tural economist says.

Although it may be possible to engineer changes in the environment to at least partially compensate for natural limitations — such as by fertilizing fields to increase yields — a "law" of diminishing returns comes into play, Brown says. A point is reached at which each additional increase in fertilizer brings smaller increments of benefit, he says. At the end, the increased benefit of using more fertilizer is offset by the cost of the fertilizer or of applying it. This same law of diminishing returns applies, he says, to drilling for oil and gas, to mining raw materials, even to the ability of the environment to absorb pollutants. "Technological advances may more than offset declines in resource quality for awhile," Brown writes, "but at some point the most ingenious attempts to compensate for nature's limitations will no longer be adequate."

Ken Chen and Karl Lagler, in their 1974 book *Growth Policy,* further argue that policymakers exacerbate the problem by using technology to relax ecosystem constraints rather than to curb rates of growth and consumption. Technological answers generate many new problems, they say, because until now technology "has been able to wield its power primarily by bleeding natural resources and the environment."

Brown claims that scarcity-induced price hikes in resources are among "new inflationary forces" shaping the expanding world economy. The way to manage these new forces may not be to manipulate economic theory so much as to require simpler life styles among the affluent and new policies that stress sustainability rather than growth, he says.

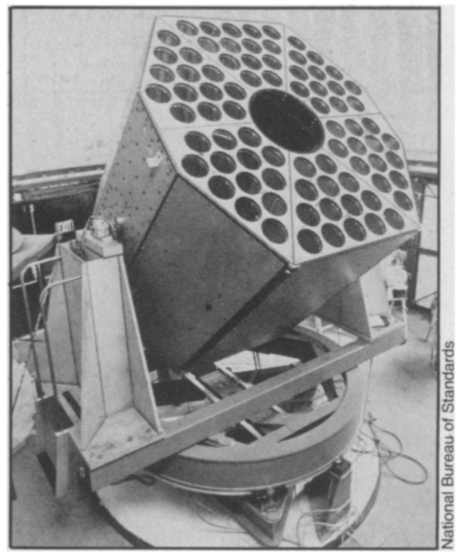
One way nations have maintained "reasonable" unemployment rates with growing populations is by sustaining a growing economy, Brown writes. But as economic growth slows globally—and signs already indicate this is beginning, he says — the unemployment situation will loom more persistently. Coping with a permanently low- or no-growth economy will be a challenge, he predicts; society will have to change radically.

He foresees resource-conserving, labor-intensive societies that require resource recycling and energy conservation. Population planning will have to accompany economic planning, he thinks. And developing countries must detach themselves as much as possible from the economic state of developed countries, he says. Those developing countries may be able to maintain their economic growth—beyond the period or throughout the period that developed countries do — if they look to sharing resources and technologies among themselves, he says.

To tackle the difficult transition ahead, Brown says, economists must learn now to factor the state of biological systems into their forecasts and policies as they now factor in energy considerations. □

# Seeing the sky through a fly's eye

People tend to think of a telescope as something to look through. Publicity drawings of even the largest and latest of astronomical telescopes tend to show a human figure bent over an eyepiece. Yet there is little or no actual looking through telescopes nowadays — except possibly for the hell of it. Pointing of modern telescopes is done by computer and the actual observing is done by various photomultipliers or solid-state photoregistration devices.




An eye at the eyepiece is even more superfluous when what the telescope seeks is a laser beam reflected from the moon. Better a device that can tell precisely where that came from. Also superfluous is the rather large field of view of the usual astronomical telescope. The Apollo 11 astronauts left the retroreflectors that receive the laser beams sent from earth and bounce them back in well-determined locations. What was desirable was a telescope that gathered a lot of light from a small and, by astronomical standards, extremely well-determined area. These considerations led James E. Faller, a physicist with the Joint Institute for Laboratory Astrophysics in Boulder, Colo., an organization jointly operated by the National Bureau of Standards and the University of Colorado, to design what is called for obvious reasons the fly's eye telescope.

Instead of the single fairly large aperture of the usual astronomical telescope, Faller combined 80 small ones, each 19 centimeters in diameter. Because of the small size of the apertures he could use lenses instead of the mirrors customary in ordinary telescopes. The 80 apertures all look at the same narrow area, and the light received by all of them is combined by further optical arrangements inside the instrument. The result is a fairly large total aperture or light-gathering capacity concentrated on a narrow area of the target. The instrument looks ungainly, but is compact, light and portable. In fact, the fly's eye was driven to San Francisco, shipped to Honolulu, transferred by barge to the island of Maui and trucked to an observatory on the 3,000-meter summit of Mt. Haleakala.

The Maui station collaborates in the lunar ranging program with another receiving station at the McDonald Observatory of the University of Texas. Maui was chosen after much discussion because it is on a different geotectonic plate — Hawaii is on the Pacific plate; Texas is on the North American—and it might be possible to detect the difference in plate motion between the two. In addition to the lunar ranging program, the fly's eye can also be useful in stellar spectroscopy, photometry and point-source astronomy. □

# Commoner attack on Big Mac, et al

Is nothing sacred? Hamburgers may cause cancer, according to a report at the meeting of the American Society for Microbiology in Las Vegas. Barry Commoner and colleagues at Washington University in St. Louis have found that extracts from beef broth and pan-fried ground beef produce genetic changes in bacteria in the standard Ames test. Mutation-causing agents have been previously identified in meat that was charcoal broiled or cooked directly in a flame. But this is the first example of mutagens formed at ordinary (U.S.) cooking temperatures, researcher David Kreibel told Science News.

"The cooking condition is essential to effect," Kreibel says. Mutagens are generally rated by the number of revertants, erally rated by the number of revertants, bacterial colonies on a laboratory plate that exhibit a specific genetic change. The beef substances, like many mutagens, had to be activated by enzymes from mammalian liver.

Beef stock cooked down to a paste gives 5,000 revertants per microgram, more than five times the potency of nitrosamine (900 revertants per microgram). A quarter of a well-done hamburger cooked in an electric hamburger maker gives 1,000 to 3,000 revertants, about 100 times the background level. A rare-cooked hamburger, however, shows only 10 percent as much mutagenic activity. No activity was found in hamburger broiled in an oven or cooked in a microwave oven.

The explanation for the various degrees of potency is totally a function of cooking temperature, Kreibel proposes. There is good heat transfer if a hamburger is placed