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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

25 November 1977, Volume 198, No. 4319

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This outstanding refrigerated centrifuge spins six liters or six blood bags — 50% more than most floor models. Its modular Multi-Disc™ adapters are not only a delight to work with, they also hold a surprising number and variety of tubes.

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These two superior centrifuges are what you'd expect from Beckman, the most respected name in centrifugation. For brochures on the J-6 and TJ-6 write to Beckman Instruments, Inc., Spinco Division, 1117 California Ave., Palo Alto, CA 94304. Ask for SB-480/490.

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SCIENCE

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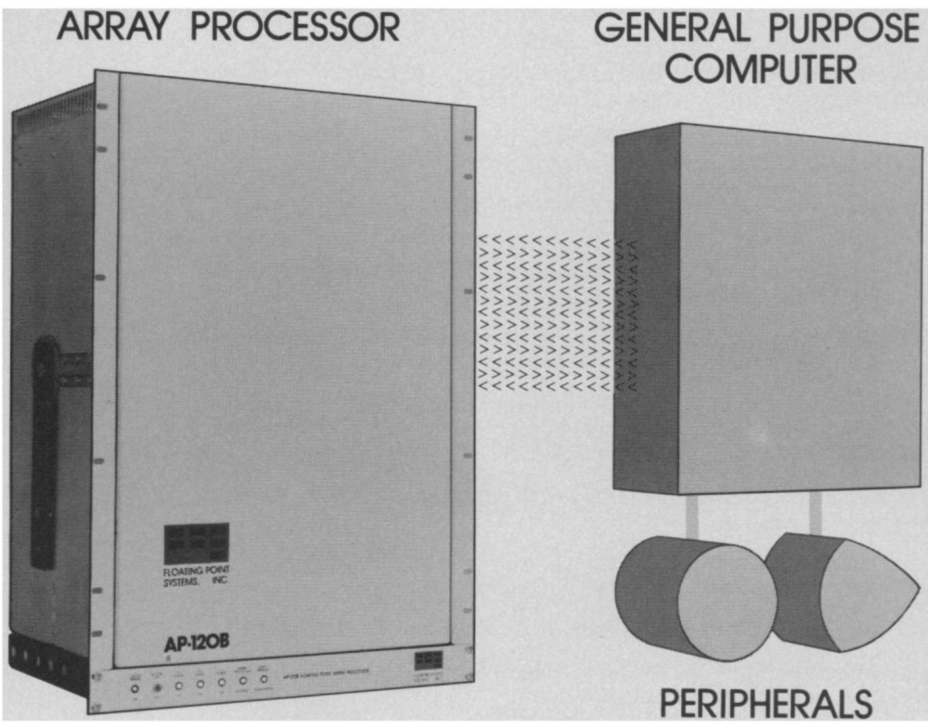
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

COVER

Engraved vignette from title page of Christopher Scheiner's *Rosa Ursina*, a book on sunspots published in 1630. Bear (ursa) and rose (which elsewhere symbolizes the sun) were derived from the name and heraldic insigne of the Duke of Orsini, who sponsored the work. Astronomer-bear in upper chamber projects an image of the sun and sunspots on a card, illustrating Scheiner's invention of the helipscope. Drawings of the sun made in this way allow a modern reconstruction of the 17th century rotation rate of the sun. See page 824. [By permission of the Houghton Library, Harvard University]

A new advance in scientific computing



A breakthrough in computer architecture, the Array Processor is bringing unparalleled computational power to continually growing numbers of applications in **research, engineering,** and **signal processing.**

The Array Processor is **a computer in its own right,** specifically designed **for extremely efficient processing of large vectors or arrays** of data. Although fully capable of working in an independent system, the Array Processor is typically implemented as a powerful complement to a host computer (which acts primarily as a controller), greatly increasing the computational power of the entire system.

The Array Processor **takes blocks of data and instructions** from the complementary CPU or other device and **performs the computations** called for **at speeds of 100 to 200 times greater than** a stand-alone computer. This means that **a minicomputer** based system can have its computational throughput increased to a degree only available on the largest, and most expensive mainframe computers. It also means that **a large mainframe can have its throughput increased up to 20 fold.** The rationale is simply this: if massive computations are required to effect a simulation or algorithmic model, why not design a programmable processor to handle these tasks efficiently. FPS has pioneered this approach by designing extremely efficient, cost effective Array Processors, interfacing them to all popular computers and providing a package consisting of software development programs, diagnostic programs, and an extensive math library. All documentation and support are provided to bring the systems promptly on line. The significance of this approach becomes evident when one realizes that for **less than $50K** he can have the power of a multi-million dollar CDC 7600 immediately available to implement his scientific analysis programs. Hundreds of FPS Array Processors are in use today.

Time and again the Array Processor has allowed significant research to be accomplished where before budgets did not allow access to the computational power required. This accessability has also produced a catalytic effect allowing new research ideas to come forward for implementation.

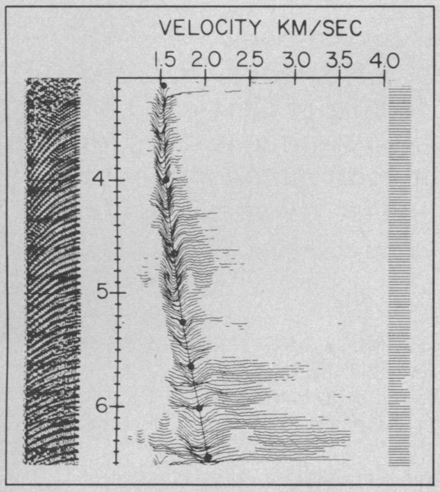
Architecturally, Floating Point Systems' Array Processors consist of fast registers, program memory, data memory, **a pipelined floating-point adder,** and **pipelined floating-point multiplier**—all interconnected by **seven parallel synchronous data buses.** These features are combined with a fast **(167 nanosecond)** instruction cycle. While the conventional computer instruction word can only specify a single operation, such as a **multiply, add, memory fetch, decrement, or test, the FPS Array Processor can do all of these operations in a single 167 nanosecond cycle.** The result is the ability to do the reiterative computations required on large vectors or arrays of data in a very short time.

There is another "unexpected" benefit from this kind of computer architecture. Most algorithms used to implement scientific models and their associated data sets are naturally structured in vector (array) form. While the conventional computers of today require restructuring of the models, the design of the architecture and instruction set of FPS Array Processors is virtually congruent to the mathematical models. Researchers using Array Processors find that they **can readily write new program routines** either in **FORTRAN IV** through their host computer or in **the Array Processor's own assembly language.**

Powerful models can be readily implemented through the extensive FPS Scientific **Math Library (SML) of more than 250 routines** callable through the host FORTRAN. New programs can be added to the SML using the assembly language of the Array Processor.

For example, **Peter Buhl** of the **Lamont Doherty Geological Observatory of Columbia University** applied these techniques to the analysis of **marine seismic reflection data.**

...the Array Processor

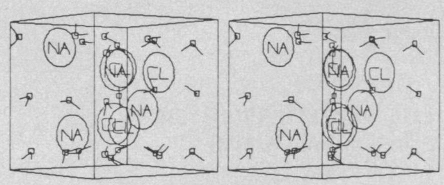


The above data is a plot of the earth's response due to an air gun source at 24 locations along the earth's surface. The vertical scale is propagation time in seconds. Sound velocity in the earth is determined by fitting one-sided hyperbolas to the data. This fitting is done in the Array Processor by multiple cross-correlations of short time windows of the 24 traces. The strength of the correlation as a function of propagation time and assumed velocity is plotted in the center graph as a downward deflection. A line through the deflection troughs defines velocity vs. depth. **The center graph requires 100 million multiply-adds.**

Sound velocity data as a function of depth of the earth provides valuable information about the nature of the strata. A single velocity analysis via a multiple cross-correlation (or semblance) technique required **six hours with conventional computational equipment.** Utilizing an **FPS Array Processor reduced this time to three minutes,** (a 120X throughput improvement) thereby allowing these velocity analyses to be done at closer spacings along the line of profile, **adding an extra dimension to earth cross sections.**

Floating Point Systems' Array Processor also forms part of a system used to process nuclear reactor operating data generated by **reactor safety experiments.** The portion of that system developed by **Sam Sparck, Senior Development Engineer at the Time/Data Division of GenRad, Inc.** is a real-time multi channel **digital filter subsystem.** Input data arrives in buffers of variable length at rates from 50 to 650 buffers/sec. Maximum throughput requirement is 131,000 words/sec. The Array Processor program performs data demultiplexing into separate channel buffers, digital filtering/decimation, bounds checking, and remultiplexing of the decimated data into output buffers. **Decimation ratios of 3:1 to 6,000,000:1** are attained. Certain **selected parameters are tested in real-time** for bounds exceedance, and when exceedance conditions are detected, an audible and visual alarm is generated to alert system operators.

In the area of pure science, a Floating Point Systems' Array Processor is used by researchers at the **University of California, San Diego** to integrate **several hundred coupled differential equations** in the study of the **molecular dynamics of chemical reactions.** A dynamic display system then processes the vector positions of the atoms and shows them in 3D moving images. Chemistry is a field with obvious needs for large increases in computer power. Its fundamental axioms are well known, but the computations involved in applying these axioms are so extended that as yet only relatively simple systems have been studied from first principles.



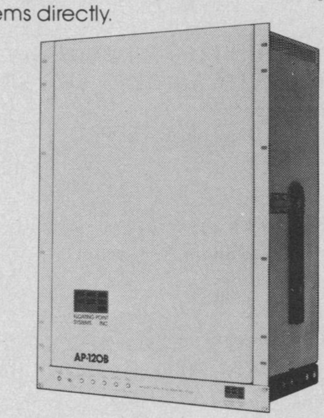
Hard copy output of single time step in the dissolution and solvation of a salt crystallite in water is shown here. You can see this stop-action in striking depth if you fuse the two pictures together into a single stereoscopic image with a slight crossing of your eyes. The experimenters actually have moving 3D pictures literally at their fingertips. The calculations are aimed at a deeper understanding of molecular processes in terms of the motions of the atoms involved.

While the computational limitation of this generation of Array Processors does exist, its potential contribution to technology has yet to be discovered in many areas of scientific analysis. Every day numerically intensive array processing techniques are applied to new areas of research and engineering.

Today **Array Processors can be found in** the calculation, reconstruction, and enhancement of **images** (X-ray, satellite, and seismic)...the **conversion of speech** signals into compressed digital data and the subsequent resynthesis...the composition of images in **radio astronomy**...the statistical analysis of the data affecting **economic models**...the **simulation of mechanical systems,** airframes, and environments... and more.

The Array Processor has literally created a new era in signal processing and scientific computation. An FPS Array Processor interfaced to a **minicomputer** provides the computational power of a megadollar mainframe at a fraction of the cost...combined with a **major mainframe,** it brings the user the computational ability previously available only at tremendous cost.

To learn more about Array Processors...use the coupon below or contact Floating Point Systems directly.



The age of Array Processing is here...and Floating Point Systems is the Array Processor company.

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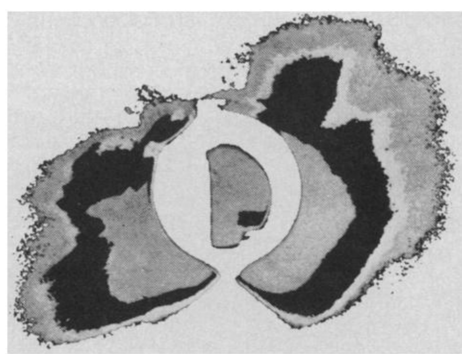
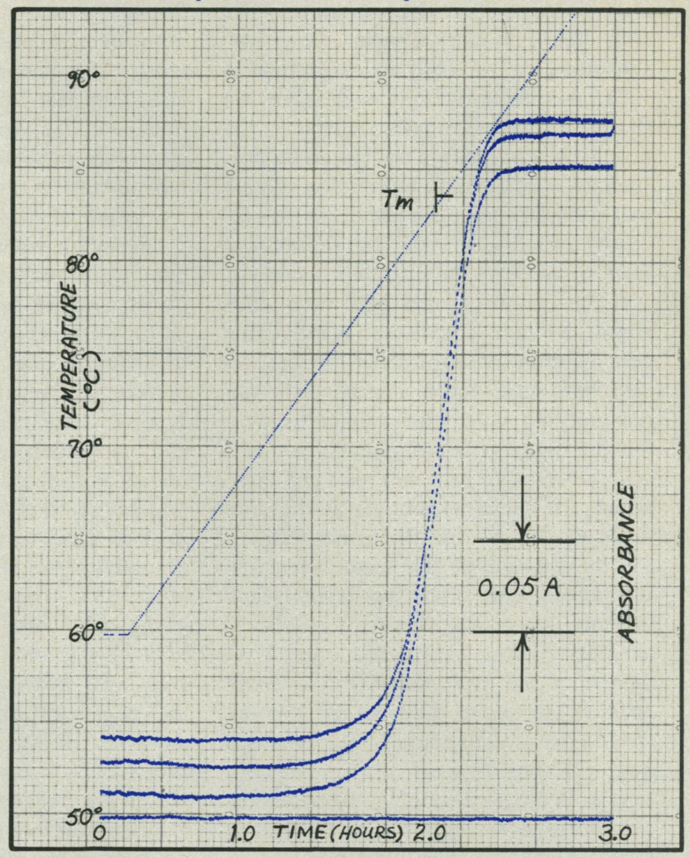


Three simultaneous assays of M. lysodeikticus DNA versus a buffer blank at 260 nm. Calculated T_m was 83.75°C, with all three samples agreeing within ± 0.04°C. The Thermoprogrammer, using quartz cuvettes, provided linear temperature scanning at 0.25°C per minute, with the Reference Compensator producing the indicated baseline flatness. The Analog Multiplexer allowed recorder presentation of temperature and absorbance.



For temperature-dependent assays like this thermal melt, temperature control is as vital as photometric accuracy.

Gilford's new Thermoprogrammer is an all-electronic system for maintaining or scanning temperature anywhere in the 0 - 100°C range.

Convenient Sample Handling

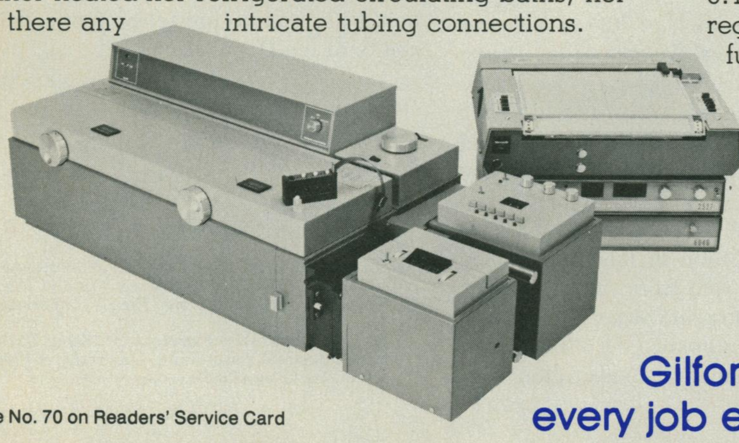
Individual quartz cuvettes, easy to fill and empty, are available in sizes selected for thermal melts, enzyme analysis, microtubule studies, and similar applications. Setup is easy: for fixed temperatures, you adjust two controls; for scanning, you just set the limits for the required temperature range and select scan speed -- 0.25, 0.5, or 1.0°C per minute. And with thermoelectric sample temperature control, you use neither heated nor refrigerated circulating baths, nor are there any intricate tubing connections.

Significant Savings in Time

You no longer wait for temperature of a circulating liquid to stabilize; thermoelectric control is much faster. Samples from the refrigerator reach operating temperature in seconds. You can reduce temperature quickly -- as fast as 28°C per minute -- and change from 4°C to 37°C and back to 4°C in as little as a minute and a half.

Greater Accuracy

Thermoelectric (Peltier) devices in close contact with the sample provide surer, quicker heating and cooling, faster response. Continuously displayed to within 0.1°C, temperature is regulated to within ±0.05°C regardless of ambient temperature or humidity. For further convenience, there are outputs for monitoring temperature on a printer or multiplexing it in sequence with absorbance on a recorder.



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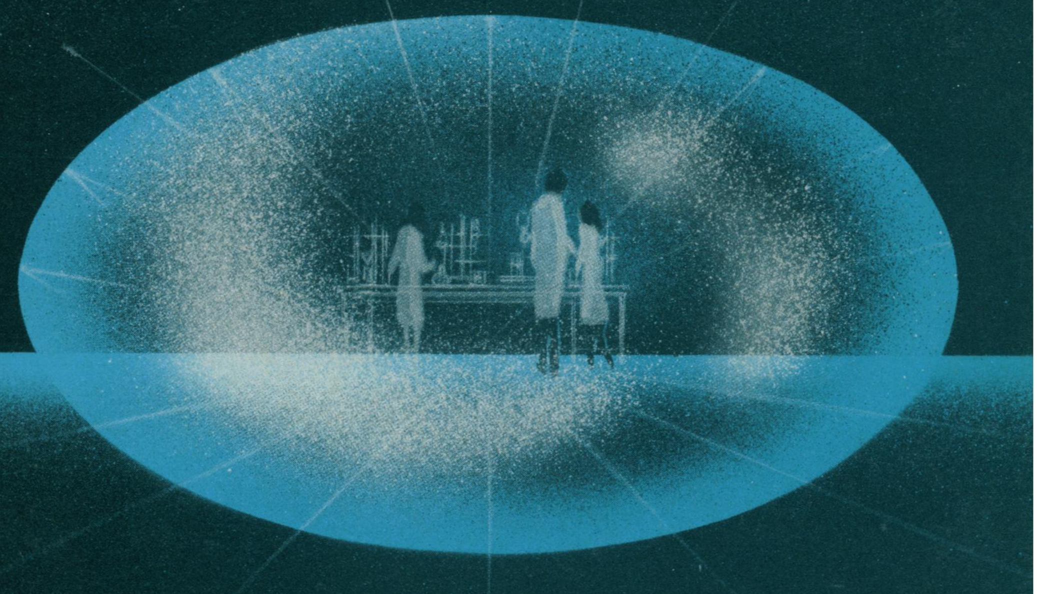

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Intergovernmental Cooperation in Science

One of the uncomfortable truths about the postwar arrangements for science and technology in the United States has been the small role of state and local government. A trilateral relationship took form, linking the federal government with private industry and universities. Only in the last decade, mainly through the initiative of the National Science Foundation, have the states and cities been invited to the table. In President Carter's reorganization of the White House offices, the short and happy life of the Intergovernmental Science, Engineering and Technology Panel came to a premature close when it was abolished and its functions "transferred to the President."

With chronically slim resources, the National Science Foundation has supported a versatile array of experimental projects aimed at linking state and local governments with scientific research and technology. Among other things, NSF is nourishing a network of cities and science advisers to match needs with available know-how. In another experiment, it is testing linkages between local governments and industrial firms. And a third experiment connects state governments with a supportive federal laboratory consortium. In the face of skepticism, NSF has hung tough in its belief that modest but strategic investment in intergovernmental science will yield benefits in terms of productivity and service delivery. It is a refreshing glimpse of the better side of government.

Inflated expectations of a blessed union between science and state and local government, on the other hand, are not helpful. Enough has been learned to tell us that progress will be slower than we might like. True, state and local governments are fighting a storm of dilemmas of urban decay, modernization, law enforcement, air and water management, energy conservation, and human services. But defining needs in terms that science or technology can address is a thorny business. Simplistic jargons of technology transfer are not helpful. Applications of sophisticated technology often are not affordable within tight budgets. Problems of uncertainty, in many ways, are more intransigent at these levels of government than at the national level. The Balkanized state of power centers and the mixture of "strong" and "weak" governors and other elected officials are barriers to introducing change with economies of scale.

Still, with all of these problems, governors and mayors and legislators are reaching for scientific and technical advice, and the profile of state and local government is changing. Public interest groups such as the National Governors Conference, the National Conference of State Legislators, the Conference of Mayors, the National Association of County Officials, the National Municipal League, and the International City Managers Association are all converging in the sponsorship of new arrangements to bring science and technology into the act. A National Conference on Earthquake and Related Hazards, arranged by the Council of State Governments and the University of Colorado, will inform state government officials about risk assessment, hazard reduction, and earthquake prediction.

An important dimension is being added to the commonly perceived agenda of science and technology. Although it comes tardily, its value should not be underestimated. If science and technology can offer a brighter future to federalism, a new measure of utility can emerge where public and private investment in research and development is argued. But there is a great deal still to be done to test and develop a better match between state and local needs and federal research and development priorities. This will not be accomplished by arm's length relationships, and certainly not if the states and cities are viewed simply as passive markets for the end products of federally oriented research and development. Congress knew what it was doing when it legislated entrée for the states and cities to the science policy staff of the President. If that opening is not somehow assured, a useful initiative will have been checkmated.—WILLIAM D. CAREY

(Continued from page 814)

erally—a tighter monetary policy to attract capital and improve the balance of payments, for example, while expansionary fiscal policy improved employment. Tight money worked against the employment target and fiscal expansion worked against balance-of-payments equilibrium, but these untoward effects were dominated by the strength of the money policy on the payments target and fiscal policy on employment.

Utility Measures

In *Trade and Welfare* Meade makes enormous gains by the use of a device of dubious validity—cardinal measures of utility, rather than the normally acceptable ordinal ones. (One is prepared to say in economics that A is better off in situation X than in situation Y, but not, as a rule how much better, nor is one able to say how A's welfare in X or Y compares numerically with B's welfare in situation X or Y.) Comparing marginal values to marginal costs, and giving weights to the welfare of different countries in different circumstances, Meade works through the theory of economic welfare, and thereafter the cases for and against control of trade and of factor movements, in the two-country case and for many countries. He explores at length the "theory of the second best" which states that, if the conditions necessary for an optimum optimorum cannot be realized, movement in the direction of free trade may be dysfunctional. The best in this instance is the enemy of the good. At this level, it sounds trivial, but by exploring cases of marginal and structural adjustments, working through the requirement of efficiency and of equity, he is able to distinguish between utopian and second-best types of policy with a thoroughness that has kept the book alive in the 22 years since its publication.

While Ohlin and Meade share the Nobel award for 1977 and write on the same subject, they are entirely different sorts of persons. Ohlin is a public man, Meade a private man. They barely knew one another. But the economics profession, international economists in particular, and, to the extent that economists solve real problems, the world is in their debt.

CHARLES P. KINDLEBERGER
Department of Economics,
Massachusetts Institute of Technology,
Cambridge 02139

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(Continued from page 819)

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