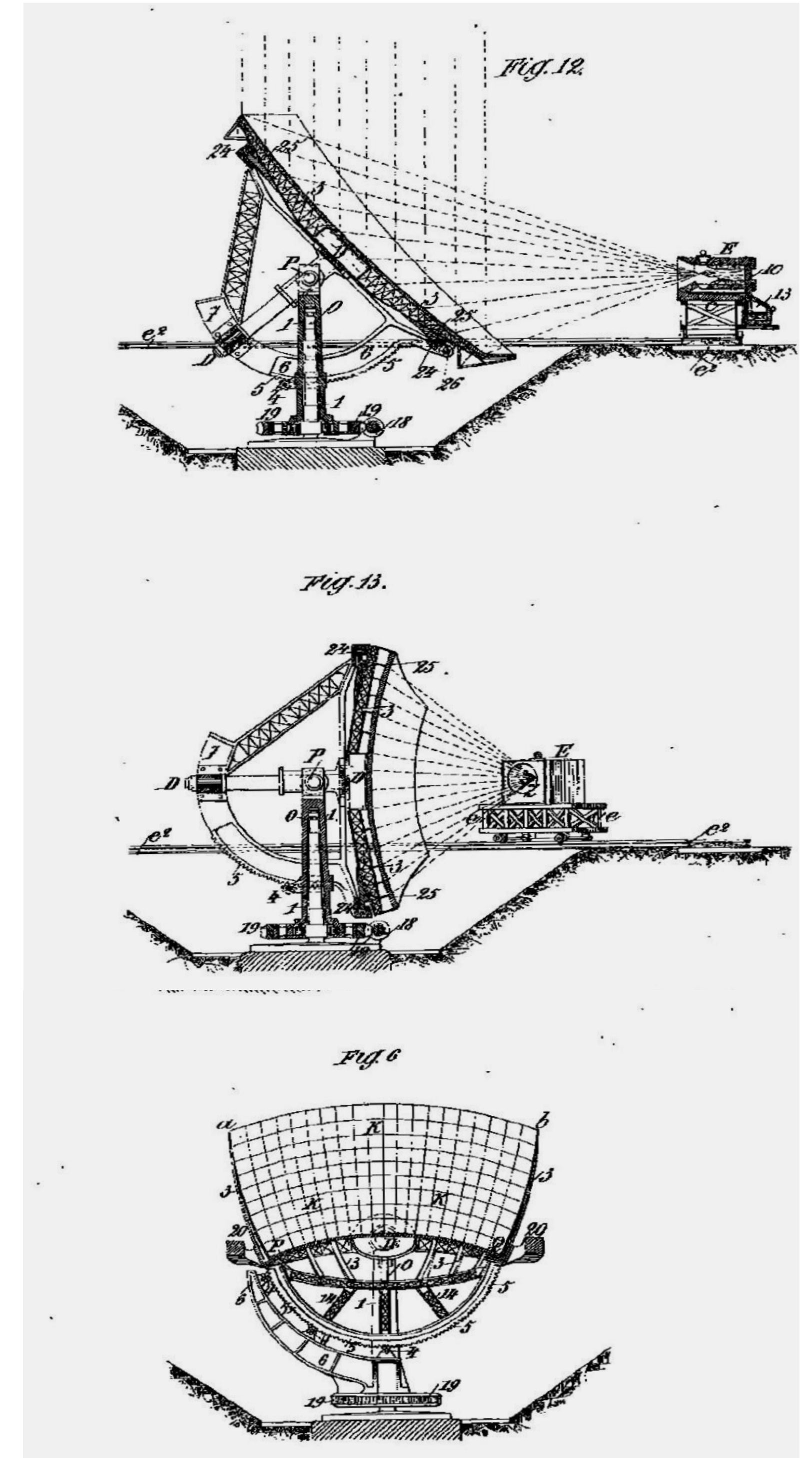


1900
AUBREY ENEAS
SOLAR MOTOR WITH CLOCK MECHANISM ROTATING THE MIRROR ALONG A TOWER

1900 Other american scientists fearing a global energy crisis, such as Aubrey Eneas, also proposed improved versions of Mouchot's solar engine, also with the aim of converting solar energy into mechanical work.



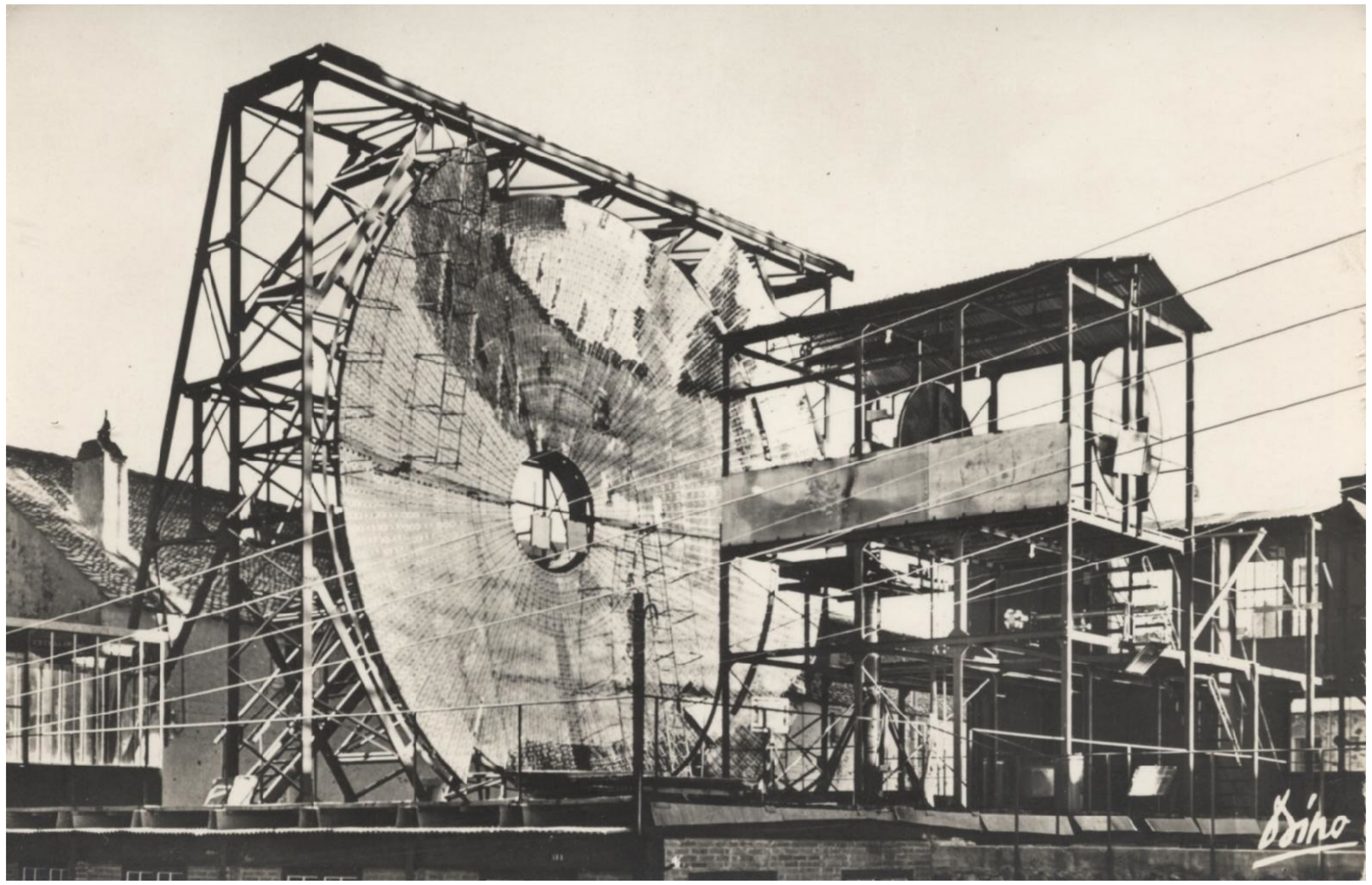
1904
PADRE HIMALAYA
"PYREOLOPHORE", UNIVERSAL EXHIBITION IN ST. LOUIS, MISSOURI



1904
PADRE HIMALAYA
PLANS OF THE "PYREOLOPHORE", UNIVERSAL EXHIBITION IN ST. LOUIS, MISSOURI

1900 Manuel Antonio Gomes, surnamed Padre Himalaya, a Portuguese engineer established in Paris, experimented with solar energy to obtain maximum high temperatures, as a tool for chemistry or metallurgy. He built the first solar furnace in Sordède, France.

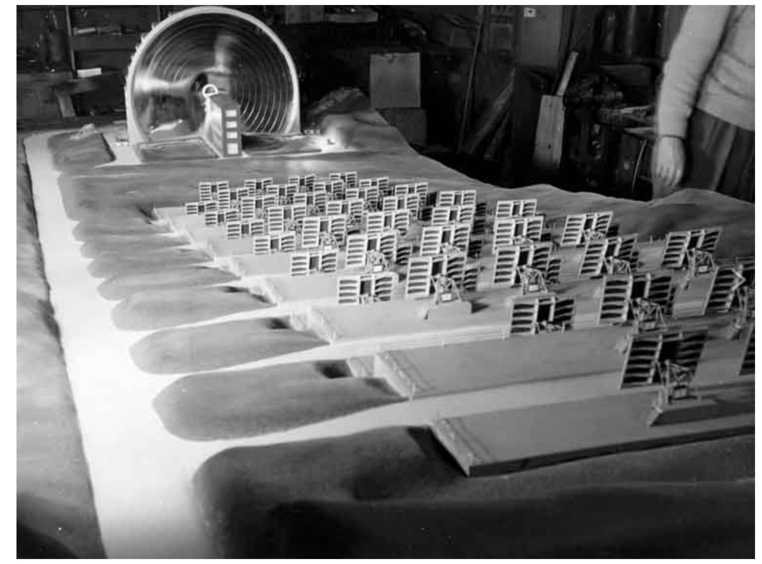
1904 In the United States, Padre Himalaya built his second solar furnace for the Universal Exhibition in St. Louis, Missouri, for which he received the Grand Innovation Prize.



1949
FELIX TROMBE
SOLAR FURNACE IN MONT LOUIS

Half a century later, French engineer Félix Trombe takes over the production of high temperatures with solar furnaces.

1949 He contructs a solar furnace in Mont-Louis, France, with which he is able to obtain temperatures as high as 3'000°C. His goal was to melt metals and extract very pure substances, in order to make new and more effective refractory materials. This led to Centre National des Recherches Scientifiques (CNRS), which had supported Felix Trombe's experiments, to create a subsidiary (ProMES) specialized in solar research - and solar research becomes a national concern.



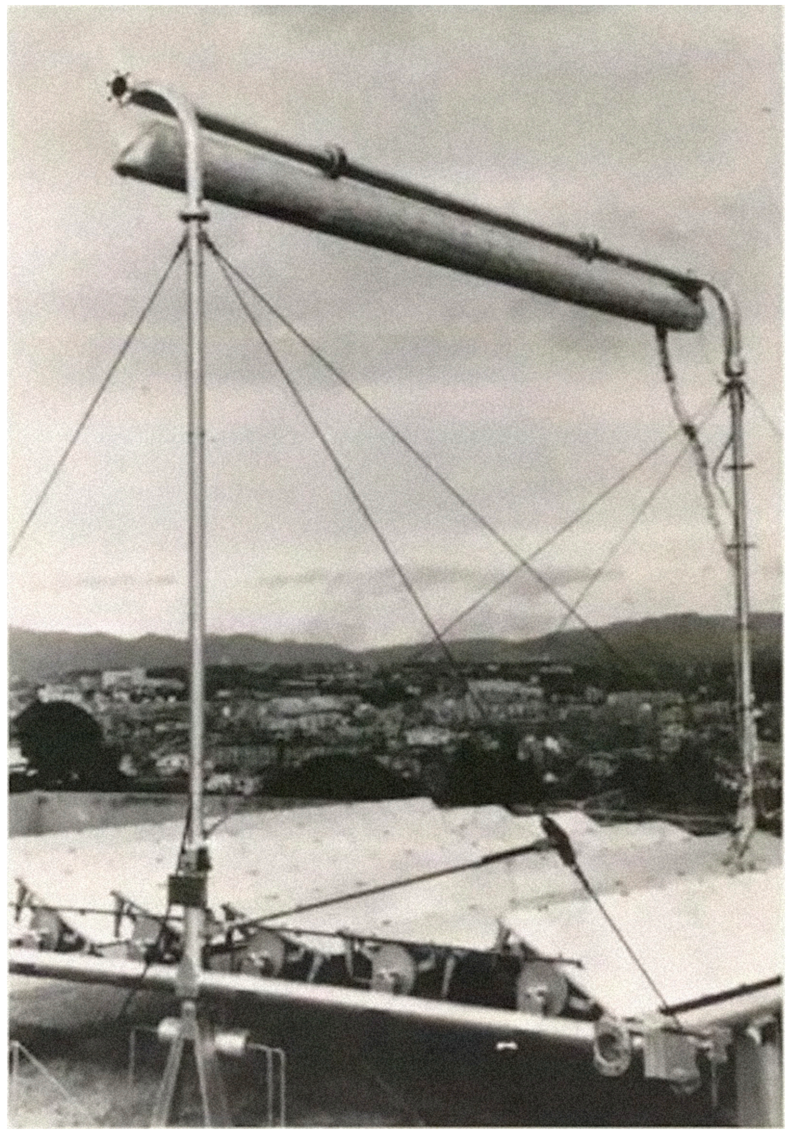
1958
CNRS
MODEL FOR THE PROJECT OF SOLAR FURNACE IN ODEILLO, FRANCE

1969
CNRS
CONSTRUCTION OF THE SOLAR FURNACE AND HEADQUARTER BUILDING IN ODEILLO, FRANCE

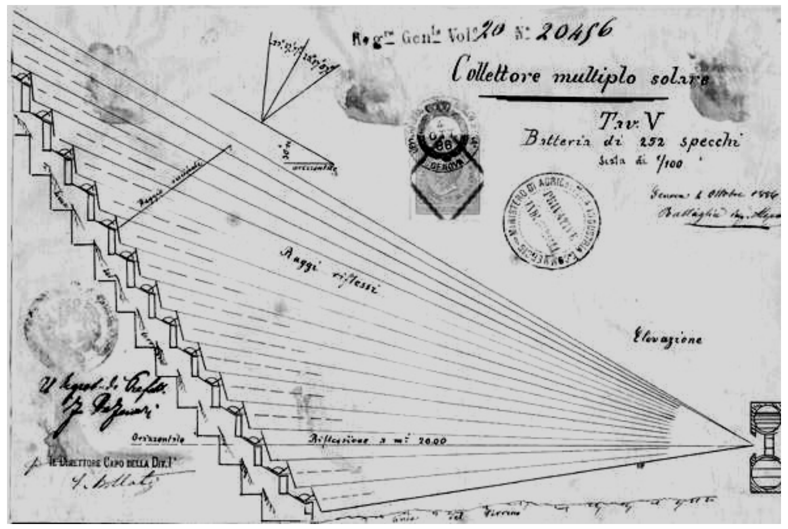
1969 The CNRS builds a solar furnace in Odeillo destined for research, and moved the ProMes headquarters from Mont-Louis into the new building of the furnace. The furnace consisted of a 54 meter high and 48 meter wide parabolic mirror and a field of 68 heliostats. It was the first and only heliostat field in the world at that time.

The oil crisis reorientated the solar research towards electricity production - then produced via fossil fuels. Until then, all solar technologies had been used for mechanical application or, in the case of the solar furnace, for chemistry and metallurgy. The CNRS also began the research for heat storage in chemical fluids.

4
G. FRANCIA'S SOLAR POWER TOWER

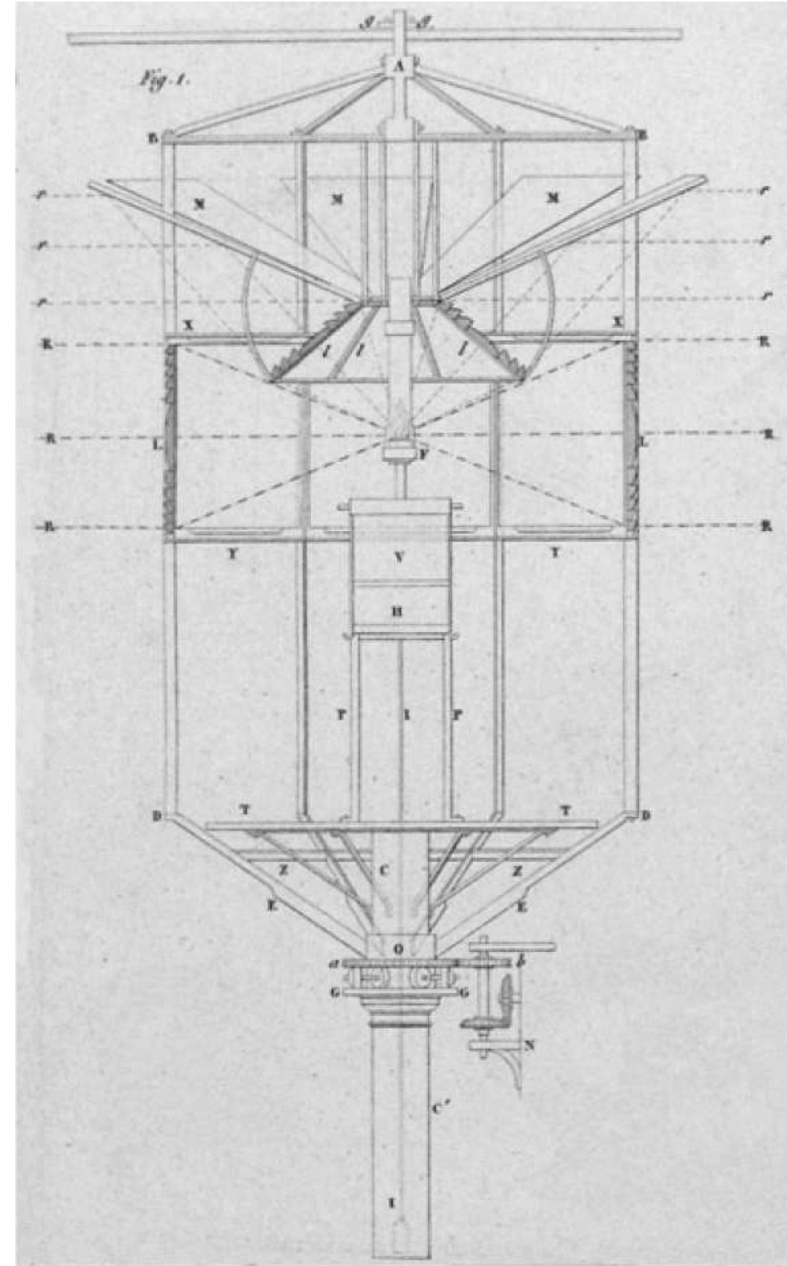


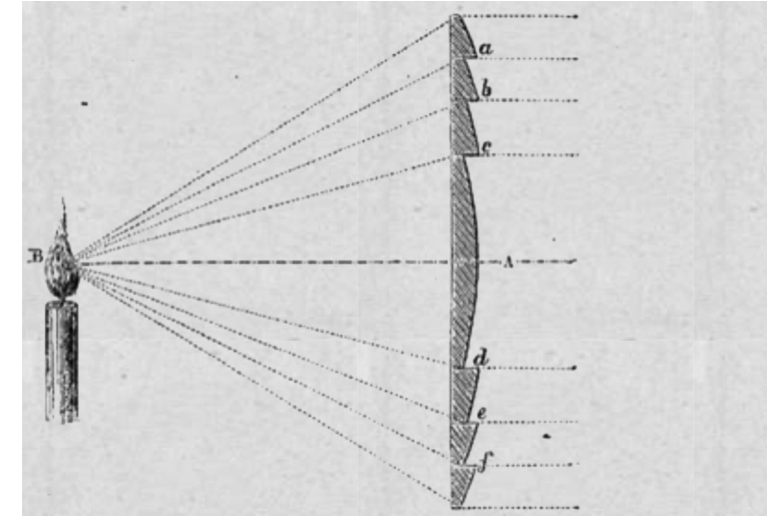
1960
GIOVANNI FRANCIA
LINEAR FRESNEL REFLECTOR SOLAR PLANT IN MARSEILLE



1960
ALESSANDRO BATTAGLIA
PATENT DRAWING FOR LINEAR FRESNEL REFLECTOR SYSTEM

1960 Italian engineer Giovanni Francia was working on solar technologies to produce electricity on a large scale. In collaboration with the CNRS, having shifted their interest towards electricity production, Francia built a prototype in Marseille. The system they developed was a linear fresnel reflector, which another italian engineer, Alessandro Battaglia, had already been working on. The fresnel system was the first step in dividing a unique curved reflecting surface into multiple punctual entities, the heliostats. This was an answer to the challenge of constructing large-scale solar stations.



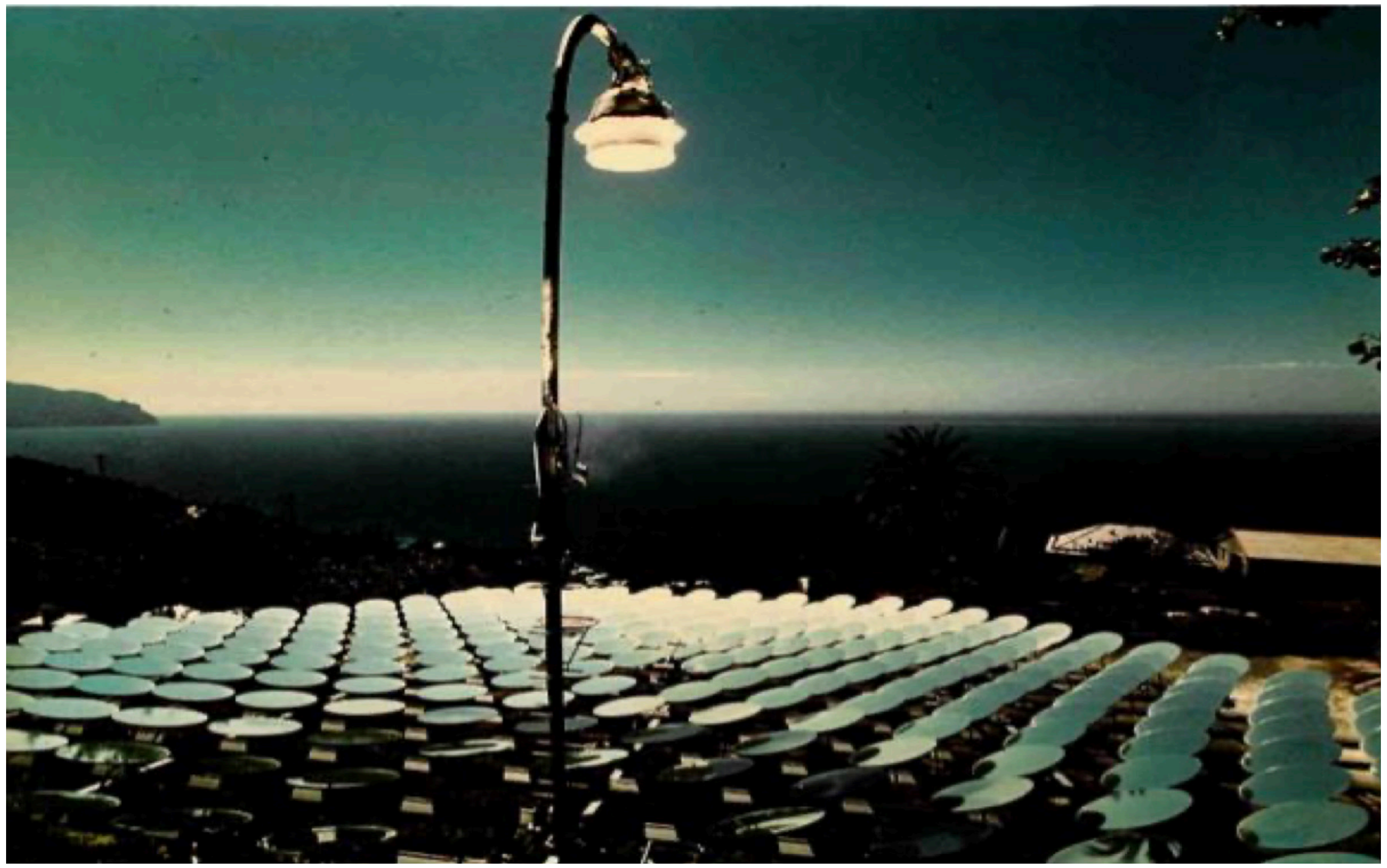


1822
AUGUSTIN FRESNEL
PLAN OF LIGHTHOUSE WITH FRESNEL LENSES

The fresnel system goes back to a lens developped by french engineer Augustin Fresnel in the 1820's for lighthouse lanternas. In his case, he used this lens to diverge the rays of puntual source light source.

1821
GOOGLE MAPS (2020)
ARC DE TRIOMPHE IN PARIS, FRANCE

1821 A prototype of A. Fresnel's the lighthouse lanterna was mounted for testing on the Arc de Triomphe, then under construction, for observers kilometers away to evaluate the effectiveness of the light.

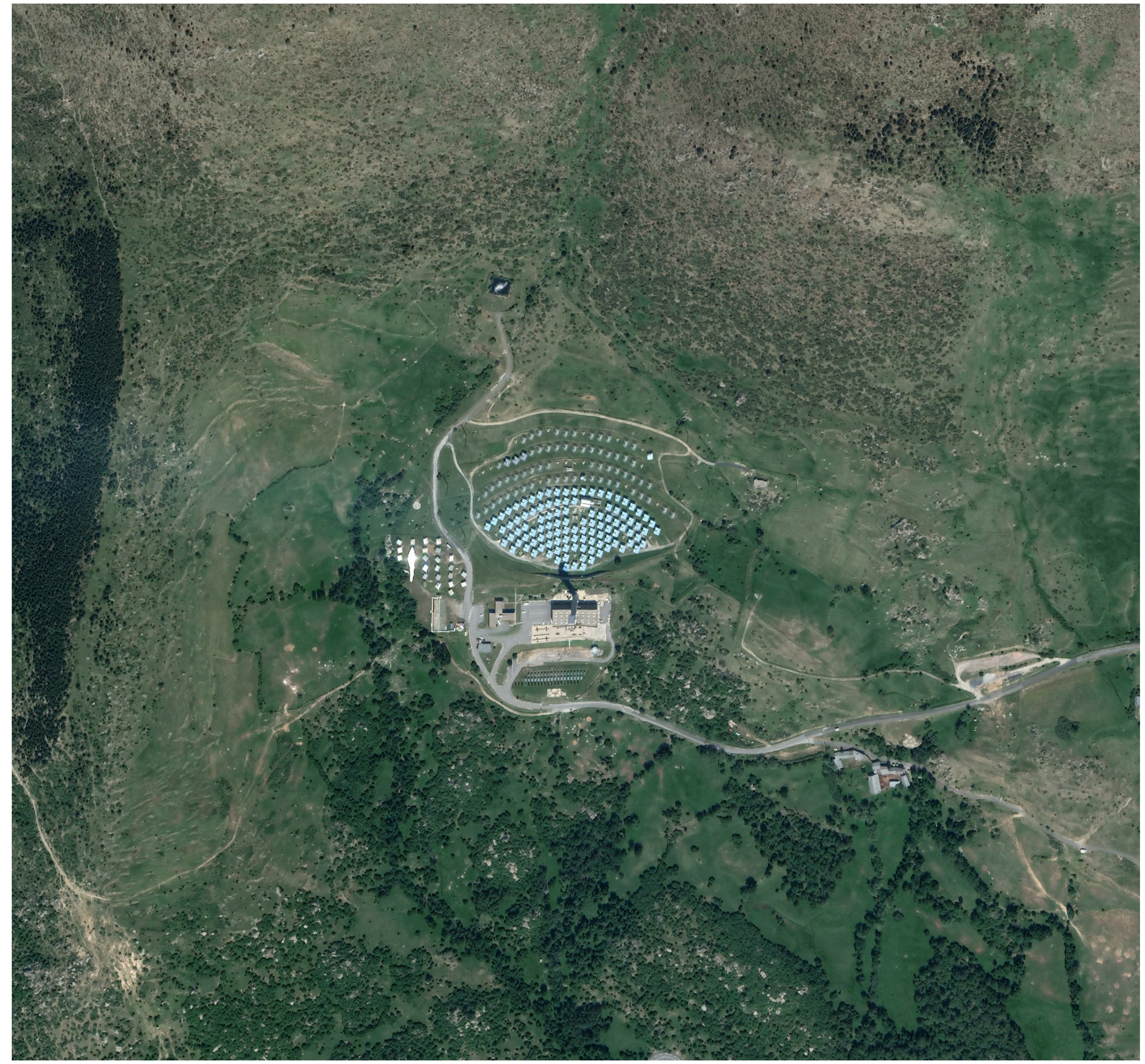


1965
GIOVANNI FRANCIA
SOLAR POWER PLANT WITH POWER TOWER IN SANT'ILARIO, ITALY

1965 Giovanni built the first solar tower system in Sant'ilario, but this time for the italian authorities. The fresnel system was the first step of dividing the curved reflector into smaller independant and punctual entities - heliostats. The sant'ilario power plant was the first to use an array of circularly arranged heliostats, concentrating the sun rays onto a receiver placed in elevation in the center, thus enabling the system to function on a much larger scale.

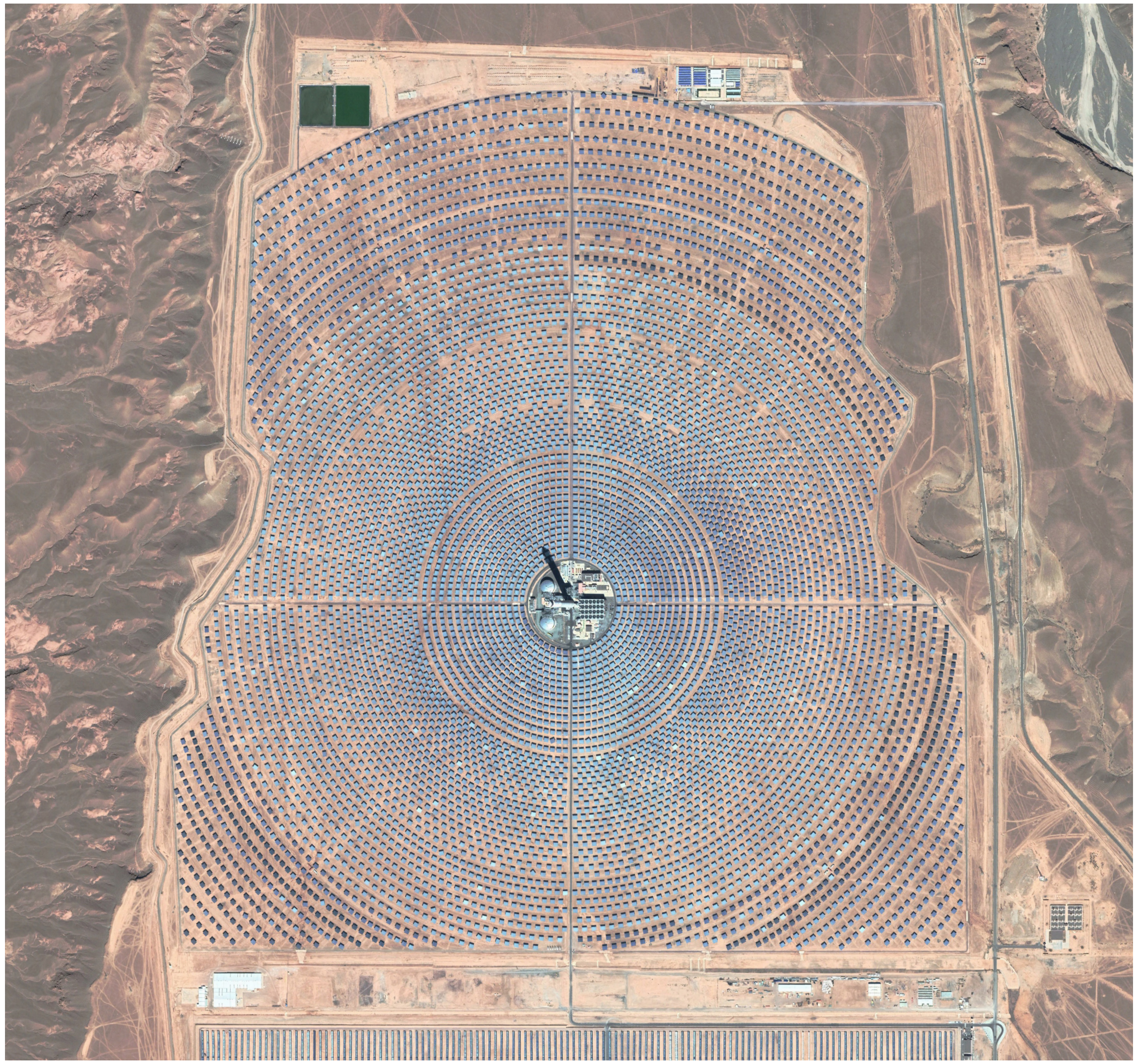
1981
ENEL
EURELIOS SOLAR PLANT WITH POWER TOWER IN ADRANO, SICILY

1981 Francia's research concretized itself over a decade later. Eurelios in Adrano, Sicily, the world's first large-scale power tower, started feeding electricity for the Italian national grid. A report of ENEL, the Italian national electricity board, in 1991 stated that : « This conclusion, which is shared by the great majority of world experts, leads us to think that tower and mirror-field solar plants will not give rise, even in the medium and long term, to industrial applications of any importance ». The plant was deactivated, and eventually dismantled in 2011.



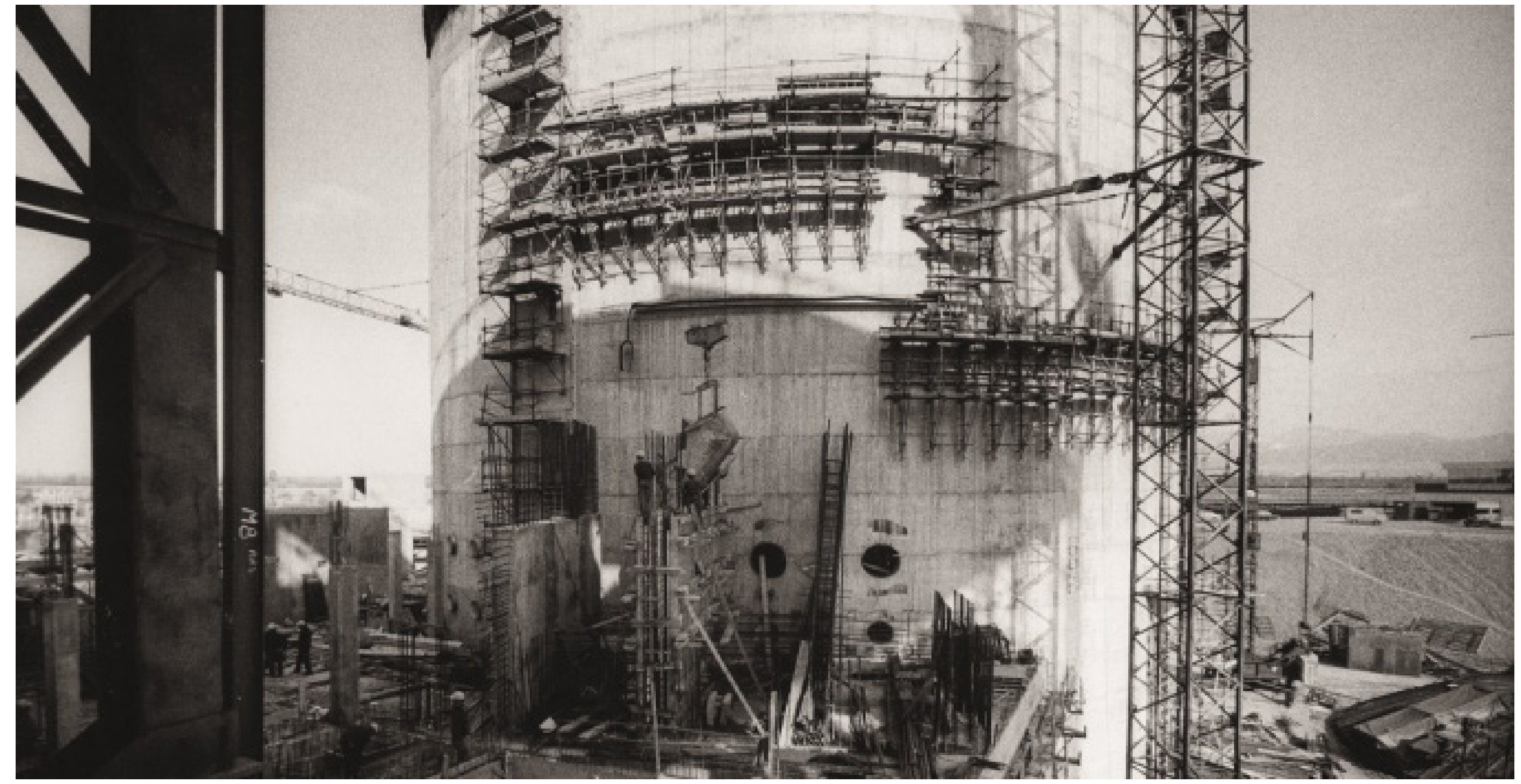
1983
GOOGLE EARTH (2018)
THEMIS SOLAR PLANT WITH POWER TOWER IN TARGASSONE, FRANCE

1977 The CNRS started planning the Themis solar plant according to Francia's solar tower system. It started operating and producing electricity for the national grid between 1983 and 1986. After the success of nuclear energy in France it was put on hold, and since the 2000's revived for research purposes. It was among one of the first solar power tower plants in the world.



2018
GOOGLE EARTH (2020)
POWER PLANT WITH POWER TOWER IN OUARZAZATE, MOROCCO

In spite of every previous project of solar power towers being considered too inefficient, the design of the future solar powers built since the 2000's hasn't evolved much. They have only been made more efficient, and since the 2010's are the favored form of solar plant.

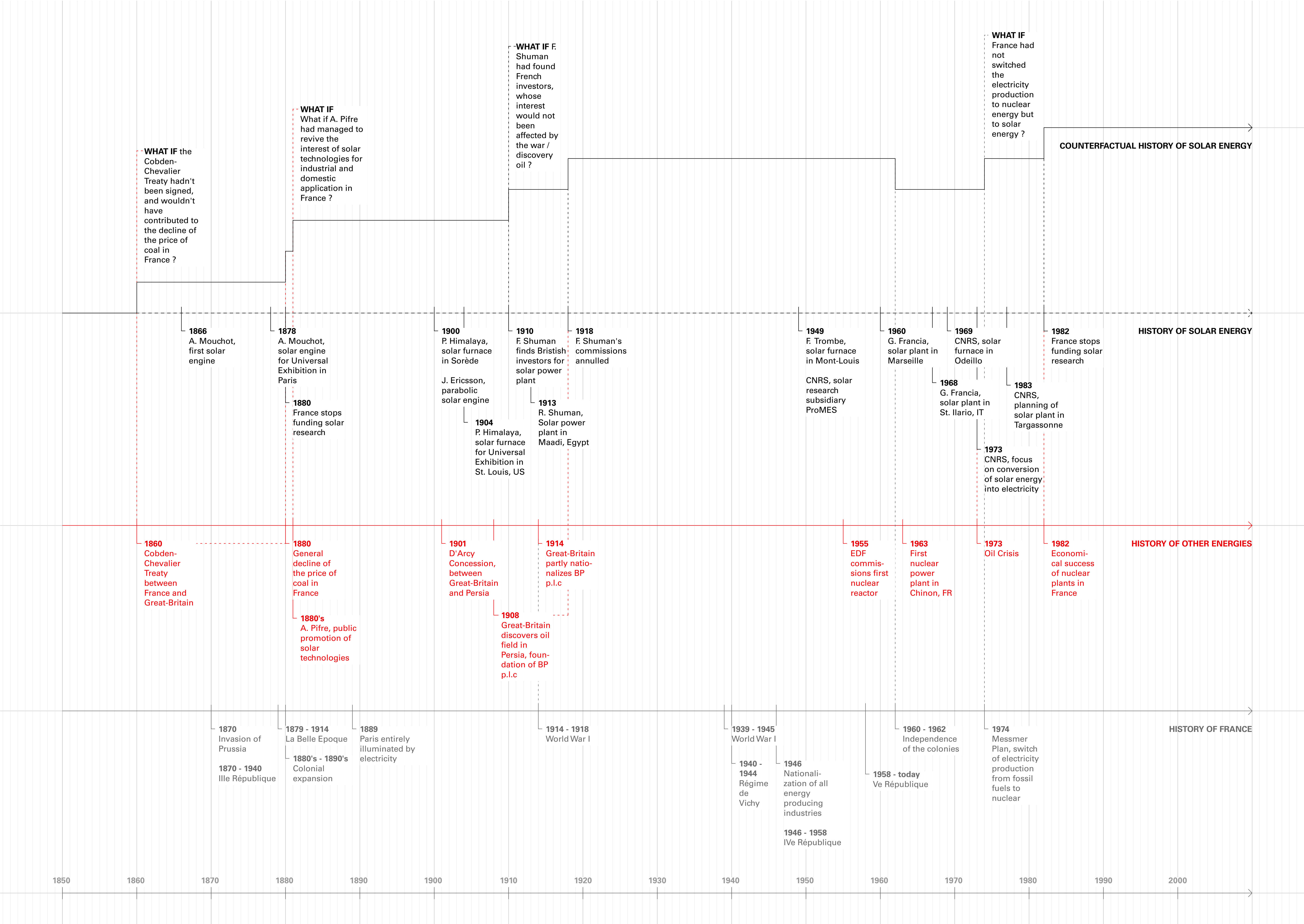


1977
CNRS
CONSTRUCTION OF A NUCLEAR POWER PLANT IN FESSENHEIM, FRANCE

By 1946, France had nationalized all energy producing industries. In the late 1950's, France started researching nuclear power for civil use and inaugurated her first nuclear power plant in 1963 in Chinon.

The oil crisis of 1973 amplified France's concerns about their lack of indigenous energy resources and the need for energetic independence. In 1974, the Prime Minister Pierre Messmer annouced : « It is true that France has not been very favored by nature in terms of energy resources. We have almost no oil on our territory, we have much less coal than England and Germany, and less gas than Holland. Our great fortune is our nuclear power ». He took the decision to shift all electricity production from fossil fuels to nuclear energy, and established the Messmer Plan, aiming to build 13 nuclear power plants in the following two years, and then continue with a rhythm of 6 per year. Today, France produces 70% of her electricity from nuclear energy.

WHAT IF the previous investments in solar technologies and their progress in our alternative history had culminated into France not investing in the construction of nuclear power plants in 1974, but in the construction solar power plants ?



WHAT IF the Cobden-Chevalier Treaty hadn't been signed, and wouldn't have contributed to the decline of the price of coal in France ?
WHAT IF What if A. Pifre had managed to revive the interest of solar technologies for industrial and domestic application in France ?
WHAT IF F. Shuman had found French investors, whose interest would not been affected by the war / discovery oil ?
WHAT IF France had not switched the electricity production to nuclear energy but to solar energy ?
COUNTERFACTUAL HISTORY OF SOLAR ENERGY
1866 A. Mouchot, first solar engine
1878 A. Mouchot, solar engine for Universal Exhibition in Paris
1880 France stops funding solar research
1900 P. Himalaya, solar furnace in Sorède
J. Ericsson, parabolic solar engine
1904 P. Himalaya, solar furnace for Universal Exhibition in St. Louis, US
1910 F. Shuman finds British investors for solar power plant
1913 R. Shuman, Solar power plant in Maadi, Egypt
1918 F. Shuman's commissions annulled
1949 F. Trombe, solar furnace in Mont-Louis
CNRS, solar research subsidiary ProMES
1960 G. Francia, solar plant in Marseille
1968 G. Francia, solar plant in St. Ilario, IT
1969 CNRS, solar furnace in Odeillo
1973 CNRS, focus on conversion of solar energy into electricity
1982 France stops funding solar research
1983 CNRS, planning of solar plant in Targassonne
HISTORY OF SOLAR ENERGY
1860 Cobden-Chevalier Treaty between France and Great-Britain
1880 General decline of the price of coal in France
1880's A. Pifre, public promotion of solar technologies
1901 D'Arcy Concession, between Great-Britain and Persia
1908 Great-Britain discovers oil field in Persia, foundation of BP p.l.c
1914 Great-Britain partly nationalizes BP p.l.c
1955 EDF commissions first nuclear reactor
1963 First nuclear power plant in Chinon, FR
1973 Oil Crisis
1982 Economical success of nuclear plants in France
HISTORY OF OTHER ENERGIES
1870 Invasion of Prussia
1870 - 1940 IIIe République
1879 - 1914 La Belle Epoque
1880's - 1890's Colonial expansion
1889 Paris entirely illuminated by electricity
1914 - 1918 World War I
1939 - 1945 World War I
1940 - 1944 Régime de Vichy
1946 Nationalization of all energy producing industries
1946 - 1958 IVe République
1958 - today Ve République
1960 - 1962 Independence of the colonies
1974 Messmer Plan, switch of electricity production from fossil fuels to nuclear
HISTORY OF FRANCE
1850
1860
1870
1880
1890
1900
1910
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1930
1940
1950
1960
1970
1980
1990
2000