LASING IN THE SUN

Applications abound for a new energy converter — both on earth and in space

BY JANET RALOFF

It might just prove to be a phoenix. Born last year as embers of government interest in developing and funding the Solar Power Satellite (SN: 4/22/78, p. 256) lay dying, this fledgling could ultimately revive interest in SPS, or illuminate new vistas — such as the launching and propulsion of laser-powered vehicles. Alive and well, the major question facing the first solar-pumped gas laser is, "Will it fly?"

The laser was actually pumped, or powered, with a four-kilowatt sunlight simulator for the first time last October by a research team at the National Aeronautics and Space Administration's Langley Research Center in Hampton, Va. In the gas-laser system being developed by Willard Weaver and Ja H. Lee, incoming sunlight excites an iodine compound and raises it to a higher energy level. The unstable excited molecule then fights to relax to its initial energy state. It accomplishes this decay through lasing — emission of its excess energy in the form of light photons.

Earlier efforts to power a solid laser with sunlight died when the lasing medium — a neodymium rod — proved unable to dissipate waste heat quickly enough. The newer gas laser avoids that problem by passing or cycling its lasant — currently fluoropropyliodide (C_3F_7I) — rapidly through the tubular conduit where lasing occurs.

So far, because of the particular gas used, this first-generation solar gas laser is anything but efficient. In fact, it is sensitive to a mere one percent of the total solar spectrum, the 250-to-290-nanometer range. And according to a report to be published in the July APPLIED PHYSICS LETTERS, while its sunlight-to-laser efficiency measured was 50 percent of the theoretical limit, that was still only 0.1 percent.

The lasing chemical has another drawback. "As it lases it self-destructs," Weaver says. Photochemical breakdown pulls iodine (I_2) out of the molecule, contaminating what remains; if the iodine isn't removed, it will eventually quench the lasing. Ideally, processing steps should be added to the laser system to filter out contaminating breakdown products and to chemically rebuild the original C_3F_7I. This could permit a closed-loop continuously operating laser.

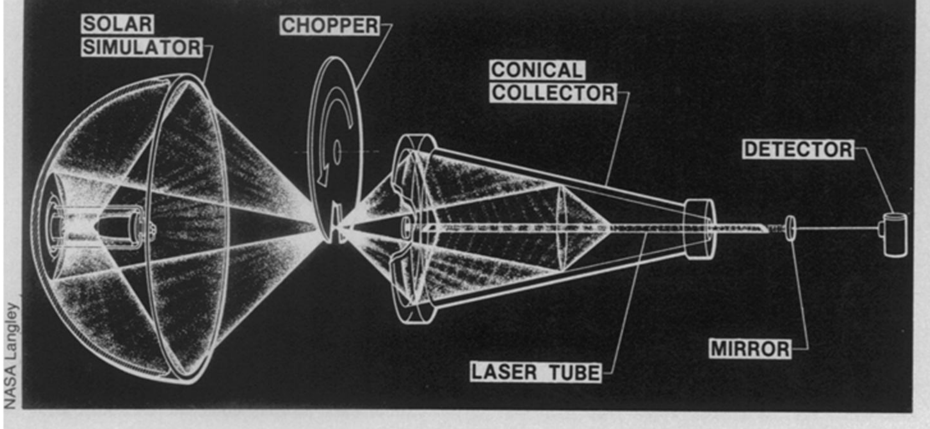
Even running the sun simulator at peak power, "We've only gotten five watts out," Weaver says. But he adds that European tests with the lasant indicated it could deliver up to a trillion watts and operate at temperatures up to 700 K. While these criteria led to the NASA researchers' interest in the chemical, they're still scouting for better candidates. One that has captured their attention is an arsenic-iodine compound that can tap seven percent of the solar spectrum and is less susceptible to chemical self-destruction. "But if we could make noodle soup lase efficiently, we would use it," Weaver jokes.

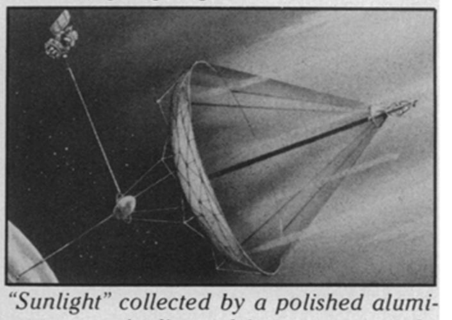
How the laser might be harnessed will be discussed this August at the 16th Intersociety Energy Engineering Conference in Atlanta. Among envisioned uses are beaming of power from solar-pumped laser stations in orbit to propel aircraft traveling about the earth's upper atmosphere, to propel orbital-transfer vehicles (carriers to transport cargo from space-shuttle orbit, perhaps 100 miles up, to geosynchronous-satellite orbit, roughly 22,000 miles up), or to propel missions into the farther reaches of the solar system. Used to launch vehicles from the moon, or to power materials-processing outposts in space, it also could save the cost of ferrying propellants and nonrenewable fuels into space, notes F. Carl Schwenk, manager of NASA's Space Utilization Systems office. And while Weaver won't discount the military's potential interest in the technology for killer satellites, he suggests the most likely near-term application would be to beam concentrated thermal energy to earth-based stations — a laser version of the popular Solar Power Satellite. SPS, whose funding dried up this year, would have transmitted power collected in space to earth via microwaves.

"Lasers always allow you to make things smaller," Schwenk says, explaining why they could eventually revive the costly and beleaguered SPS concept. Both earth and ground-based laser-energy receivers could be made smaller than those that would have been used in the minimum-size microwave-SPS scheme. While the numbers bandied about vary, Weaver sees a solar collector in space on the order of 300 meters in diameter for a 100-megawatt laser-power system. (One assumption included in the planning is that eventual laser systems would run at a 10 percent overall efficiency for solar-energy conversion.) In contrast, an envisioned 5,000-MW microwave SPS would need a solar collector on the order of 29 square miles in size. Earth-based receivers for energy beamed down would be likely to range from a football-field-sized collector for laser-power systems to one the size of Rhode Island for the microwave-power scheme.

But perhaps the major tradeoff between schemes is power availability. Only large thunderstorms are likely to seriously attenuate microwave-power transmission to earth, whereas moderate clouds could hinder or obliterate laser beams. A November 1980 study by R. E. Beverly concluded that outside the Southwest, "power availabilities in excess of 80 percent are unattainable in most geographical regions of the United States if only a single receptor site is available for each transmitted laser beam." Multiple ground stations, hundreds of miles apart, would lessen the problem somewhat. There has been speculation about whether the laser could bore holes in clouds, but it's not clear that beams with wavelengths as small as the Langley group's laser would deliver can be counted on to do so.

Right now, Weaver doesn't worry about that. His team has proved that the solar-laser works. That's only a "meager first step," he admits, but "from here we hope it's really going to grow." □





"Sunlight" collected by a polished aluminum cone is directed into a quartz tube where it excites a gas into lasing (left). Exiting laser beams could power spacecraft or earth energy stations (above).