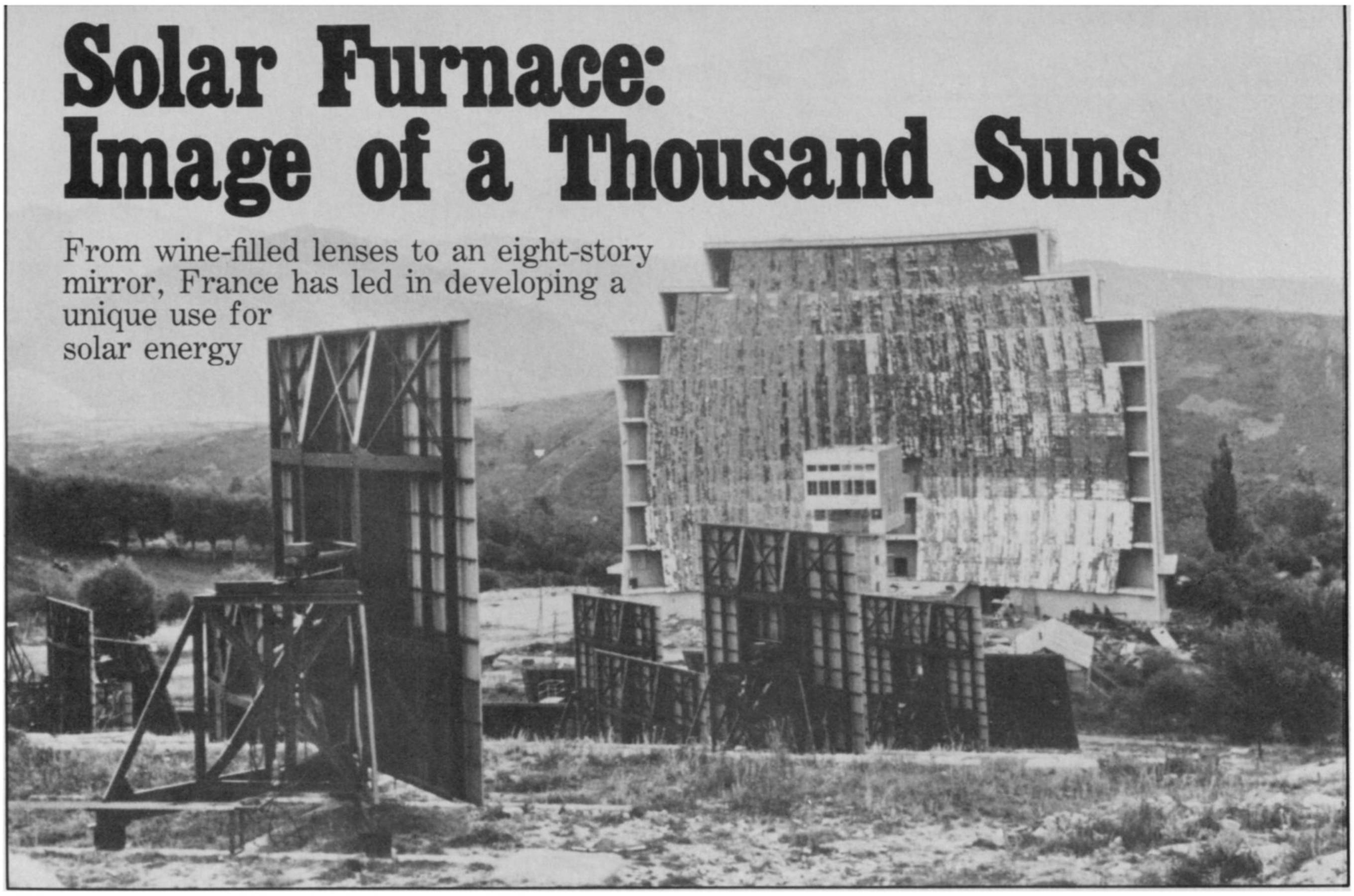
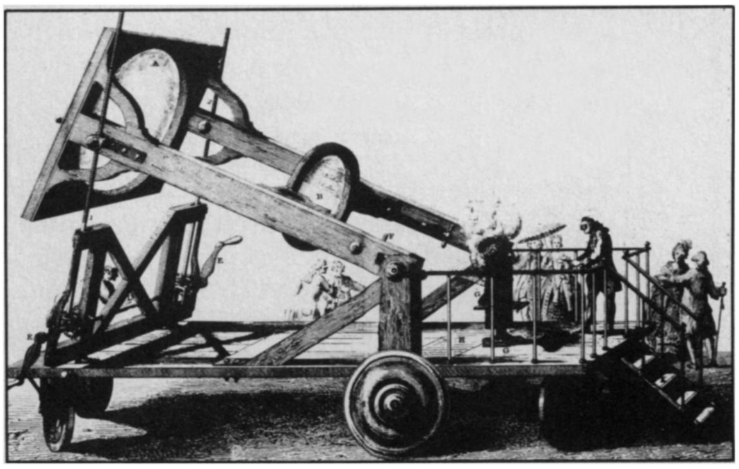
Solar Furnace: Image of a Thousand Suns

From wine-filled lenses to an eight-story mirror, France has led in developing a unique use for solar energy



Le Four Solaire d' Odeillo

BY JOHN H. DOUGLAS



Flat, movable heliostats track sun and reflect its beams onto main parabolic mirror (above). Lavoisier melted steel with his early solar furnace; lenses were made of hollow glass filled with wine.

In the late 18th century, the great French chemist Antoine Lavoisier built a sophisticated solar furnace capable of melting steel and even platinum and of reducing a diamond to graphite. For the task, he focused the sun's rays on a target using two huge lenses made of hollow curved glass, filled with wine spirits (only the French!). Today, France again leads the field of high-temperature solar devices with its eight-story-high parabolic reflector in the Pyrenees. It hopes to market commercial versions around the world.

The giant parabola, and the mountainside of flat mirrors that keep the sun's light trained on it, make a strange sight in this mile-high ski resort area. The steep, snowy terrain—served by an ancient wooden rail car—receives about one kilowatt of solar energy per square meter, which is concentrated a thousand-fold by the parabola. The weather is not ideal, but about 1,200 hours operation per year can be logged by the furnace.

The reason for building such a relatively expensive heating device is that some high-temperature experiments cannot be conducted in conventional units and under some circumstances smaller models may someday become commercially competitive. One unique feature of the furnace is that the heat comes from only one direction, along a beam. This allows hollowing out the center of solid blocks of material, for example, to make crucibles. By opening and closing a giant shutter, sudden bursts of energy can hit a target. Such "thermal shocking" is becoming increasingly important in materials research. Finally, by having the light beam pass through a quartz window into a closed chamber, materials can be melted in a very closely controlled atmosphere to prevent contamination—a difficult trick with many furnaces.

Operation of the facility is simple in principle but requires sophisticated electronics to perform. The parabola, which faces north, is built into one wall of a thin building that holds offices and laboratories for the scientists at Odeillo. In front of it, on the mountainside, the south-facing flat mirrors, called heliostats, must be carefully controlled to track the sun's movement. Fully 70 percent of the cost of the installation was devoted to these heliostats. Lavoisier could simply have an assistant turn a crank to make his lenses follow the sun, but coordinating the movements of the 63 large mirrors so as to provide just the right amount of overlap on the parabola to give a uniform beam on the target, requires complex automation. Also, the 18-by-23-foot heliostats must be able to withstand the 60-mile-an-hour winds that frequently whip around the mountain. Precise adjustment of the heliostats took two years.

Light from the heliostats reflects from 9,500 mirror facets that make up the giant parabola onto a focal point 18 meters away, where a small, raised control center houses targets up to 200 square centimeters in area. Temperatures as high as 3,800 degrees C can be obtained with some targets. The concentrated light beam will begin to melt through a 10-millimeter-thick steel plate in only 3.5 seconds.

Already the unique characteristics of the furnace have been exploited to advantage in conducting a variety of experiments:

- The United States has contracted with the French to use the Odeillo facility to subject radomes to thermal shock. These devices are the nonmetallic covers used on aircraft and missiles to protect sensitive radar equipment, while permitting radar microwaves to pass through unhindered. Only a solar furnace can provide the needed burst of pure energy, from one direction, on such a large surface. To perform the operation, shutter doors are placed a few feet in front of the focal point; they must be water cooled and can open and shut in about one-tenth of a second.

- When crucibles are made from refractory (heat-resistant) materials for use in preparing alloys, the materials must often be chosen for their ease in manufacturing rather than suitability to the particular alloy. Using a slowly turning centrifuge that opens toward the beam of light in the solar furnace, however, a crucible can be hollowed out of a solid piece of material chosen solely for its refractory properties. An industrial crucible of 80 liters can be prepared by this method in about two or three hours. Crucibles made from such exotic substances as boron can also be made by casting material melted in a controlled atmosphere, using the furnace's special chamber.
- Plans are underway at the furnace to test boilers for proposed solar power generating stations, to determine the best surface materials, geometric shapes and working cycles. To be efficient, such power stations must operate at very high temperatures, which will require considerable research on boiler design. Several countries including France and the United States (SN: 8/16/75, p. 109) have launched pilot studies of such "power tower" concepts, and the Odeillo facility will be one of the few places in the world that suitable testing can take place.

Claude Royere, chief of operations of the solar furnace, described to SCIENCE NEWS French hopes for the eventual commercial viability of this type of installation. In tropical countries, especially those with large desert areas, scattered population and few natural resources, small-scale solar furnaces might be used for such mundane tasks as baking bricks. Such a project could, for example, keep villagers from cutting down scarce trees for firewood—a growing problem in many areas (SN: 9/27/75, p. 198). Even in some developed countries, solar furnaces might enable a mine operator to partially process his ore before shipping it to market. Such smelting could be done in remote areas without the need for nearby power generation and without causing the pollution usually associated with such processing.

The key to such plans, Royere says, is the lowering of heliostat costs through mass production, which may follow development of the "power tower" concept. France clearly has a substantial head start in solving some of the problems involved in the sophisticated technology of high-temperature solar devices. □