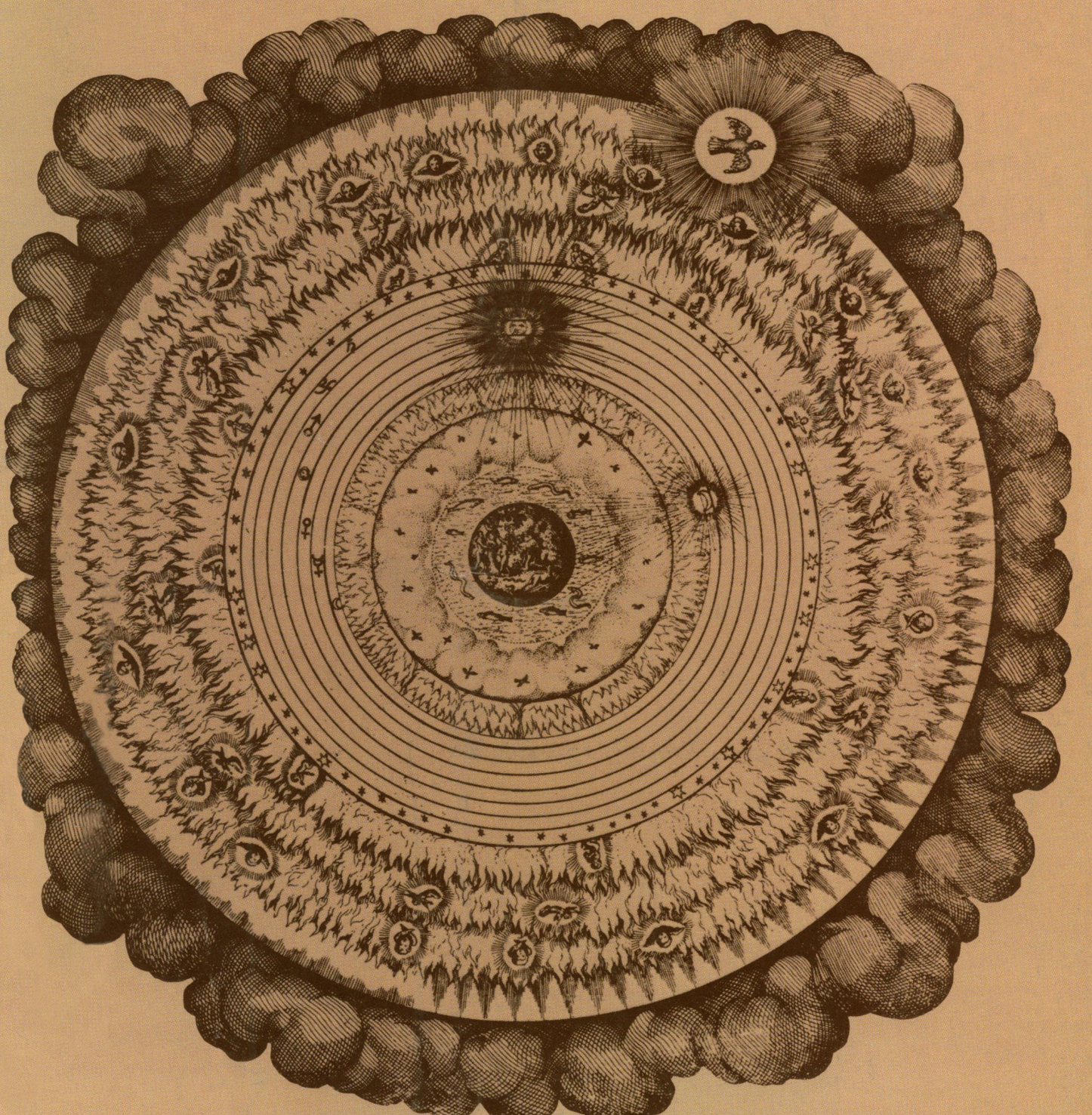
23 November 1984 • Vol. 226 • No. 4677 $2.50

SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

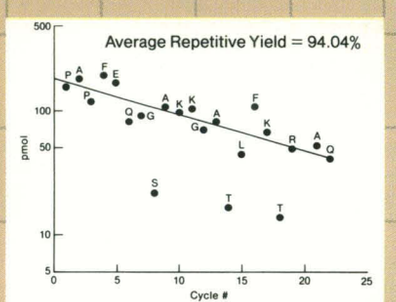


System 890M:

The Protein/Peptide Sequencer with Enhanced Microsequencing Capability and Autoconversion

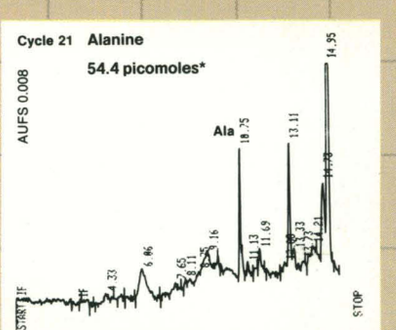
System 890M features microsequencing sensitivity and automatic in-line conversion of sequenced residues to PTH derivatives.

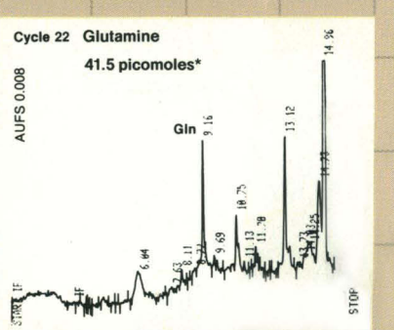
For example, with a loaded sample of 200 picomoles of Cytochrome C, a 94% average repetitive yield was achieved with an intercept sensitivity of 178 picomoles.



In-Line Autoconversion

With Beckman sequencers, conversion takes place in individual tubes in the fraction collector. *Not* in an intermediate or common vessel. There is no extraction, no additional solvent and no loss of PTH amino acids. And, particularly important, there is virtually no chance of cross-contamination. HPLC traces from the Cytochrome C run show the quality of the resulting derivatives.





Value and Economy

There's even System 890M+, the Sequencer *plus* a matched HPLC detection system priced just a little more than what some ask for a sequencer alone.

The Proof is In the Data

Detailed applications and product data are available now from Beckman Instruments, Inc., P.O. Box 10200, Palo Alto, CA 94304, or P.O. Box 76, 1211 Geneva 6, Switzerland.

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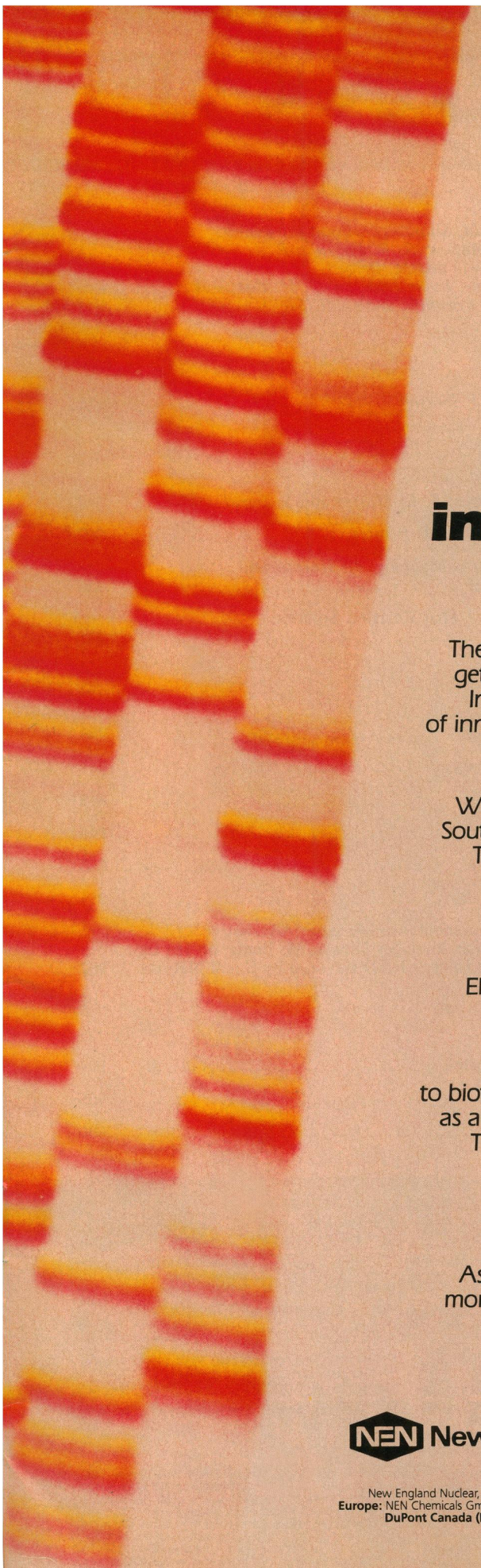

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^{35}S-Nucleotides
Perhaps the best example of our commitment to biotechnology is our ^{35}S-nucleotides, pioneered by NEN as a superior alternative to the conventional use of ^{32}P. The technical and safety advantages of using ^{35}S are widely recognized, and we are collaborating with the research community to develop further applications.

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COVER

The Creation of the World (*genesis mundi*) from the four-volume encyclopedia on human knowledge (*Ultriusque cosmi majoris*, 1617–1619) by Robert Fludd, a distinguished physician of early 17th-century London. At the center are Adam and Eve in the earthly paradise, surrounded by the celestial spheres, the sphere of star, and the outermost sphere—the empyrean—of purest fire. The Copernican Revolution overthrew this medieval cosmography, but the Cartesians and Newtonians retained the principle of theistic creation of a universe of finite age. See page 940. [From The *Cosmographical Glass: Renaissance Diagrams of the Universe*, by S. K. Heninger, The Huntington Library, San Marino, California, 1977]

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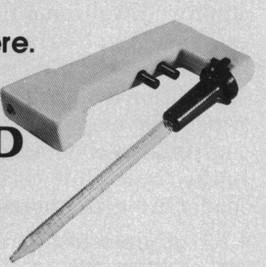

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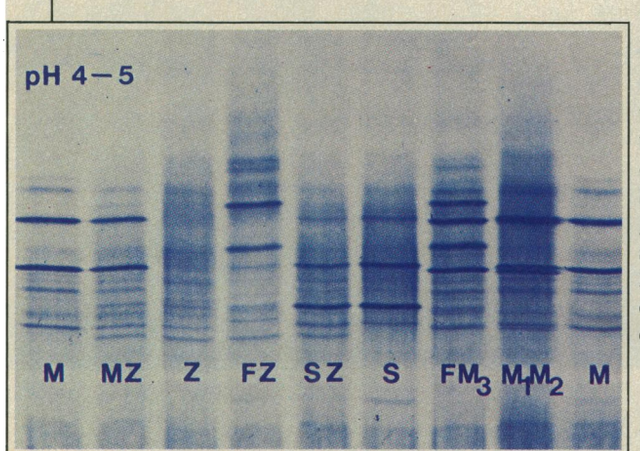
READY-TO-USE GELS FOR MAXIMUM CONVENIENCE

All the owner of the LKB Horizontal Electrophoresis System needs to cover a wide range of electrofocusing applications is a supply of the popular and successful LKB Ampholine PAGplates. These allow the researcher to avoid the time and trouble involved in casting gels in the laboratory, while guaranteeing both high resolution and excellent reproducibility. As many as 96 samples can be separated simultaneously on a single PAGplate, enabling users with high workloads to spend their time screening samples instead of casting gels.

Eight phenotypes of α_1-antitrypsin are clearly identified using one of the convenient LKB Ampholine PAGplates ▼



ULTRATHIN GELS FOR MAXIMUM ECONOMY

Anticipating the need for less expensive electrofocusing gels, LKB developed the new UltroMould: a simple device designed to cast bubble-free gels as thin as 0.1mm in less than 30 seconds. Based on a patented sliding plate method, UltroMould is easy to use, producing perfectly accurate and uniform gels and ensuring a high standard of reproducibility. Adding UltroMould to the LKB Horizontal Electrophoresis System means that significantly less gel solution and smaller sample volumes are required, resulting in far more economical electrofocusing.

LKB UltroMould casts bubble-free ultrathin gels in only 30 seconds, making gel casting quicker, easier and more certain ▶

THICK GELS FOR MAXIMUM CAPACITY

Original electrofocusing techniques used thicker gels, and even today you may still wish to work this way in order to achieve higher capacity. The LKB Horizontal Electrofocusing System lets you easily cast and run Ampholine gels up to 2 mm thick, allowing much greater sample volumes to be analyzed successfully. The 2 mm thick gels are also ideal if you are new to electrofocusing and are following a procedure described in the literature.

After the thick gel has been cast, the sample is introduced with the help of the sample application foil ▶

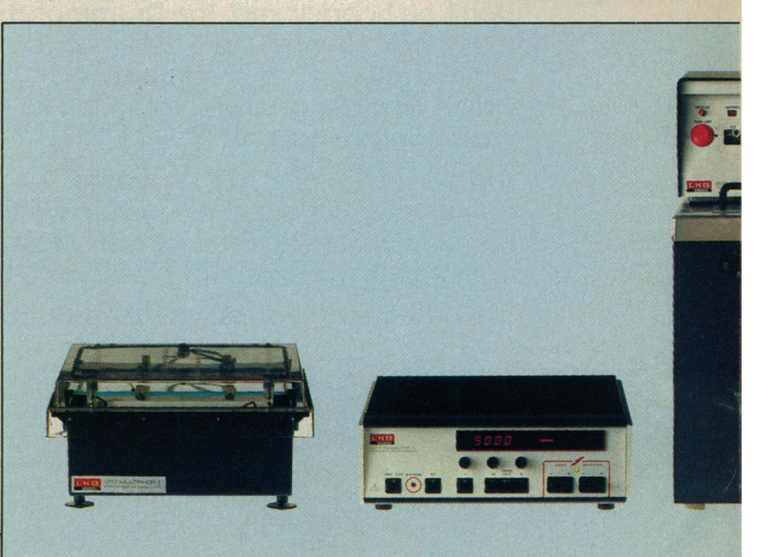
This is one in a series of advertisements describing the unrivalled versatility of the LKB Horizontal Electrophoresis System. For further information about analytical electrofocusing, and the many other applications of the system, send today for our brochure.

THE LKB SYSTEM

Only LKB can offer the research scientist a complete, integrated system in which each component works with and complements all the others. Based on the new and improved Multiphor II, the system also includes a 5KV power supply, thermostatic circulator, laser densitometer and data evaluation software.

In addition to the instrumentation, LKB provides a range of 18 major kits plus a complete programme of high quality chemicals, supplies and accessories, backed by the full worldwide support of the market leader in electrophoresis and electrofocusing.

LKB–the electrophoresis experts.

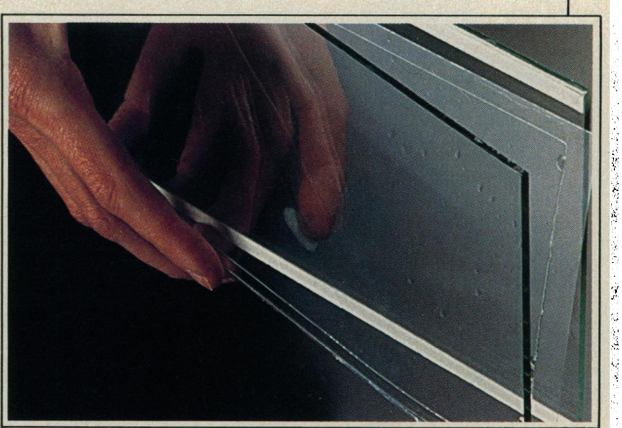


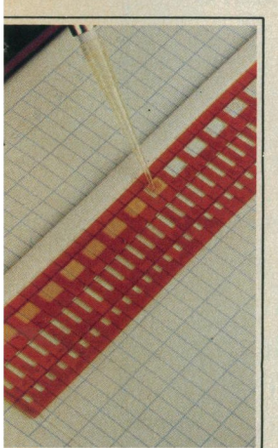
ectrophoresis System do you also get...

analytical electrofocusing

AGAROSE GELS FOR MAXIMUM POROSITY
Another of the many options available to the user of the LKB Horizontal Electrophoresis System is the application of Agarose electrofocusing gels. LKB supplies extremely pure agaroses, carefully developed for electrofocusing, and the original capillary casting method simplifies the task of producing 0.5 mm gels on GelBond Film backing sheets. Agarose is non-toxic and easy to handle and the entire analysis procedure, including casting and running, is very rapid.

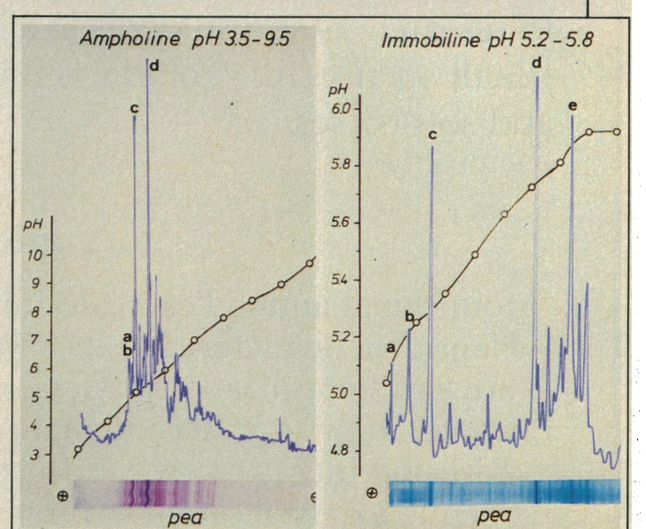
Separating the GelBond Film from the glass plate gives a 0.5 mm agarose gel, firmly attached to its support and ready to use ▶

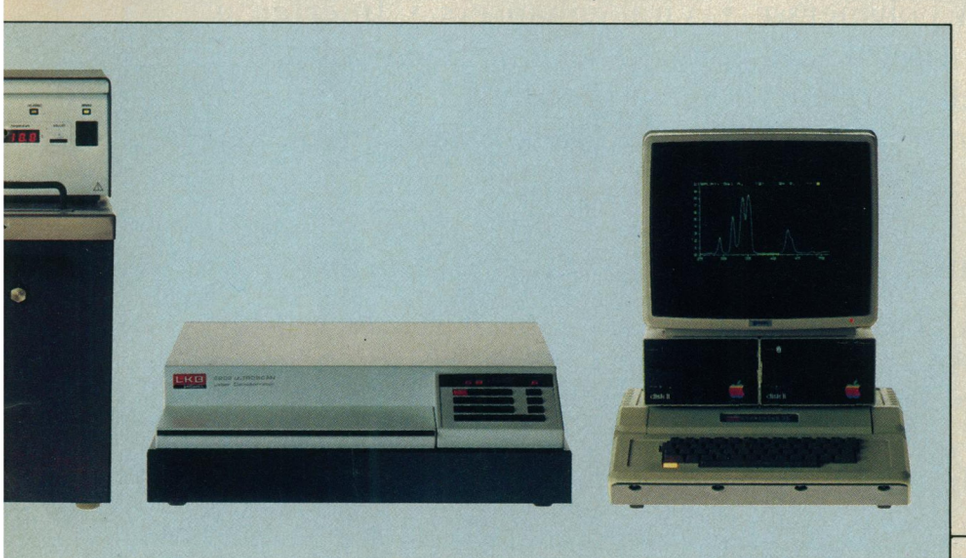




IMMOBILINE GELS FOR MAXIMUM RESOLUTION
The unique LKB Immobiline System is significantly different to traditional gels in that its pH gradient is an integral part of the gel. The system is designed to allow the user to select a pH gradient as wide as 3.0 pH units, or as narrow as 0.1 pH units, anywhere in the range 3.6 to 9.5. This tailoring of the gradient to suit specific applications permits extremely high resolution to be achieved with the LKB Horizontal Electrophoresis System. Stable and reproducible linear gradients having a slope as low as 0.01 pH units/cm are possible, allowing you to separate proteins whose pI values differ by as little as 0.001 pH units.

Comparison of traditional electrofocusing and LKB Immobiline System (courtesy of Dr A Görg et al, Technische Universität, München) ▶





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NAPCO's new Model 3810 Hi-Low temperature incubator lets you simulate day/night conditions with a degree of flexibility that no other incubator offers.

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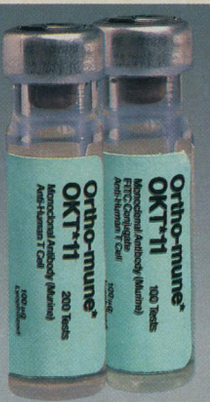

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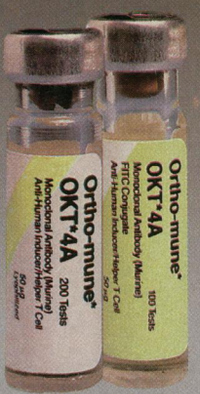

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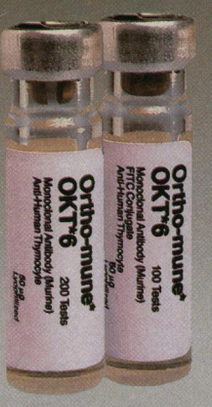

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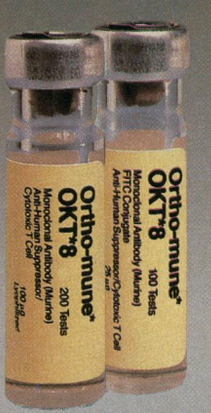

OKT8

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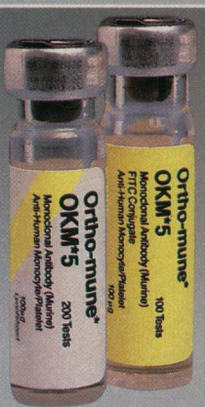

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FITC Conjugated
Goat Anti-mouse IgG

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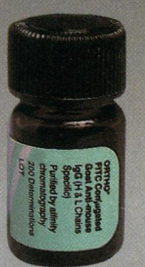
B Cell sIg Marker



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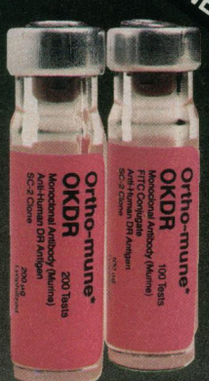

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PDB –
A bovine diagnostic base with significant advantages over human plasma

Armour Pharmaceutical Company, a leader in blood fractionation technology, introduces three new products for more convenient formulation of diagnostic standards, calibrators and controls.

Plasma Diagnostic Base . . .

- *PDB*
- *PDB - I*
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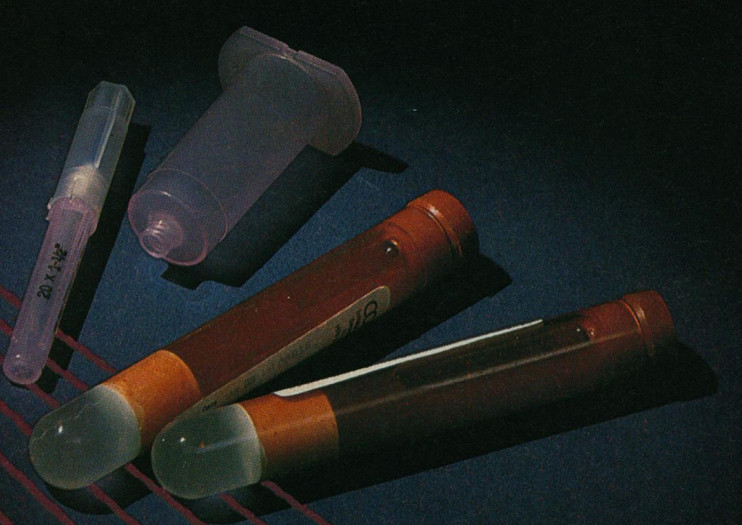
The sensible alternative to human plasma.



Armour Pharmaceutical Company

Biochemicals – a commitment to the '80s

Closely approximates human biochemical profiles, costs significantly less, no hepatitis risk

Historically, pooled human plasma has been used as the protein base for manufacture of standards, calibrators, and controls for clinical chemistry. Today, increasing numbers of clinical chemists agree that bovine-based products have significant advantages over human plasma-based products. Armour Pharmaceutical Company has taken this concept one step further — to offer the convenience of preprocessed bovine protein base in three levels — covering the whole range of values required in the field.

SPECIFIC ADVANTAGES OF PDB

- *Closely approximates human biochemical profiles.*

  PDB is available in three levels — with major constituents already adjusted to cover the whole range of values required in the field.

- *Costs significantly less.*

  PDB is a preprocessed protein concentrate ready for formulation. Little, if any, further processing is required. Because it's concentrated, there's latitude for adjustment of minor analytes and economies in lyophilization.

  No need to deal with inventory, testing, or possible spoilage of individual units of raw material.

  Because most of the process — and the control — is done by Armour Pharmaceutical Company, you get a more controlled product. Our large lot size assures uniformity.

- *No hepatitis risk.*

  PDB eliminates the need for testing and record keeping on individual units of raw material, not to mention the risk of infection to the end user.

PDB

Plasma Diagnostic Base is a preprocessed protein concentrate prepared from defibrinated bovine plasma. The basic level is analogous to a low A/G, low lipid human serum, offering maximum flexibility to the user for independent adjustment of individual analytes. PDB-Basic has reduced levels of salts, and other analytes are normal or lower than normal relative to human serum to facilitate final formulation. Since most pathological conditions characterized by abnormal A/G usually result in reduced ratios, PDB-Basic is the preferred base for use as an analog of low human abnormal controls.

PDB-I

Plasma Diagnostic Base — Level I is a bovine analog of normal human serum. The A/G ratio and cholesterol concentration are elevated to approximate normal human levels. PDB-I eliminates the need for user adjustment of two highly significant and expensive components. PDB-I is analytically equivalent to a normal human plasma product with most of the processing — and the control — done by Armour Pharmaceutical Company.

PDB-II

Plasma Diagnostic Base — Level II is a bovine analog of an elevated lipid human serum with normal A/G ratio. Elevated serum cholesterol levels may be indicative of a variety of pathological states such as coronary artery disease, diabetes mellitus, nephrosis, hepatic and thyroid diseases as well as endocrine dysfunctions. On the other hand, pathological states characterized by abnormalities in A/G ratios usually result in reduced, rather than elevated, ratios.

PDB-II rounds out the PDB line to cover the whole range of values required in the field.

PDB-II is analytically equivalent to a human plasma-based product with bovine lipoproteins added to give an elevated lipid content and bovine albumin added to give a normal A/G.

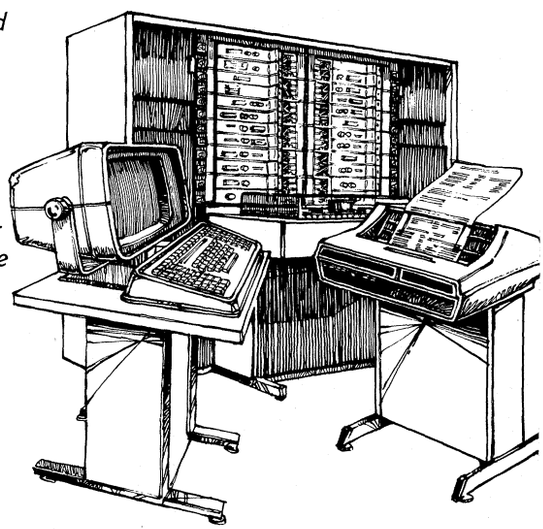
PDB-II eliminates the inconvenience — and the expense — of making these adjustments yourself. Levels of other components are similar to basic PDB. Most of the processing — and the control — are done by Armour Pharmaceutical Company. With significant advantages over human plasma, PDB is the sensible alternative.

40 YEARS IN BLOOD FRACTIONATION TECHNOLOGY.

For nearly 40 years, Armour Pharmaceutical Company has been a leader in the development of blood fractionation technology. And for more than 35 years, Armour Pharmaceutical has manufactured Bovine Albumin for biochemical and diagnostic applications.

But we are more than just a biochemical manufacturer — we are a pharmaceutical company that has dedicated its efforts to producing the highest quality raw materials for the diagnostic industry — since 1886.

For an interchange of technical information on Plasma Diagnostic Base (PDB) call 1-800-431-4505 or write: Technical Service Manager, Biochemicals, Armour Pharmaceutical Company, P.O. Box 511, Kankakee, IL 60901



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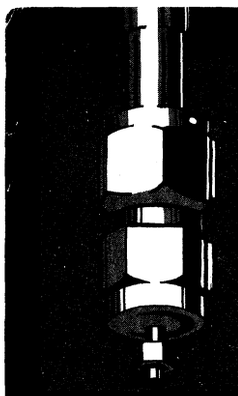

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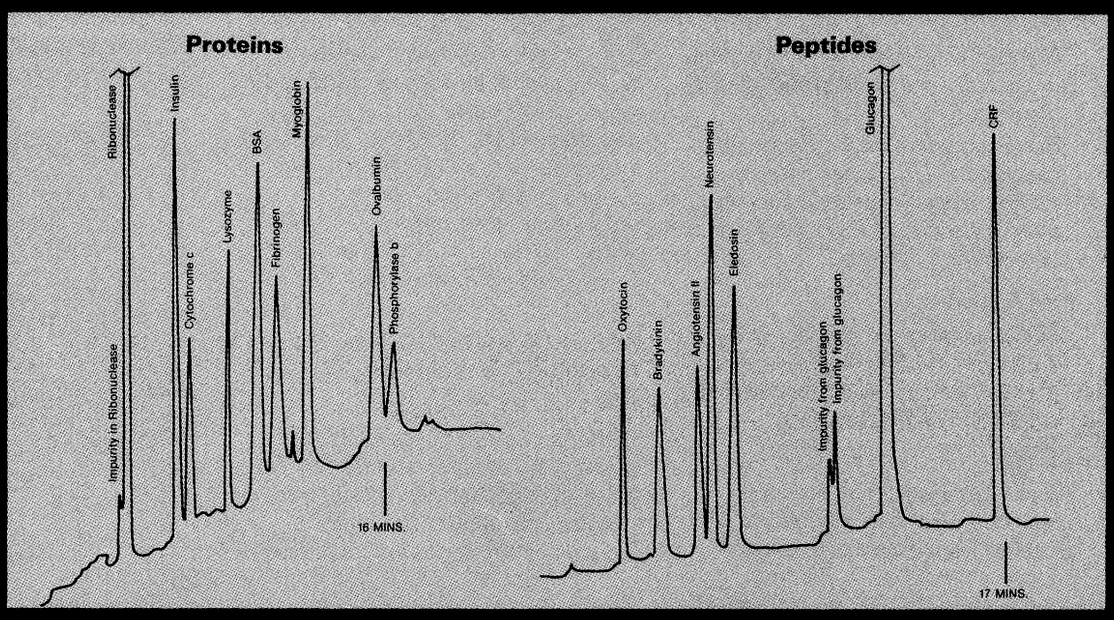

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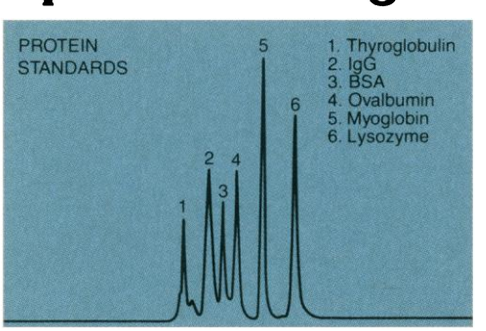

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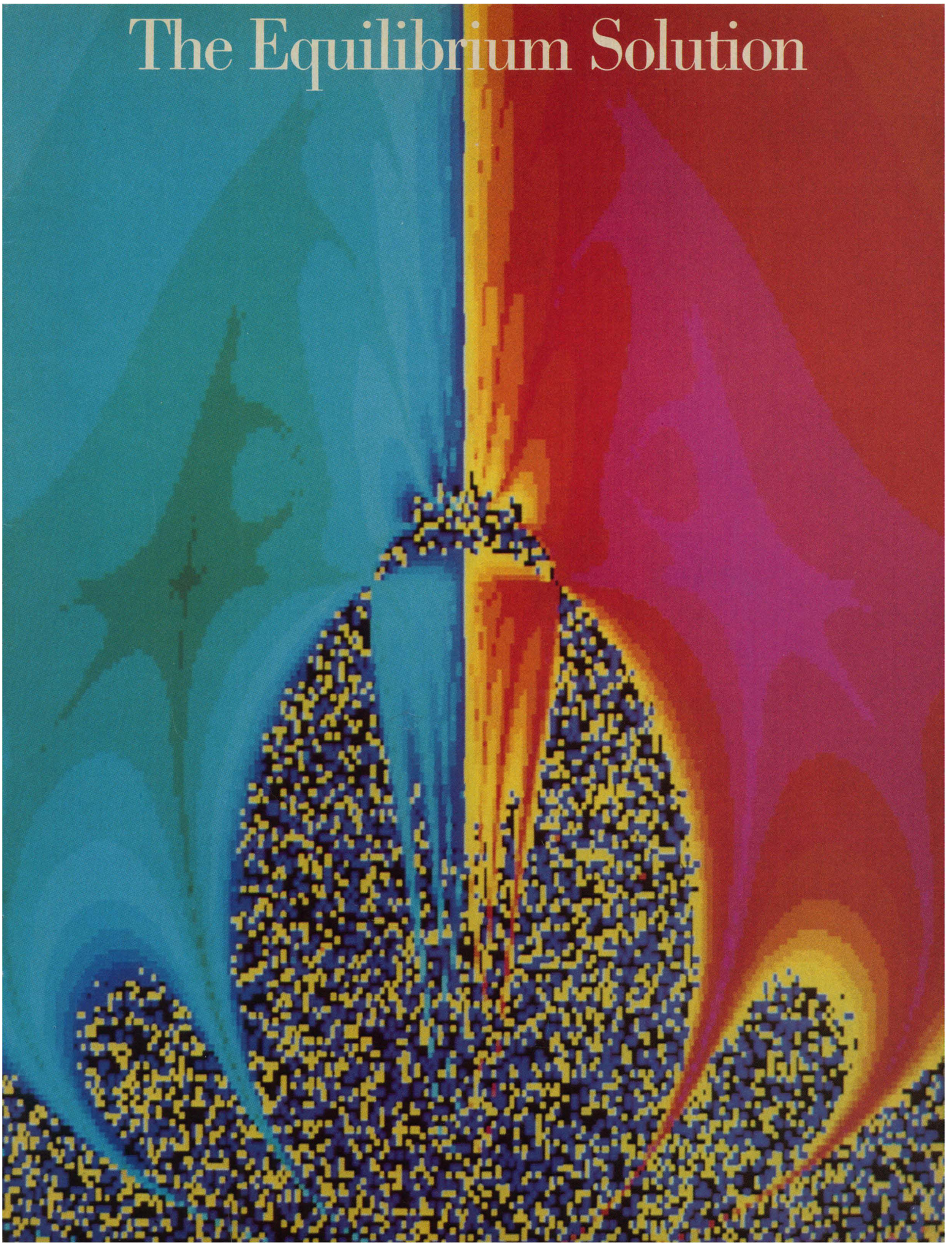
The Equilibrium Solution



The Equilibrium Solution

Rapid, reliable methods for solving chemical equilibrium equations have long been sought by scientists asking fundamental questions about systems as varied as the atmosphere, the human body, and the internal combustion engine. An interdisciplinary collaboration at the General Motors Research Laboratories has produced a breakthrough with potentially universal applications.

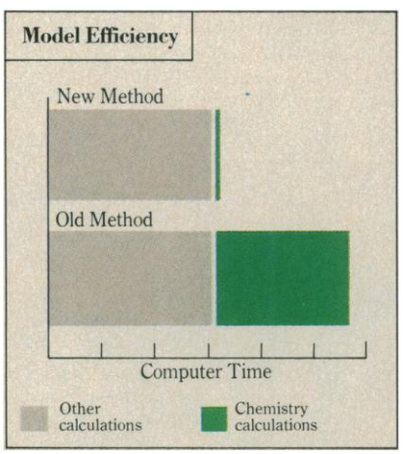
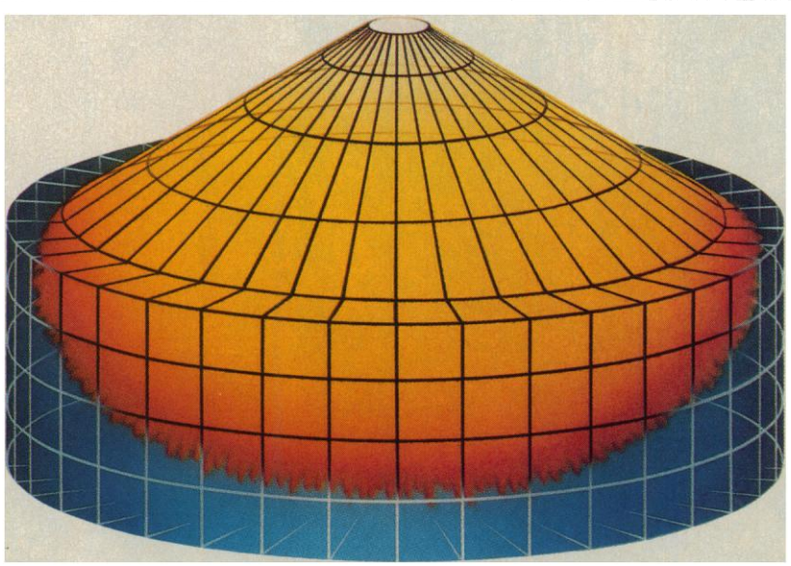


Figure 1: Computer time required by an engine combustion model. Time required for chemical calculations decreased greatly with the new methodology.

Figure 2: Artist's illustration of a chemically reacting flow. The physical space is divided by a latticed network into units of volume, and the solution must be recalculated for each grid point at each instant of time.



WHEREVER CHEMISTRY is involved, the need to solve chemical equilibrium equations arises. Although methods for solving such equations have existed for some time, they do not offer the speed demanded by the most challenging problems. For example, predicting the composition of gases inside an engine cylinder may require as many as a million equilibrium calculations per cycle. Two researchers at the General Motors Research Laboratories have developed a systematic way to reduce the mathematical complexity in these problems, thus making it possible to solve them rapidly.

Chemical equilibrium occurs when the rates of a forward and reverse reaction are equal. Mathematically, this statement usually translates into a system of nonlinear polynominal equations. Until now, there has been no fast reliable method for solving such systems. Solutions to particular problems have demanded thorough familiarity with the physical conditions. In most cases, this means partial knowledge of the answer.

Dr. Keith Meintjes of the Fluid Mechanics Department and Dr. Alexander Morgan of the Mathematics Department began their research by considering recent advances in the theory of continuation methods. They concluded that a suitable continuation algorithm could be relied on to solve the nonlinear polynomial equations that make up chemical equilibrium systems. In this insight lies the realization that the solution can be obtained without any knowledge of the physical nature of the problem.

In seeking the most efficient implementation of the continuation method, the researchers discovered that chemical equilibrium equations can always be systematically reduced to a substantially simpler mathematical form. The reduced systems have fewer unknowns and a smaller total degree. The total degree of any system is the product of the degrees of each of its equations. Reducing the total degree makes a system easier to solve. A typical combustion problem with ten equations and total degree of 192 was reduced by the researchers to two cubic equations with a total degree of nine.

The reduced systems can then be systematically scaled to fit within the limits imposed by computer

arithmetic. The range of coefficients in chemical equilibrium systems tends to be too large or too small for the arithmetic of the computer. Consequently, the solution process can fail. By construction of an effective scaling algorithm, this arithmetic constraint can be eliminated. Suitably reduced and scaled, the equilibrium systems can then be solved reliably by the continuation method.

THUS, Drs. Meintjes and Morgan accomplished their original goal of developing an innovative reliable approach to solving chemical equilibrium equations. They also made a final, unexpected discovery. Certain standard solution techniques, which fail on the original systems, can be made absolutely reliable when applied to the reduced and scaled systems. These methods, which are variants of Newton's method, are also many times faster than continuation.

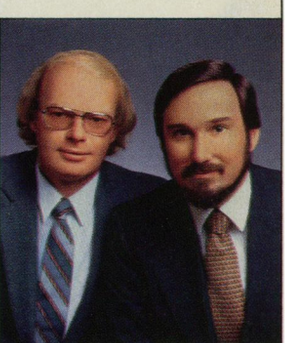
This research has produced an extremely effective solution strategy—reduction of the equations, followed by scaling of the reduced systems, followed by the application of a suitable variant of Newton's method. The simplification of the systems, which was originally formulated to facilitate the implementation of the continuation method, proved to be the critical factor enabling the use of fast techniques.

In one application, the chemical equilibrium calculations are part of a model which predicts details of the flow, turbulence, and combustion processes inside an engine. By using their methodology to develop an equilibrium solver for this application, the researchers greatly increased the model's solution efficiency (see Figure 1).

"It was the characteristic structure of equilibrium equations," says Dr. Meintjes, "that allowed us to perform the reduction. The unexpected mathematical simplicity of the reduced systems suggests that even more efficient solution methods may be discovered."

"Critical to this research," says Dr. Morgan, "was the dialogue between disciplines. I hope that this dialogue will continue as scientists and engineers in diverse fields explore the capabilities of this new methodology."

THE MEN BEHIND THE WORK



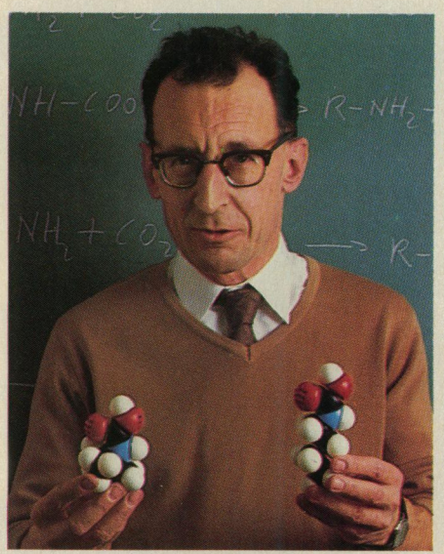
Dr. Keith Meintjes, a Staff Research Engineer in the Fluid Mechanics Department, joined the General Motors Research Laboratories in 1980. Dr. Alexander Morgan, a Staff Research Scientist in the Mathematics Department, joined the Corporation in 1978.

Dr. Meintjes (left) was born in South Africa. He attended the University of Witwatersand, where he received a B.Sc. and M.Sc. From 1973 to 1975, he taught fluid mechanics and engineering design at the university. He then went on to study at Princeton University, where he received an M.A. and Ph.D. in engineering. His doctoral thesis concerned numerical methods for calculating compressible gas flow.

Dr. Morgan (right) received his graduate degrees from Yale University in differential topology. His Ph.D. thesis concerned the geometry of differential manifolds. Prior to joining General Motors, he taught mathematics at the University of Miami. His book, "Applications of the Continuation Method to Scientific and Engineering Problems," will soon be published by Prentice-Hall.

How Exxon developed can double the productivity

Guido Sartori's work on hindered amines may impact an entire industry.



Removing impurities such as carbon dioxide and hydrogen sulfide from natural, refinery, and synthesis gases is an expensive, energy-consuming process.

But at Exxon Research and Engineering Company a new chemistry discovery, and cross functional teamwork, have led to the development of a new technology—one that significantly decreases the cost and increases the capacity of commercial gas treating processes.

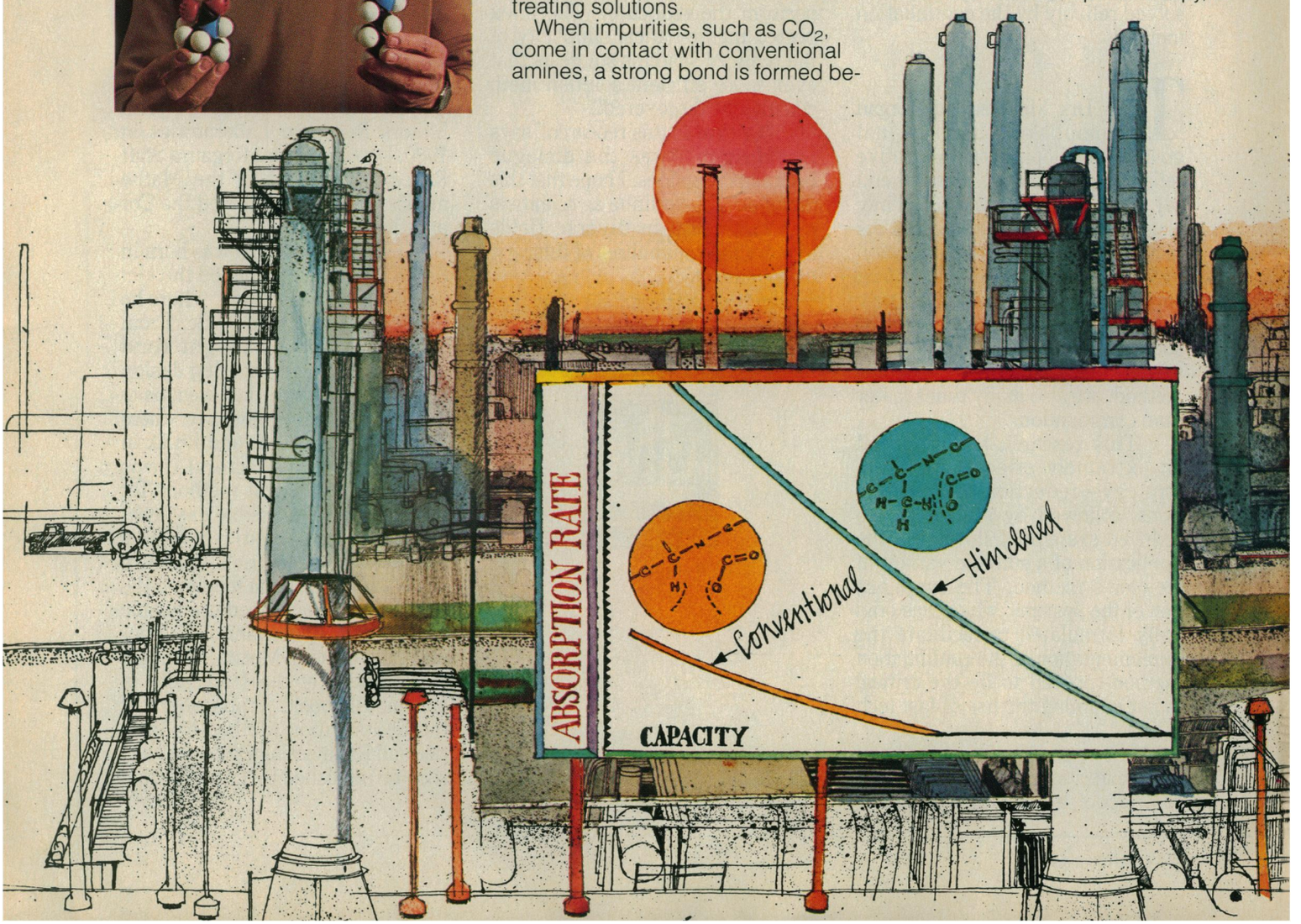
Research Led to a Discovery

Guido Sartori, a chemist in Exxon Research and Engineering Company, had been conducting research on amines—organic nitrogen-containing molecules—to increase both the absorption rate and capacity of gas treating solutions.

When impurities, such as CO_2, come in contact with conventional amines, a strong bond is formed between the CO_2 and the nitrogen atom of the amine. This strong bond ties up a disproportionate amount of useful amine. Sartori theorized that both the absorption rate and capacity of the amine would be improved if the bond at the nitrogen site could be weakened. Continuing research revealed the advantages of a whole new class of amines, which he called hindered amines.

Observing Molecular Behavior

Sartori and others began a comprehensive evaluation of the discovery, utilizing the company's advanced analytical capabilities. To understand the behavior of hindered amines, and to monitor reactions, Sartori employed the results of carbon-13 nuclear magnetic resonance spectroscopy, a



new molecules that of gas treating plants.

state-of-the-art technique not previously used for this purpose.

Further research confirmed the hindered amines' capability to substantially increase the rate and capacity of carbon dioxide absorption through the formation of low stability bonds. Low stability was achieved by placing a bulky substituent next to the nitrogen sites, thereby hindering bond formation with CO_2. Building on this new understanding, he synthesized new molecules to meet the performance requirements for specific applications.

Integrated Innovation

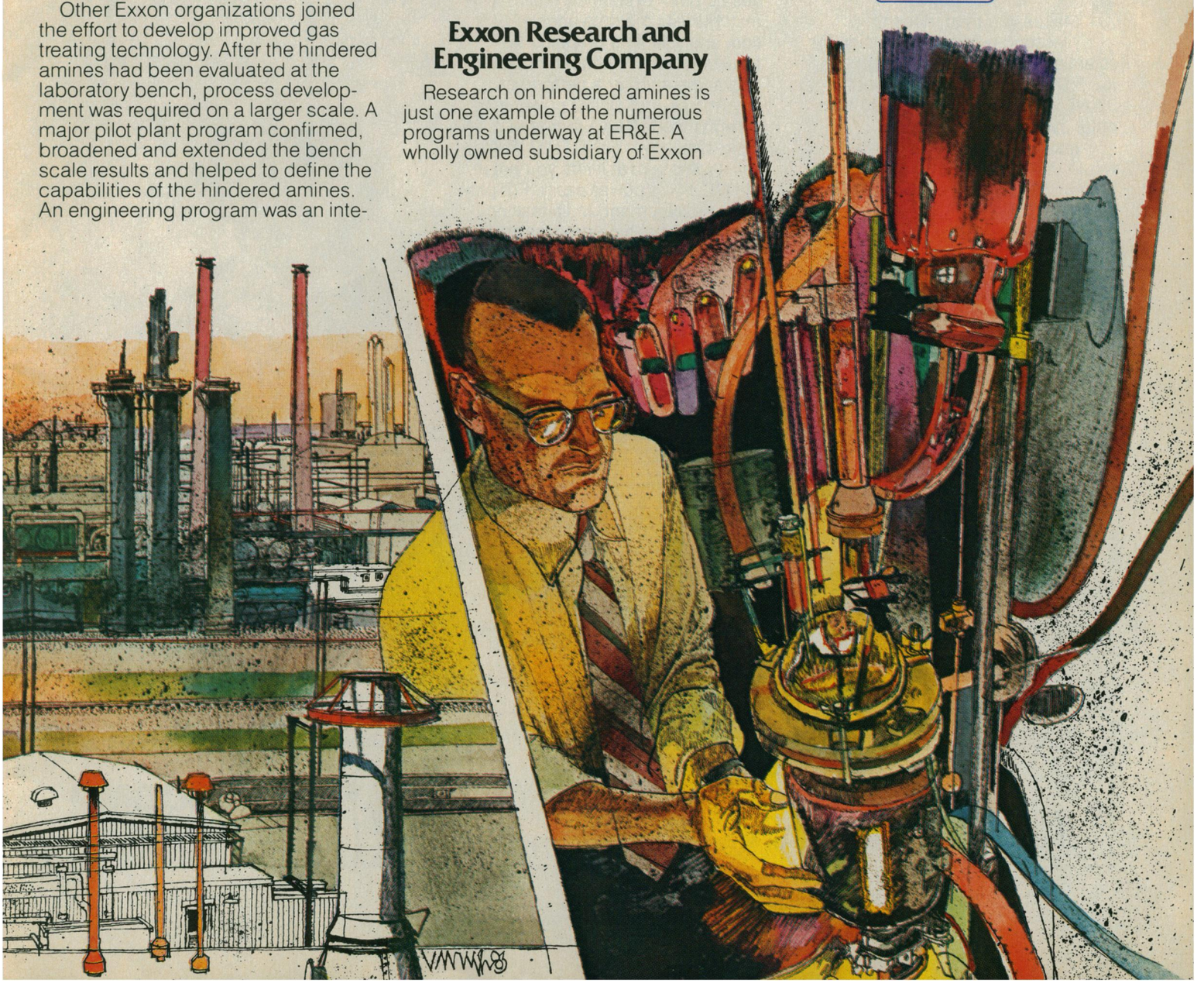
Other Exxon organizations joined the effort to develop improved gas treating technology. After the hindered amines had been evaluated at the laboratory bench, process development was required on a larger scale. A major pilot plant program confirmed, broadened and extended the bench scale results and helped to define the capabilities of the hindered amines. An engineering program was an integral part of the research and development required to convert these laboratory discoveries into commercially feasible technologies. Capacity increases of 50% have been achieved commercially using this technology with no added facilities.

Through integrated innovation–the combined efforts of the company's basic research, process development, and engineering staffs–hindered amine technologies advanced from scientific discovery through commercial use in less than three years. Further research has enabled ER&E to identify or synthesize other practical hindered amines.

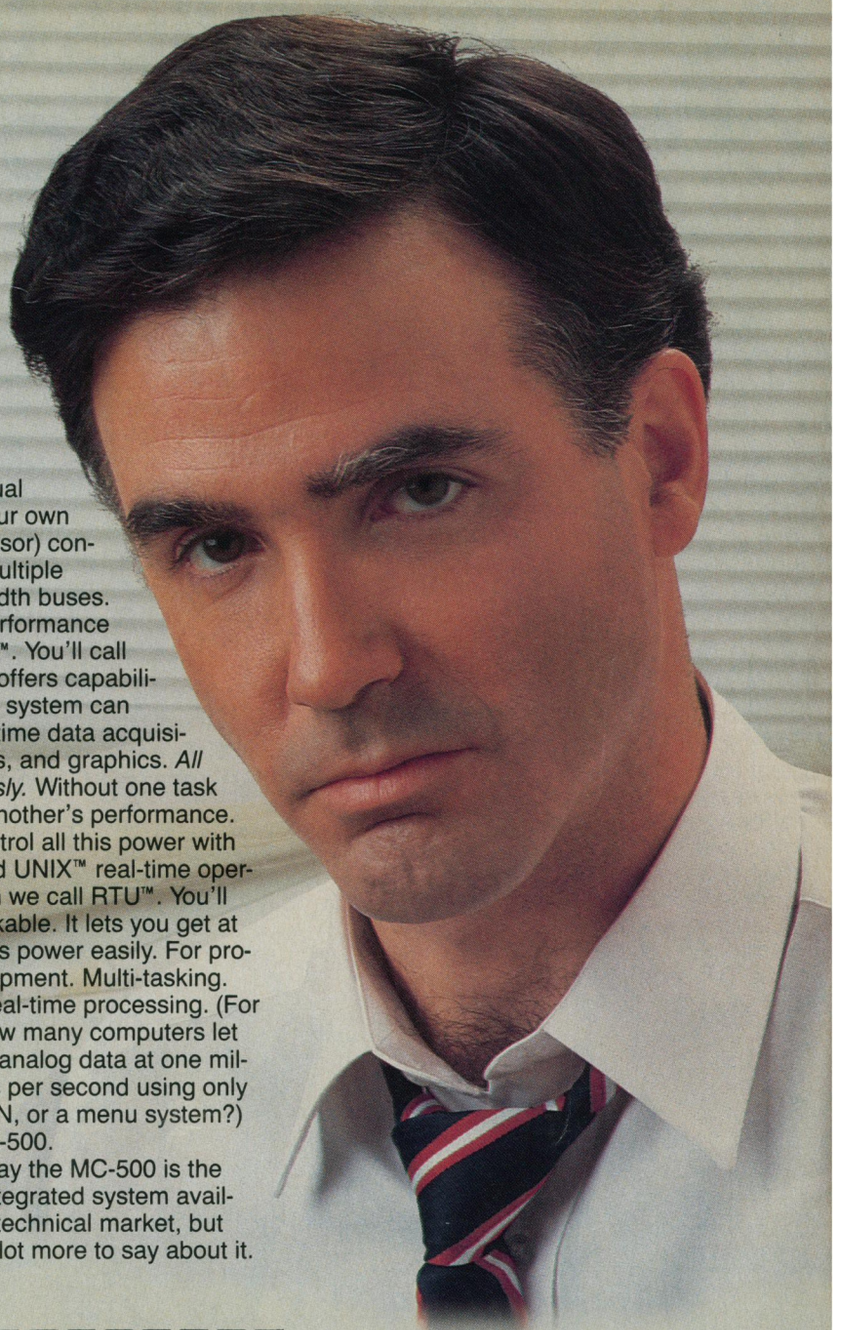
Exxon Research and Engineering Company

Research on hindered amines is just one example of the numerous programs underway at ER&E. A wholly owned subsidiary of Exxon Corporation, ER&E employs some 2,000 scientists and engineers working on petroleum products and processing, synthetic fuels, pioneering science and the engineering required to develop and apply new technology in the manufacture of fuels and other products. For more information on Exxon's hindered amine technology or ER&E, write Dr. E. E. David, President, **Exxon Research and Engineering Company, Room 804, P.O. Box 101, Florham Park, New Jersey 07932.**

EXXON



Perfect for mad scientists.



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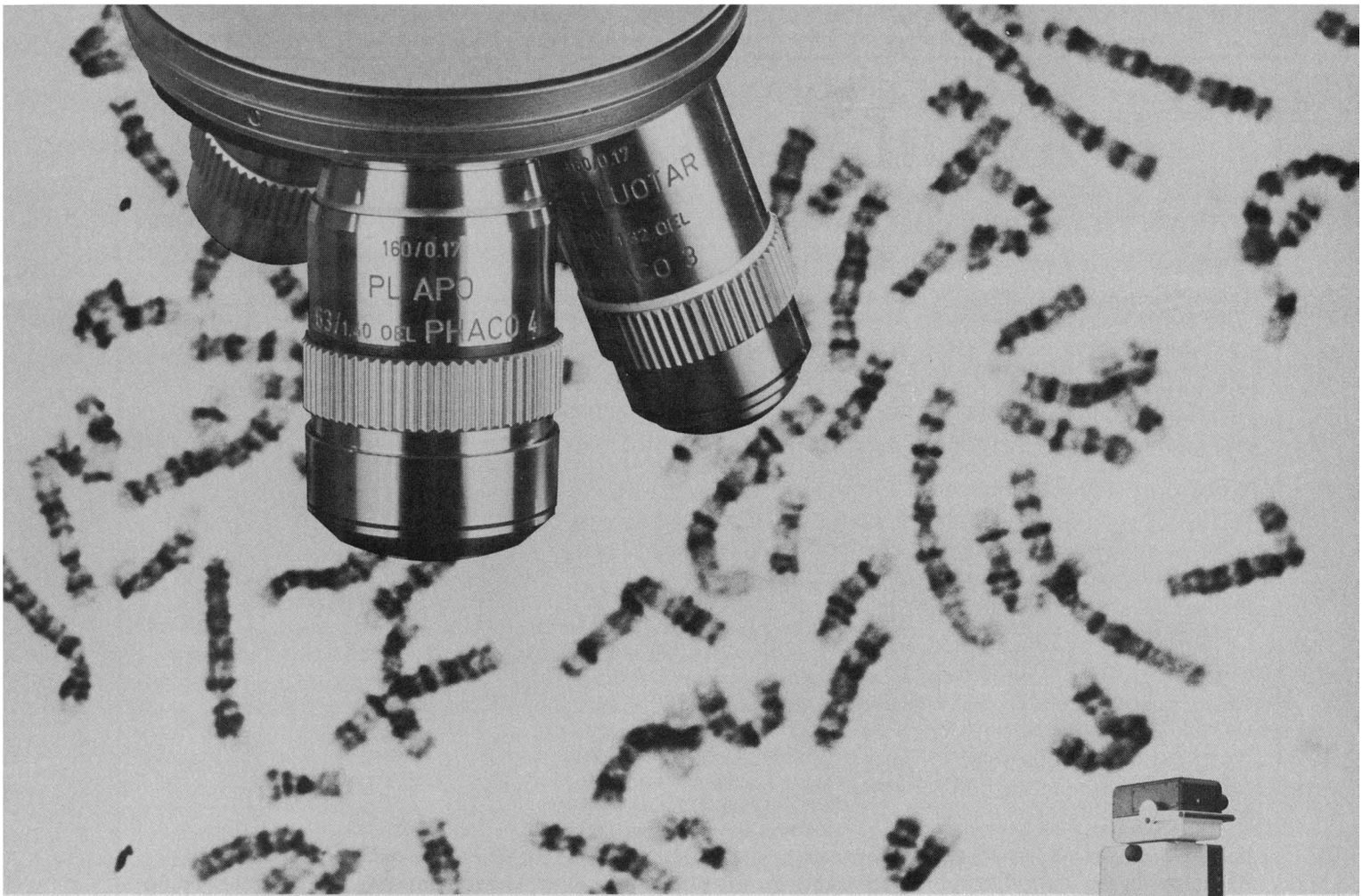

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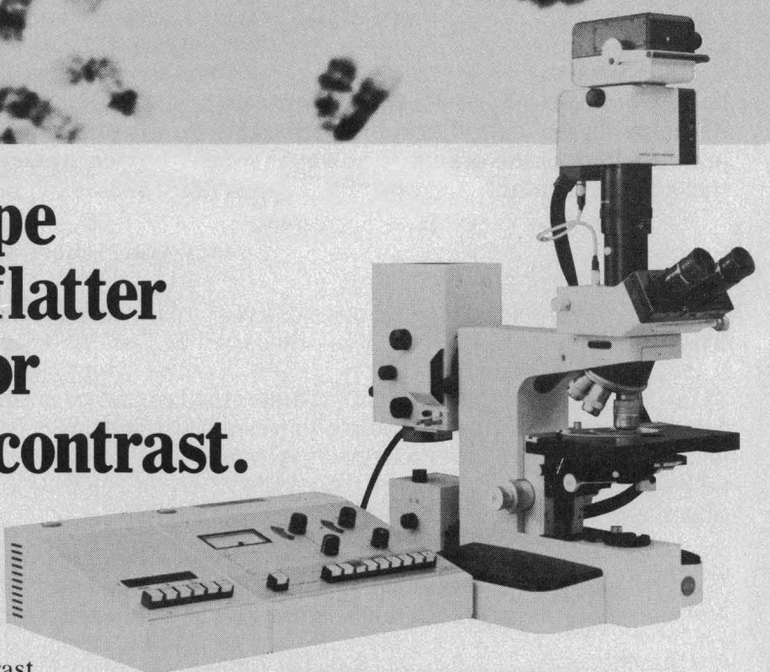

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23 November 1984, Volume 226, Number 4677 **SCIENCE**

The Vernov Radiation Belt (Almost)

Nearly 30 years ago the Soviet Union startled and frightened us by launching Sputnik 1, the world's first artificial satellite. Less than a month later they launched Sputnik 2, which contained, in addition to a dog, some instrumentation built by S. N. Vernov and his staff at Moscow State University. The purpose of the instrumentation was to make measurements of cosmic rays above the earth's atmosphere. The first American satellite, Explorer 1, carrying similar cosmic-ray instrumentation, would not be launched for nearly 3 months. The Soviet spacecraft passed well into the intense zone of radiation that would shortly be called the Van Allen radiation belt. Why, then, was the radiation belt discovered by the American rather than the earlier Russian satellite?

The Russian radiation detector faithfully responded to the radiation belt while within it. However, Vernov and his colleagues had no immediate knowledge of these detector responses because Sputnik 2 was launched into an orbit that precluded direct detection within the Soviet Union. When the satellite was over Moscow and the Russian tracking stations, it was at a low altitude and therefore beneath the radiation belt. When the satellite was at higher altitudes and its radiation detectors were signaling the presence of the belt, Sputnik 2 was over the horizon and could not be heard by the Russian tracking stations.

Although radio signals from Sputnik were picked up all over the world as the satellite proceeded in its orbit, no one else knew what the signals meant. For reasons of secrecy, the Russians had not made arrangements to have anyone else receive data from the satellite and pass the data along to them. The first the Russians knew of the radiation belt was when they learned that James Van Allen had presented Explorer 1 data to support his announcement of the discovery. The announcement was made at the National Academy of Sciences some 6 months after the launching of Sputnik 2.

Retrospective analyses of records received in Australia and South America, for example, showed that Sputnik 2 had indeed signaled the presence of the radiation belt well in advance of Explorer 1. But, because of their perceived need for secrecy, the Russians missed making one of the most dramatic discoveries in space science. If theirs had been the open program of space exploration that the American program was (and is), credit for the discovery would have gone to Vernov, irrespective of who received the satellite radio signals and decoded them. The radiation belt would today be called the Vernov radiation belt.

Secrecy in scientific matters, although undoubtedly serving to keep competitors unaware of intentions, progress, and techniques, has the obvious disadvantages of hindering the two-way flow of information and diminishing the inspirational effects provided by open communication. It also appears that blocking or hindering external communications has an unintended adverse effect on internal communications. The institutional procedures and the mind-set that accompany the deliberate suppression of the open exchange of information in one arena spill over into others where they are unnecessary or even unwanted. Some observers believe that the poor internal communications in Soviet science is a direct consequence of their penchant for secrecy.

The United States has been able to stay ahead in most areas of research by moving so fast that the competition has not been able to keep up; the flow of knowledge that is a natural consequence of the openness of our programs has been one of our strengths. Because the freedom we enjoy in scientific communications is one of the causes of our excellence in research, we should guard this freedom jealously.—A. J. DESSLER, *Director, Space Science Laboratory, Marshall Space Flight Center, Huntsville, Alabama 35812*

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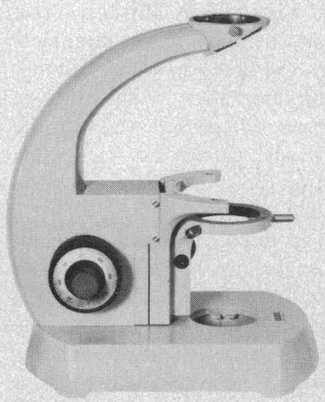

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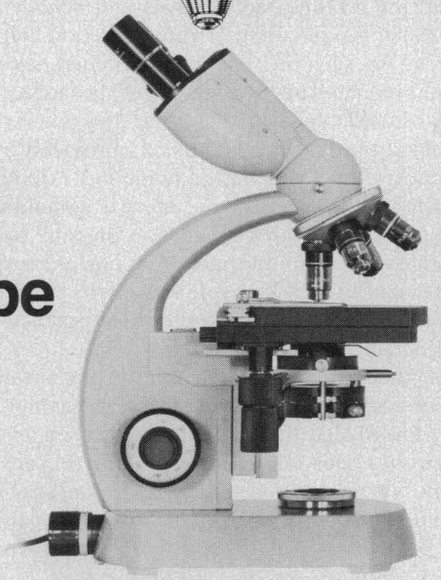

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