SCIENCE

24 January 1964

Vol. 143, No. 3604

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FERN ANTHERIDIA

The new portable Mark 280 doubles resolution of traces without sacrificing frequency response! And . . . you get instantaneous rectilinear ink records of unparalleled accuracy and clarity. Forced fluid writing presents traces, at frequencies to 35 cps full scale, on low cost chart paper. Dual channels each have 50 divisions in an 80 mm width, with trace width constant at one-tenth of a chart division. So now, you can easily detect minute signal variations and take *full* advantage of a ½% system accuracy. Matched solid-state amplifiers provide a sensitivity of 0.5 millivolts/div. Operating controls include attenuator, pen-position, variable gain and 12 push-button chart speeds. No other recorder can match the total capability of the Mark 280. Write for details.

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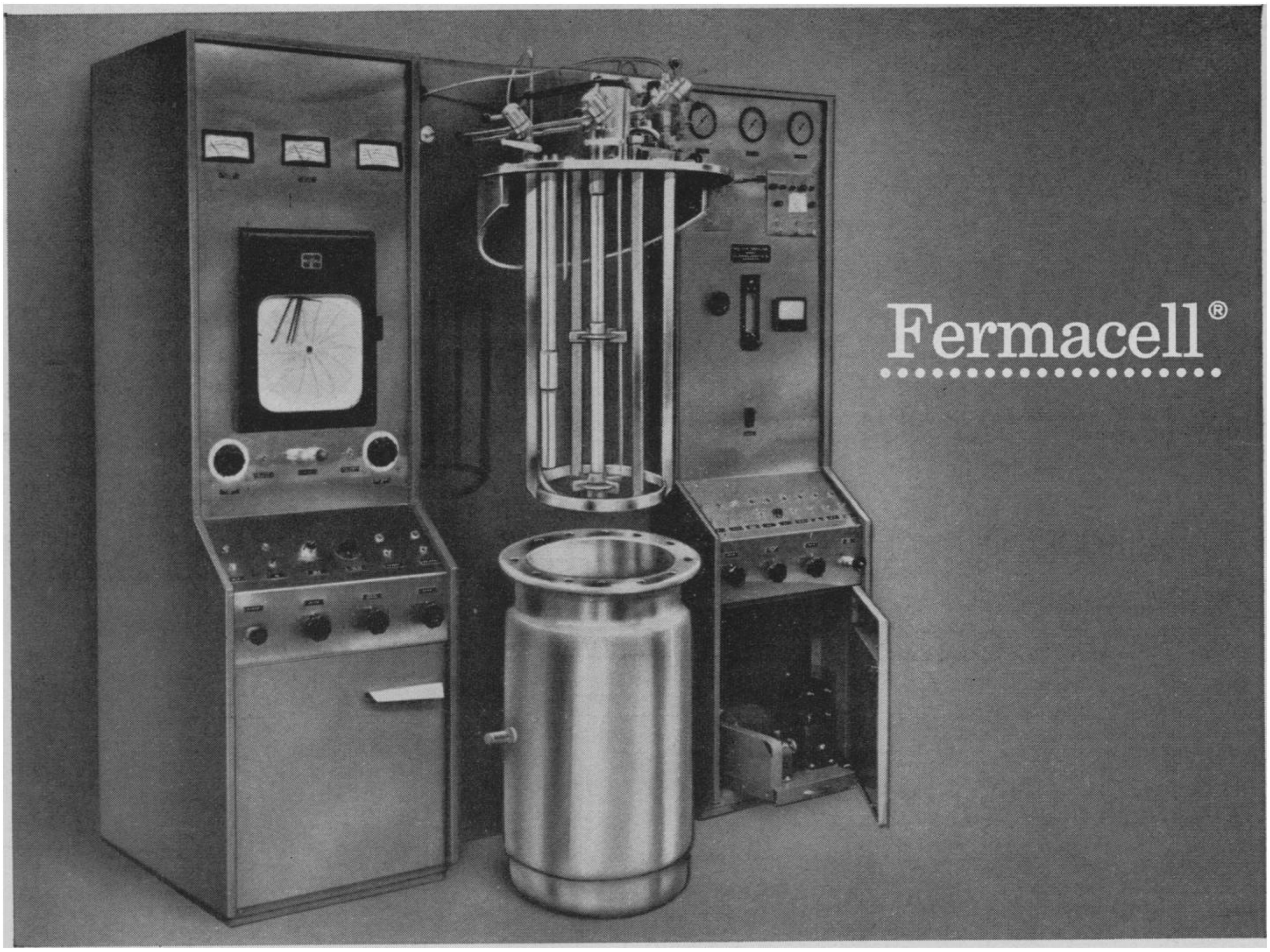
DIVISION OF CLEVITE 37TH AND PERKINS, CLEVELAND 14, OHIO



The Fermentor with the Removable Vessel

For laboratory, pilot-plant and small-scale production of microbial cells

The Fermacell is a general purpose fermentor used for basic laboratory research as well as pilot-plant and small-scale production of microbial cells. It is available in two sizes for working volumes up to 40 or 100 liters and is designed for batch production and continuous culture.

Rigid Control. This culturing apparatus is a completely steam-sterilizable system, fully integrated for rigid control of agitation, aeration, temperature, pressure, foam and pH. It is used for growing aerobic and anaerobic bacteria, streptomycetes, molds and yeasts, as well as mammalian and plant tissue cultures.

Easy to Handle and Easy to Use. The Fermacell's fermentor vessel can be removed quickly by one person in less than three minutes for cleaning as well as emptying and refilling. This design permits complete access to process lines, ports, and electrodes mounted in the stationary fermentor head plate.

Send for 12-page Illustrated Catalog No. FMS/1244

NBS New Brunswick Scientific Co., Inc.
1130 Somerset Street, New Brunswick, N. J.

FERMACELL FEATURES

Removable Fermentor Vessel is easy to handle, easy to clean; provides complete access to the fermentor interior.

Replaceable Shaft Seal Assembly is designed for repeated steam sterilization and a long life of positive sealing without danger of contamination. Seals are contained in a removable cartridge to facilitate inspection and replacement.

Rigid Temperature Control is maintained within ±0.5°C from 5°C above water supply temperature to 60°C.

Integral Recirculating Water Conditioning System circulates cold or heated water to fermentor jacket on control demand.

Extremely Versatile for a wide range of microbial studies. Components are designed for simple removal and cleaning as well as flexibility of operation. Choice of interchangeable spargers and impellers in four different models.

Broad Range of Accessories include Automatic pH Control, Photosynthetic and Ultraviolet Illuminators, Air Incineration System, Air Humidifier, Air Compressor and other equipment.

Easy to Operate—all controls are conveniently mounted on the front of the apparatus.

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SCIENCE

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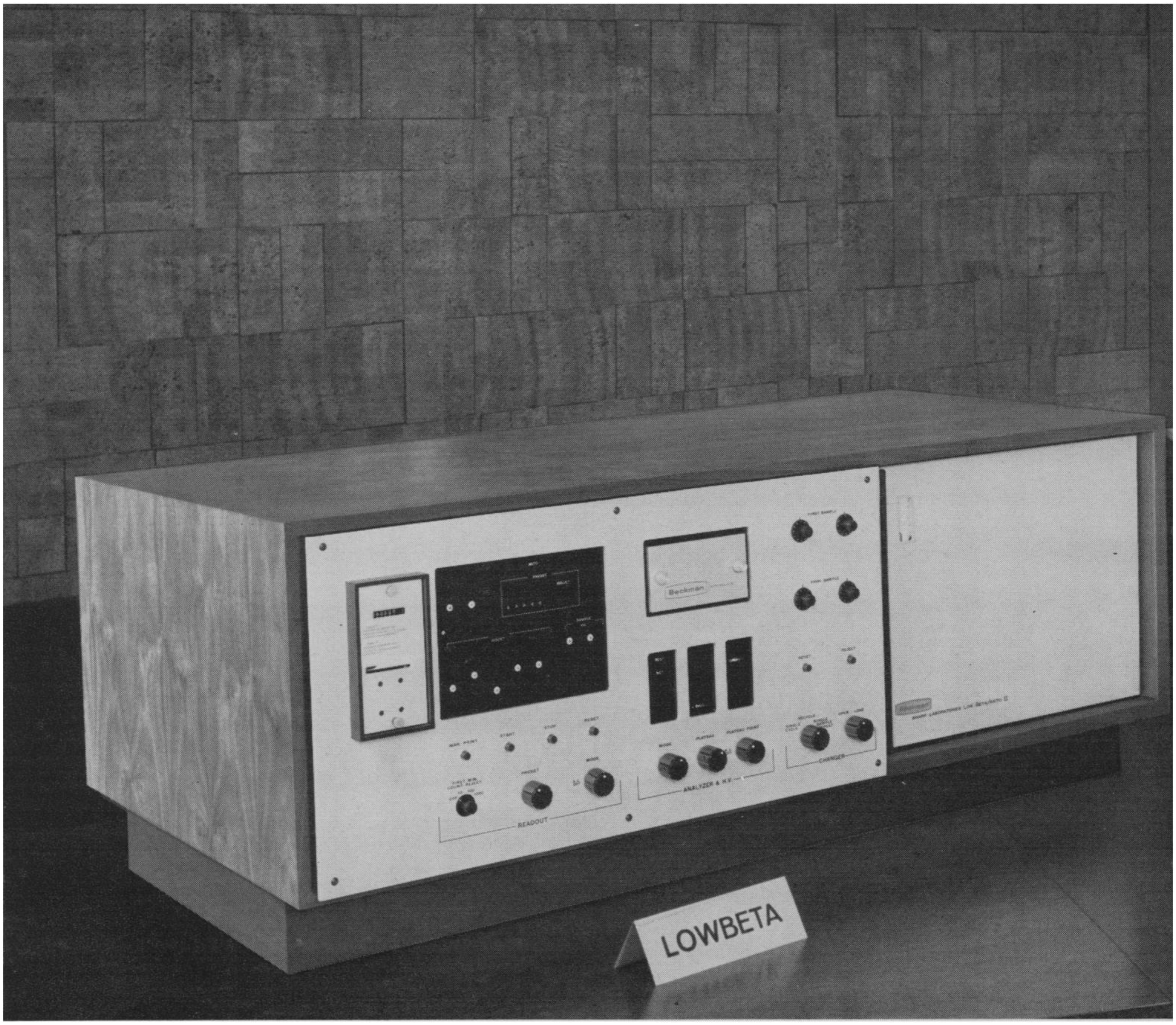
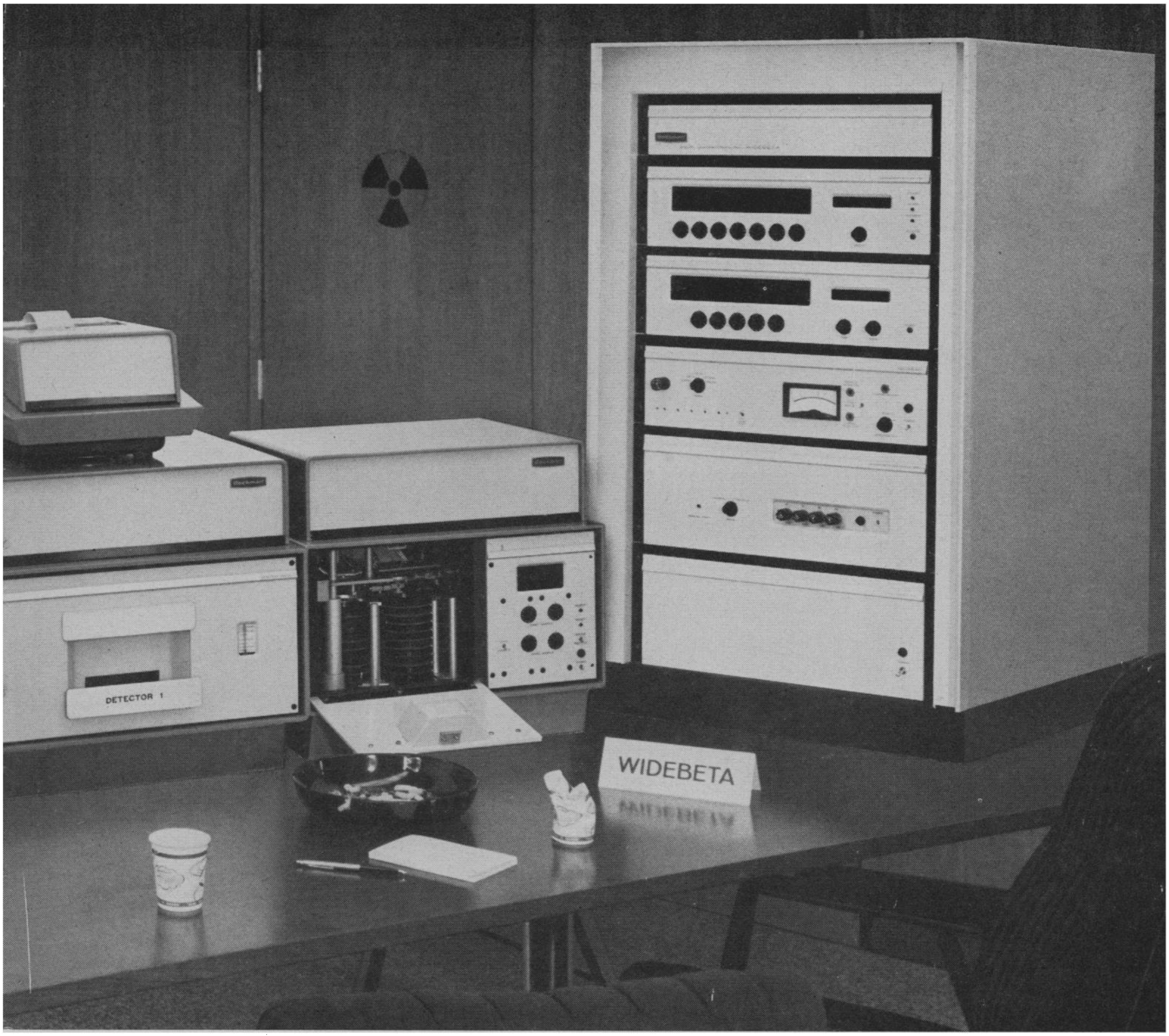
COVER

Sperm cells emerging from an antheridium of a gametophyte of *Anemia phyllitidis.* After exposure of the fern to gibberellic acid, large, knob-like antheridia form. Long, slender rhizoids and the sculptured spore coat are visible (about × 547). See page 373.



We first asked ourselves, "Do they have the proper background?"

(The question came up just before the Sharp Radioactivity Counting Systems joined the Beckman family. The answer...yes, the lowest background available and fully reproducible too.)



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Its background is the lowest at any price. And it's the first to guarantee that 95% of all given background measurements in a 24 hour period will be within ±2 standard deviations of the average background counting rate. This assures you precise, error-free sample counting. Sensitivity over the entire planchet area is uniform. New overlapping detectors see to that.

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You may select from 12 different LOWBETA II systems depending upon your requirements. Visual and printed readouts. Either geiger or proportional gas operation. Manual or automatic versions. And with three different detector sizes (including the new 5″ size).

WIDEBETA is the most advanced planchet counting system in the world.

It combines the lowest background and full reproducibility with the widest counting range of any system. WIDEBETA performs equally well at a few counts per hour or over one million counts per minute. And with a loss of less than 1% at one million. Live timing is behind this.

WIDEBETA offers full automation. Automatic sample changer handles up to 100 samples. Automatic pulse height sorting and blanking allows simultaneous alpha-beta counting as well as energy separation of mixed beta emitters. Automatic background subtraction provides net count information directly. Digitally presettable timing decades permit automatic normalization of data to percentage of a standard.

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The IEC HR-1 . . . Highest Speeds Highest G's and now CONTINUOUS FLOW!

If you demand extraordinary performance and versatility plus continuous flow capabilities in a high speed centrifuge, you can significantly increase your lab's output and capacity by adding an IEC HR-1.

With the exclusive new **Helixtractor** continuous flow unit, the HR-1 separates micro-deposits from large volumes with efficiency gains up to 300/400%. Further, the Helixtractor is completely aerosol free; can be removed and autoclaved as a unit, so it is ideal for centrifuging infectious materials.

HR-1 delivers 18,500 rpm. Forces to 41,320 x G. Holds any temperature between −20°C to +10°C within 1°C. It offers 5 high-G angle heads and 70 accessories including a Maxiforce Ring that permits spinning 250 ml plastic bottles to 26,300 x G.

If you presently own an HR-1, the Helixtractor is available to you right now. Demand a demonstration.

If you are considering a high speed centrifuge the HR-1 is easily the most reliable, versatile, high performance instrument in the standard price range.

WRITE FOR BULLETIN O.

Helical separation takes place in a transparent plastic coil. Material is introduced into the spinning helix through a central stationary hub. Solids collect along the tubing wall as a paste. Different phases are easily identified and isolated simply by cutting the tubing.

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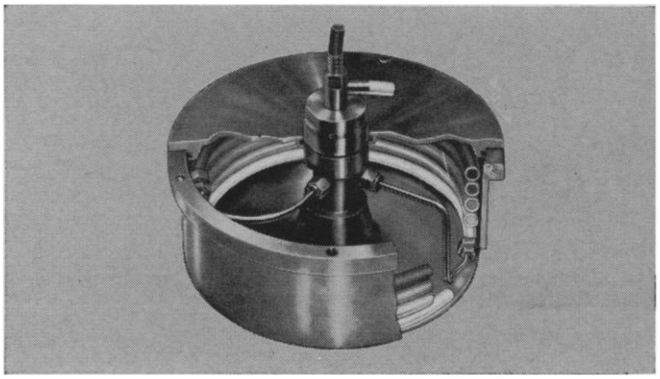

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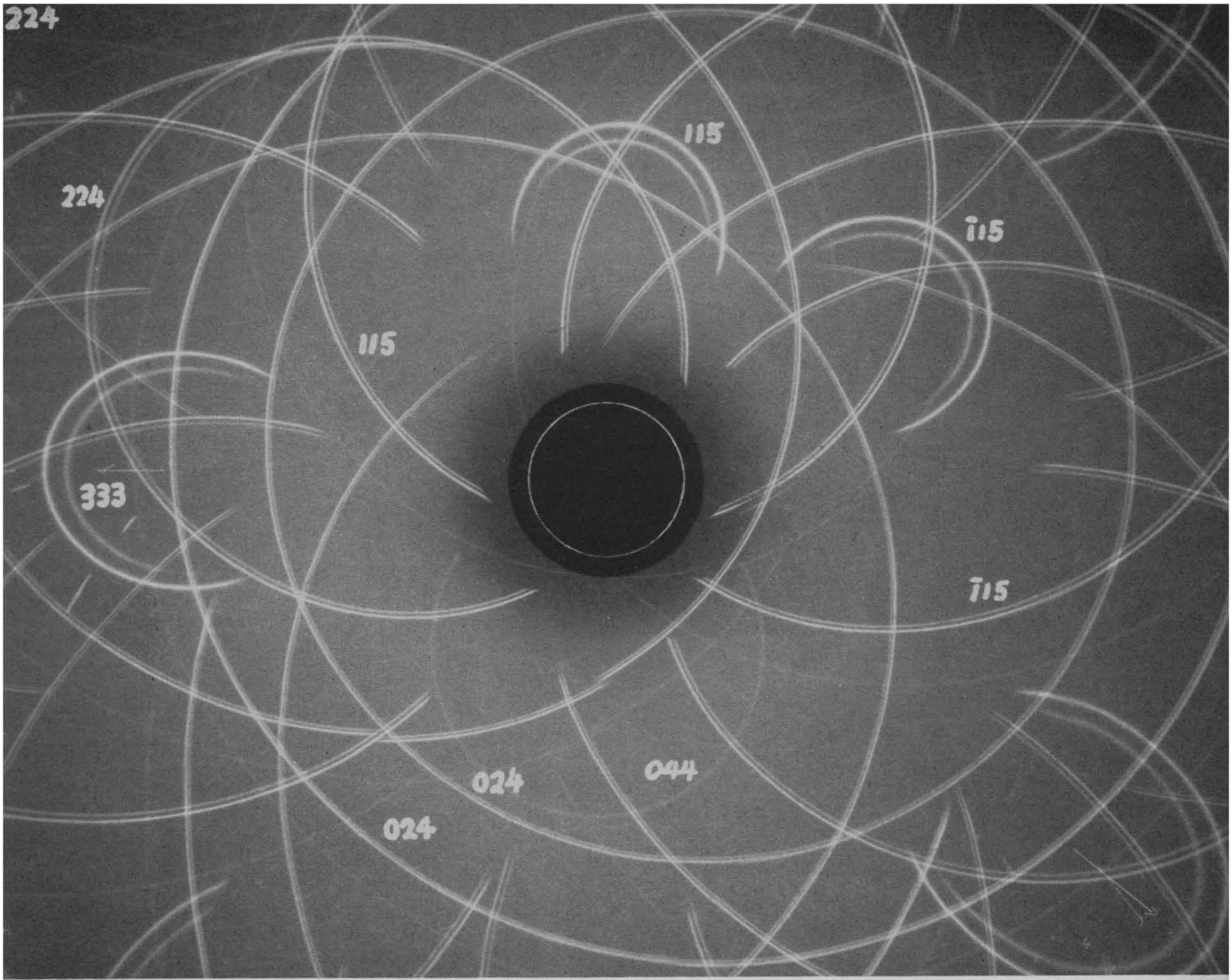
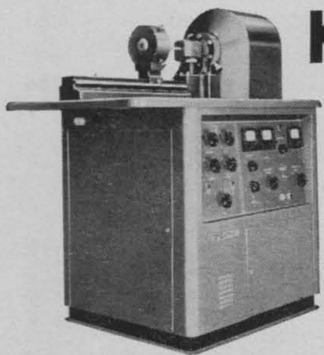


Back-reflection divergent X-ray beam photograph from Rigaku Microflex unit of Al-3.85% Cu crystal. Solution heat-treated at 540°C. and water-quenched.

KEY TO TOUGHER SPACE-AGE MATERIALS



The New—and Unique—Rigaku Microflex Microfocus X-ray Unit

To help science in its quest for new materials with unprecedented capabilities, Perkin-Elmer makes available a unique instrument for study of crystalline structures. One application of the Rigaku Microflex Microfocus X-ray unit is the divergent beam method of obtaining patterns representing interatomic spacings, lattice parameters and local lattice misalignment. These can be converted into a topographical mapping of lattice misorientation in the crystal.

The divergent beam technique is described in "Investigation of Crystalline Imperfections and Properties of Materials" by Professor S. Weissmann of Rutgers University. The article appeared in the June 1963 issue of AMERICAN SCIENTIST.

X-Ray Back-Reflection Divergent Beam Method

"... An electron beam originating from an electron gun is focused by means of electromagnetic lenses onto the tip of a long, horizontal capillary tube, where a thin metal foil is placed as an X-ray target. When the tube is operated at a suitable voltage, an X-ray beam with characteristic radiation emerges from the tip of the X-ray tube, exhibiting a divergence of nearly 180°

"When this beam impinges on the test crystal, which is placed at a distance of 1-3 mm from the tip of the capillary tube, diffraction patterns of the characteristic spectrum in transmission as well as in the back-reflection region are obtained. Of particular interest are the back-reflection patterns, which can be obtained with much greater ease than the transmission patterns.

"Each ellipse corresponds to a definite set of atomic planes ... The patterns are recorded on the same film at different specimen-to-film distances and the diffraction angle of the atomic set of planes is directly determined from the precisely known distance between consecutive film positions.

"Modifications of the interatomic spacings resulting from physical or chemical processes can be well-studied by the divergent beam method ..."

You are invited to write for further information about the divergent beam method and the Rigaku unit, to Perkin-Elmer Corporation, Distributor Products Department, 910 Main Avenue, Norwalk, Connecticut.

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ERB & GRAY DIVISION

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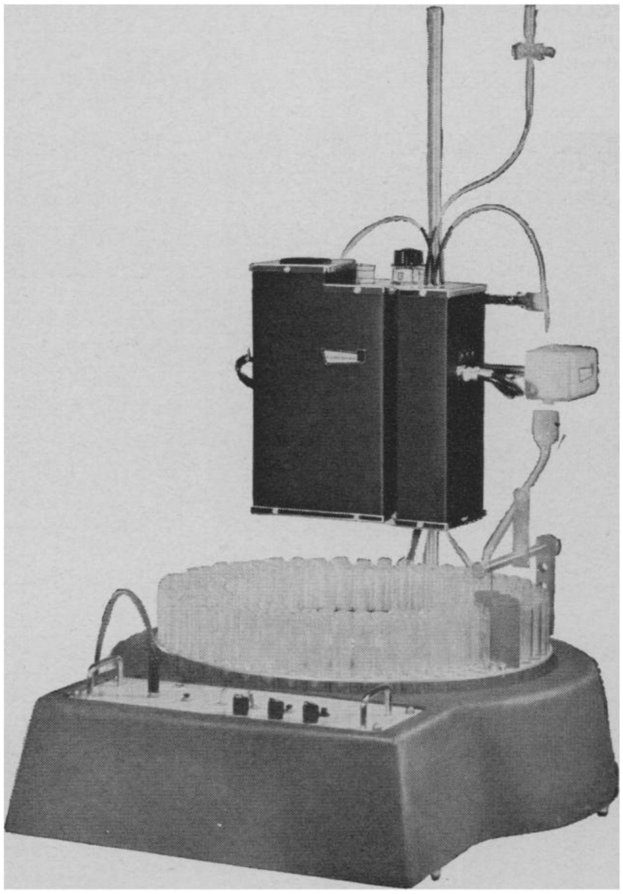

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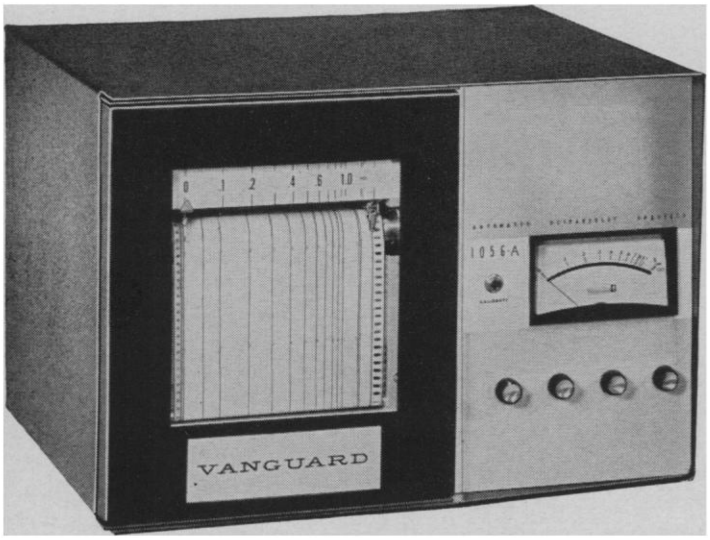

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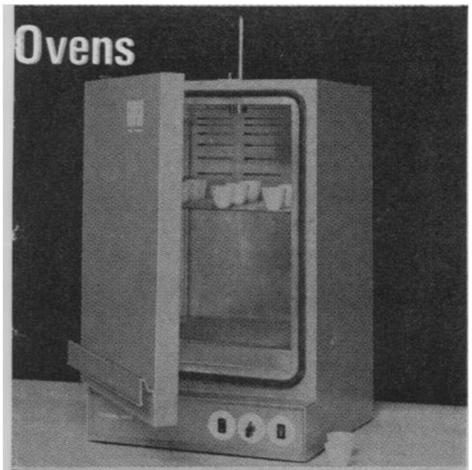
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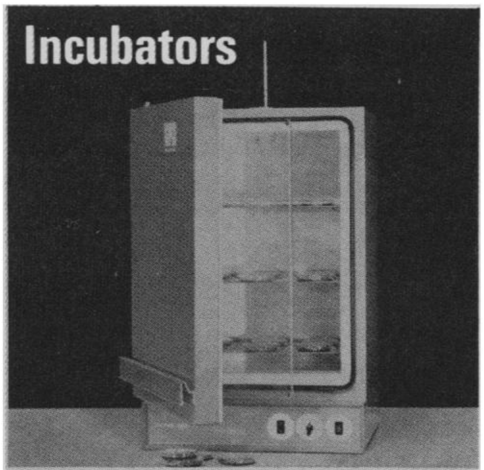
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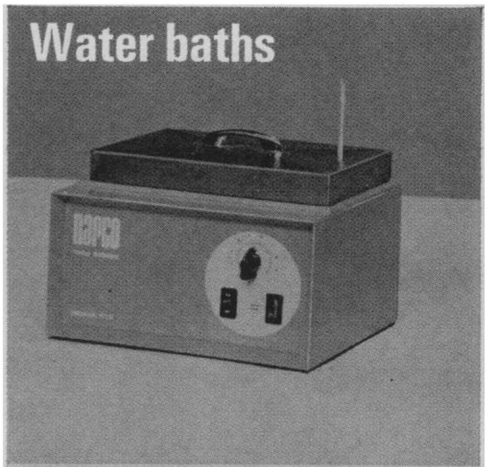
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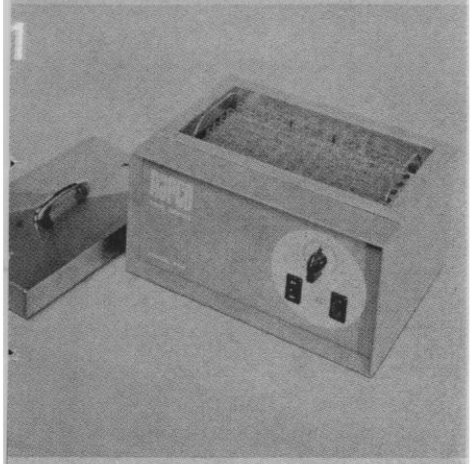

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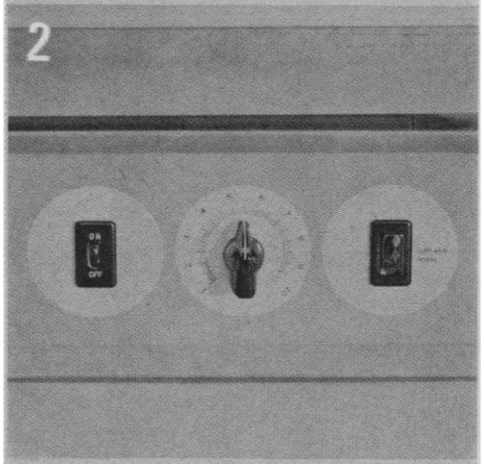

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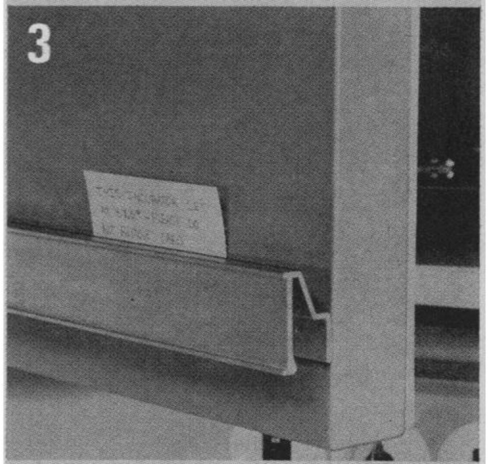

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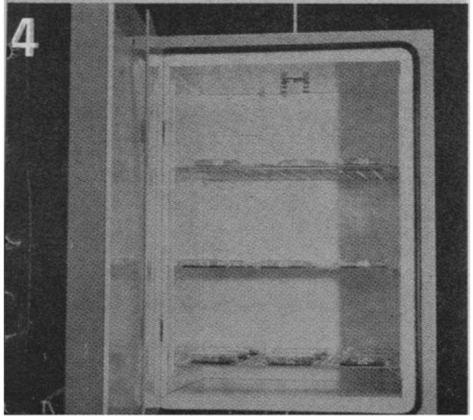

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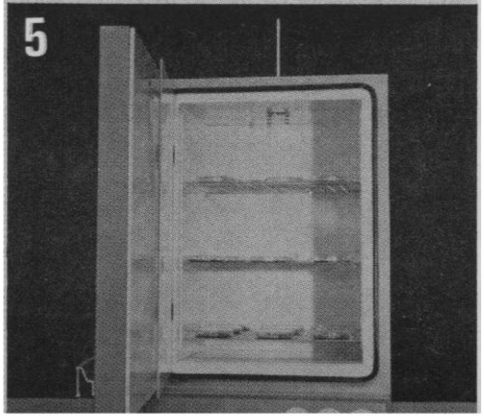

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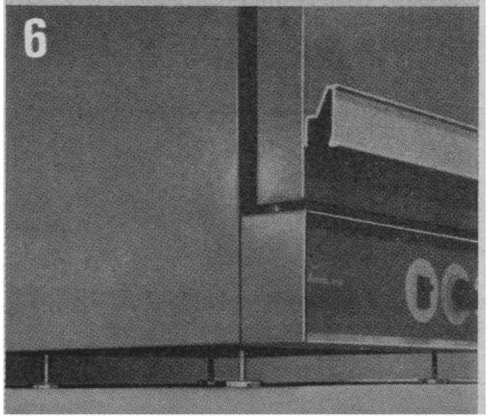

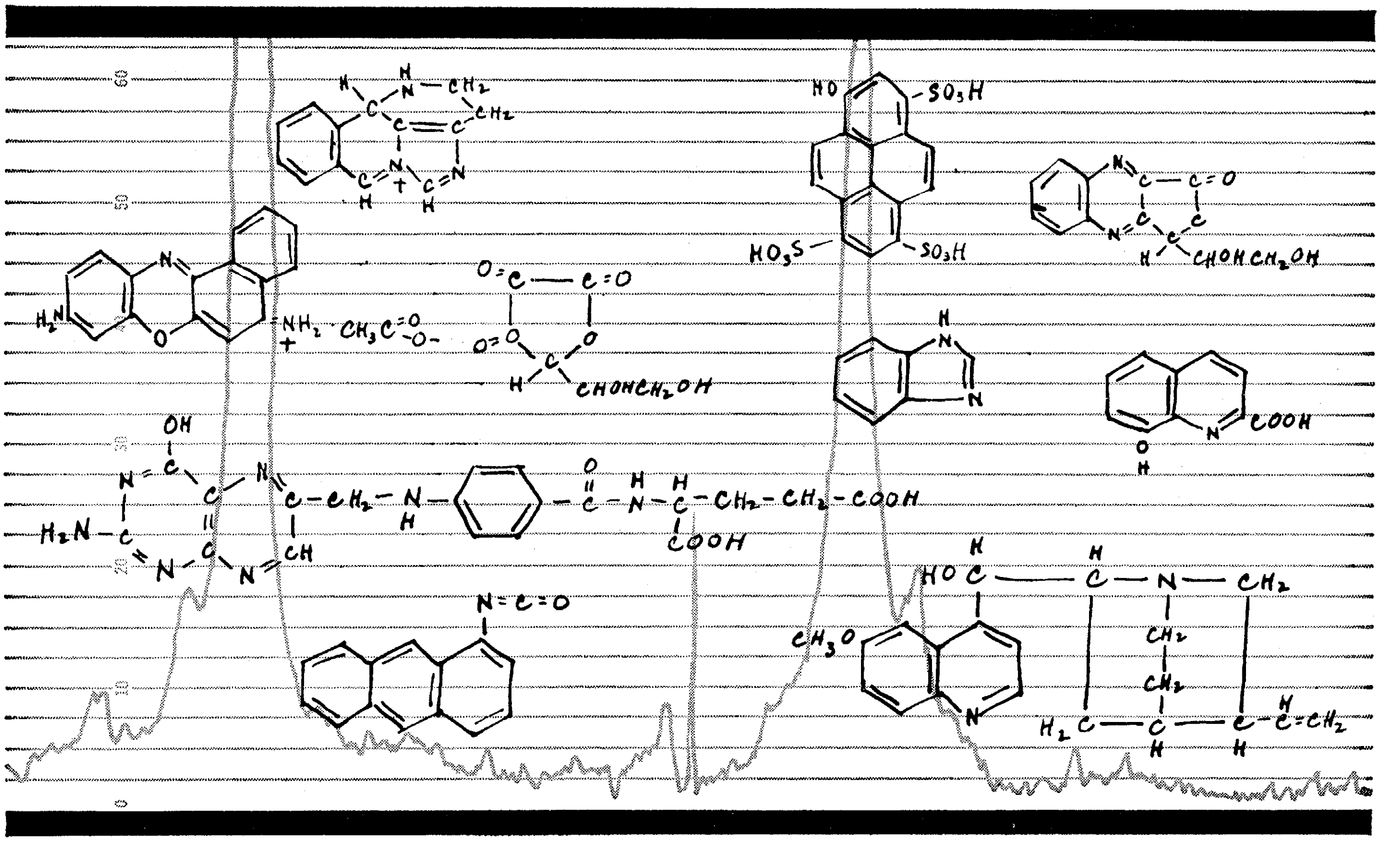

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SG5030	Butyl Ether
SG9216	Carbon Disulfide
SG2601	Carbon Tetrachloride
SG8266	1-Chloro-2,2-dimethylpropane
SG5023	Chloroform
SG2825	Cyclohexane
SG7602	Cyclopentane
SG5636	1,2-Dichloroethane
SG5509	Dichloromethane
SG5974	N,N-Dimethylformamide
SG2347	p-Dioxane
SG5086	Ether
SG5212	Ethyl Acetate
SG2946	Ethyl Formate
SG2952	Ethyl Propionate
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SG2859	Methanol
SG5696	2-Methylbutane
SG2826	Methylcyclohexane
SG5264	Methyl Formate
SG1240	Nitromethane
SG2466	Pentane
SG2233	iso-Pentyl Alcohol
SG2857	iso-Propyl Alcohol
SG5029	Pyridine
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SG5962	Tetrahydrofuran
S5037	Toluene
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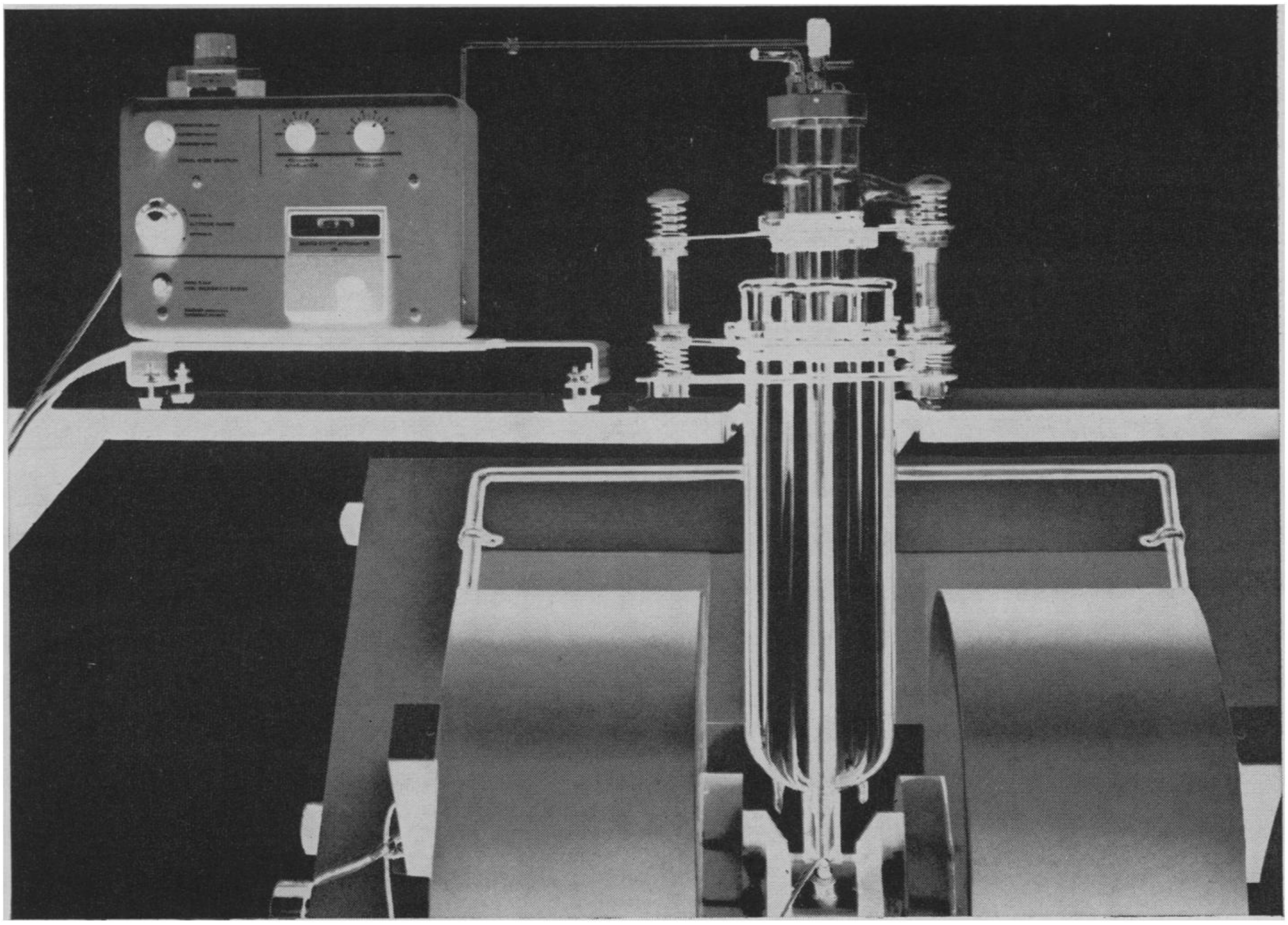

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Edited by: Reidar F. Sognnaes.
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Experience of the United States with its arid zones as reported to the first UNESCO Conference on Arid Lands in Latin America.

Price: $12.00. *AAAS Member's Cash Price:* $10.00.

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Edited by: David W. Bishop.
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1962. 202 pages. 136 illustrations.
Edited by: E. O. Butcher and R. F. Sognnaes.
The fields of anatomy, dentistry, dermatology, medicine, pathology, and zoology are represented in this volume.

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#69. Biophysics of Physiological and Pharmacological Actions.

1961. 612 pages. 212 illustrations.
Edited by: Abraham M. Shanes.
A bird's-eye view of a number of principles now considered important. Useful for teaching, as well as for research purposes.

Price: $13.50. *AAAS Member's Cash Price:* $11.75.

#68. Sciences in Communist China.

1961. 884 pages. 23 illustrations.
Edited by: Sidney H. Gould.
". . . strongly recommended to all who are in search of facts and source material on the sciences in China."—*Science*, 22 September 1961

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#67. Oceanography.

1961. 2nd printing, 1962. 665 pages. 146 illustrations.
Edited by: Mary Sears.
"I know of no other volume that so well defines oceanography, its purpose, opportunities and requirements."—*Science*, 9 June 1961

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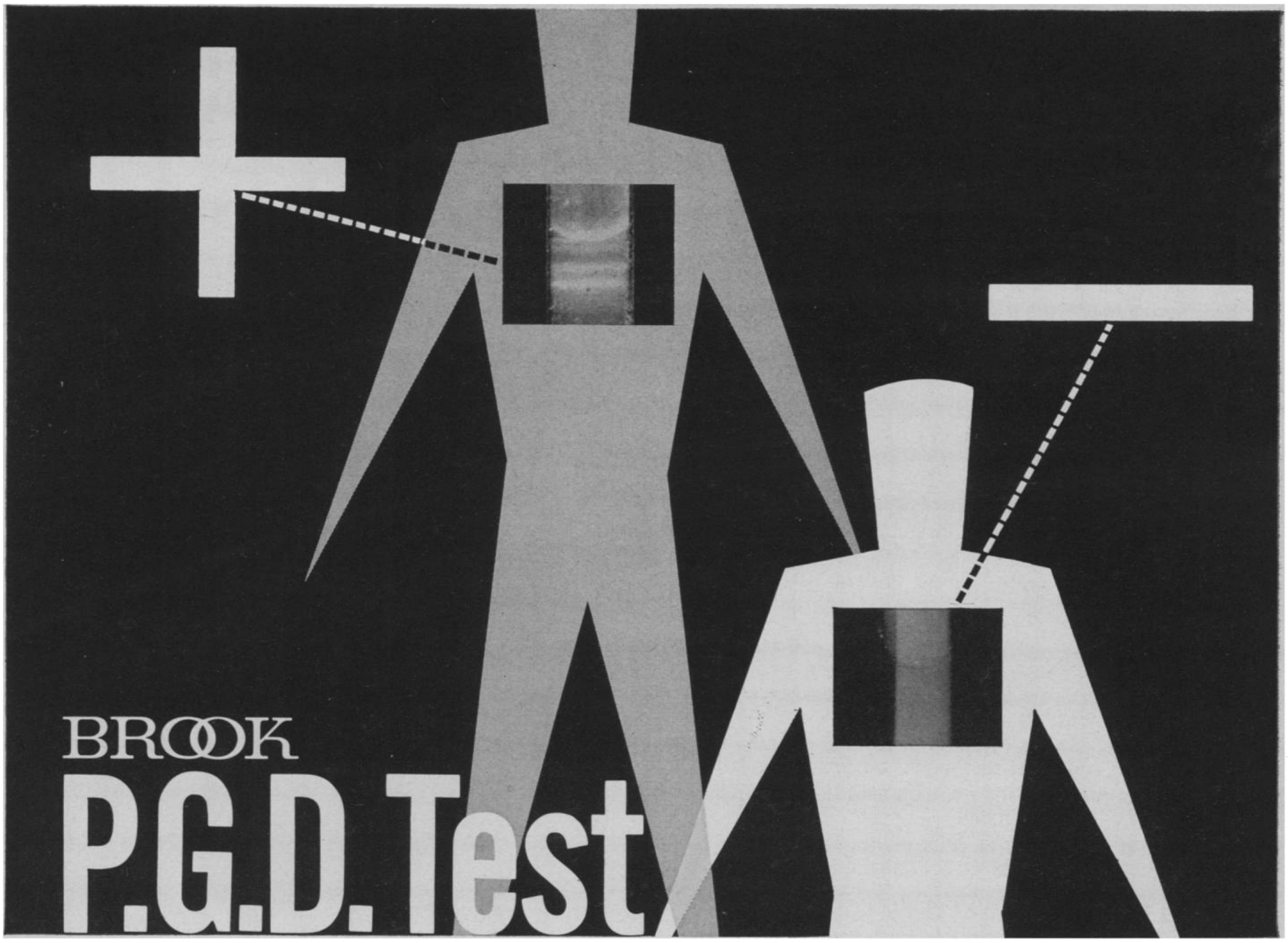

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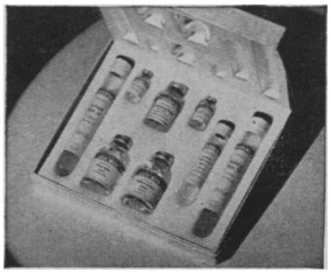

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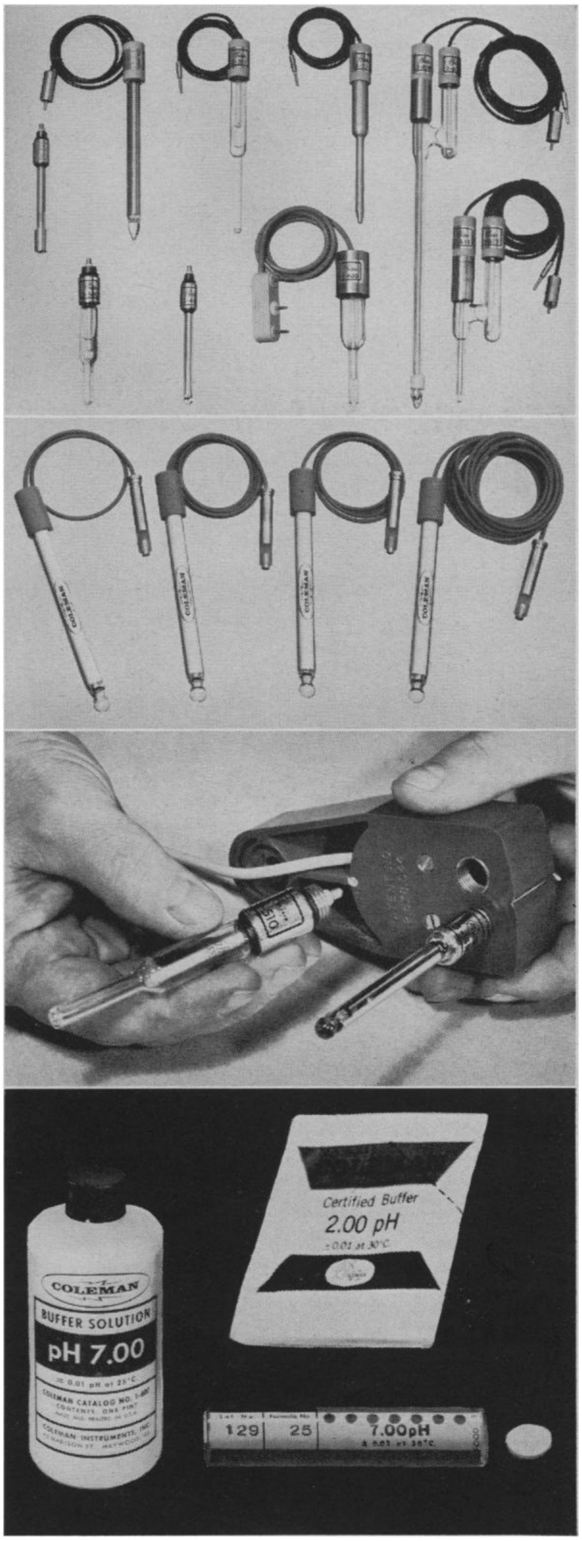

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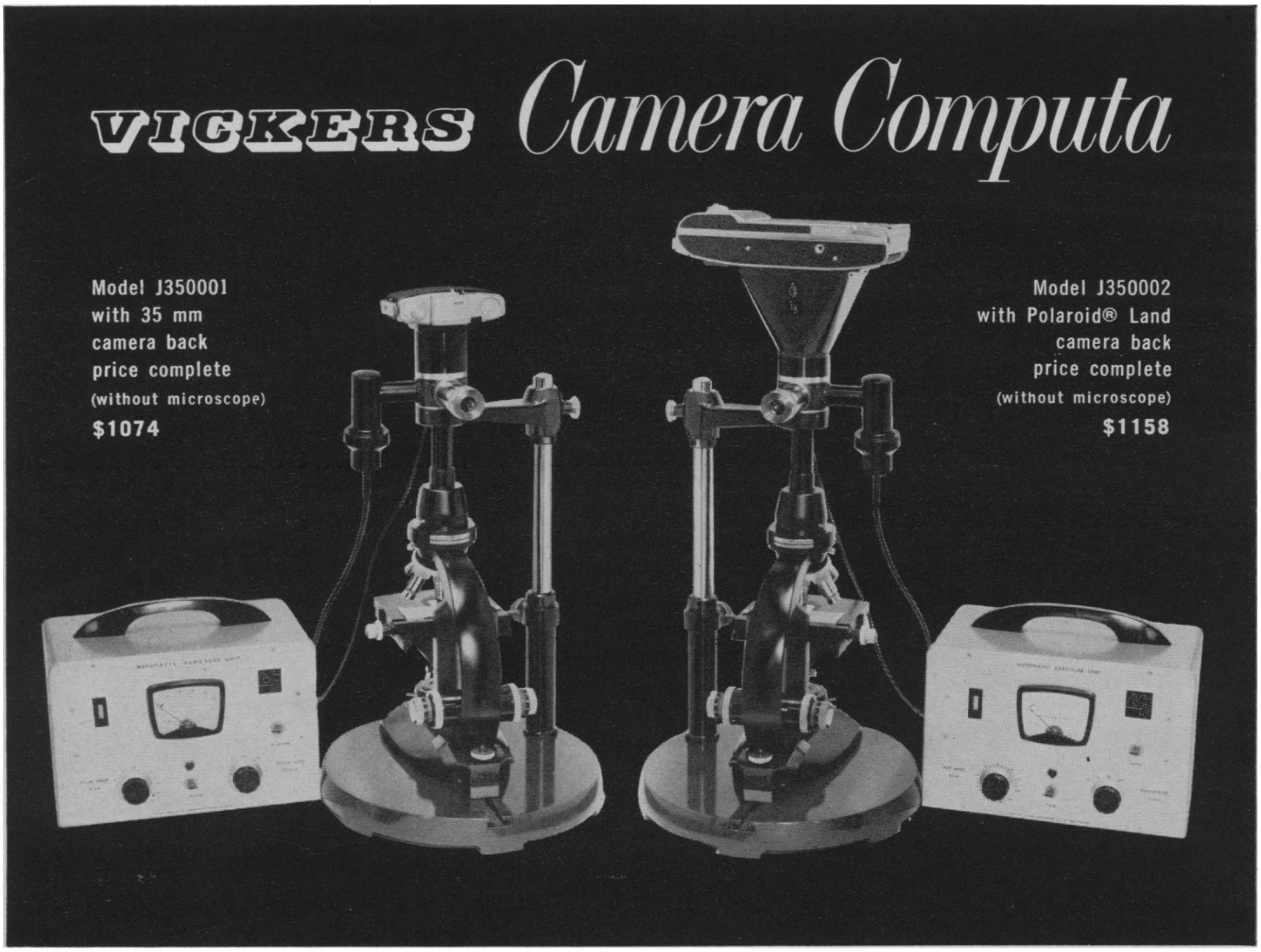

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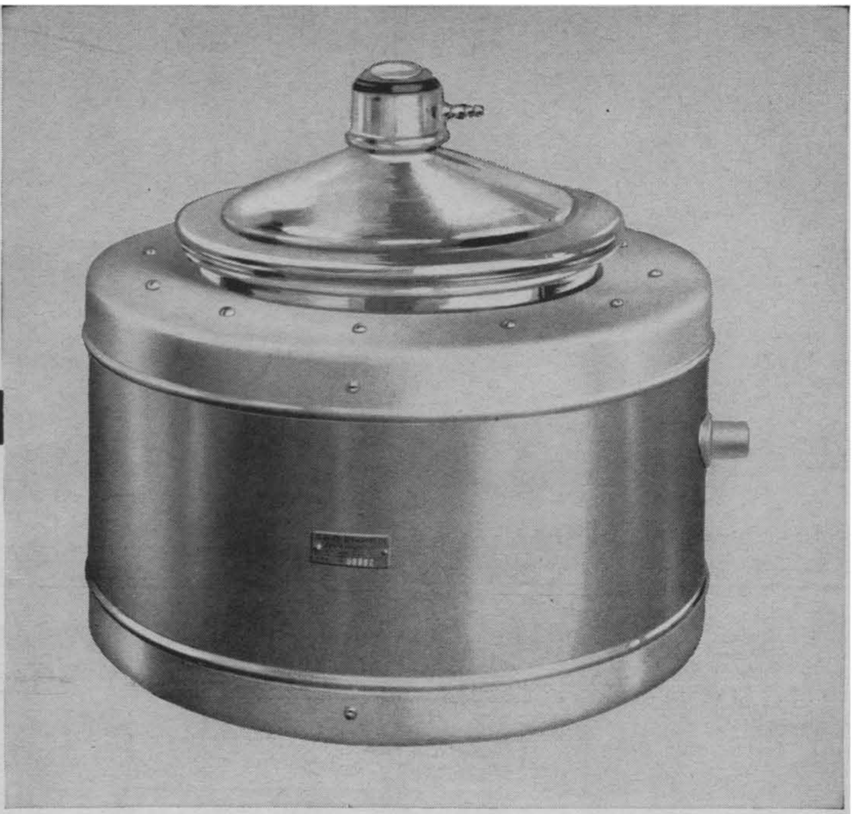

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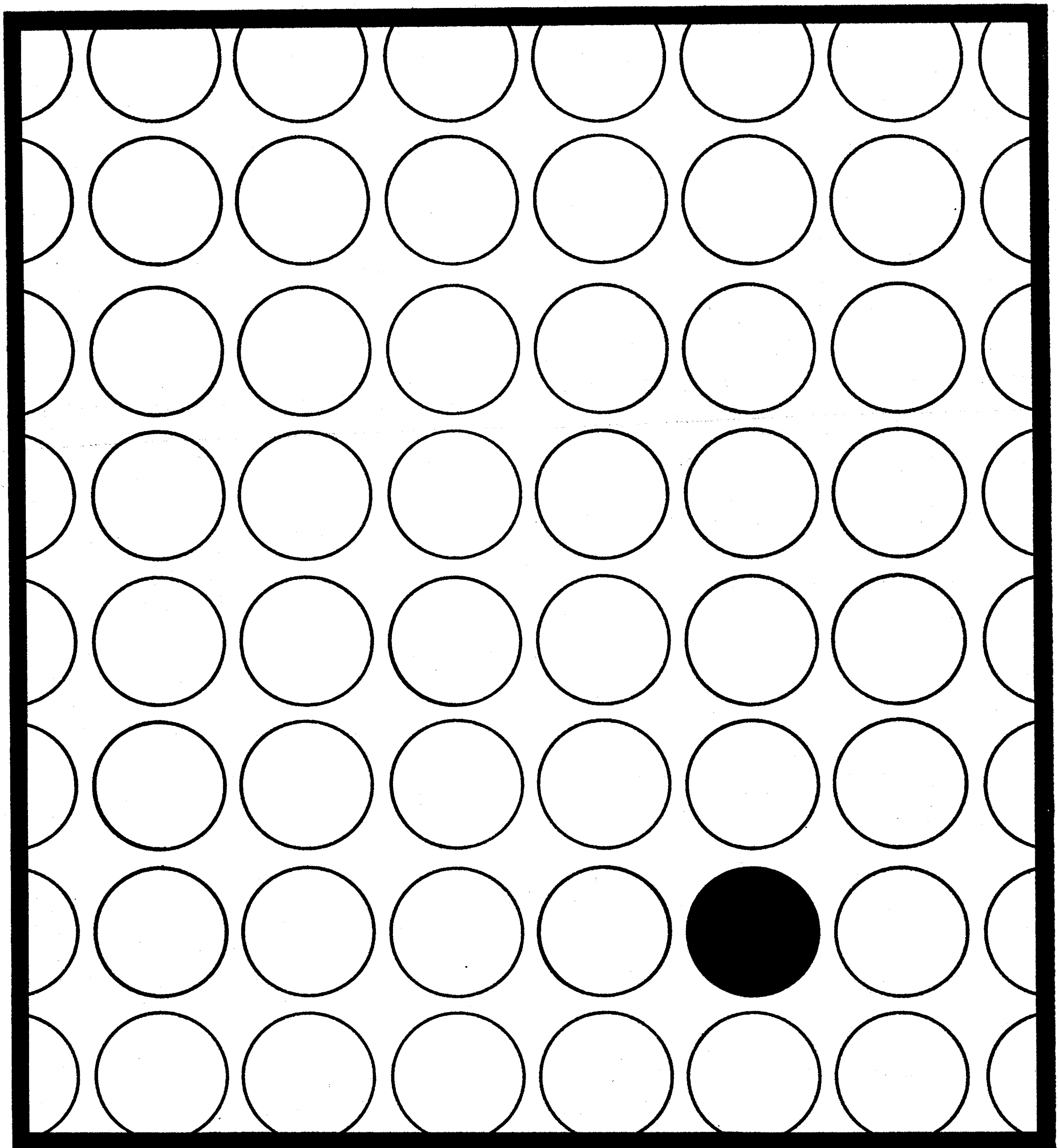

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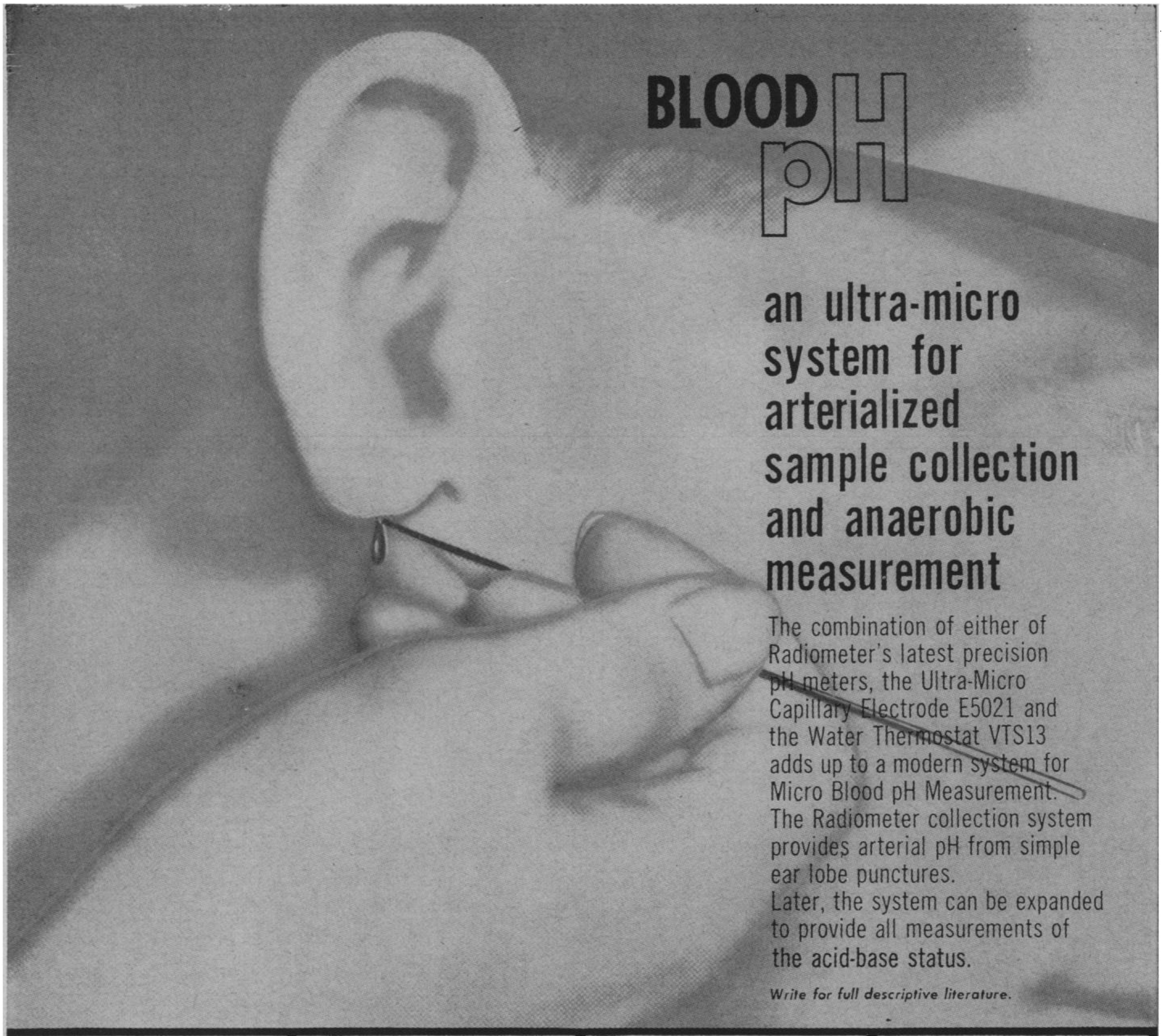

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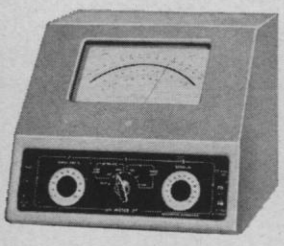

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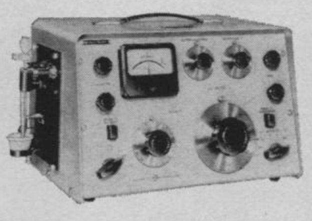

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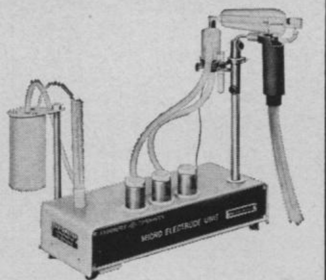

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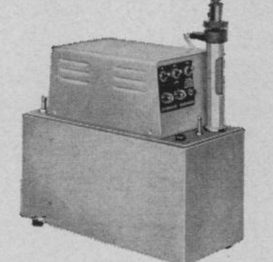

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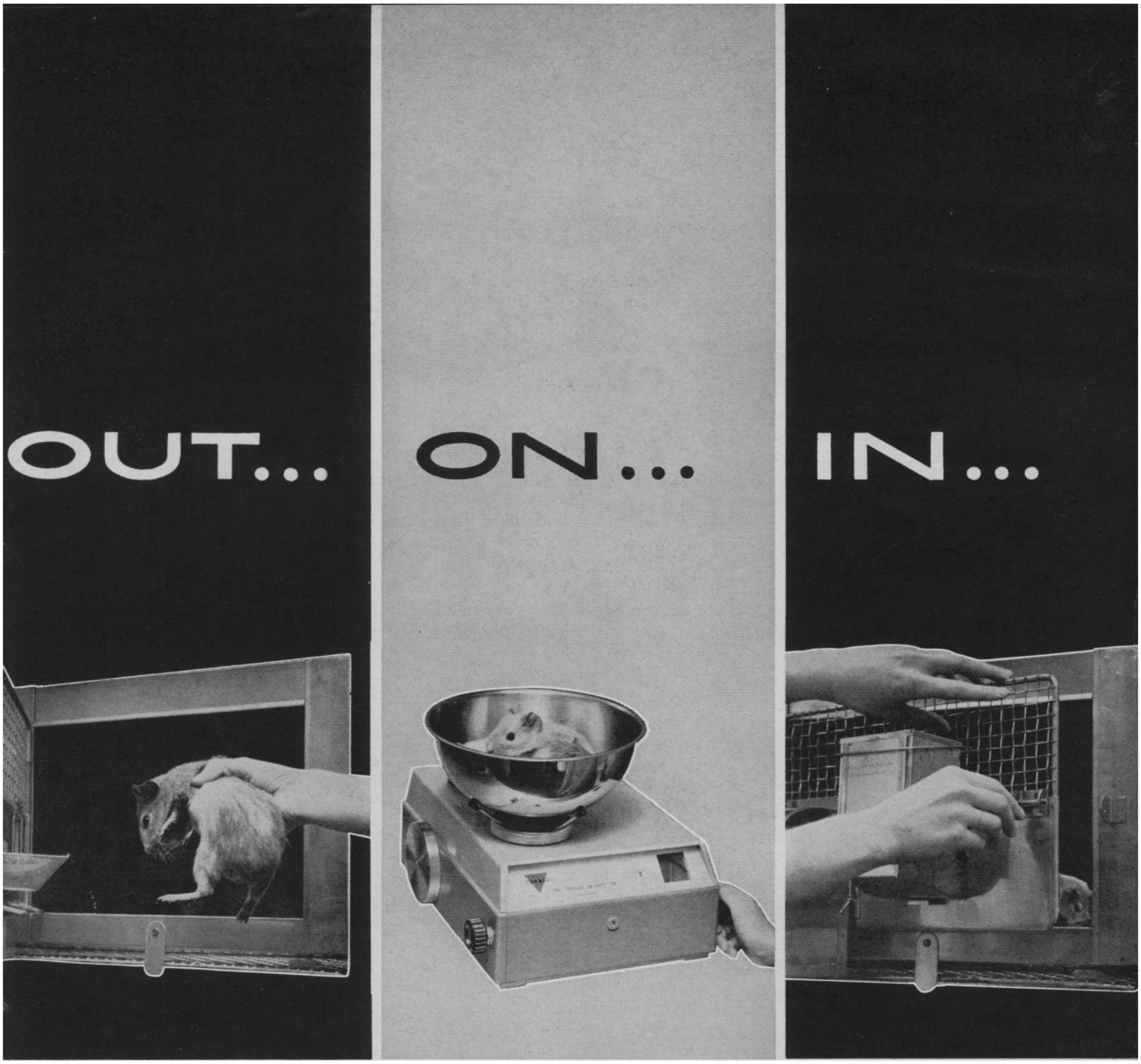

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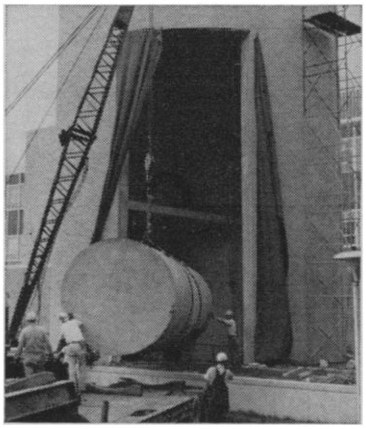
Modern experimental facilities create an atmosphere that attracts, and holds, the scientists and engineers needed to sustain academic excellence. Such technical leadership also provides a firm base for new industrial enterprise, and serves as a basis for productive collaboration between research groups and interested sponsoring agencies.

Kentucky Pledged $100,000

At the University of Kentucky a Van de Graaff 5.5-million-volt Model CN particle accelerator was purchased after the State of Kentucky pledged $100,000 from the capital building fund and the Kentucky Research Foundation made $75,000 available. The balance of the expenditure came from other resources available to the university.



The University of Kentucky Van de Graaff is housed in a special cylindrical structure — part of the university's impressive new Chemistry-Physics building.

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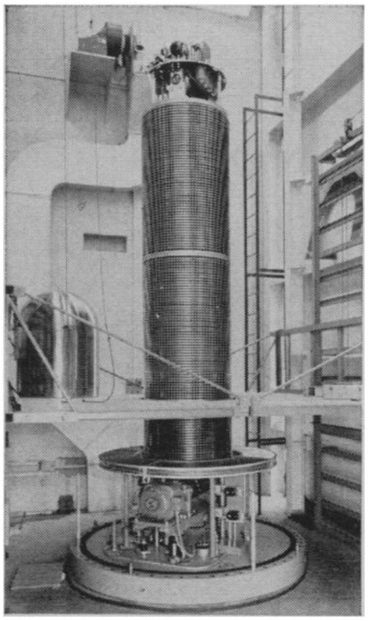

New 5.5-million-volt Model CN particle accelerator was purchased by the University of Kentucky with the help of state agencies.

At first, the accelerator will be used by the university to accelerate protons, deuterons, or Alpha particles. With pulsed beam, the physics department will carry out time-of-flight measurements to aid the study of neutron-induced reactions.

Extensive and precise studies of the interrelationships of various nuclear reaction amplitudes will be conducted with the aid of the intense, high quality beams from the accelerator. Knowledge of these amplitudes will eventually permit the quantitative determination of configurations of nuclear levels.

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While the Van de Graaff will be used mainly for investigation of nuclear structure physics, it will also be at the disposal of all the university's departments engaged in scientific studies under research grants or contracts from federal and industrial agencies. It will be operated by the faculty and graduate students on an estimated yearly budget in excess of $150,000 when at full capacity.

New Product Line Available from ARCO

High Voltage Engineering's ARCO Division, Walnut Creek, Calif., has introduced a new line of products designed for use in the high vacuum, microwave, and particle accelerator industries.

The products, which are being offered as standard items, have been developed and tested by ARCO during the past ten years, and are a direct result of extensive effort associated with advanced high power accelerators. Included in this group are:

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HIGH VOLTAGE ENGINEERING

24 January 1964, Volume 143, Number 3604

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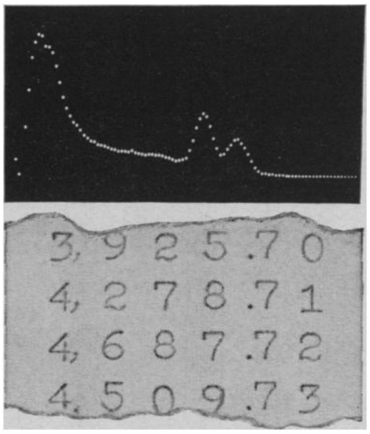
The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

Scientists and Their Images

In dealing with the public relations problems confronting scientists today we should pay more attention to our unities and less to partisan conflicts among the sociological groups we serve. For a long time there have existed fairly stable images of the scientists in government, in industry, and in academic institutions. Taking a metaphor from physical optics, one might say that these images have always been more virtual than real. But they are different, and persistent. Would it be fair to say that the academic scientist has had an enlarged, the government scientist a reduced, and the scientist in industry a perverted image? Among the respective groups this situation has led to mutual disparagement of these images rather than of their realities. Thus, the industrial scientist resents the assumption of superiority and virtue which he finds in his image of the academic scientist, and the latter condemns the worldly ambitions he sees in his image of the industrial scientist, while the two unite in looking down upon their image of the government scientist (unless, of course, the latter is that curious new creature the scientist-administrator). Meanwhile, the image of the scientist or engineer working in classified territory remains outside the visible spectrum. The scientist at a research center, however, leads a charmed, if transitory, life. He is too new for a clear image to have formed, but, thus far, the objectionable characteristics of the other images seem to be lacking.

The real images of these three or four varieties of scientists have been changing rapidly and coming to resemble one another more closely. It is high time we realized this. For, to offset this integrating process, new images of science and scientists are emerging. This change has been fostered by the interests of the various sectoral groups and arises from their competing demands for funds and for personnel. To the public, science emerges from these images as the savior of the world, and scientists as its disciples. This propaganda should surprise no one. What more powerful justification could there be for securing the wherewithal from reluctant donors? Indeed, a plausible case for this view can be made both from the record and from the promise of things to come. However, the fallacy is obvious: for social progress, science is necessary but not sufficient; many minds and abilities besides those of scientists are required. Moreover, for the material progress which this image elicits, science has limitations: its progress is slow, erratic, unpredictable, and at any given time science is highly productive only in a limited number of cases. To cultivate such a virtual image is unrealistic and leads to extravagance and frustration. Furthermore, under this image we scientists will become divided—among ourselves and among the competing groups we serve. In addition, we shall run the grave risk of losing the humility and integrity which have always dignified our profession.

Among the assets of science of far more profound significance in the long run are the thrill of discovery, the stimulus to imagination, the breadth of outlook, and the deepening of understanding of our world and our fellow men. These qualities are inherent in the real image of science. They carry with them the assurance of success in the solution of our technological problems, but as a by-product rather than as a single-minded aim. In this real image, science is one with all creative endeavor and will contribute in important and unique fashion to a higher appreciation of purpose, to a greater realization of hopes, and to the fuller preparation of coming generations for their dynamic future.—Alan T. Waterman



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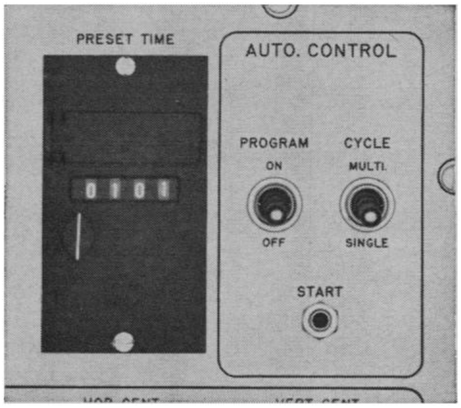

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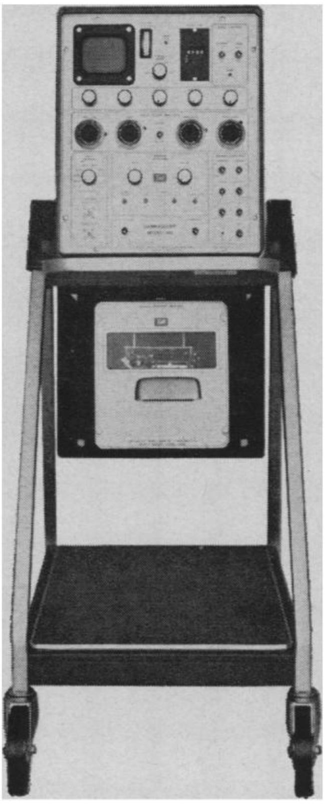

The Gammascope provides extremely fast and accurate analysis of whole body counts, thyroid uptake studies and virtually all other medical and biological applications of nuclear radiation. Yet the price of the Gammascope, including a digital printer, is comparable to that of most single-channel scanning spectrometers.

After initial set-up and calibration the Gammascope will automatically accumulate 100 channels of data — no manual or electrical scanners are needed. The entire analysis operation takes a small fraction of the time that would be required by a single-channel spectrometer.

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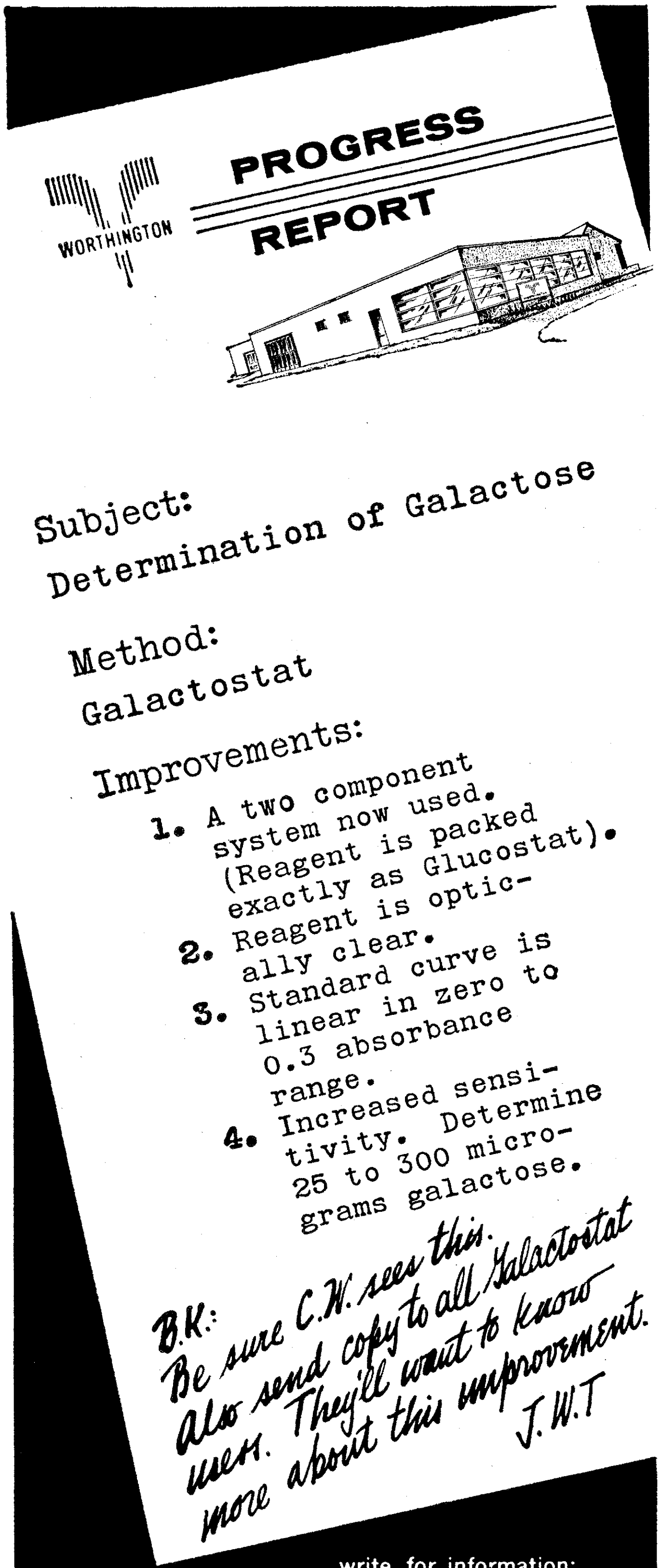

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Life: Origin and Evolution

The origin and evolution of life continues to receive considerable attention, partly because of the synthesis of biologically significant molecules (amino acids, purines, and so forth) under conditions presumed to have been prevalent on the primitive earth, and partly because of the possibility of determining the presence or absence of life elsewhere in our solar system. As a sequel to an international meeting in Moscow, in 1957, on the origin of life, a meeting was held 27–30 October 1963 in Wakulla Springs, Florida, on the origin of prebiological systems.

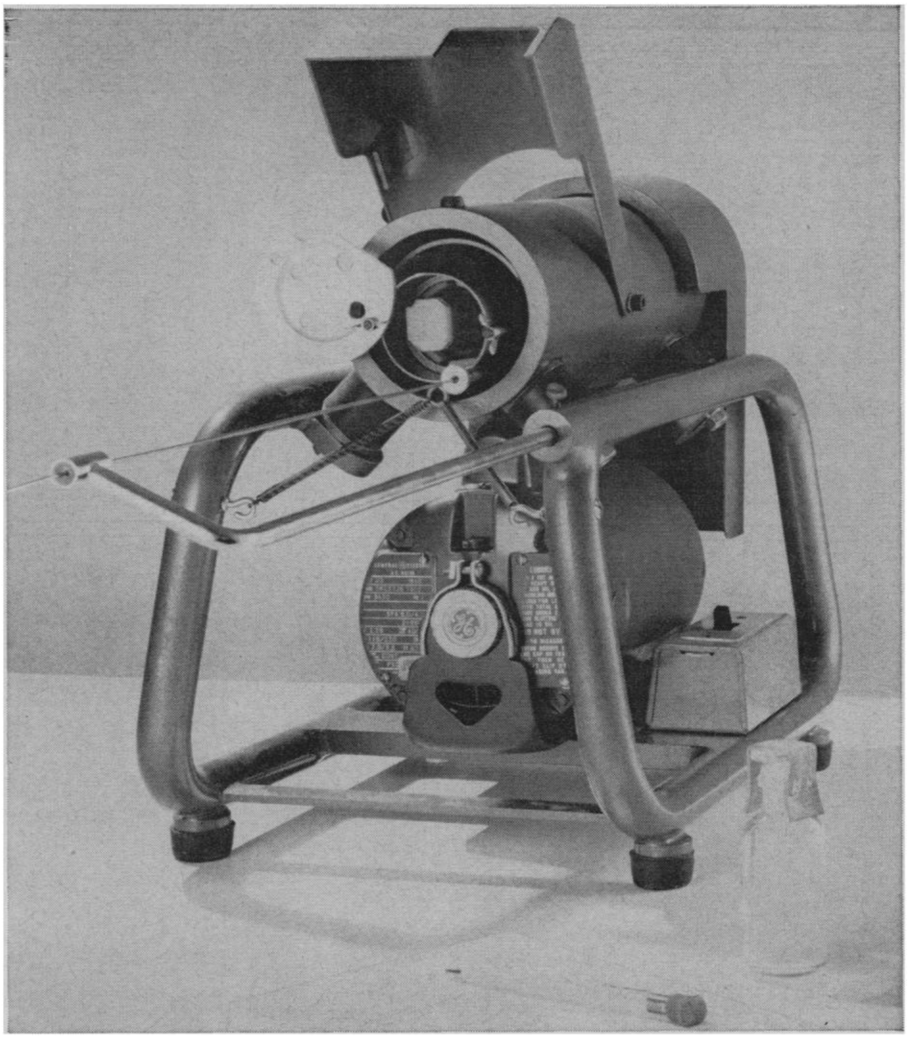
Two pioneer workers in this field, J. B. S. Haldane (Genetics and Biometry Laboratory, Orissa, India) and A. I. Oparin (A. N. Bakh Institute of Biochemistry, Moscow, U.S.S.R.), met for the first time, bringing their knowledge and insight to the participants, who covered topics from small molecules through macromolecules to precellular organization.

In the opening session, on perspectives, Haldane discussed the data needed for a blueprint of the first organism and questioned whether DNA was necessary. Could not a protein have had information-transfer capability? He and others expressed the opinion that the best way to gain insight into the origin of life was through the synthesis of a primitive cell and through study of components of modern cells. M. S. Blois (Stanford University) suggested random polymers as a matrix for chemical evolution, illustrating his comments with the fact that melanin-like material is produced by the action of ultraviolet light on solutions of tyrosine or phenylalanine. The folly of probability was discussed by P. T. Mora (National Institutes of Health) who felt that an understanding of the transition from chemical to life was impossible through modern physics and chemistry. J. D. Bernal (University of London) was absent because of illness and his paper was read by Haldane. Bernal postulated the possibility of organic synthesis in the primeval dust cloud before the earth was formed.

The climax of the first day's meeting was the evening lecture by A. I. Oparin. In a historical survey of the scientific approach to the origin of life, he outlined the growth of the idea from Darwin's work to the active experimentation of today. (Interpreting for Oparin was T. Dobzhansky, Rockefeller Institute.)

The second day was devoted entirely to small molecules. J. R. Vallentyne (Cornell University) discussed the relationship between the geological and thermal stability of amino acids. Aspartic acid, for example, is thermally labile but geologically stable. In the other amino acids, the geological and thermal stability are the same. The asymmetric hydrogenation of some carbonyl compounds was described (S. Akabori, Osaka University) and the mechanisms of the synthesis of purines and pyrimidines from nonliving starting materials were outlined (J. Oro, University of Houston).

K. Harada and S. W. Fox (Florida State University) noted that 14 of the common amino acids can be synthesized thermally by passing a mixture of methane, ammonia, and water through a heated silica tube at a temperature of 900° to 1000°C. Highly significant in this synthesis is the fact that only naturally occurring amino acids are formed. Electric discharges and ionizing radiation on simple mixtures have been known to yield amino acids, some of which are not found in nature. K. Grossenbacher and C. A. Knight (University of California, Berkeley) described the effect of electric discharges on a mixture of methane, ammonia, hydrogen, and water. In a typical experiment only 0.1 percent of the methane was left after 26 days of sparking. The formation of HCN appeared to be autocatalytic. Of great interest was the observation that some spherules, ranging from 50 to 800 Å in diameter and consisting partly of organic material, were produced. C. Sagan (Harvard University and the Smithsonian Institution) outlined the astrophysical evidence for the role of ultraviolet light in the possible synthesis of nucleoside phosphates in primitive times. It seems likely that the early reducing atmosphere was at least slightly transparent between 2400 and 2900 Å. Ultraviolet light penetrating this partial window must have been absorbed by purines and pyrimidines in the early oceans. The primordial organic synthesis of nucleic acid constituents was described by C. A. Ponnamperuma (NASA Ames Research Center). With methane, ammonia, and water, and the energy sources thought to have been available in primitive times, the purines (adenine and guanine), the sugars (ribose and deoxyribose), the nucleoside (adenosine), and the nucleotides (AMP, ADP, and ATP) can be synthesized step by step. A. Szutka



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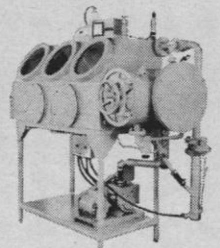

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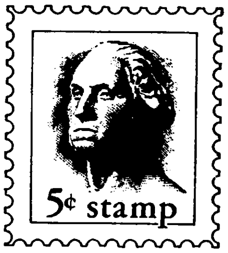

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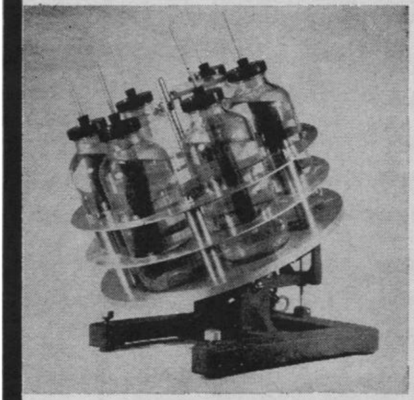

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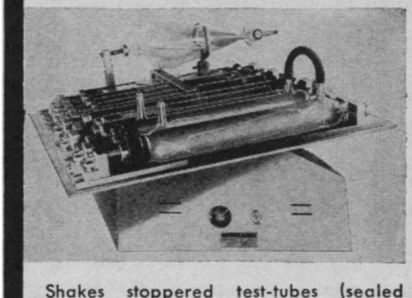

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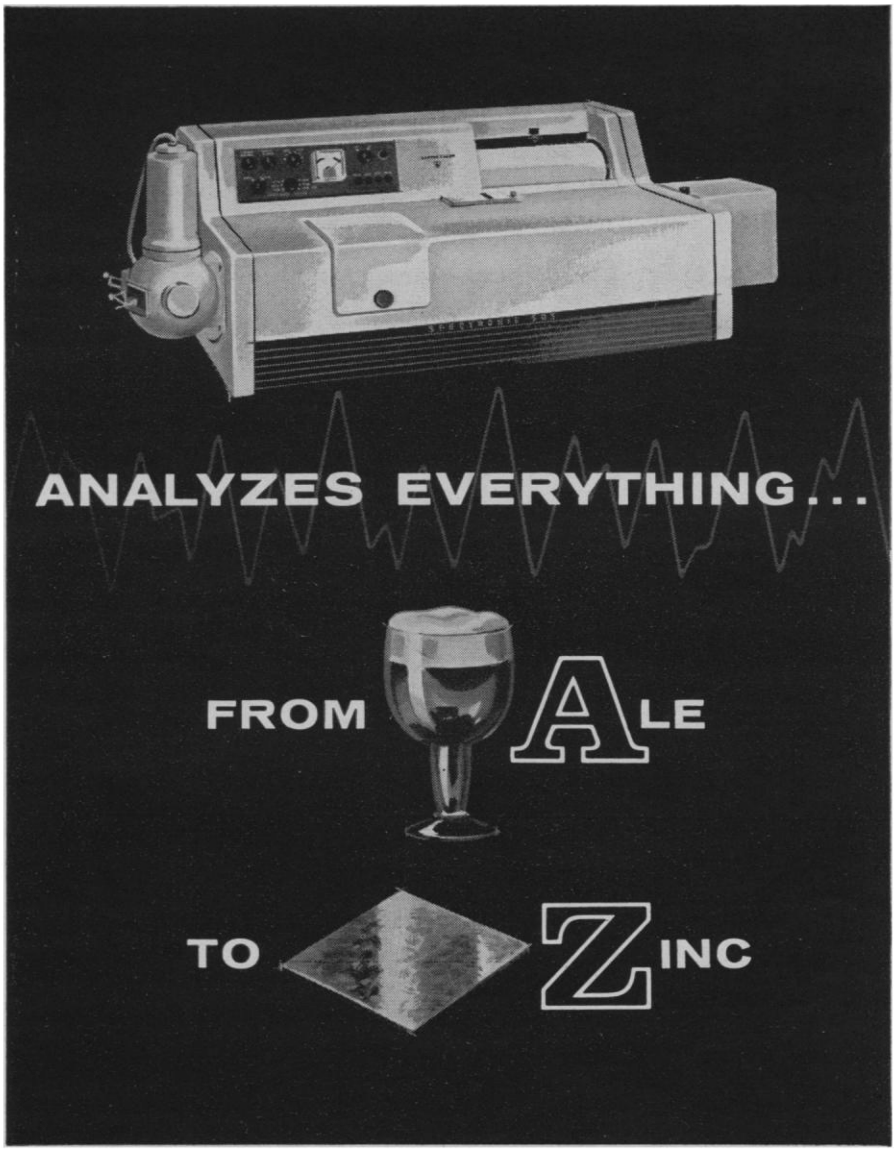
(University of Detroit) showed how porphin-like substances could have been formed by the γ-irradiation of pyrroles, thereby demonstrating that the basic structures required for photosynthesis may have been already available in the primordial "soup."

The third day's discussions centered on macromolecules. That study of the mechanism of replication may be overemphasized today as far as the origin of life is concerned was suggested by F. Lipmann (Rockefeller Institute), who feels that it may be a mistake to concentrate too much study on the nucleic acids and that the origin of the vitamins may be an important point being overlooked. G. Schramm (Max-Planck Institut für Virusforschung, Tubingen, Germany) discussed the synthesis of nucleosides and polynucleotides from metaphosphate esters. At this point Dobzhansky took great exception to the use of the term "natural selection." He felt that natural selection should be used in a Darwinian sense only and that "prebiotic" natural selection is a contradictory expression. A definition of terms was discussed, but without clear resolution. A. Schwartz (Florida State University) discussed thermal polymerization of nucleotides and amino acids in the presence of polyphosphoric acid; this substance permits decreasing the temperature for polymerization to as low as 65°C.

Oparin, who has done pioneering research on coacervate droplets and their usefulness as a precellular model, described many of the chemical reactions possible with coacervates. Harada next discussed the thermal polymerization of proteinoid from 18 naturally occurring amino acids and noted the more significant properties of this proteinoid, including the production of microspheres by boiling the proteinoid in water and allowing it to cool.

In discussing some aspects of the chemistry and morphology of microspheres, R. S. Young (NASA Ames Research Center) suggested that a membrane was necessary to provide an internal environment suitable for replication and the origin of life, and that the microsphere may be a more stable model than the coacervate droplet. Some significant experiments with microspheres, including apparent ATP-splitting activity in microspheres containing zinc, have bene conducted by Fox, whose results have indicated that such thermal syntheses may have taken place on the primitive earth in areas of volcanic activity.



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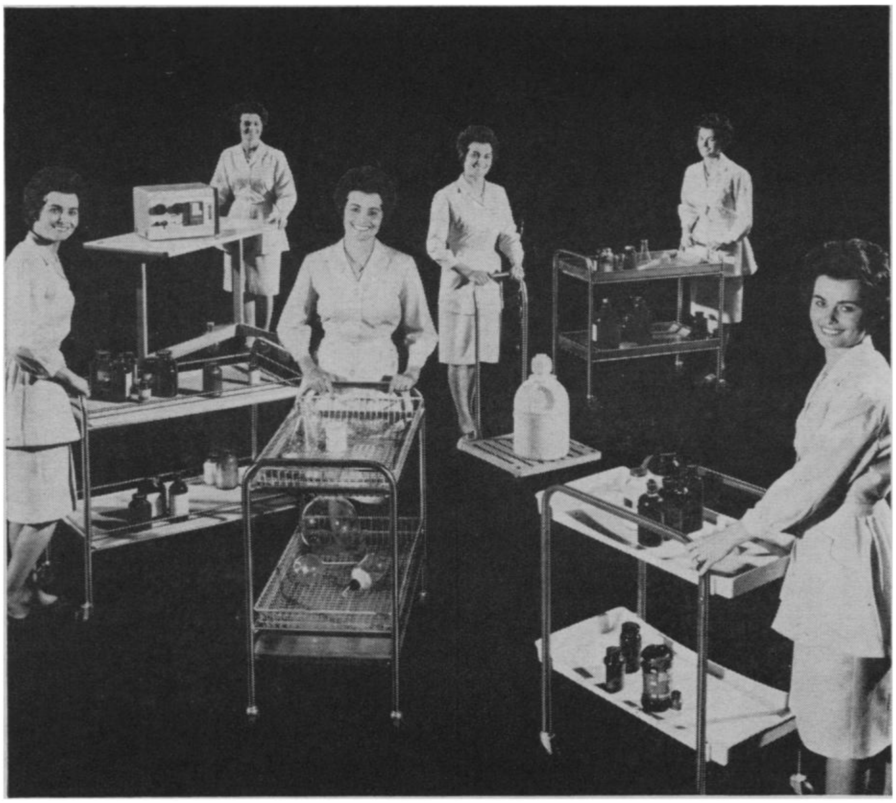

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The need for definition of terms such as "Darwinian" and "natural selection" and "chemical" and "biological evolution" was pointed up by H. H. Pattee (Stanford University) who suggested that evolution according to the Lamarck concept was possible at the molecular level and that evolution cannot occur in the primitive molecule according to the Darwinian concept.

T. H. Jukes (University of California, Berkeley) noted that understanding and interpreting the DNA code may make an important contribution to an understanding of evolution.

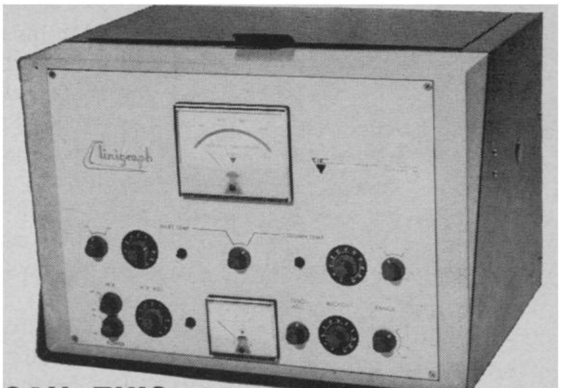
H. Gaffron (Florida State) was concerned with the role of light in evolution. He suggested that the early photosynthetic mechanism may have produced free oxygen. The wavelengths of light used may have been quite different from those used today.

The meeting was sponsored by the Institute for Space Biosciences of Florida State University and the National Aeronautics and Space Administration. Facilities and arrangements for the meeting were provided by S. W. Fox and his associates of Florida State University. The proceedings were opened with an official welcome from the president of Florida State University, G. Blackwell, and F. Quimby, head of the Exobiology Program of NASA. The meeting included 31 participants from the United States, England, Germany, Russia, Japan, and India. Several suggestions were made that such meetings should probably be held with greater frequency, and that this one was a most profitable experience.

RICHARD S. YOUNG
CYRIL PONNAMPERUMA
Exobiology Division, Ames Research Center, Mountain View, California

Photosynthesis

Photosynthetic mechanisms of green plants was the subject of a symposium held at Airlie House in Warrenton, Virginia, 14–18 October 1963. The major theme of the meeting was the determination of the sequence of electron transport steps in chloroplasts, especially as related to two experimentally separable light reactions. The problem was approached by the techniques of difference spectroscopy (B. Kok, K. Witt, J. Olson, W. Bonner, and B. Chance), analysis of fluorescence and delayed light emission (L. Duysens, W. Butler and N. Bishop, J.



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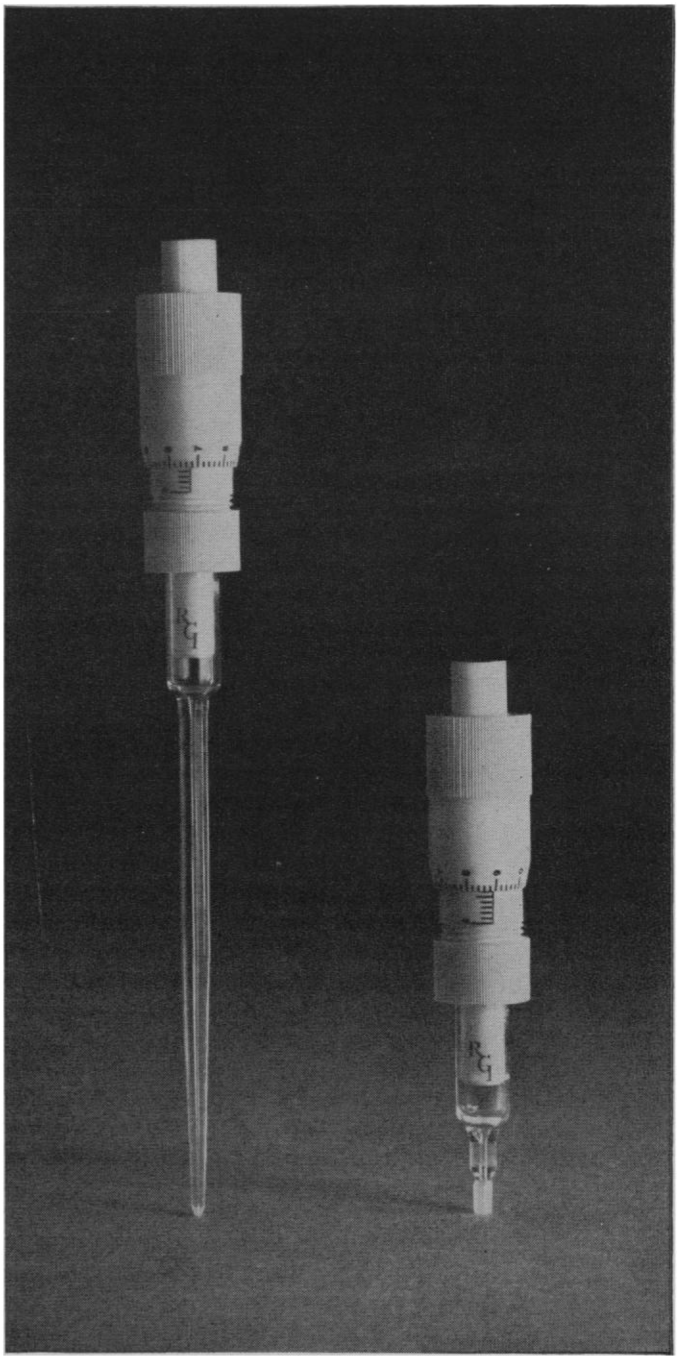

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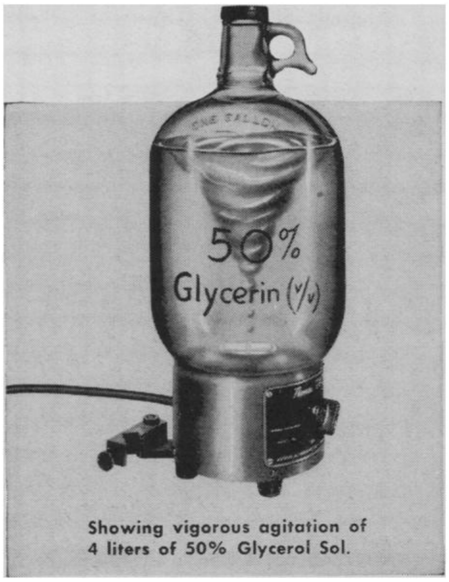

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Rosenberg and J. Franck, W. Arnold, and others), electron paramagnetic resonance (E. Weaver and H. Beinert), sensitive analysis of oxygen or carbon dioxide exchanges (J. Myers, C. S. French, M. Hommersand, Govindjee, Blinks and many others), by study of genetic mutants (R. P. Levine, N. Bishop, and H. Gaffron), a new type of liquid sampling for mass spectrometer analysis (G. Hoch), and study of the biochemistry of isolated chloroplasts (D. Arnon, A. Trebst, and others). From the results of such varied experiments during the past few years, some major points have been established with certainty.

There appear to be two photosystems. One (designated "II" by L. N. M. Duysens) contains part of the total of chlorophyll *a* and a high proportion of the accessory pigments; the other ("I") contains most of the long wavelength absorbing and nonfluorescent chlorophyll *a*. System II is closely related to the dehydrogenation of water and the evolution of oxygen; activation of system I causes electrons to move to the low potential (highly reducing) end of the chain.

Pigment connected to system I transfers its energy to a special chlorophyll *a* (P700), behaving as a one-electron redox intermediate (B. Kok). The photo-oxidized pigment, in turn, oxidizes cytochrome *f* (H. Witt and B. Chance both showed this reaction occurs even at 77°K). The newly found copper enzyme plastocyanin (S. Katoh and A. Takamiya) might be part of the very same charge transfer complex. From these data and others, a well thought of but not universally accepted scheme for electron transport would be similar to the one proposed by Hill and Bendall, with the following sequence:

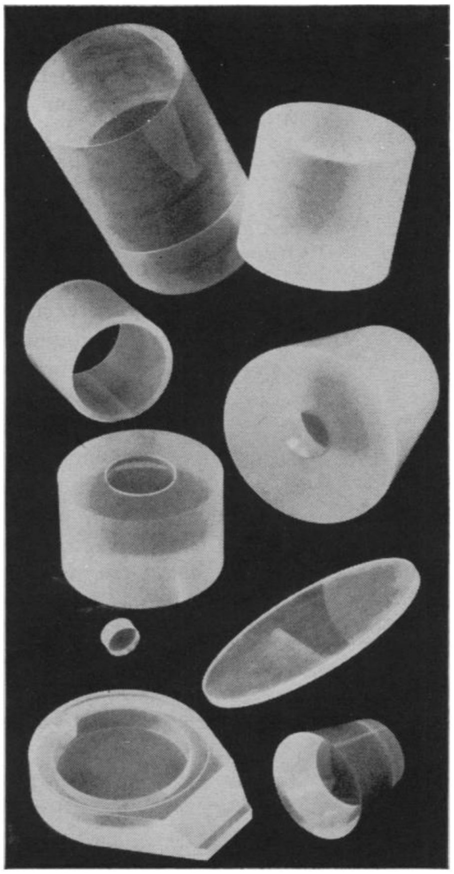
$$\begin{array}{l}
\mathrm{H_2O} \xrightarrow{\quad\text{system II}\quad} \\
\text{pigment Q} \longrightarrow \text{cytochrome } b_6 \longrightarrow \\
\text{plastoquinone} \longrightarrow \text{cytochrome } f \longrightarrow \\
\text{pigment 700} \xrightarrow{\quad\text{system I}\quad}, \\
\text{ferredoxin} \longrightarrow \text{transhydrogenase} \longrightarrow \\
\hfill \text{NADP}
\end{array}$$

The last three steps are found only in the reduction of nicotinamide adenine dinucleotide phosphate (NADP); other redox compounds are reduced without the need for the two sequential terminal enzymes (A. San Pietro and H. E. Davenport). Pigment Q (for quencher) is an unknown component (proposed by L. Duysens) which is supposed to function in the second light act in a way analogous to P700 in the first, but on a different potential level. The kinetics of pigment Q have been followed from the effects of different lights on the fluorescence of chlorophyll *a* (L. N. M. Duysens and W. Butler). H. Witt identified pigment Q with plastoquinone but his assumption was not unanimously supported—Duysens considered plastoquinone to be an early but not a primary product of the second photoreaction. Biochemical evidence for plastoquinone participation seemed quite firm on the basis of extraction and re-addition experiments (R. A. Dilley, A. Trebst, and H. Witt), but they are not enough to show its exact location. Trebst indicated at least two sites for pigment Q participation, based on differential extraction; Dilley, Crane, and Henninger reported a complex set of specificities for different electron acceptors on adding back varying mixtures of the seven or eight quinones that they isolated from chloroplasts. An entirely different approach, the study of genetic mutants of the electron transport path in *Chlamydomonas*, is beginning to yield information consistent with the general pattern of electron transport previously noted (R. P. Levine).

Although cytochrome b_6 played a large role in Hill's original theoretical proposal and would provide a logical site for ATP formation, evidence for its participation in chloroplast electron transport is as yet almost nonexistent. W. Bonner reported that the cytochrome b_6 absorption spectrum essentially disappears as chlorophyll develops in greening leaves. Only J. Olson, using *Euglena* chloroplasts previously extracted by aqueous buffers, could see a spectroscopic sign of b_6 reduction; here its reoxidation in the dark was very slow.

Most of the schemes currently considered are based on a sequential participation of the intermediates between the two photoacts. Even this was challenged by J. Franck and J. Rosenberg and by B. Kok, who considered the present evidence compatible with the possibility that both photoacts operate rather directly upon only one component or at least in one complex. A third possibility indicated by G. Hoch is that the primary products of each photoact have a rather similar potential; their energies are coupled to raise one of the products to the required (oxidative) strength.

Significant for their absence were decisive data relating to the site of phosphorylation (in the middle of the chain or at the low potential end), the



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hypothetical existence of a primary electron acceptor for light step I with midpoint potential on the order of −0.55 volts ("X" above), and the details of the oxygen evolution process.

The phenomenon of enhancing one wavelength of light by a second, which led directly to the original concept of two separate pigment systems, was reviewed by Govindjee. J. Myers pointed out that at this level the major remaining problem is that of the mechanism of the division of incoming quanta between the two systems. Two alternative models proposed by Myers ("spillover" versus "separate package") were treated in mathematical terms by T. Bannister and M. Vrooman. It is interesting to note that three separate approaches—polarography with whole cells (C. S. French), measurement of traces of oxygen evolution from isolated chloroplasts as a result of single light flashes (C. P. Wittingham and P. Bishop), and mass spectrometry (G. Hoch)—show that the product of light reaction I is stored and is consumed by the consequences of photoact II.

The improved mass spectrometric techniques of G. Hoch and O. Owens clarified many aspects of the longstanding controversy on the relation between respiration and photosynthesis. Evidently low light intensities inhibit the normal dark respiration, and higher light intensities induce a new and higher oxygen uptake. The earlier inhibition is accomplished by system I alone, and may represent a competition between chloroplasts and mitochondria for phosphate and adenosine diphosphate (ADP); that is, photosynthesis may inhibit respiration for approximately the same reason that respiration inhibits glycolysis.

Turning to reactions of isolated chloroplasts and the nature and function of purified components, K. Fry and A. San Pietro described evidence implicating iron as the electron carrier in chloroplast ferredoxin. D. I. Arnon told how the cyclic electron flow (supporting phosphorylation) can occur by adding large amounts of ferredoxin under anaerobic conditions, in the absence of the second photoreaction. S. Katoh noted the action of plastocyanine, a new copper enzyme, in the electron flow of chloroplasts and G. Forti examined the reactions of extracted cytochrome *f*. Interaction of chloroplasts with added redox components was detailed very thoroughly for numerous soluble quinones (A. Trebst), for indophenol dyes (D. Keister), and

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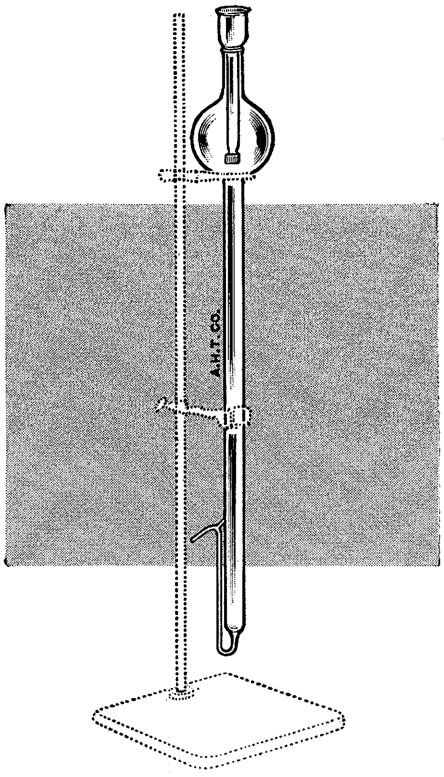

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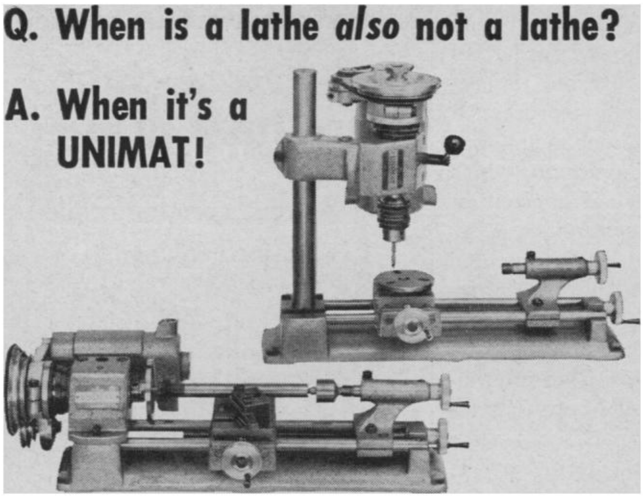

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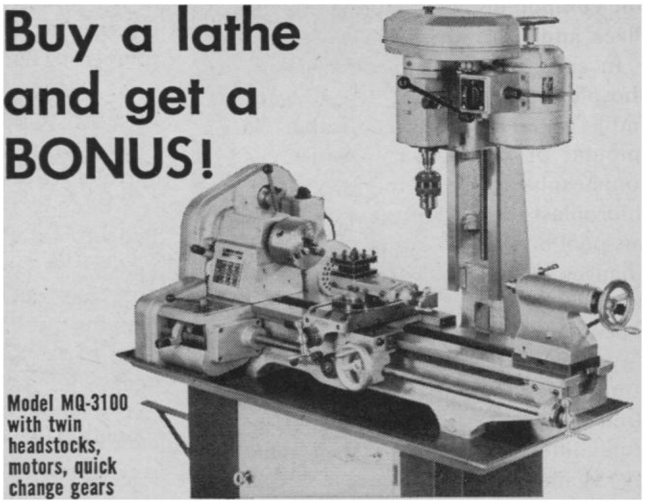

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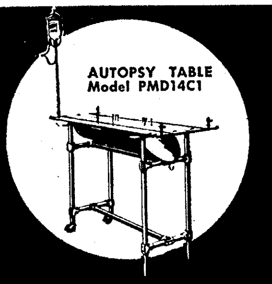

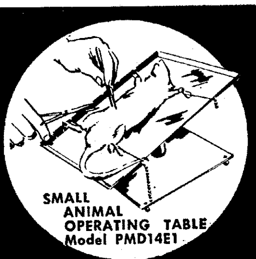

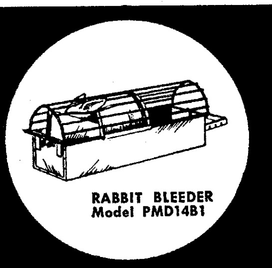

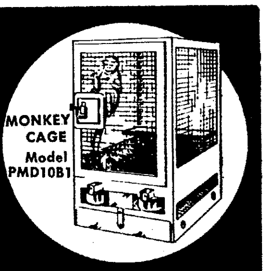

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In considering the mechanism of the phosphorylation steps, A. Jagendorf and G. Hind reported rather large amounts of a temporary, light-induced, nonphosphorylated intermediate in chloroplasts. The nature and function of this pool both require more clarification. Changes in chloroplast geometry (measured by light scattering) are evidently dependent on the presence of high energy intermediates of the phosphorylation process (L. Packer). Jagendorf and Hind reported similar changes, under quite different conditions, but depending again on the presence of high-energy intermediates. R. Lumry commented on the feasibility of an interconversion of chemical and mechanical energy in the chloroplasts. In reviewing the concept of coupling of electron flow and phosphorylation, M. Avron described a series of uncouplers, noted his recent discovery of a protein coupling factor, and pointed out conditions where coupling is much tighter than heretofore observed.

The general chemical structure of chloroplast membranes (designated "thylakoids") was considered by W. Menke. Among other things the amino acid composition of the fundamental protein of lamellae was found to be remarkably uniform among a very wide range of algae and higher plants. Analytical data, including small angle x-ray scattering, proves that the lamellar structure consists of lipid layers sandwiched between two layers of loosely connected globular proteins. The nature of the lipids present was noted by A. A. Benson. The concept that lamellar structure requires the presence of pigment molecules was severely challenged by L. Bogorad on the basis of electron microscope pictures of a series of mutants in a blue-green alga, all of which had one or more pigments missing and yet develop recognizable lamallae. The microphysical techniques of R. A. Olson lead him to believe that only the long wavelength absorbing, far-red fluorescing form of chlorophyll *a* (presumably the "P700" of Kok, intimately concerned with photoact I) is rigidly oriented with respect to the lamellar structure.

Pioneering efforts at subfractionating chloroplasts for the purpose of obtaining photoactive minute particles or chlorophyll-protein complexes were reported by A. Takamiya *et al.*, M. B. Allen and J. C. Murchio, and J. S. Kahn. Some relevant photochemical

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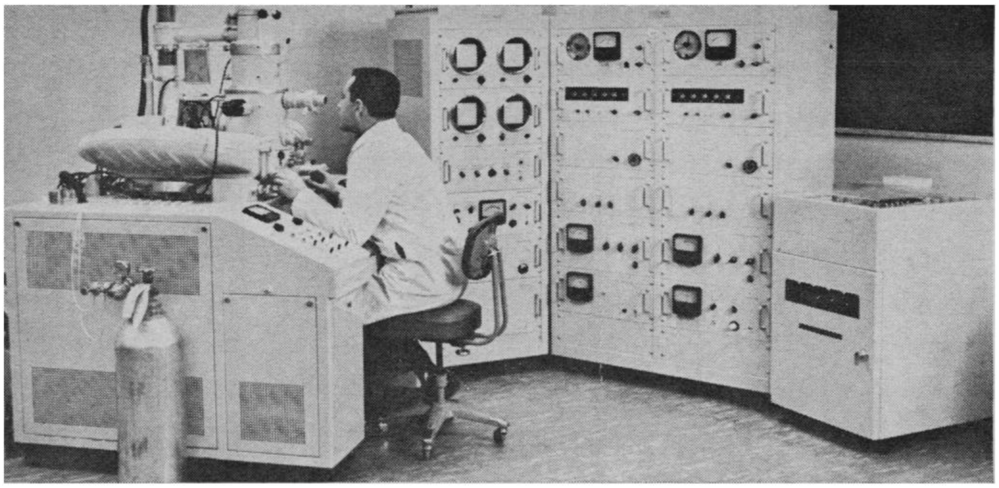

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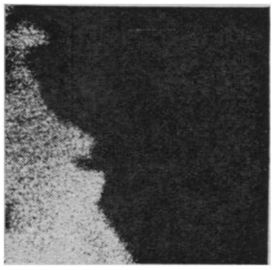
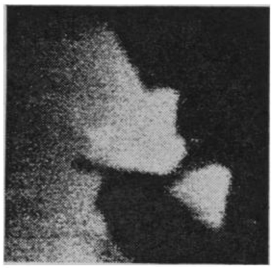
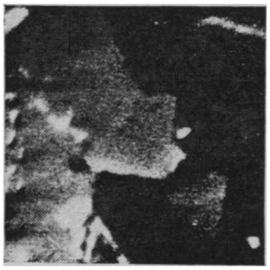


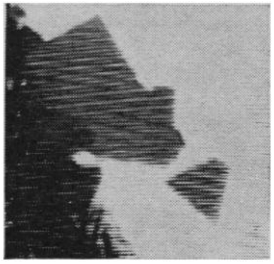
Characteristic X-ray Image by Cu $K\alpha$



Characteristic X-ray Image by Fe $K\alpha$



Back-scattered Electron Image



Absorbed-electron Image

(nonenzymatic) reactions were described briefly (L. Vernon, A. San Pietro and associates). Two aspects of the chemistry of isolated phycobilins, in relation to absorption and fluorescence emission spectra were noted—J. Bergeron on the dimerization of the protein and E. Fujimori on the effects of *p*-chloromecuribenzoate (PCMB). Both authors extrapolate their results to the situation in the intact cell; Bergeron concluded that the fluorescence of blue-green algae at 680 mμ is in part due to phycocyanin itself. After a detailed review of their work with the dimers of chlorophyll, S. S. and M. Brody suggested that the dimer is present and functional in vivo.

The path of phosphorus in *Chlorella* cells was noted by S. Miyachi. The recent kinetic studies of A. Bassham on the path of carbon in photosynthesis show clearly that in vivo the initial carboxylation reaction must lead in part to directly reduced intermediates (either a triose or a hexose phosphate) instead of producing two phosphoglyceric acid molecules as the isolated enzyme does. This concept was reinforced by inhibitor studies of M. Gibbs and by his convincing demonstration that aldolase is absent from blue-green algae. Both authors favored a more direct role for some enzyme-containing sulfhydryl in the initial carboxylation and reduction, and both speculated on the participation of ferredoxin without the use of reduced nicotinamide adenine dinucleotide phosphate (NADPH). N. E. Tolbert and C. P. Whittingham and R. Hiller reviewed the existence of the two-carbon "glycolate pathway" in photosynthesis, again a region not envisaged in the classical schemes of M. Calvin. Both groups pointed out that: (i) the conditions favoring major turnover in the glycolate pathway are just those found ordinarily in nature (high light, low carbon dioxide, and high oxygen), and (ii) it is already known that a very major fraction of oxygen uptake by green leaves in the light occurs through glycolic acid oxidase, a known enzyme in the pathway. The actual site of origin of the original two-carbon intermediate (phosphoglycolic acid, according to Tolbert) is still unresolved.

B. Vennesland reviewed the closely woven concepts of Warburg as to the interrelationships between respiration, carbon dioxide fixation, phosphorylation, the nature of the light reaction, and oxygen evolution. These concepts were found to be consistent with the data obtained directly by Vennesland with isolated chloroplasts, but do not explain many other data presented at this meeting and elsewhere. The ideas of Warburg vary considerably from those of most other workers in photosynthesis, and no reconciliation between them appears possible at the present time.

A great many of the papers attempted to present a brief review and overall perspective of the work from each particular laboratory over the past 2 or 3 years. In view of this, and the rather extensive coverage of active laboratories at the meeting, the volume to be published by the National Academy of Sciences–National Research Council in the near future should be a valuable record of the state of photosynthetic research in the early 1960's.

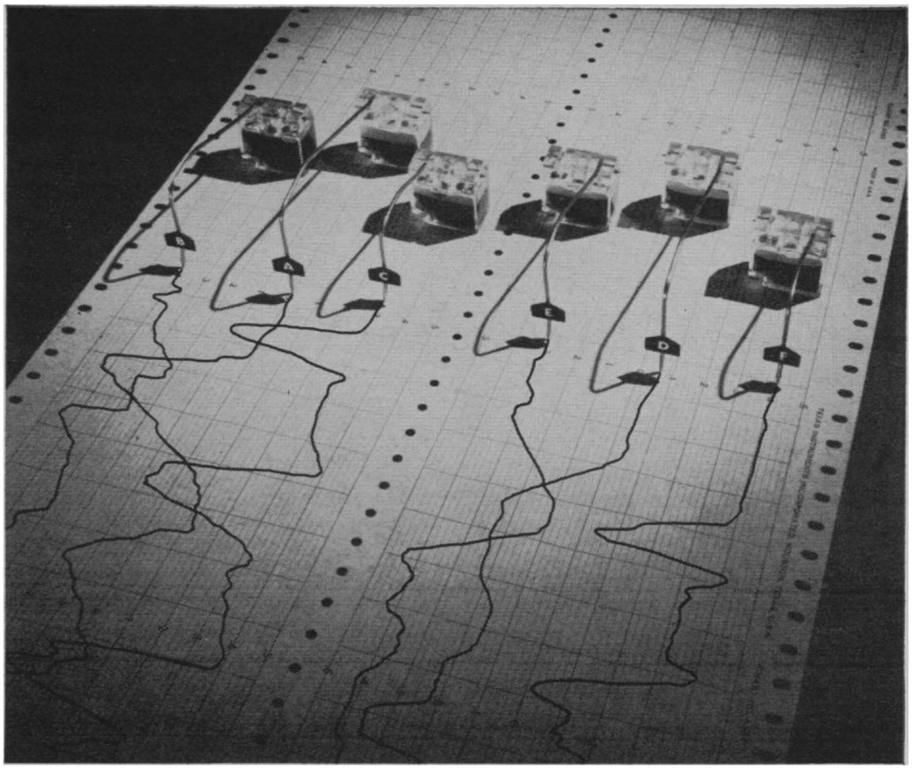
The meeting was sponsored by the Photobiology Committee of the National Academy of Sciences–National Research Council and received financial support from the National Science Foundation.

A. T. JAGENDORF
B. KOK
Johns Hopkins University and
Research Institute of Advanced Studies, Baltimore, Maryland

Silica

Various aspects of present and future research on silica were discussed at the annual symposium of the American Ceramic Society (New England Section) at Massachusetts Institute of Technology, 29 October.

C. Frondel (Harvard), in his introductory remarks, considered areas where research is still needed for the understanding of the various polymorphs of silica. He revealed that quartz as an entity has been well known for over 2000 years and reviewed the three periods in which the investigation of silica polymorphs has been especially intense. Currently the details of the crystal structure and chemical composition of the silica polymorphs and silica glass are under intense study. Water in silica minerals may occur as tetrahedral OH groups. He noted also that the silicon-oxygen bond lengths vary considerably both in silica and silicates and that symmetrical SiO_4 tetrahedra are only approximations of the true structure. Recent investigations have settled affirmatively the controversies regarding the existence of tridymite in the pure state;



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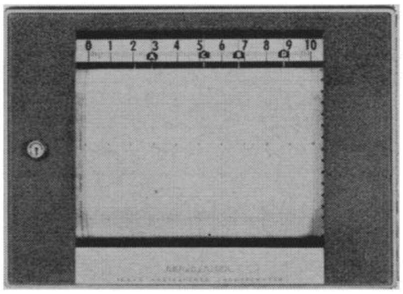

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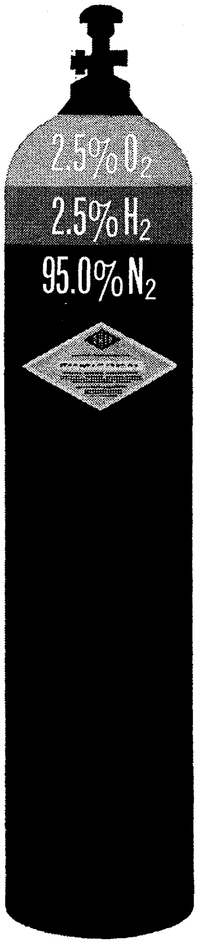

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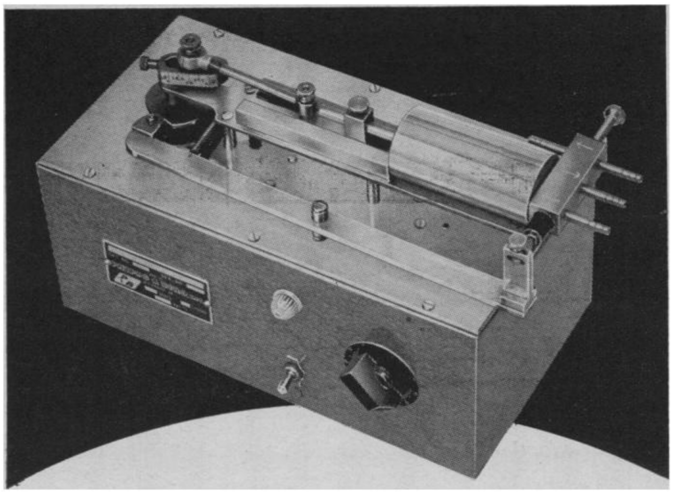

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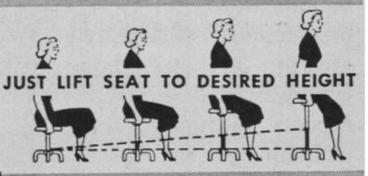

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however, it is still a matter of conjecture why cristobalite shows such little variation in crystal structure while tridymite is known to be quite variable.

While Frondel had suggested that only 11 polymorphs of silica exist and thought it unlikely that many new ones will be discovered, Sosman (Rutgers) remarked that in his opinion there are 22 or more polymorphs of silica. Sosman considers that there are nine varieties of tridymite, six of which are varieties of tridymite S, as described by investigators at Pennsylvania State University, and three are varieties of Pennsylvania State's tridymite M. Frondel's classification adheres to Fenner's long-standing recognition of only three tridymites. In addition, Sosman lists five amorphous phases, including what he calls "silica M," produced by neutron bombardment, "supra-piezo-vitreous silica," and "compacted silica."

William Campbell (Lexington Laboratories), who suggested the theme of the meeting, spoke briefly on the microsolid solutions in quartz. He noted variations in physical properties such as density, unit cell dimensions, absorption spectra, indices of refraction, and radiation darkening in relation to specimen composition. The principal experimental difficulty is obtaining the degree of precision necessary to observe the small variations in composition.

The hydrothermal crystal growth of quartz was discussed primarily from a kinetic point of view by R. Laudise (Bell Telephone Laboratories). He showed that the principal reaction for silica dissolution in pure water was:

$$SiO_2 + nH_2O \rightarrow SiO_2 \cdot nH_2O$$

with $n = 2$. To increase the solubility of silica in water, it is necessary to add some mineralizer, typically sodium hydroxide. Laudise proposed a consecutive reaction scheme consisting of the following steps: dissolution, transport by thermal convection, diffusion in the solvent phase, chemisorption, surface diffusion on the growing crystal, and attachment at kink in crystal. The latter three can be grouped as the phase boundary step and indications are that in a typical condition of hydrothermal growth, the phase boundary reaction is slowest and therefore dominates the process. A number of other crystals, including garnets, have been grown by this technique.

Discussing the optical spectra of rare earths in fused silica, W. Nelson (Owens-Illinois Glass Company) con-

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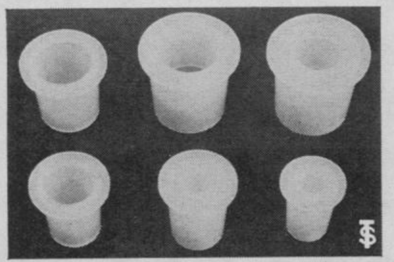

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—Ninth International Annual Conference of High Energy Physics: Plenary Sessions I-V and VI-IX, Kiev, July 15-25, 1959. (Moscow, 1960—Acad. of Sciences of USSR-Int'l. Union of Pure & Applied Physics—in 2 vols.) The set— 9.00

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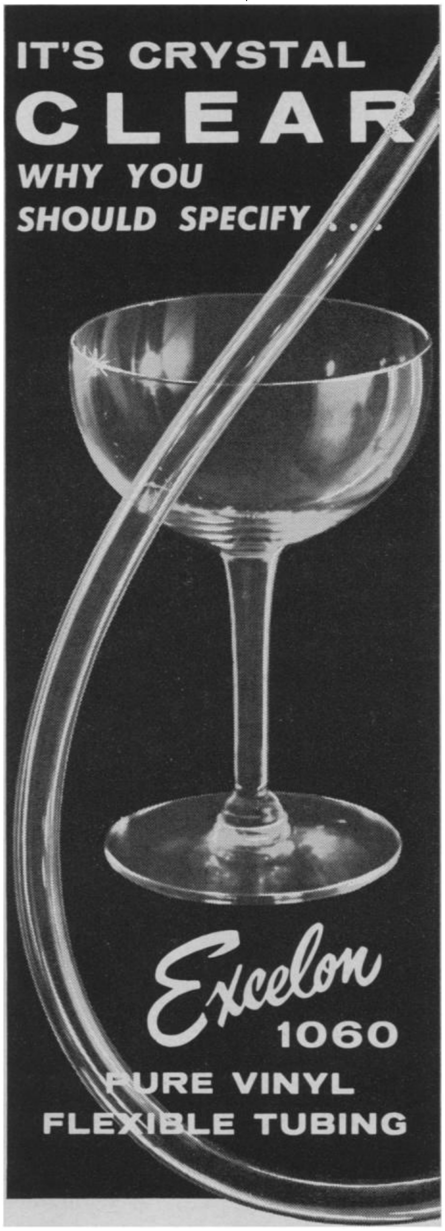
centrated on the effects that are obtained by introducing two rare earth ions into fused silica. In general the amounts of doping were less than 200 parts per million on an atomic basis. He speculated about the mechanisms of energy transfer between the rare earth ions.

For example, in the case of terbium-europium, the terbium fluorescence in the absence of europium is similar to the fluorescence of crystalline anhydrous terbium chloride. However, when small quantities of europium are added, the fluorescence becomes similar to that of crystalline terbium nitrate. Both the absorption behavior for the exciting radiation and the emmission behavior are drastically changed. The europium-terbium pair was described as behaving in a "catalytic" way, that is, the presence of europium causes the fluorescence of terbium when excited with ultraviolet. This reaction is not coincident with a terbium absorption because the europium itself does not fluoresce. The case of cerium-terbium is termed "parasitic" by Nelson because, after additions of terbium, the ions act as if they were "sapping" energy from the excited states of the cerium ions. For the combinations of lutecium-europium and of praseodymium-gadolinium the interactions are more complex and difficult to explain even conceptually.

Prior to the work of S. Weissmann (Rutgers), some investigators believed that quartz and fused silica heavily damaged by radiation approached a common state. This was based on the similarity of the density and diffuse x-ray diffraction patterns in these two cases. By use of a variety of techniques, such as electron transmission microscopy, electron diffraction, x-ray back reflection, divergent beam technique, and small angle scattering, Weissmann was able to prove the existence of micro crystals of quartz in radiation-damaged fused silica. In the case of radiation-damaged quartz he proposes a model based on the presence of clusters of silicon in the remnants of the screw channels of quartz structure. The data he amassed by these techniques proved consistent with this model and permitted calculation of the density changes from radiation that agreed with measurements.

Elias Snitzer (American Optical Company; inventor of the glass laser) discussed glass lasers and glass structure. In his early remarks Snitzer explained the principles of optical lasers,



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pointed out the fundamental advantage of a four-level system, such as the neodymium glass laser, and compared it with the three-level system, such as the ruby laser. His major point was that in the former case it is necessary only to have a small fraction of the ions in an excited state, while in the 3-level system at least half the ions must be in the excited state. Snitzer's research with neodymium glass lasers has led him to postulate that the neodymium site in silicate glass is typically a slightly distorted icosohedron. This argument is favored because the interstice in an icosohedron formed with oxygen ions is very nearly the appropriate size for a neodymium ion. In addition, icosohedra are formed from triangular sides, and triangles of oxygen are available from sides of the silica tetrehedra that are the primary structural unit of silicate glass. Icosohedral symmetry is not found in simple crystalline materials because of the inability of icosohedra to fill space. However, in the case of glass or liquids this limitation is overcome by the amorphous structure of the material adjacent to icosohedra. Furthermore, the postulated diagram for the energy level of neodymium in silicate glasses shows splitting of the ground state into two states, similar to that obtained with icosohedral symmetry. Other possible structural arrangements would require a different degree of ground state splitting. Snitzer has been able to use the principle of icosohedral coordination of the neodymium ion as a guide in the development of optimum glass compositions as hosts for the neodymium ion.

ALFRED R. COOPER
*Department of Metallurgy,
Massachusetts Institute of
Technology, Cambridge*

Forthcoming Events

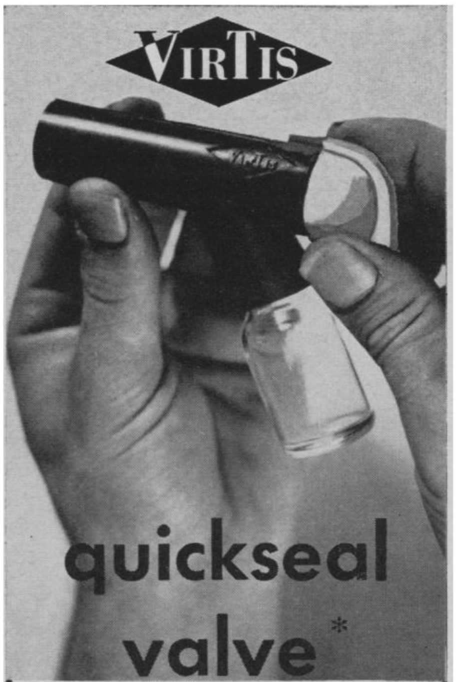
February

2–5. American Inst. of **Chemical Engineers**, annual, Boston, Mass. (J. Henry, AICE, 345 E. 47 St., New York, N.Y.)

2–7. Institute of **Electrical and Electronics Engineers**, winter meeting, New York, N.Y. (A. P. Fughill, Detroit Edison Co., 2000 Second Ave., Detroit, Mich. 48226)

2–8. **Teratology**, workshop, Commission on Drug Safety, Gainesville, Fla. (D. C. Trexler, Commission on Drug Safety, 221 N. LaSalle St., Chicago, Ill. 60601)

2–11. Scientific-Technical **Documenta-**



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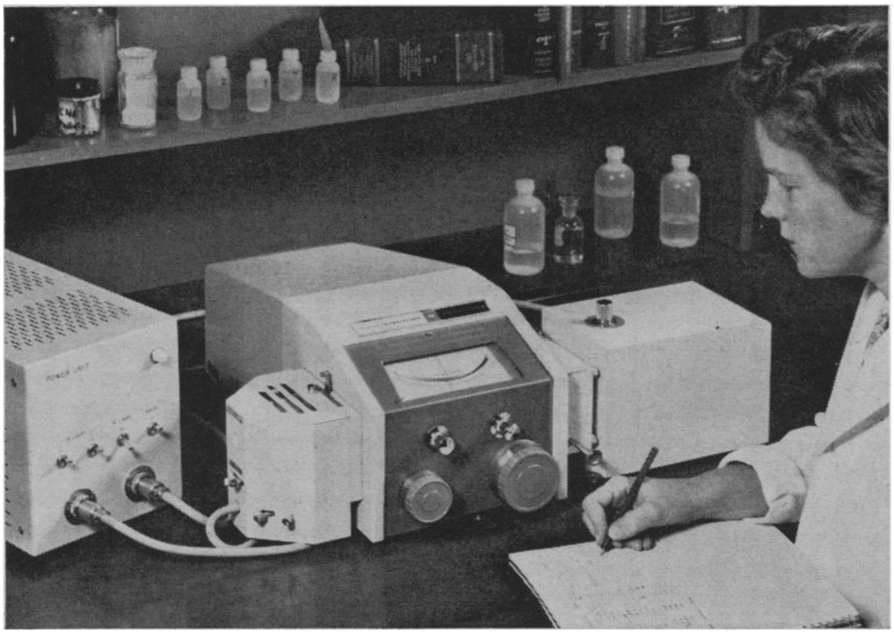

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tion and Information, intern. congr., Rome, Italy. (I. M. Lombardo, La Produttivita, Viale Regina Margherita, 84d, Rome)

3–4. Society of **Rheology**, Claremont, Calif. (T. L. Smith, Stanford Research Inst., Menlo Park, Calif.)

3–4. Perspectives in **Virology** IV, Gustav Stern symp., New York, N.Y. (M. Pollard, Lobund Laboratory, Univ. of Notre Dame, Notre Dame, Ind.)

3–7. **Materials**, intern. conf., Philadelphia, Pa. (A. G. H. Dietz, Dept. of Building Engineering, Massachusetts Inst. of Technology, Cambridge)

4–6. Society of the **Plastics** Industry, conf. of the reinforced plastics div., Chicago, Ill. (W. C. Bird, SPI, 250 Park Ave., New York, N.Y. 10017)

4–6. Cellular Biology of **Myxovirus Infections**, CIBA Foundation symp., London, England. (CIBA Foundation, 41 Portland Pl., London, W.1)

5–7. **Military Electronics**, 1964 winter conv., Los Angeles, Calif. (Inst. of Electrical and Electronics Engineers, Box A, Lenox Hill Station, New York, N.Y. 10021)

5–8. American College of **Radiology**, natl. meeting, Tucson, Ariz. (American College of Radiology, 20 N. Wacker Dr., Chicago, Ill. 60606)

7–8. **Differentiation and Development**, symp., New York, N.Y. (New York Heart Assoc., 10 Columbus Circle, New York, N.Y. 10019)

9–11. **Entomological** Soc. of America, Southwestern Branch, Monterrey, Mex. (D. F. Martin, P.O. Box 1033, Brownsville, Tex. 78521)

10–14. New Zealand Institution of **Engineers**, conf., Wellington. (F. N. Stace, P.O. Box 3047, Wellington, N.Z.)

12–16. American College of **Cardiology**, 13th annual, New Orleans, La. (P. Reichert, Empire State Bldg., New York, N.Y. 10001)

13–14. Texas **Industrial Pharmacy** Seminar, Austin. (L. R. Parker, Pharmacy Extension Service, Univ. of Texas, Austin)

15–16. **Atomic Energy**, Japanese natl. symp., Tokyo. (Atomic Energy Soc. of Japan c/o Atomic Energy Research Inst., 1-1 Shiba-tamura-cho, Minato-ku, Tokyo)

16–22. **National Engineers'** Week, sponsored by the National Society of Professional Engineers, 2029 K St., NW, Washington, D.C. 20006)

17–19. American **Standards Assoc.**, 14th annual conf., Washington, D.C. (ASA, 10 E. 40 St., New York, N.Y. 10016)

17–20. **Metals** for Use at High Temperature, intern. symp., New York, N.Y. (D. A. Parks, Inst. of Metals Div., Metallurgical Soc., 345 E. 47 St., New York, N.Y. 10017)

17–21. **Information** Storage and Retrieval, 6th, Washington, D.C. (L. W. Hattery, American Univ., 1901 F St., NW, Washington, D.C. 20006)

19–21. National Soc. of **College Teachers** of Education, Chicago, Ill. (E. J. Clark, Indiana State College, Terre Haute, Ind.)

19–21. **Solid-State Circuits**, intern. conf., Philadelphia, Pa. (L. Winner, 152 W. 42 St., New York, N.Y. 10036)

19–22. American **Educational Research**

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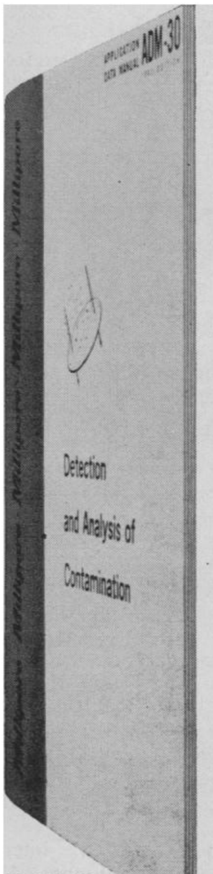

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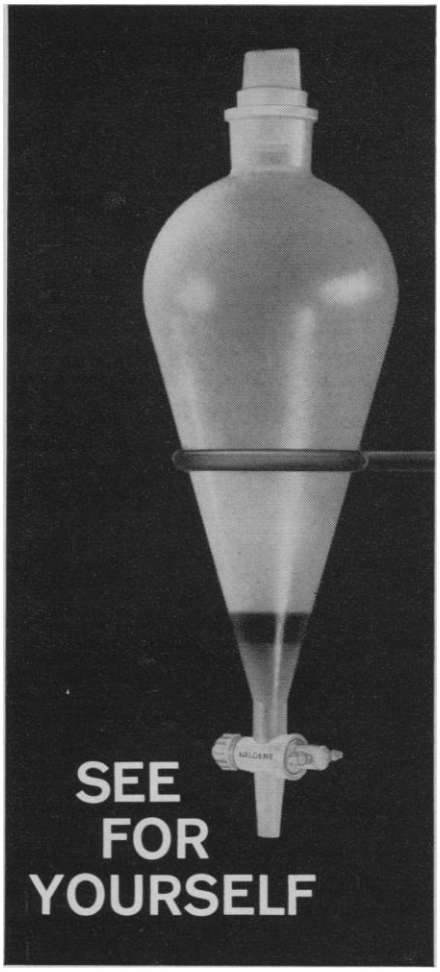

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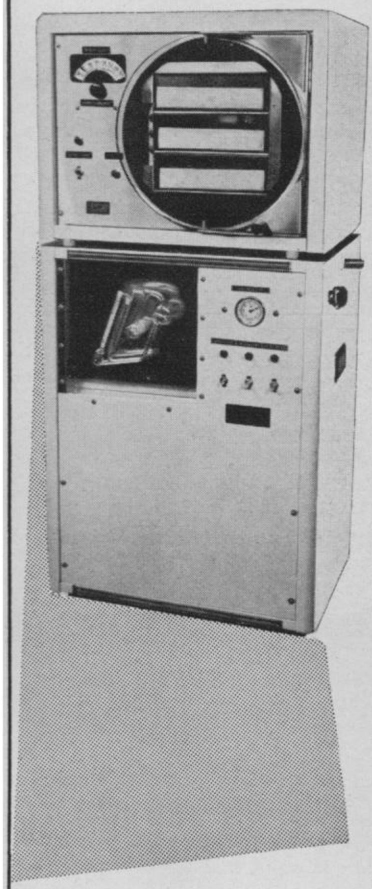

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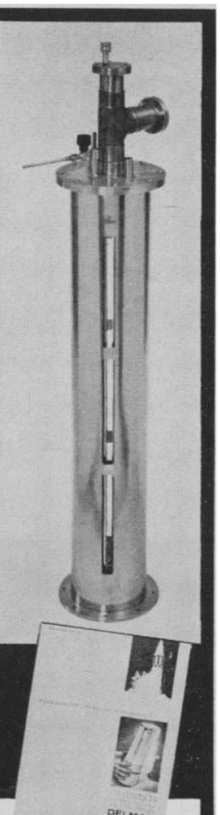

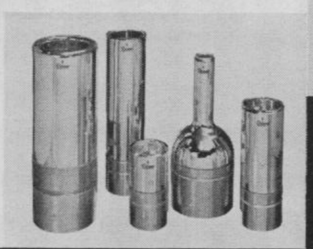

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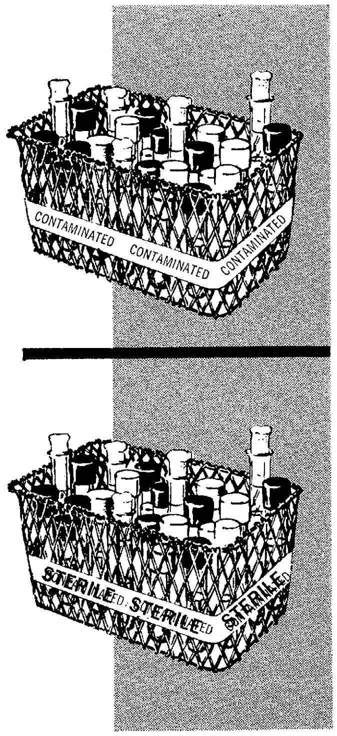

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19–5. Pan American **Medical** Assoc., 39th congr., the Americas, during a cruise aboard the S.S. *Independence.* (J. J. Eller, 745 Fifth Ave., New York, N.Y.)

23–27. Technical Assoc. of the **Pulp and Paper** Industry, 49th annual, New York, N.Y. (TAPPI, 360 Lexington Ave., New York, N.Y. 10017)

23–28. **Otorhinolaryngology and Bronchoesophagology**, 9th Pan American congr., Bogota, Colombia. (C. M. Norris, 3401 N. Broad St., Philadelphia, Pa. 19140)

24–25. Atmospheric Movements of **Radioactive Materials**, Geneva, Switzerland. (World Meteorological Organization, Geneva)

24–25. **Writing-Improvement** Programs for Engineers, seminar, New York, N.Y. (C. A. Meyer, RCA Commercial Engineering, Harrison, N.J.)

24–28. Institution of **Electrical Engineers**, intern. conf. on transmission aspects of communications networks, London, England. (IEE, Savoy Pl., London, W.C.2)

25–26. **Dairy Engineering**, natl. conf., East Lansing, Mich. (C. W. Hall, College of Agriculture, Michigan State Univ., East Lansing)

26–28. **Biophysical** Soc., Chicago, Ill. (W. Sleator, Jr., Washington Univ. Medical School, 660 Kingshighway, St. Louis 10, Mo.)

26–28. **Scintillation and Semiconductor** symp., Washington, D.C. (G. A. Morton, RCA Laboratories, Princeton, N.J.)

27–28. Cellular Basis for the Action of **Cardiac Drugs**, Philadelphia, Pa. (Heart Assoc. of Southeastern Pa., 318 S. 19 St., Philadelphia 3)

27–28. National Assoc. for **Mental Health**, annual conf., London, England. (General Secty., 39 Queen Anne St., London, W.C.1)

27–29. American Acad. of **Forensic Sciences**, Chicago, Ill. (W. J. R. Camp, 1853 W. Polk St., Chicago 12)

27–29. American **Physical** Soc., Tucson. Ariz. (K. K. Darrows, American Physical Soc., Columbia Univ., New York, N.Y. 10027)

March

1–4. Canadian Assoc. of **Radiologists**, annual, Vancouver, B.C. (A. I. Ekstrand, 1555 Summerhill Ave., Montreal 25, P.Q., Canada)

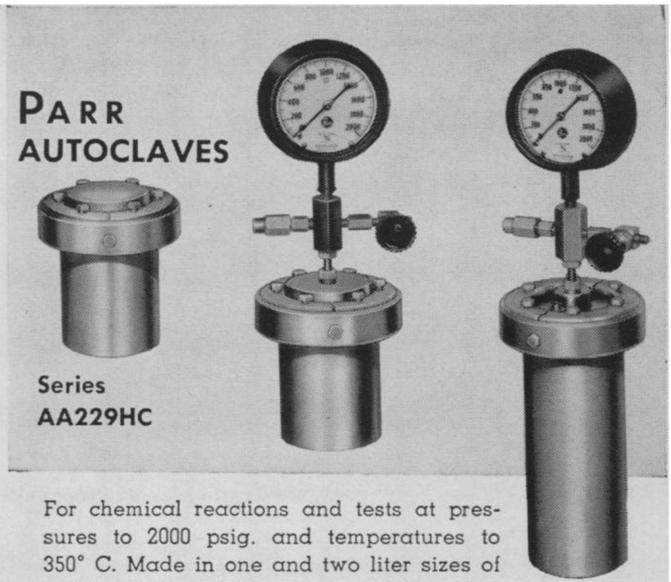
1–15. **Raman Spectroscopy**, colloquium, Stuttgart, Germany. (J. Goubeau, Dept. of Chemistry, Technische Hochschule Stuttgart, 7 Stuttgart N)

2–4. Fundamental **Cancer Research**, 18th annual symp., Houston, Tex. (R. J. Shalek, Dept. of Physics, Univ. of Texas, Houston)

2–6. **Analytical Chemistry** and Applied Spectroscopy, Pittsburgh, Pa. (R. B. Fricioni, Allegheny Ludlum Steel Corp., Research Center, Brackenridge, Pa.)

2–6. Applied **Meteorology**, 5th conf., American Meteorological Soc., Atlantic City, N.J. (A. Hilsenrod, Federal Aviation Agency, Atlantic City)

3–7. Inter-American **Nuclear Energy** Commission, 5th, Valparaiso, Chile.) Pan



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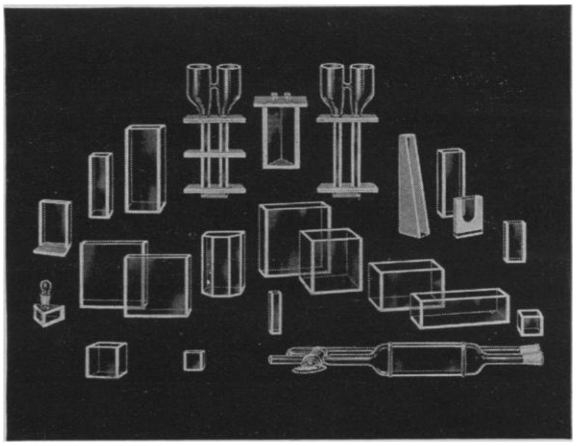

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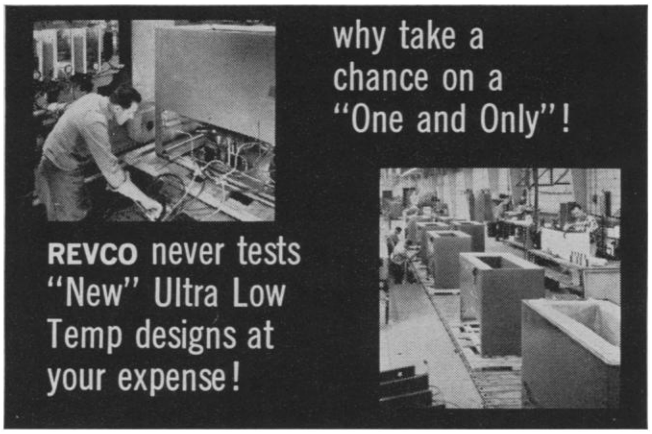

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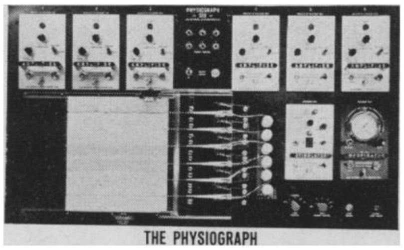
- circulation times
- oxygen tension
- pulse—rate, contour, velocity
- electrocardiography
- heart rates
- heart sounds
- electroencephalography
- rheoencephalography
- glandular secretions
- galvanic skin response (GSR)—skin resistance, autonomic response
- temperature
- others



THE PHYSIOGRAPH

RECORDERS

Your choice of:
- One to six recording channels
- 12 fixed speed chart drive
- Continuously variable speed chart drive
- Rectilinear ink writing
- Curvilinear ink writing

OPERATIONAL SIMPLICITY of this precision equipment permits immediate use by personnel untrained in electronics

ACCESSORIES

PLUG IN MODULES and SPECIAL PRODUCTS
E & M manufactures a broad line of accessory products to provide a fully compatible recording system. Send for 32 page, fully-illustrated catalog, #105.

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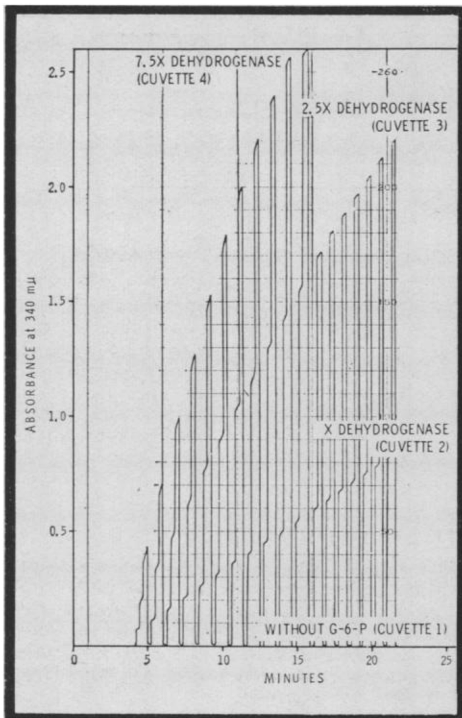
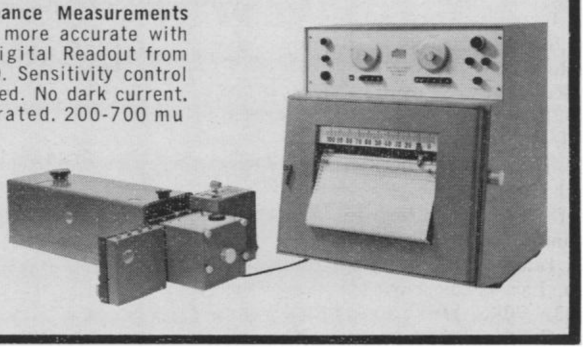


Enzyme Assays Simplified

...with Linear Recording of Absorbance on Multiple Samples

The Gilford Model 2000 Multiple Sample Absorbance Recorder significantly reduces data gathering time and effort by making the measurement of enzyme reaction rates a more exact, virtually automatic procedure. This versatile Absorbance measuring and recording system is also readily converted for liquid column chromatography, DNA-RNA thermal denaturation, sucrose gradient centrifugation and other techniques. Stable, linear recordings of Absorbance are provided with full scale deflection of any 0.1 O.D.. or greater, between 0.1 and 3.0 O.D.—plus, full scale deflection of 0.1 O.D. in the presence of high background densities. The automatic cuvette positioner precisely stations up to four "standard", micro or flow cells in the sequence desired and with dwell time adjustable from 1 sec. to 45 min. Write for brochure and quotation.

Conventional Absorbance Measurements are also easier and more accurate with the Model 2000. Digital Readout from 0.000 to 3.000 O.D. Sensitivity control and shutter eliminated. No dark current. Completely line operated. 200-700 mu wavelengths.



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