SCIENCE

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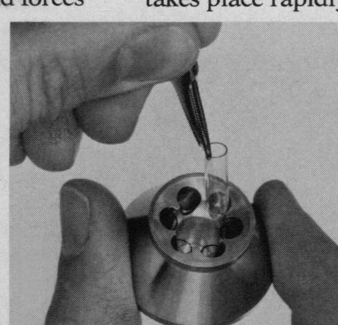

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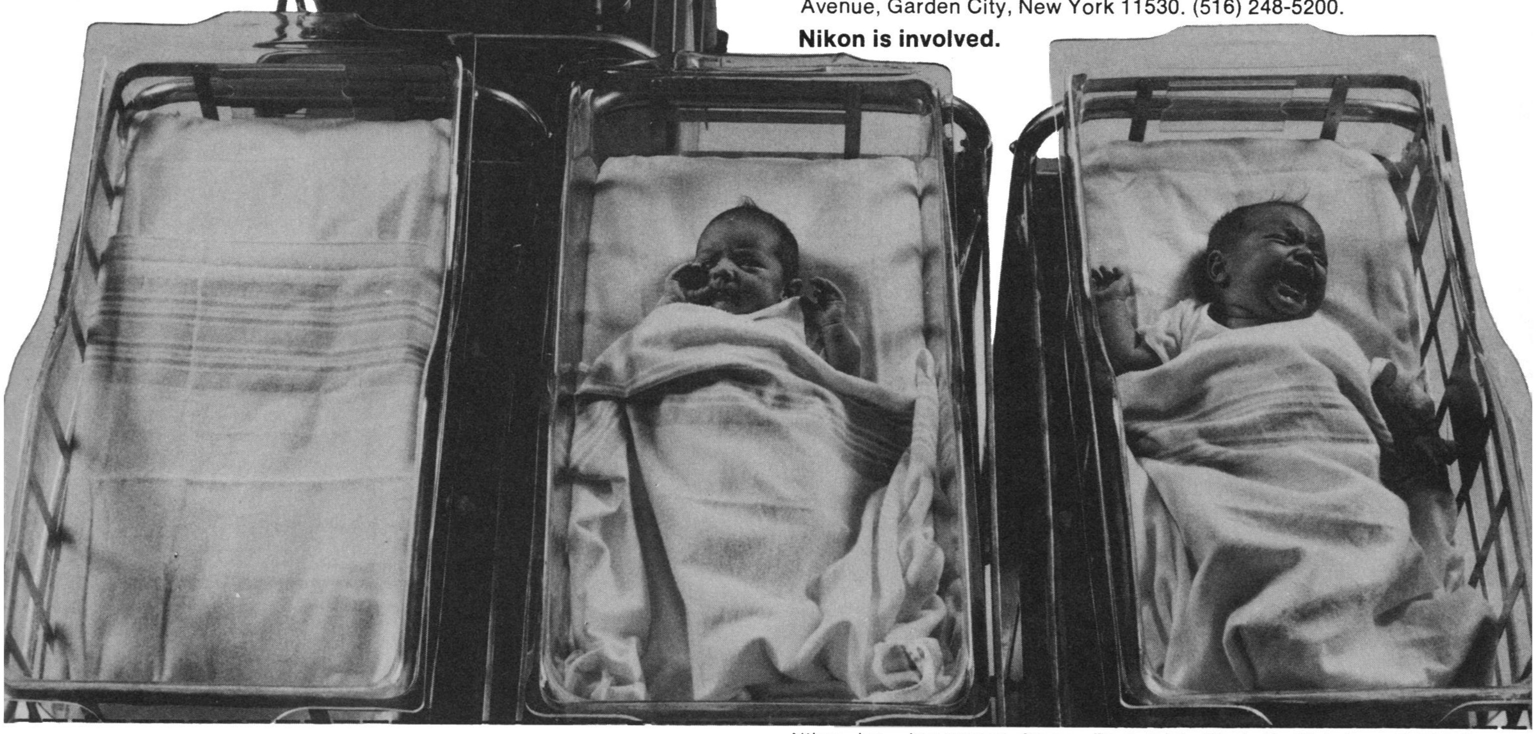

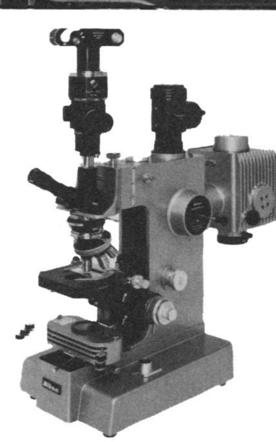

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress. Postmaster: Send Form 3579 to SCIENCE, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005.

COVER

Portion of central China. Lines on side show trend of the Altyn Tagh (alternatively Astin Tagh or A erh chin) fault, perhaps the greatest active continental strip-slip fault in the world. See page 419. [ERTS photo (8) No. 14-490-40625-A0]

consequences are often so painful that governments will usually go to considerable lengths to avoid it. Including the social costs of production in market prices, as Hueckel and others suggest (although the practical difficulties of doing so are substantial), would remedy some of the defects of the market alluded to above, but only by increasing the painfulness of the market's impact on individuals. The critical question therefore is, Do we have the political will to reform the market if this will involve personal sacrifice? or, more colloquially, Who will bell the environmental cat?

This by no means exhausts the issues Hueckel has failed to consider—thermodynamic limits to technological advance, limits to the invention and application of knowledge to human problems, and many other questions only hinted at above (for example, the social and political implications of accepting the "Faustian bargain" of modern technology) that I have discussed in detail elsewhere (*1*). Hueckel has considered technology and the market price system in artificial isolation from ecological and other practical realities. His optimism about future economic and technological growth would therefore appear to be ill-founded.

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Hueckel criticizes the Meadows-Forrester assumption that, with continued economic growth, "world resource usage will approach the corresponding U.S. rate." Hueckel promotes instead the sound theoretical economic position that the technology employed to achieve a given end will reflect the "prevailing structure of the relative prices of those inputs [capital, labor, and resources]." It would seem to follow that poor countries characterized by surplus labor, few natural resources, and a scarcity of machine capital would be utilizing labor-intensive, resource-saving technology.

Hueckel uses the examples of 19th-century England and 19th-century United States to bolster his contention. At that time, appropriate technologies were in the initial evolving state in both countries. Hueckel ignores the fact that today's nonindustrialized country *imports* technology along with a host of social images reflecting what is the appropriate salary and lifestyle of an employee in the modern sector. The despair of development economists is that, lacking indigenous technologies, underdeveloped countries are forced to "select" the capital-intensive, labor-saving technology which appropriately enough reflected the then optimal input mix of the Western countries creating it.

The continuation of this practice seems certain for as long as the most promising students from underdeveloped countries are sent abroad for a postgraduate education in the "most advanced" technologies. Attempts are now being made to create research institutes in underdeveloped countries themselves, but whether these centers will come up with technologies that will weaken the relationship between economic growth and increased use of nonrenewable resources is a question open to much debate, as is the question of how soon such innovations would be dispersed in the field. The lag time between innovation and widespread acceptance is also a crucial factor in forecasting the West's needs in a time of changing resource prices.

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Hueckel states that "the high pressure [steam] engine was cheaper to build but apparently was more extravagant in its fuel requirements." High pressure steam means high temperature steam which gives a greater thermodynamic efficiency according to the following relationship.

$$\text{Efficiency} = \frac{\text{Inlet temperature} - \text{Exhaust temperature}}{\text{Inlet temperature}}$$

A high pressure steam engine delivers more power for less fuel than a low pressure engine. In addition, a high pressure engine probably produces more power per unit weight, which would mean that less material would be required for its construction.

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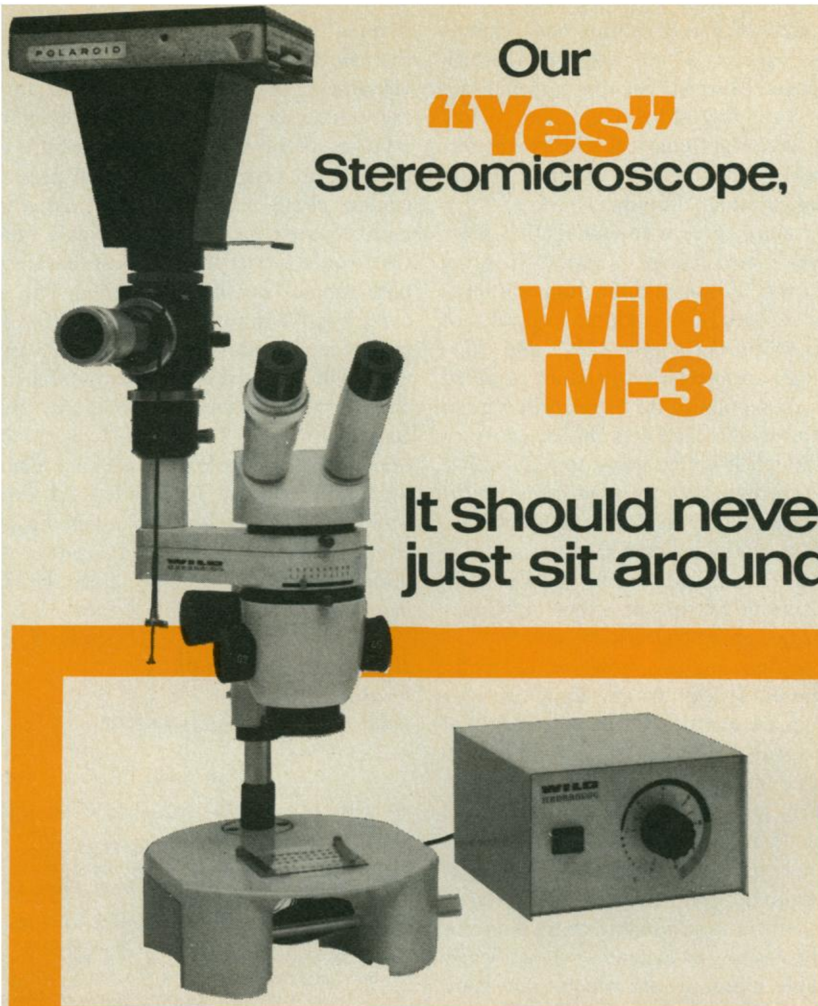
Although much of my article was devoted to the question of physical limits to economic growth, of the letters printed here, only Edens' is explicitly concerned with that issue. Ironically, Edens accuses me of "an overly narrow time perspective" and then raises the same issue as that raised by Mishan—that the development of the modern industrialized nations has depended upon the availability of fossil fuels—an issue which I criticized in the article as "the result of a lack of sufficient [historical] perspective."

The past two and one-half centuries clearly have been unique in human experience; but, as I argued in the article, Edens' "dynamic factor" in past growth has not been society's dependence upon fossil fuels but rather society's ability "to advance its technological knowledge to the point where those resources could be employed for the satisfaction of human wants." It is, after all, that knowledge that makes a given material useful to society; and the fact that terrestrial deposits of those materials might some day be exhausted does not necessarily imply that economic growth must stop, only that knowledge must continue to advance. The fact that past technological change has not been random and capricious but rather has occurred in a systematic manner in response to market forces causes me to take an optimistic view of the probability for future advances in knowledge.

Clearly if we confine the discussion to our own planet [a constraint which O'Neill (*1*) argues is unnecessary], no one can deny that there is a physical limit to energy and mineral use—a point made by Daly and others elsewhere (*2*) and suggested by Ophuls' reference to "thermodynamic limits." That, however, is an obvious and rather uninteresting statement; the relevant question is whether society is now sufficiently close to that limit to warrant concern, and it is here that I must respectfully disagree with my critics. As Brooks and Andrews have noted (*3*), "the literal notion of running out of mineral supplies is ridiculous. The entire planet is composed of minerals, and man can hardly mine himself out."

Of course, those authors warn that the effort to obtain those resources might involve costs in the form of pollution, changes in land use, changes in the international distribution of wealth and power, or other disturbances which society is unwilling to bear—a fact of which I am quite aware, in spite of Ophuls' charge that I argue "as if ecology had never been discovered." Indeed, I find such a charge surprising, particularly in light of his reference only two paragraphs later to the very policies I proposed to reduce environmental damage. He criticizes those policies on the ground that they do the job "only by increasing the painfulness of the market's impact on individuals"—a rather perplexing criticism, since the external costs of production, of which pollution is only a part, are already borne by individuals. The effect of "including the social costs of production in market prices" simply would be to monetize those costs and to reallocate them so they are borne by those individuals who consume the goods and services whose production is causing the pollution. If the policies can be enforced efficiently, there would be little increase in the total cost borne by society. Obviously such a reallocation would involve personal sacrifice for some, but that sacrifice would be com-



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Energy Alternatives for Brazil

In 1973 the developing countries had built or begun to build economies in which cheap oil was a crucial energy source. Suddenly the price of oil jumped and they were without means to pay for it. Their three general choices now are to decrease consumption of energy, to harvest the sun, and to go nuclear.

Nowhere is there enthusiasm for curtailing use of energy, because this would be synonymous with curtailing development. Harvesting the sun is the desirable solution. However, little thought has been given to converting solar energy to versatile forms. Thus, an important and disturbing consequence of the oil crisis has been to push the world toward going nuclear.

Among the "developing countries" Brazil is one to be watched, for it is emerging as a leader in adopting nuclear energy and in harvesting the sun.

When many people think of Brazil, they have visions of a lanquid, exotic country. The Brazil that matters is tough-minded, energetic, imbued with a sense of its own "manifest destiny." In many ways, Brazil today is reminiscent of the United States of generations ago. Vast areas of the country are unoccupied. Were the potentials of the country realized, it could probably sustain more people at a higher standard of living than could the United States. Brazil is only at the early stages of using its intellectual resources. The first university at São Paulo was founded in 1932. The first sizable group of bachelors in geology were graduated in 1962. There is now a growing research and development establishment. More than 4000 scientists attended the recent meeting of the Brazilian Society for Progress of Science. In the higher echelons of government are experts knowledgeable in technology, some of whom were trained in the United States.

Brazil has enjoyed a rapidly expanding economy and earlier was hailed as a new Japan, but the sharp rise in cost of oil was a blow. The country is heavily dependent on the use of oil in transportation, but it produces only about a fourth of its needs. It was faced with the prospect of a long-term slowdown of its drive toward an expanded economy. The government responded by maintaining imports of oil sufficient to permit continued growth of the economy even though a trade deficit was incurred. However, the government also entered into negotiations with West Germany aimed at achieving nuclear self-sufficiency. As a result, in about a decade Brazil will have eight additional large power reactors, uranium isotope enrichment facilities, a fuel element fabricating plant, and a processing plant for spent fuel capable of producing plutonium. Brazil plans to pay for much of the new installations by exporting uranium.

While it is possible today to buy and transfer large-scale nuclear technology, there is no comparable possibility in the use of solar energy. If a worldwide stampede toward nuclear proliferation is to be slowed, development of this alternative energy source must be speeded.

In the parts of the tropics where rainfall is adequate, utilization of plant materials has great potential. The combination of maximum solar radiation and a long growing season leads to huge annual yields. Brazil is already using plant energy and exploring means of greater exploitation. Thus, some of the country's gasoline currently contains 15 percent ethyl alcohol and charcoal and is employed in smelting much of the country's steel.

Brazilian scientists are impressed with the potential of cassava (manioc). This plant grows well on poor soils such as the laterites. In some soils, yields of more than 50 metric tons per hectare have been obtained. The principal component, starch, can easily be fermented to ethyl alcohol. At today's oil prices, costs for such alcohol would be very favorable. An automobile engine designed expressly for alcohol is being developed. Brazilians point out that because of the absence of sulfur and the low combustion temperature, exhaust gases would be virtually pollution free. Brazil's current energy needs could be largely met by devoting about 1 percent of its total area to cassava.

It is to be hoped that in solving its own energy problems Brazil will come to choose to exert world leadership not in facilitating nuclear proliferation but in providing the tropical countries with examples of how best to harvest and utilize solar energy.—PHILIP H. ABELSON

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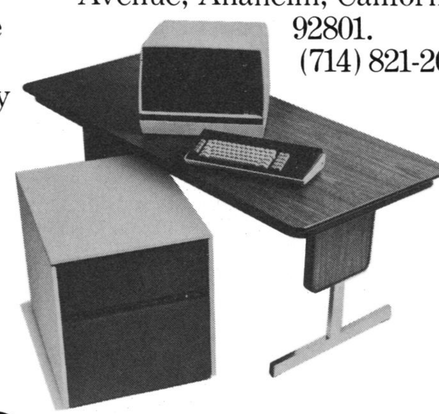

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The model 44 Darringer has analog indication and digital readout and requires no calibration. The analog indicator brightens in proportion to target temperature with a response time of 0.5 second. The digital readout is accurate to within ± 0.5 percent. Readout is from 0° to 1000°F or from 0° to 600°C and is selectable. The device is portable and operates by battery. The on-off switch is located in a pistol grip. Telatemp. Circle 847.

Chromatography Adsorbents and Supports

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Newly offered instrumentation, apparatus, and laboratory materials of interest to researchers in all disciplines in academic, industrial, and government organizations are featured in this space. Emphasis is given to purpose, chief characteristics, and availability of products and materials. Endorsement by *Science* or AAAS is not implied. Additional information may be obtained from the manufacturers or suppliers named by circling the appropriate number on the Readers' Service Card (on pages 418A and 483A) and placing it in the mailbox. Postage is free.—Richard G. Sommer

Sonic Digitizer

Graf-Pen model GP-3/3-D will convert descriptions of three-dimensional objects to digital form suitable for input to data-processing systems. Sets of *X*, *Y*, and *Z* coordinates are generated for points bounded by the sensors. The object is placed within the operational area. The operator traces the object with a stylus which generates sonic pulses on command or continuously. The pulses represent slant-range distances to each of the three axes which are then converted to orthogonal coordinate sets. Science Accessories. Circle 845.

X-ray Spectrometer

A new spectrometer offers the advantage of both microprocessor and minicomputer data-reduction techniques. Every X-ray energy element line, escape peak, and sum peak is recorded in the memory bank. The system will perform quantitative element analyses. Microprocessor sequential control elements substantially replace hand-wired programmable controls. Analytical Instrument Division, Kevex. Circle 848.

Fig. 1. The CT/3 current measuring system from EG & G/Environmental Equipment has a field calibration unit for on-site testing of sensor operation prior to and after deployment. Software packages are available for processing the collected data.

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Film Balance

This device measures surface pressure (difference of surface tension between pure surface and covered surface) as a function of the area occupied by molecules of a film. Monolayers of polar substances may thus be investigated. One application is the transfer of a monolayer to a carrier such as glass or metal semiconductor for other investigations. The device consists of a measuring unit and a control panel. Brinkmann Instruments. Circle 849.

Literature

Liquid Scintillation Vials are described in a brochure which includes several new products. Wheaton Scientific. Circle 851.

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