

Precise Measurement of Earth's Rotation

Measurements of earth's size, shape and rotation, as well as possible continental drift, could be made with an accuracy 10 times higher than possible today with a radio technique so new scientists are just beginning to explore its possibilities.

The technique uses the earth, itself, in effect, as a giant radio antenna.

The system has the rather formidable name of "long base line interferometry." Using it, the arrival of radio waves from far-away sources in the sky can be accurately timed—to within a billionth of a second—over distances as great as the earth's diameter, slightly less than 8,000 miles.

The first application of the new method was to measure the sizes of sources of radio waves in the heavens much more precisely than had previously been possible.

Equally exciting to scientists is the fact that the new technique makes it possible to take measurements of earth itself that were previously obtainable only by optical methods requiring months or years. These measurements, such as the precise determination of earth's rotation, can be made in hours or days with long-line interferometry.

Key to the new technique is precise timing of the arrival of radio signals from a distant source at two widely separated receiving antennas without a physical link between the two stations, either by cable or radio. This can be done with synchronized atomic clocks that tick at a rate dependent only upon the very stable frequency with which atoms vibrate.

Two commercial atomic clocks can be set simultaneously, then transported to distant stations to set even more accurate hydrogen masers, which are also atomic clocks, at each location.

Although the hydrogen clocks at each of the two sites would not necessarily show the same time to more than a millionth of a second, they would tick at the same rate for at least a day, just as two good wristwatches do for a certain length of time after they have been synchronized.

The time at which the source's radio waves are received at each antenna is recorded, usually on magnetic tape. The two records are then analyzed by a computer that calculates the time difference between them, which is an accurate yardstick of the distance between the two stations.

The new method of precise timing to link two widely separated stations could be used to:

- Check on continental drift. If the

receiving antennas were located on the West Coast and Hawaii, for instance, a change in the distance between the two of as little as one inch could be detected in a year.

- Measure how changes in the average wind patterns affect the weather. When such information is combined with data from satellites concerning earth's heat balance, detailed investigations of the causes of major storm systems could be made for the first time.

- Determine the twice-daily variation in the length of the day caused by oceanic tides. This, in turn, would tell scientists whether the earth is rotating at a constantly slower rate or if the slowdown fluctuates. How the earth's rotation rate is decreasing is an important factor in theories of the origin of the earth and moon, as well as the birth of the solar system.

- Measure the slight variations in when and by how much the earth is deformed. A rise and fall of about four inches at any station could be easily detected.

- Open up a whole new range of measurements of changes in the shape

of the earth itself, as well as its surrounding atmosphere.

What would be needed to make these measurements would be two pairs of 85-foot antennas, each set located a few thousand miles apart—on the East Coast and West Coast for most of the observations; across an ocean in the case of continental drift.

Dr. Thomas Gold of Cornell University's Center for Radiophysics and Space Research, Ithaca, N.Y., says that the new radio astronomy technique could be used to determine the variations in the speed of rotation of the earth to a precision possibly at least 10 times better than present optical techniques.

Dr. Gordon J. F. MacDonald, on leave from the University of California at Los Angeles as vice president for research at the Institute for Defense Analysis, Arlington, Va., suggests that the radio technique could be combined with optical observations of the moon by reflected laser beam to obtain information about both the earth's rotation and the moon's motion. The combined information would then give "basic dynamical data of the solar system." ◊

TECHNOLOGY OR POLITICS

Economists Debate Military-Industrial Concentration

Since former President Eisenhower warned against a military-industrial complex seven years ago, opposition to the defense industry has become something of a crusade.

Aerospace and other industries are described as captives of the Pentagon, incapable, or nearly so, of operating in the civilian sector. The military-industrial complex is seen as a Frankenstein's monster that threatens to control the state which created it.

When American economists gathered in Washington for their annual meeting, they heard such charges leveled against the Defense Department and its supplying industries. Several fiery addresses drew large, attentive crowds and inspired harsh debate.

Dr. Murray L. Weidenbaum, professor at Washington University, St. Louis, and former economist for the Boeing Company, claimed that defense industries have so lost initiative through close association with Pentagon management that they may not now be able to transfer efforts to such projects as upgrading ghettos.

Dr. Walter Adams of Michigan State University made an even stronger, more threatening argument when he said Government, through Defense, has created power concentrations which "tend to breed on themselves and to defy public control."

Both men discounted the notion of a conspiracy. Rather, says Dr. Adams, the defense complex represents a natural coalition of interest groups—including Government, industry, labor and legislators—with a stake in defense and space. The danger, he says, is lack of a strong counterforce to assure that the public interest prevails. "The danger persists that power will be coalescing, not countervailing, that the political cloakroom will displace the economic market place."

Dr. Seymour Melman, professor of engineering at Columbia and specialist in conversion to a peacetime economy, says the dangerous centralized power has already been realized.

"There has been fashioned, inside the Government," he said, "a true transformation of the essential character of Government and society," with peak economic and political power in the hands of the Defense Department—which points toward a "Soviet-type state capitalism." The DOD controls some \$40 billion a year, he said, and the result is a squandering of the nation's resources.

Responding to the heated arguments, Dr. George Stigler of the University of Chicago accused the speakers of muckraking with very little evidence to back them up.

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been documented," he said. "I deny that there is any evidence for a military-industrial establishment."

The industries that produce for the Defense Department represent people skilled in getting money from the Government, said Dr. Stigler. They will build whatever the Government wishes, whether tanks or low-cost housing.

Calling the session with Adams and Melman a disgrace, Dr. Stigler, a former president of the economic association, said that in place of research and evidence, it had produced sermons. "We have two soapboxes and two orators up here."

Dr. Adams, however, couched his denouncement of military industries within a larger economic argument that big industry is often not the result of natural, competitive growth, but the creature of Government action.

"My hypothesis," he said, "holds that industrial concentration is not the inevitable outgrowth of economic and technical forces, nor the product of spontaneous generation or natural selection." Instead, industrial giants often arise by way of "unwise, man-made, discriminatory, privilege-creating Governmental action."

Government creates private privilege through its defense contracts, research and development support, patent policy, tax privileges, stockpiling arrangements, tariffs and quotas and subsidies, said Dr. Adams. An example is the complex of subsidies and production control powers accorded the oil industry where "in the name of conservation the Government does for the oil companies what they could not legally do for themselves."

The military industrial complex is only a special instance of political interference in the market place, the result of which is industrial concentration, said Dr. Adams.

To the extent that industrial giants are the creatures of political power, and not technological necessity, "there is nothing inevitable about their survival" or that of the public policies which preserve them.

EDUCATION

Public Money, Private Control

Colleges and universities in the United States desperately need money; they also need a buffer against the kind of political control that could come with Government subsidies. How to get both at once is the so-called crisis in higher education.

At the moment public money is flowing at growing rates into support of the big private universities. If this trend

continues private universities will become increasingly public and lose much of the autonomy they now have, says Dr. Clark Kerr, former president of the University of California.

When that happens, says Dr. Kerr, autonomy of all universities—now protected in part by the standards of private institutions—will be threatened. "The big universities are really on the firing lines these days... we've got to have better buffers," says Dr. Kerr.

Dr. Kerr's dismissal from the presidency last year, following student riots and due apparently to political changes in California, sent waves of concern through the academic community and highlighted a threat to university autonomy.

Dr. Kerr advocates as one solution that all universities set up private trustee boards like that at Harvard. The Government would then subsidize higher education with lump sums channeled through the private boards which would be independent of political control. In this way, says Dr. Kerr, public universities could become more private.

"I think there is something to this separation of university and society as there is to separation of church and state," says Dr. Kerr. "I'm a pluralist. I believe in many centers of power."

Dr. Kerr gave his solution at the annual meeting of the American Economic Association in Washington following a symposium on the economics of higher education.

Symposium members focused on the merits and demerits of a student loan bank which would finance the education of any student in the country, at the university of his choice, with up to \$15,000. (SN: 9/23/67).

In return a student would agree to pay a tax based on his working income and lasting perhaps 30 years.

The repayment would be keyed to income; some students would never repay the full loan while others would repay more. Such an educational opportunity bank was recently proposed by a White House science committee headed by Dr. Jerrold Zacharias of the Massachusetts Institute of Technology.

Dr. Zacharias, from the audience at the meeting, said "universities should be running scared," facing the prospect of depending on Congressional appropriations every year.

Dr. Alan Cartter, chancellor of New York University, endorsed the bank concept as very promising but questioned whether so much educational cost should be shifted from parents to students.

Dr. Kerr also favors the bank but says it cannot be a total solution to financial troubles of American universities. It should, however, further both university and student autonomy.