some string, a stone, an oil lamp, a pointer, a few pegs, and a gallon of water—we are convinced that we could achieve the required accuracy in one night's observation. Our philosophy is if we can devise an experiment today which was equally feasible 6000 years ago, it is fair game to use it to establish the limits of accuracy that could have been achieved. That a different method may have been used is of secondary importance.

To support our contention that an accuracy of 1′ is feasible, we quote from another letter (*1*) We received. O'Keefe writes, "There is no real problem about aligning within 1′. Remember that a rifleman will put 10 shots out of 10 within the innermost ¼-inch circle on a target 50 feet away using open sights and supporting his rifle with his hands. This is just about 1′. Given any kind of firm support, it is possible to point to a much higher accuracy. The last of the astronomers to prefer open sights to telescopic sights was Hevelius; I believe he got an accuracy greater than that of Tycho Brahe, whose errors were about 40″."

O'Keefe also mentions the possibility of transferring a meridian from one set up at a distance, as does Stephenson. O'Keefe further points out that such a reference meridian would differ by 4′ westward if it was only 6 km to the east. The transfer of such a meridian is by far a more difficult task than on-the-spot alignment, but we would be interested in an outline of the procedure and the result of a test experiment. Nevertheless, these questions are secondary to the question of the limit of precision that is feasible, which is Stephenson's main question. Even if we knew the exact procedure used, we could not know its accuracy. We can ask our physics students to repeat certain measurements a number of times in order to establish the standard deviation of the distribution, but only two pyramids were aligned with such accuracy. However, we can examine other constructions. In an article (*2*) in the London *Daily Telegraph*, A. R. Michaelis wrote:

> There is now to hand an all too short announcement that geophysicists in Uzbekistan have observed that the great masonry sextant of the Observatory of Samarkand has moved by 10 minutes of arc since it was built in 1428.
>
> This was published in Soviet Weekly on March 30, but did not mention the names of the scientists concerned. The famous observatory in Samarkand, now the oldest in the world, was built by the great Russian astronomer Ulugh Beg, who lived from 1393 to 1449. He was Governor of the Province, wrote poetry and history and loved building in a grand style.

Michaelis then continues by speculating that it would also be worthwhile to make an accurate survey of the constructions of Jai Singh II at Delhi, and at Jaipur, which were built in the 1700's.

Returning to Smiley's second point, there are many reasons why an east-west alignment cannot be accurately established. The angular width of the sun is about ½° and moves nearly 1° in azimuth per day at the equinoxes, giving immediately a ½° error between sunrise and sunset. This azimuthal difference is reversed between the two equinoxes but is not the sole source of error. The east-west condition is met only when the line of sight to the sun is a tangent to the earth's surface. The altitudes of the horizons perturb the result, which is also affected by the refraction of the earth's atmosphere. Furthermore, the refraction effect is different at sunrise and at sunset. It is therefore a fair conclusion that the east-west alignments show instead the Egyptians' well-known ability to construct right angles.

It is obvious that some questions will always be unanswerable and are thus of little use. As in many aspects of archeology, questions must be framed so as to give scope for objective tests. In the present case, if we can establish that a 1′ accuracy was not impossible, then the next stage of the debate is with the geophysicists.

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Delayed Publication

The swiftness of publication of the work of the late 19th century scientists cited by Brecher (Letters, 12 Jan., p. 128) is impressive. Nevertheless, in the case of Alfred Russel Wallace's paper "On the law which has regulated the introduction of new species," one must add another parameter—geographical distance. Written in Sarawak

in February 1855, this paper was published in England on the opposite face of the globe the same year in the September issue of *Annals and Magazine of Natural History* (*1*). During the 7 months between writing and publication, Wallace's manuscript underwent a 15,000-mile sea voyage.

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Realistic Space Goals

The title of Constance Holden's report "Space shuttle: Despite doubters, project will probably fly" (News and Comment, 27 April, p. 395) is somewhat misleading. The shuttle issue has barely scratched public visibility; so far, $400 million—only 5 percent of research and development or 1 percent of the entire program—has been spent, with another $475 million requested for fiscal year 1974. As the figure rises and when there has been time to rationally assess the program, I believe the space shuttle will suffer the same fate as Dyna-Soar, the Manned Orbiting Laboratory, and the supersonic transport (SST).

The space shuttle is the largest nondefense technological program now under way in the United States, with research and development costs alone estimated at more than $8 billion—12 times that requested for the SST. Although the shuttle's potential environmental impact is relatively slight, making it a more subtle public issue, the cost alone represents an enormous drain on technological resources. The space shuttle would be as helpful as a white elephant to the balance of payments, to national security, to energy and environmental problems, to exploratory enthusiasm, or to any other goal near and dear to the American people.

The Nixon Administration's recent cuts of the annual NASA budget to $3 billion, combined with the rapidly escalating annual expenditures for the space shuttle, imply a nearly *threefold* decrease in space sciences and applications funds (down to 11 percent of the NASA budget) over the next 5 years, according to figures recently released by NASA. The cancellation or suspension of the High Energy Astronomical Observatory, the Grand Tour of the outer planets, Venus Pioneer, and some communications satellites might be just the beginning. Scientists may start to ponder the reality that you can't do everything in space and that something must give. A little more thought should reveal that something to be the space shuttle.

The space shuttle is merely a transportation system. What payloads could we possibly put into the space shuttle if the funds to develop them have essentially disappeared over the next 5 years? Senator James Abourezk (D–S.D.) of the Aeronautical and Space Sciences Committee will be presenting an amendment which would restore $131 million taken out of space sciences and applications for the next fiscal year and reduce the space shuttle budget by that amount. Since the benefit-cost ratio is hanging on a precarious tendon, and stretching the program any further would prove uneconomical, this legislation will hopefully force NASA and the Administration to reexamine their space transportation needs and fit these needs to realistic goals over the coming years.

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Pollution Control

The discussion by Freeman and Haveman (28 July 1972, p. 322) of residuals charges provides a useful comparison between economic incentives and regulation-enforcement as strategies for pollution control. At the same time, some serious administrative problems are dismissed with little more than passing comment. Two specific points come to mind.

Freeman and Haveman justifiably note the deficiences of existing control boards that are removed from popular political control, yet they call for the establishment of regional authorities to deal with air and water pollution and solid wastes. Environmental groups typically complain that authorities are "authoritarian" in their mode of operation. Although authorities are not unique in being criticized for ignoring popular sentiment, one must conclude that opposition to regional authorities is at least partially based on an unwillingness to centralize power in the hands of powerful bureaucrats. It is possible that the successful use of effluent fees by the *Genossenschaften* in Germany is partially related to the willingness of the German population to submit to centralized controls.

The authors also note that "for most of the more significant and ubiquitous pollutants the measurement technology is available and its cost is reasonable *relative* (italics added) to the other costs and benefits associated with pollution control." Although this is an essentially accurate statement, expensive monitoring equipment is often improperly located for ambient readings, is poorly maintained, and is otherwise neglected because it is not often utilized for day-to-day decision-making. Thus our data will get better—or better utilized—only when our agency decisions utilize the data.

I concur with the authors' request for carefully prepared experiments in environmental management. This cause is not served by the casual dismissal of criticisms.

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"Our passing comment" on the establishment of regional authorities for air and water quality management included a reference to another publication, in which we discuss the political and institutional problems associated with comprehensive planning and management of water resources (*1*). In that paper we discussed the need for the policy-makers in such authorities to be representatives who are "directly elected by those who are affected by the decisions which they make" and who "represent a wide variety of disparate interests within geographically defined constituencies."

If the advantages of comprehensive planning are to be realized, these questions of constitutional and political structure must be faced, whether public policy is based on a strategy of residuals charges or one of regulation-enforcement.

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