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SCIENCE

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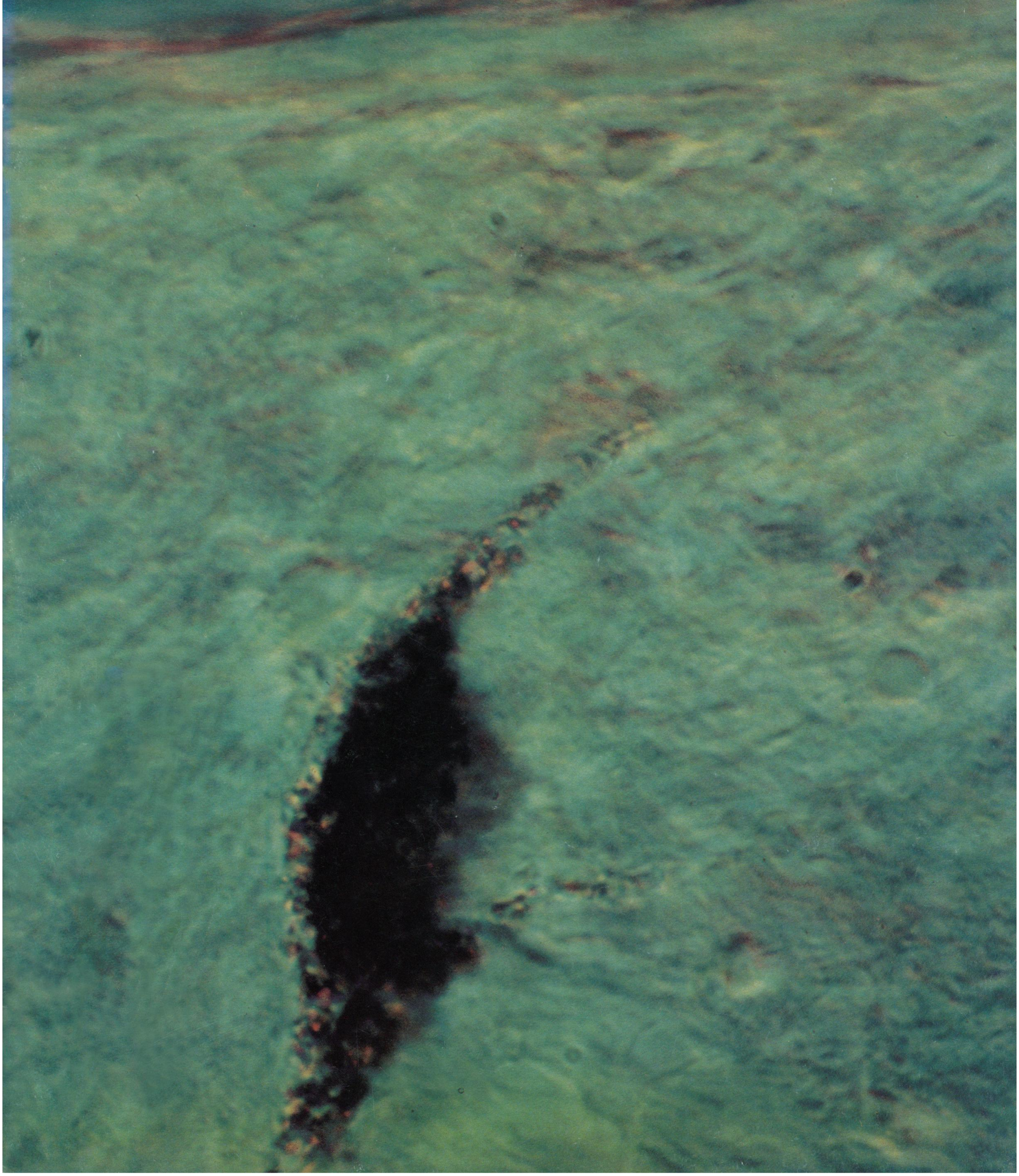

THE TJ-6 CENTRIFUGE:

Everyone says great things about it.

The TJ-6 from Beckman continues to be very popular in bioresearch, clinical and industrial labs. And users continue to tell us why, every chance they get.

They appreciate how quiet it is. They like the removable bowl that makes cleaning a snap, and the color-coded tube racks that hold so many tubes of so many sizes—from 1-mL to 50-mL tubes, and 250-mL bottles.

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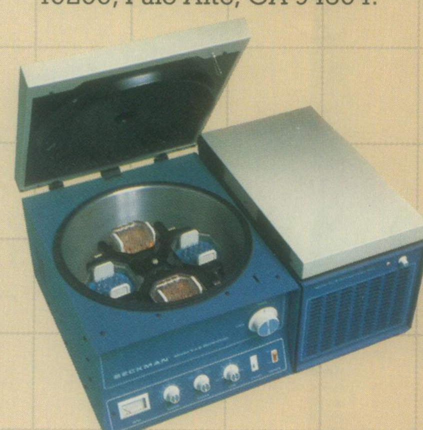
With its UL listing and CSA approval, full year warranty and seven-year rotor warranty, owners have complete confidence in the TJ-6. They're delighted with its excellent reliability, and they know that Beckman service is unsurpassed.

Users of the TJ-6R like the convenience of the frost-free refrigeration system—a first from Beckman that eliminates ice and water in the chamber and prevents sample freezing.

For a full description of the popular TJ-6 Tabletop Centrifuge, ask for brochure SB-490. Contact your local Beckman representative or write to: Beckman Instruments, Inc., P.O. Box 10200, Palo Alto, CA 94304.



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SCIENCE

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

COVER

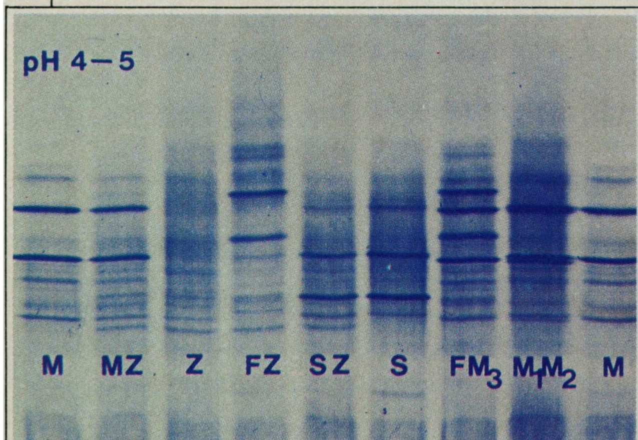
Interference contrast photomicrograph of a hypothalamic neuron (close to the ventral surface of the brainstem) retrogradely labeled with wheat germ agglutinin–horseradish peroxidase after injection in feline cerebellar cortex. The demonstration of a hypothalamocerebellar projection introduces a pathway through which cerebellum may be directly influenced by higher autonomic centers (about ×3900). See page 591. [Espen Dietrichs, Anatomical Institute, University of Oslo, Oslo 1, Norway]

Only with the new LKB Horizontal El

Unequalled flexibility in

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 ▶

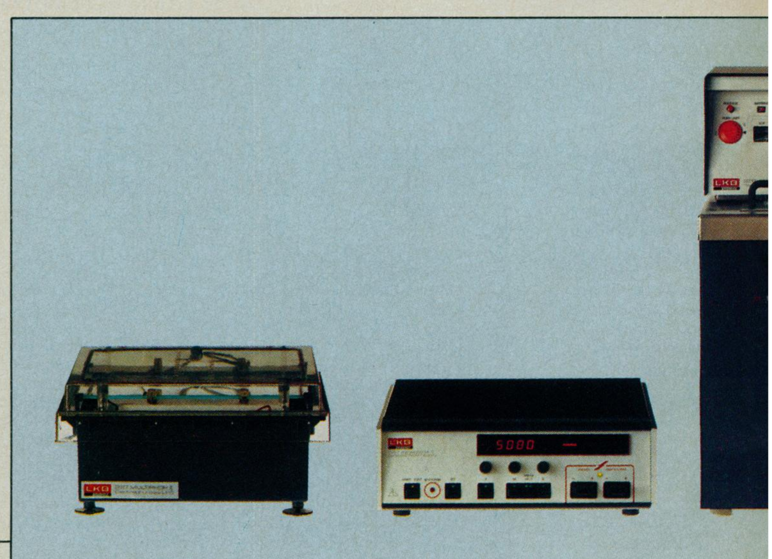
THICK GELS FOR MAXIMUM CAPACITY
Original electrofocusing techniques used thicker gels, and even today you may still wish to work this way in order to achieve higher capacity. The LKB Horizontal Electrofocusing System lets you easily cast and run Ampholine gels up to 2 mm thick, allowing much greater 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.



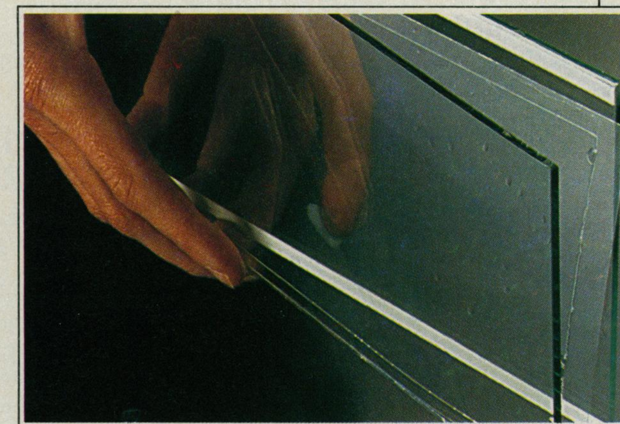
ectrophoresis System do you also get...

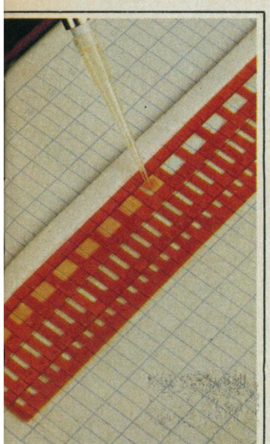
analytical electrofocusing

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 ▶

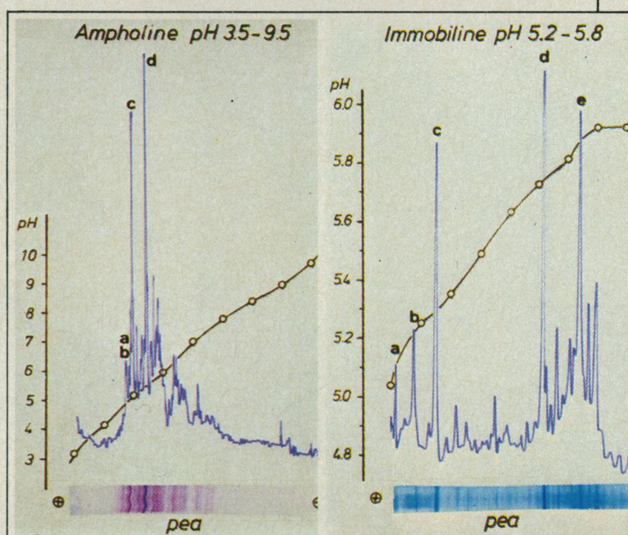


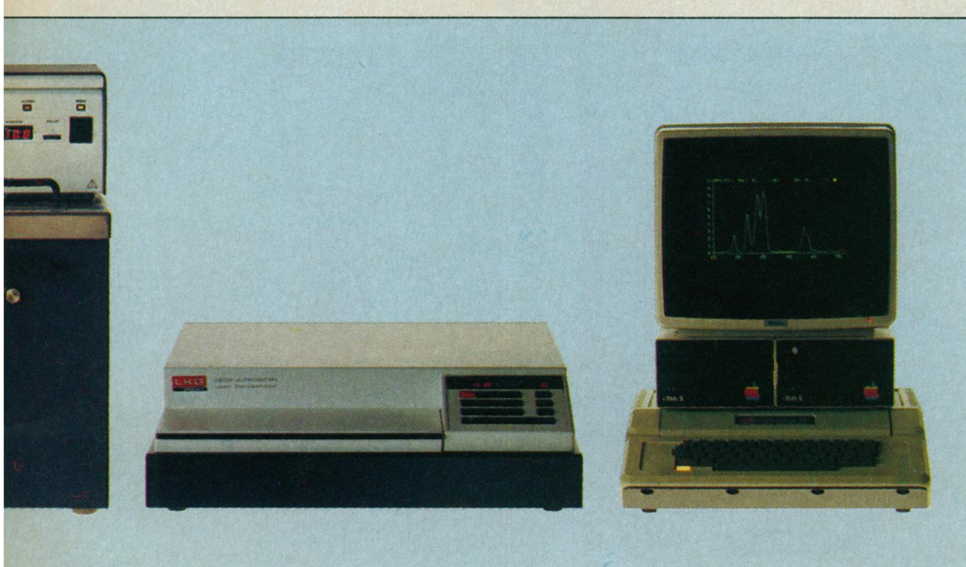


IMMOBILINE GELS FOR MAXIMUM RESOLUTION

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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How Exxon's advanced the refining of

FLEXICOKING converts 99% of even the poorest feedstocks into high-quality fuels.

A key challenge facing the oil industry today is to ensure the most efficient conversion of available crude oil supplies into the highest value products. This is increasingly difficult because, while demand is shifting toward light, cleaner-burning products, available crudes are becoming heavier.

In addition, some heavy crudes contain high concentrations of impurities, such as sulfur, nickel and vanadium, so that key catalytic refining processes cannot readily handle them. These contaminants "poison" process catalysts just as lead deactivates an automobile's catalytic convertor. Future unconventional feedstocks, such as bitumen from tar sands and shale oil, are likely to be even harder to process.

A Powerful New Refining Tool

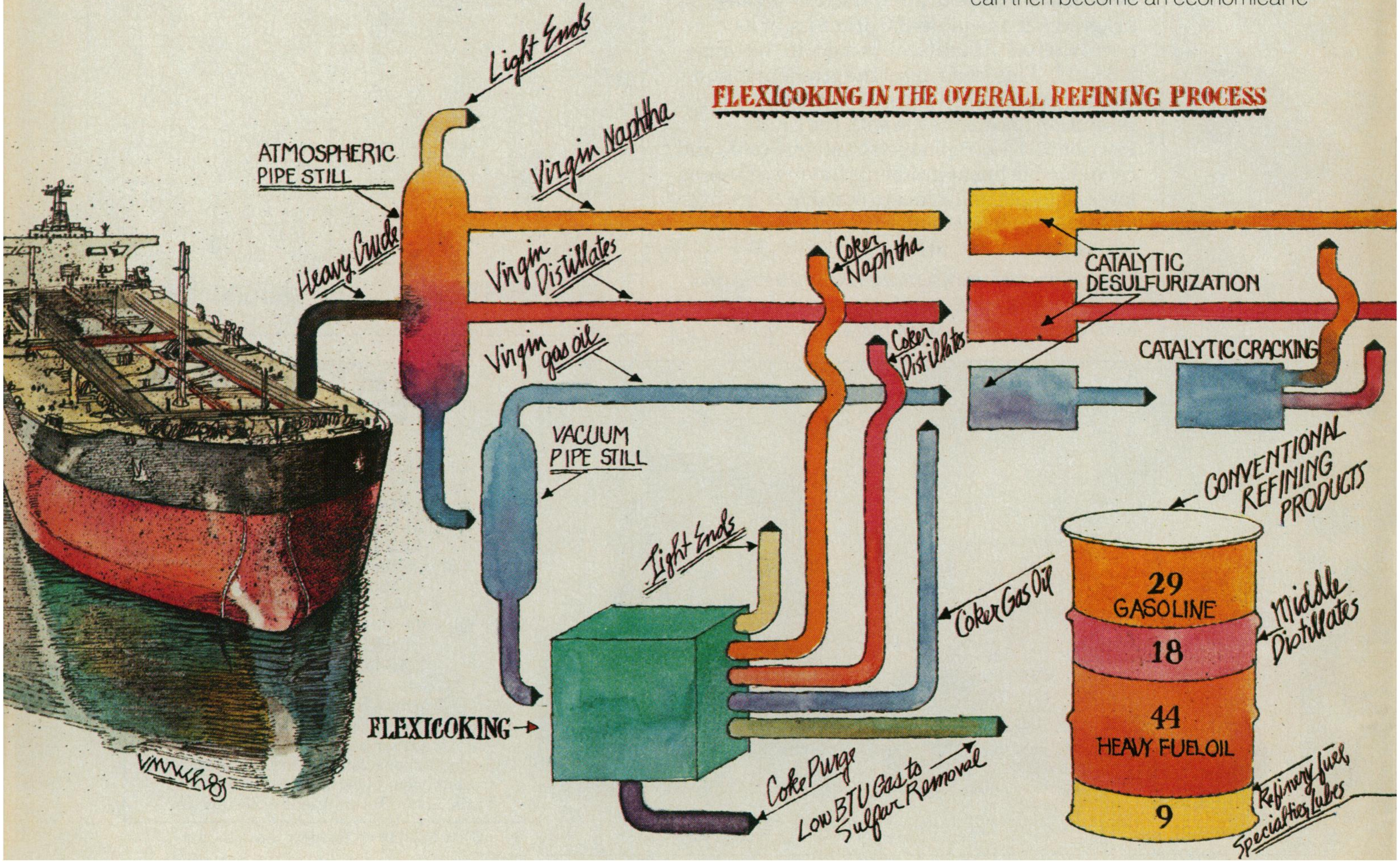
But scientists and engineers at Exxon Research and Engineering Company have a unique solution–an extremely rugged process called FLEXICOKING that converts in excess of 99 percent of the worst possible feedstocks into high-quality liquid and gaseous fuels.

FLEXICOKING relies on thermal cracking rather than catalytic cracking to convert heavy feedstocks to lighter products. Thermal conversion is not new. In the 50's, Exxon developed FLUID COKING to upgrade heavy feedstocks. FLEXICOKING further extends this pioneer thermal process with one major improvement.

In FLUID COKING, heavy feed is sprayed into a large reactor containing very hot, granular coke. The upward flow of hydrocarbon vapors and injected steam suspends the finely divided particles, permitting the hydrocarbons to contact the coke on all sides. The heavy hydrocarbon molecules fracture as they contact the hot coke. This results in additional gasoline and middle distillate liquids. However, about 30 percent of the heavy feedstock is rejected as solid coke, which represents almost 20 percent of the energy in the original feed.

Replacing Expensive Refinery Fuel

FLEXICOKING represents a key advance by converting the coke into a clean-burning low-BTU fuel gas (LBG) in a separate gasification reactor. This LBG can then become an economical re-



technology is revolutionizing difficult crudes.

placement for refinery fuels costing three to four times as much, or it can be sold to local industries. By successfully integrating coking and coke gasification into a single process, Exxon researchers have reduced the volume of purge coke to about one percent of the heavy feedstock. Metals are concentrated in this coke purge.

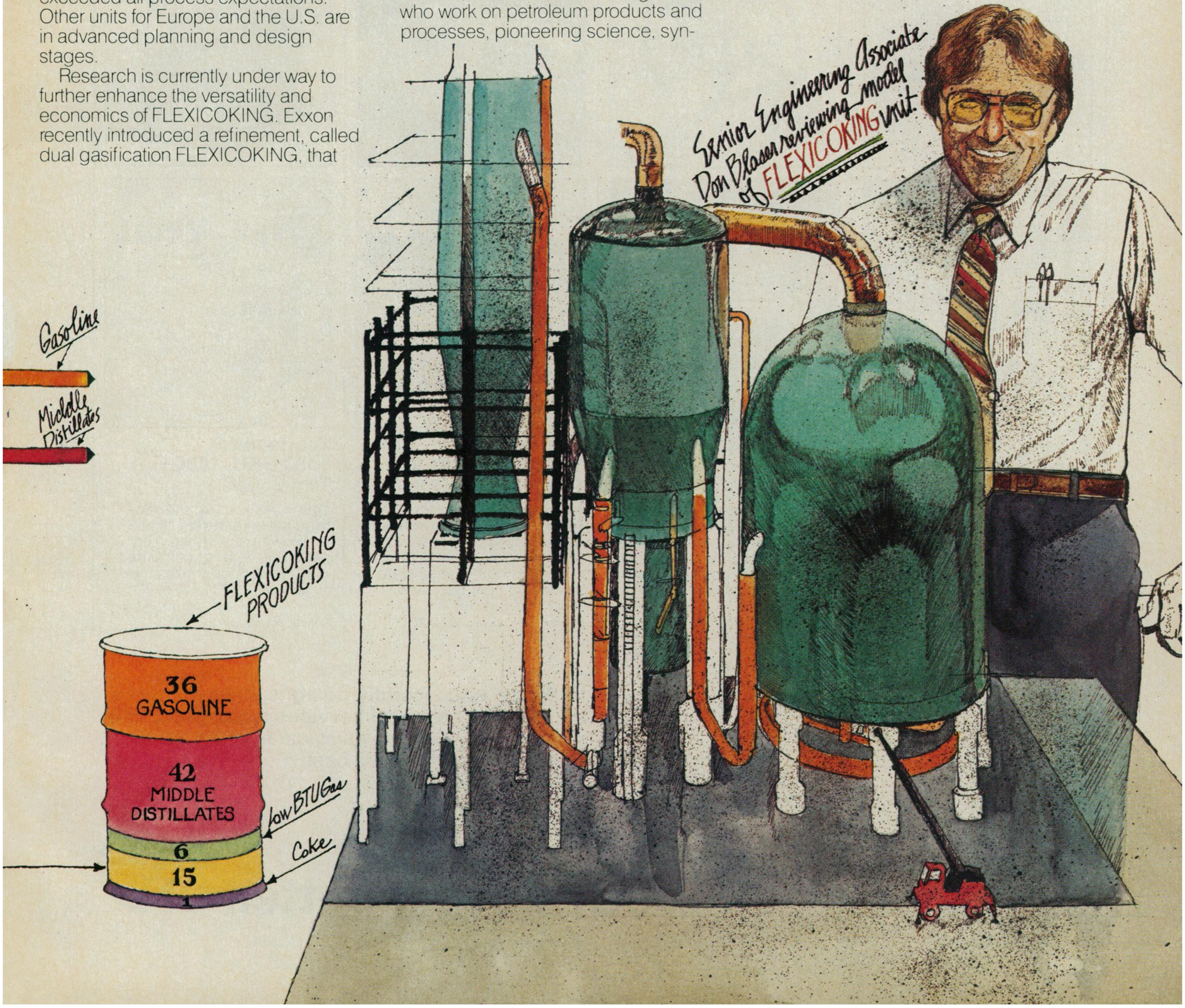
The first commercial FLEXICOKING unit went into operation in Japan in 1976. A second unit was started in Venezuela at the end of 1982 and a third in California in early 1983. Each unit has met or exceeded all process expectations. Other units for Europe and the U.S. are in advanced planning and design stages.

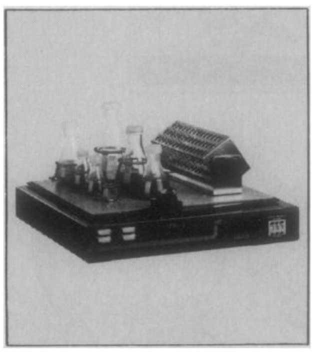
Research is currently under way to further enhance the versatility and economics of FLEXICOKING. Exxon recently introduced a refinement, called dual gasification FLEXICOKING, that enables refiners to convert part of the LBG into a nitrogen-free synthesis gas. This gas can be used as a source of hydrogen or as a feedstock for making chemicals.

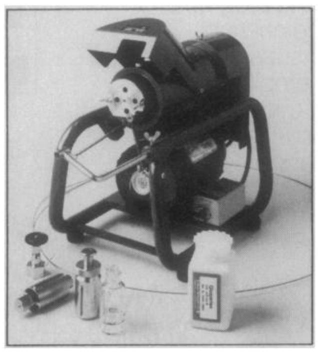
Exxon Research and Engineering Company

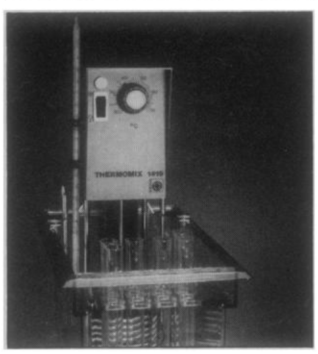
FLEXICOKING is but one product of the research and engineering programs at Exxon Research and Engineering Company. A wholly owned subsidiary of Exxon Corporation, ER&E employs about 2,000 scientists and engineers, who work on petroleum products and processes, pioneering science, synthetic fuels, and the engineering required to develop and apply new technology in the manufacture of fuels and other products. For more information on FLEXICOKING or ER&E, write to E.E. David, Jr., President, Exxon Research & Engineering Company, Room 101, P.O. Box 101, Florham Park, NJ 07932.

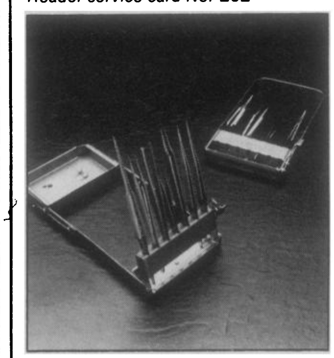
EXXON

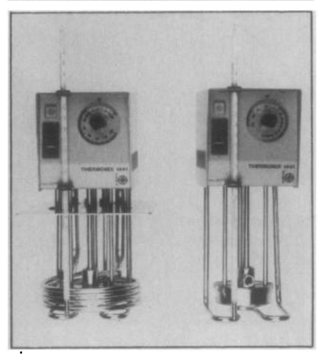


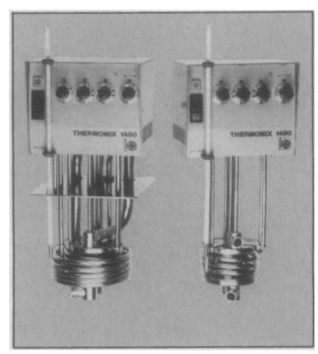












THE CAL-PUTER™

Sharp's dual-keyboard combines a scientific calculator and a BASIC computer in a portable unit that boasts a powerful 40K ROM and 2.2K RAM.

Half the story: Scientific Calculation
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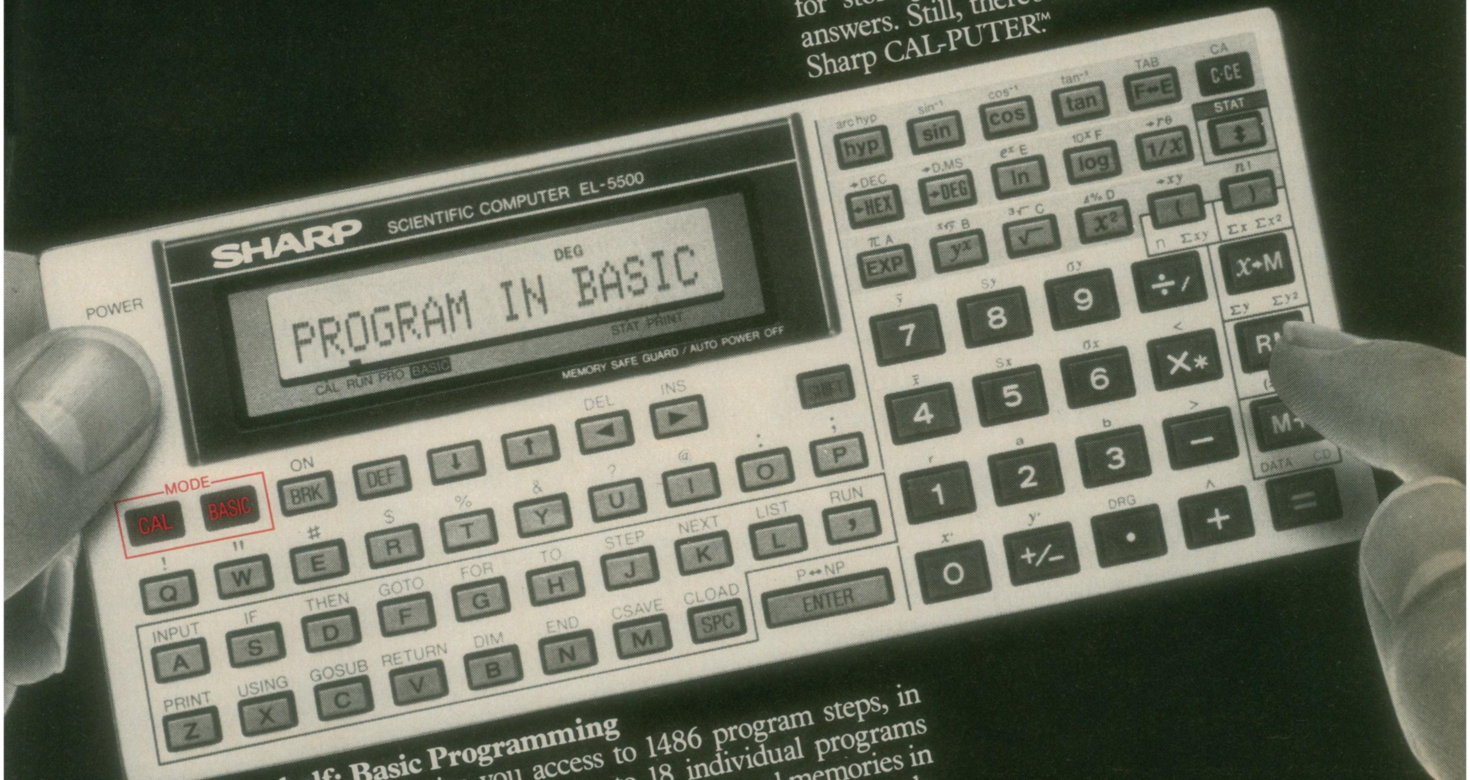
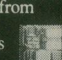


The other half: Basic Programming
A few keystrokes give you access to 1486 program steps, in easy-to-use BASIC. You can store up to 18 individual programs under different labels, and gain access to 26 additional memories in BASIC mode. Plus 18 of the most often used BASIC commands, simply by touching a key. All memories and programs are memory protected. The CAL-PUTER can also function as a scientific calculator in RUN mode. And it's easy to edit and fine-tune programs. There's even an optional printer with cassette interface for storing programs and building your own library. The Sharp CAL-PUTER. Scientific calculating combined with BASIC programming make it the best of both worlds.

Watch for our TV commercial to learn more about the latest advance in calculator technology from Sharp. We replaced a half-million transistors and diodes with one tiny "chip."



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9th AAAS R&D Colloquium Washington, D.C. 29 & 30 March 1984

Advance Registration Form (S1)

Thursday & Friday, 29 & 30 March, at The Shoreham Hotel, 2500 Calvert St., N.W., Washington, D.C.

Registrant's Name ____
(last name) (first name and initial)

Affiliation ____

Mailing Address ____
(street and number)

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(city) (state and zip) (telephone number)

☐ Please check here if you need special services due to handicap. We will contact you prior to the meeting.

Enclosed is a check, purchase order, or credit card information (see below) for:

☐ $125 Full Registration (sessions, three meals, three publications)
☐ $ 90 Partial Registration (sessions, three publications)
☐ $ 45 Student Registration (sessions, three publications; full-time graduate and undergraduate students only)

Separate Meal Tickets: Lunches, $17.50 each; Breakfast, $5. No refund for meals after 26 March.

☐ Lunch on Thursday, 29th ☐ Continental Breakfast on Friday, 30th ☐ Lunch on Friday, 30th

Packets will be mailed to preregistrants on 16 March. Registrations received after 16 March will be held at the AAAS Registration Desk at The Shoreham Hotel. All registrants will receive ***AAAS Report IX: Research and Development, FY 1985*** at or before the Colloquium, published ***Proceedings*** following the meeting, and a supplementary report, ***Congressional Action on R&D in the FY 1985 Budget,*** in the fall.

Charge to my ☐ **VISA or** ☐ **MASTERCARD** Number ____________________ Expires __________

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Return both top & bottom forms (full page) to the following address:
AAAS Meetings R&D, 1515 Massachusetts Ave., N.W., Washington, D.C. 20005

Shoreham Hotel Reservation—AAAS Colloquium (29 & 30 March 1984)

(Reservations received after 28 February cannot be guaranteed)

Names and Addresses of All Occupants of Room:

Name ____________________ Name ____________________

Address ____________________ Address ____________________

City __________ State ______ Zip ______ City __________ State ______ Zip ______

Room: _Single ($78*) _Double ($94*) _Twin ($94*)

(*Plus 10% D.C. sales tax and $1 occupancy tax.)

Arrival: Date __________ Time __________

Departure: Date __________ Time __________

Be sure to list definite arrival and departure date and time. Hotel reservations will be held only until 6 p.m. unless otherwise specified. Check-out time is 1:00 p.m.

Please indicate any special housing needs due to handicap ______________________________

Enclose separate check, made out to The Shoreham Hotel, for first night's room deposit **or** indicate major credit card number:

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argue that historical changes in vegetative cover have produced greater atmospheric loadings of CO_2 than previously believed. Although these conclusions are far from receiving universal acceptance (Research News, 9 Dec., p. 1107), their implications for global warming deserve serious consideration.

In our work, we assumed a small historical contribution of CO_2 from the biosphere and thus a relatively high fraction of anthropogenic CO_2 emissions which remained airborne (an airborne fraction of about 0.6 in 1980). We also assumed no net addition of CO_2 from the biosphere in the future. To test the sensitivity of our results to these assumptions, we developed a new scenario using the median estimate of Woodwell *et al.* of the historical airborne fraction (0.30) and their projection of future CO_2 contributions from the biosphere assuming zero population growth in 2100 (*6*). In this new scenario, we also held the airborne fraction constant over time rather than assuming, more realistically, that it would gradually increase.

Our new modeling results showed only a modest change in the medium term—the projected date of a climatically significant temperature rise (2°C) was delayed from 2040 to 2050. Longer term changes were more substantial—the assumptions of Woodwell *et al.* reduced the temperature rise projected for 2100 by 26 percent, from 5.0° to 3.7°C. Our results indicate that the estimates by Woodwell *et al.* of larger net releases of CO_2 from the biosphere and lower fraction of airborne carbon partially offset each other until forests effectively disappear (by 2060 in the scenario of Woodwell *et al.*). Thereafter, the lower airborne fraction reduces the rate of CO_2 and temperature rise.

In summary, the main conclusion of *Can We Delay a Greenhouse Warming?* appears to be robust—fossil fuel policies are unlikely to prevent a significant warming by the middle of the next century, although they could substantially reduce total warming that occurs by 2100. This study also demonstrates that learning more about the sinks and sources and thus future growth of greenhouse gases other than CO_2, and about the thermal sensitivity of the atmosphere to all greenhouse gases, will be critical to reducing uncertainty about warming in the next 50 years and beyond. Developing successful strategies for adapting to climate change will depend on better understanding of the timing and effects of global warming.

Much of EPA's research has focused on adaptation—that is, on ways to reduce potential negative effects of climate change and exploit positive ones.

For example, two pilot studies were undertaken to assess the value of anticipating future sea level rise in Charleston, South Carolina, and Galveston, Texas. The results suggest that preparing for sea level rise could reduce property losses due to storm damages and coastline erosion by hundreds of millions of dollars in each of these communities (*7*). The importance of anticipating changes in sea level to siting hazardous waste and sewage treatment facilities was also investigated. Another study analyzed the potential opportunities and risks faced by the forest products industries as a result of changes in CO_2 and climate. These and other studies clearly demonstrate the importance of narrowing remaining uncertainties about the trend and distributions of future climate change as fast as possible.

D. L. KEYES

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J. S. HOFFMAN
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Washington, D.C. 20460

References and Notes

1. S. Seidel and D. Keyes, *Can We Delay a Greenhouse Warming?* (Environmental Protection Agency, Washington, D.C., 1983).
2. National Research Council, *Changing Climate* (National Academy Press, Washington, D.C., 1983).
3. See references cited in (*1*).
4. W. Wang and J. P. Pinto, *J. Atmos. Sci.* **37**, 333 (1980).
5. D. J. Wuebbles, F. M. Luther, J. E. Penner, *J. Geophys. Res.* **88**, 1444 (1983).
6. Solid line in figure 6 of the article by Woodwell *et al.* on p. 1084.
7. M. Barth and J. Titus, Eds., *Sea Level Rise to the Year 2100* (Van Nostrand Reinhold, Stroudsburg, Pa., in press).

Keyes *et al.* appear to have missed the point of our discussion. Any reduction in the total release of CO_2, whether through conservation of energy or through improved management of forests, will be reflected in lower rates of accumulation in the atmosphere. The possibilities for reducing the buildup of CO_2 or postponing the time of doubling appear considerably greater than Keyes *et al.* suggest from consideration of fossil fuel policies alone. Adaptation is not the only strategy.

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J. M. MELILLO, B. J. PETERSON
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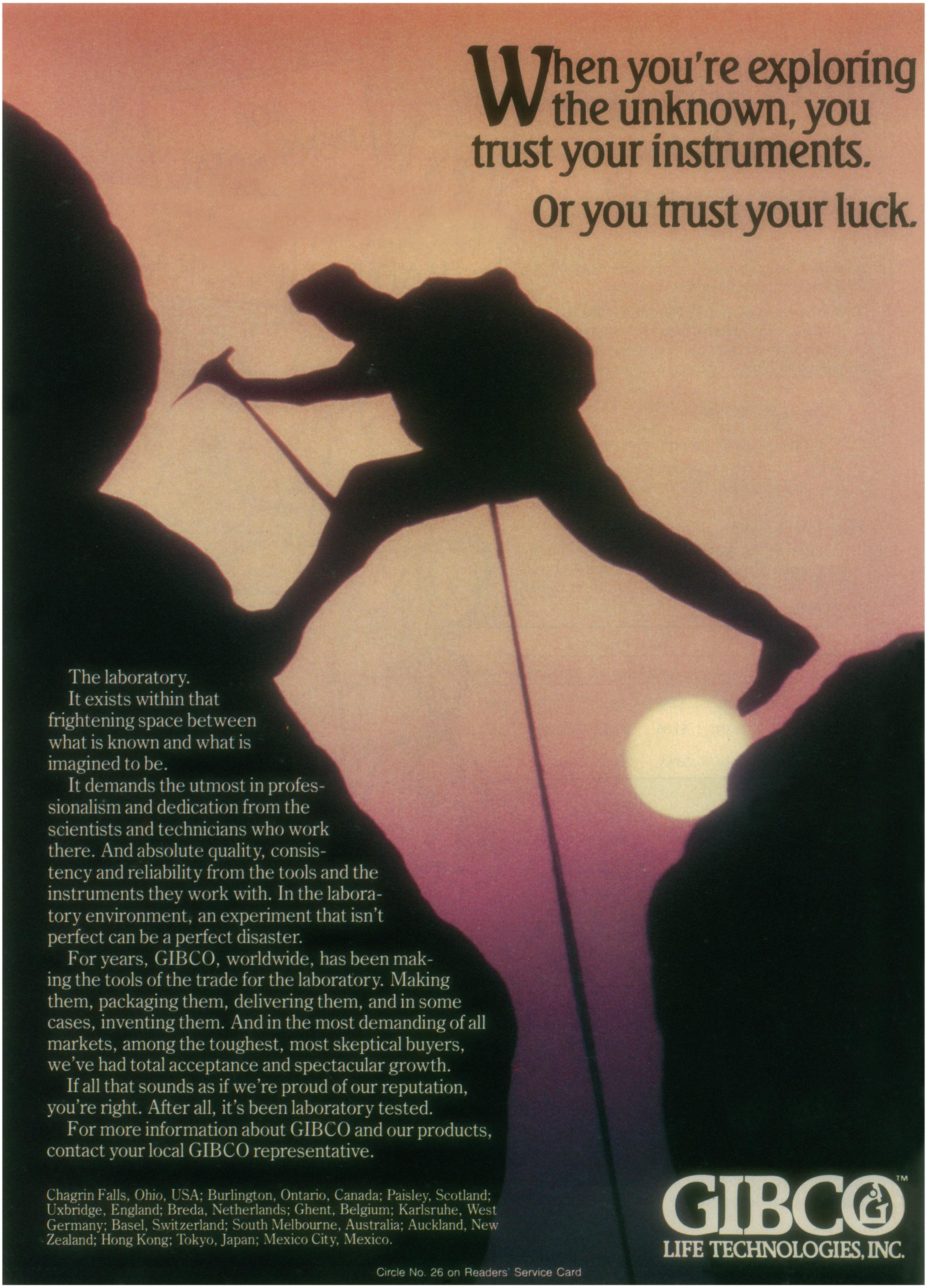
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10 February 1984, Volume 223, Number 4636 SCIENCE

Science, Engineering, and Technology

In exploring the relations among science, engineering, and technology, we are hampered by a vocabulary developed in a less technical age. Terms such as genetic engineering, social engineering, biotechnology, and management technology indicate the magnitude of change in recent years. The manner in which the terms science, engineering, and technology are used influences the course of analysis and the results of the analysis. To think of each as a process is consistent with current activities, and I am strongly attracted to the analyses that flow from this approach. Science is the process of investigation of physical, biological, behavioral, social, economic, and political phenomena. Process is used in a collective sense, encompassing everything the investigator does from the selection of the phenomena to be investigated to the assessment of the validity of the results, and includes the selection of methodology, the selection of instrumentation, the delineation of protocol, the execution of protocol, the reduction of data, the development of constructs, and the assessment of the certainty associated with the results. The details depend upon the relative roles of observation, experimentation, and theoretical modeling. The legacy of investigations of phenomena, the legacy of science, is scientific knowledge consisting of a database, an array of methodologies, and an array of concepts.

Engineering is the process of investigation of how to solve problems. Here again process is used in the collective sense to include everything the investigator does from the acceptance of the problem to the proof of the validity of the solution. The legacy of the investigations, the legacy of engineering, is engineering knowledge consisting of a database, an array of methodologies, and an array of concepts.

Technology is the process of production and the delivery of goods and services, and technological innovation is the process of investigating how to produce and deliver more effectively goods or services, modify significantly their characteristics, or create and deliver new goods or services. Again, process is a collective term and includes everything from the identification of concept to the successful delivery of a product. The legacy, technological knowledge, consists of a database, an array of metholodogies, and an array of concepts.

The sum of scientific, engineering, and technological knowledge is a continuously expanding resource of unprecedented richness and value. Without a term for this body of knowledge, it is frequently referred to as scientific knowledge. This has enhanced the arrogance of scientists, demeaned the contributions of engineers and institutions of technology, and confused issues related to national security and international competition.

A conventional wisdom of scientists is that science drives engineering and technology. A strong case can be made that both engineering and technology drive science. (Artifacts of past civilizations attest to the long practice of engineering. Observations made in breweries initiated investigations of both chemical and biological phenomena.) A less prejudicial view is that the three—science, engineering, and technology—are synergistic.

Science and engineering are generic terms—umbrella terms—each encompassing a multiplicity of disciplines. At the same time that scientific disciplines and engineering disciplines are proliferating, the two umbrellas, science and engineering, are moving closer together and may overlap, with scientists increasingly involved in problem-solving and engineers increasingly involved in the investigation of phenomena.

Many endeavors of society such as medicine and education are in part science, in part engineering, and in part technology.—ANNA J. HARRISON, *Mount Holyoke College, South Hadley, Massachusetts 01075.*

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