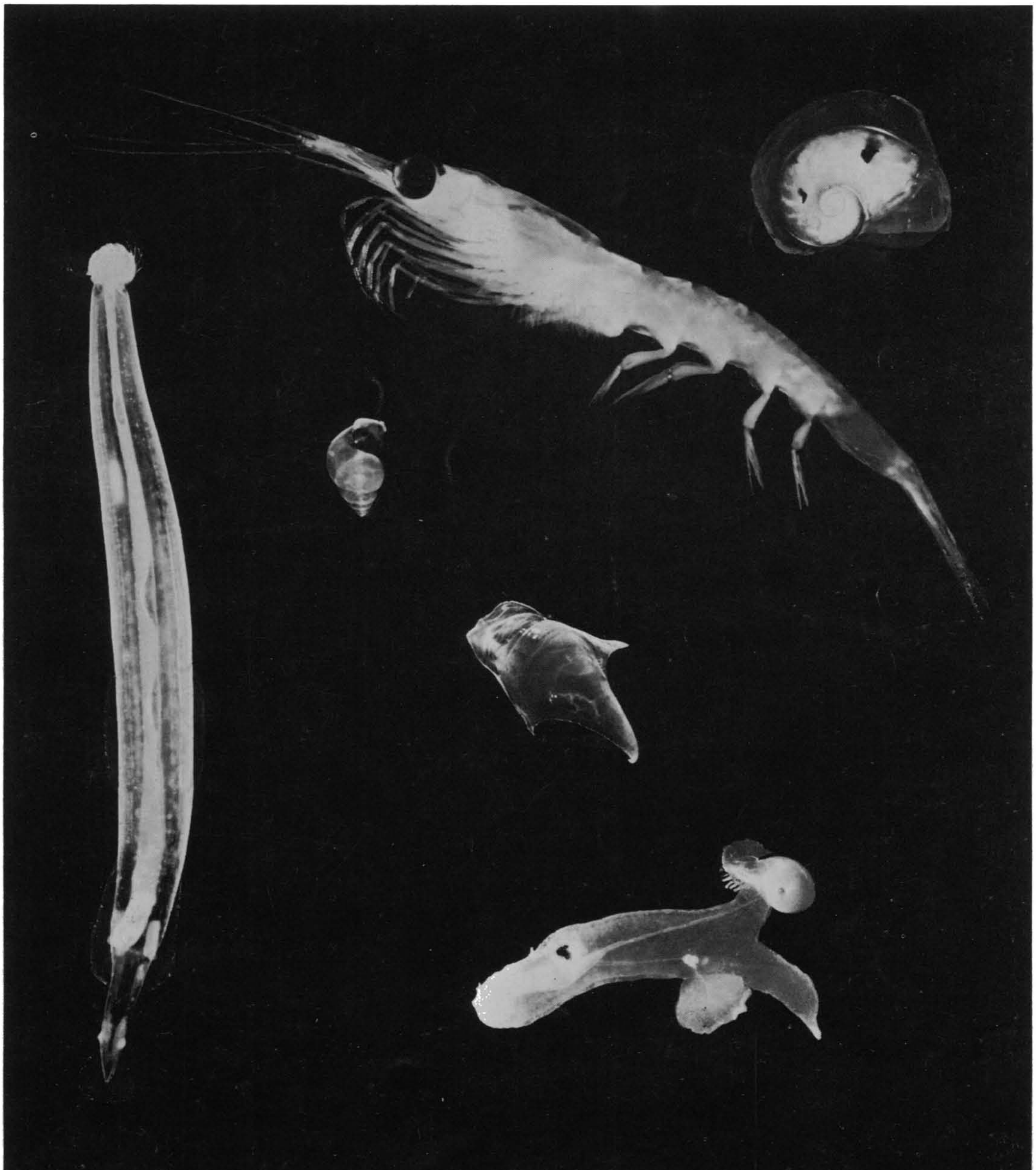
SCIENCE

3 May 1963
Vol. 140, No. 3566

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



NORTH PACIFIC ZOOPLANKTON

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COVER

The more common species of oceanic zooplankton in the North Pacific. The taxonomic groups to which they belong, together with the copepods, comprise the major portion of the animal biomass in the upper 150 meters of water. These animals are as diverse in function as they are in form. The chaetognath *Sagitta enflata* (left) and two of the pelagic mollusks, *Atlanta peroni* (top right) and *Cavolinia inflexa* (lower center), are predators; the euphausid *Euphasia pacifica* (top center) is a filter feeder, primarily on phytoplankton; and the other pelagic mollusks, *Limacina bulimoides* (upper left center) and *Carinaria japonica* (bottom) feed on particulate matter by means of mucus. Groups of zooplankton species characterize specific areas of the ocean. See page 453. [A. O. Flechsig]

NUMBER 4 IN A SERIES

How can Electron Paramagnetic Resonance (EPR) provide a chemist with information about free radical reaction mechanisms?

First, he can detect transient free radicals in the course of a reaction. He can then identify the free radical by obtaining information concerning the molecular environment of the unpaired electron. In addition, he can make a quantitative measurement of the free radical concentration; and finally, measure this concentration as a function of time.

EPR IN THE WORLD OF CHEMISTRY

IDENTIFICATION OF FREE RADICALS

In numbers 1-3 of this series, we have presented examples which illustrate the detection of free radicals using EPR. This example, No. 4, will discuss how EPR can identify free radicals.

FIG. 1, H-ATOM

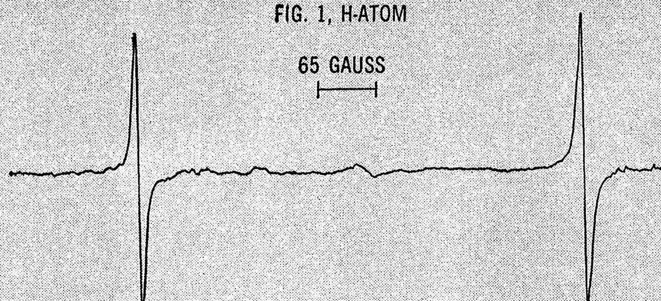
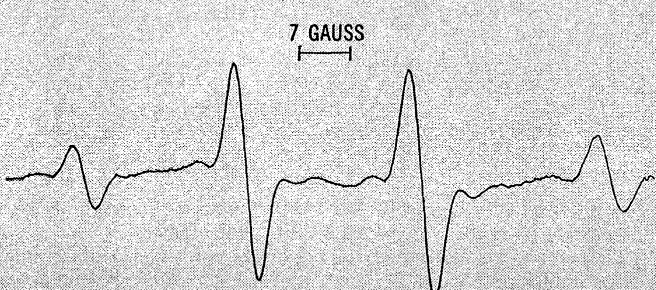


FIG. 2, METHYL RADICAL



Free radicals are often associated with molecules containing magnetic nuclei. One common example would be molecules containing hydrogen. The hydrogen nucleus has a permanent magnetic moment. If the free radical electron in its orbit comes into proximity with a hydrogen nucleus, its energy is perturbed by the "additional" magnetic field associated with the magnetic moment of the hydrogen nucleus.

The magnetic field for each hydrogen nucleus will either add or subtract from an externally applied laboratory magnetic field, thus resulting in a splitting of the electron resonance absorption into multiplets. The number of splittings depends upon the number of nuclei (n) interacting with the electron and the spin quantum number (I) of the nucleus. In the case where all nuclei are alike then there are $(2nI + 1)$ splittings possible. The strengh of the "additional" magnetic field will, of course, depend on how close the electron comes to the nucleus or, more correctly, the "spin" density at the magnetic nucleus.

It is this interaction between the magnetic nuclei and the unpaired electron which allows positive identification of the free radical. Two simple examples are illustrated in Figs. 1 and 2. Fig. 1 is the spectrum of a hydrogen atom where $n=1$, $I=½$ yielding 2 lines with a separation between lines of ~ 500 gauss. Fig. 2 is the spectrum of the methyl radical where $n=3$ and $I=½$ yielding 4 lines and a splitting of ~ 24 gauss.

Detection and identification of free radicals are not the only results obtainable from the EPR spectrum, however. It is also possible to measure the rate of free radical formation for studies of complete reaction kinetics.

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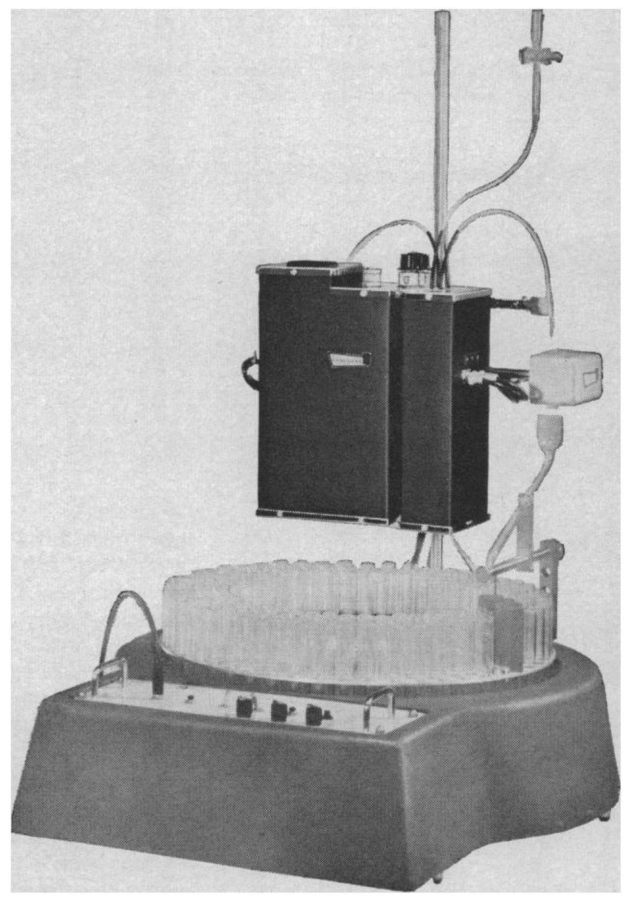

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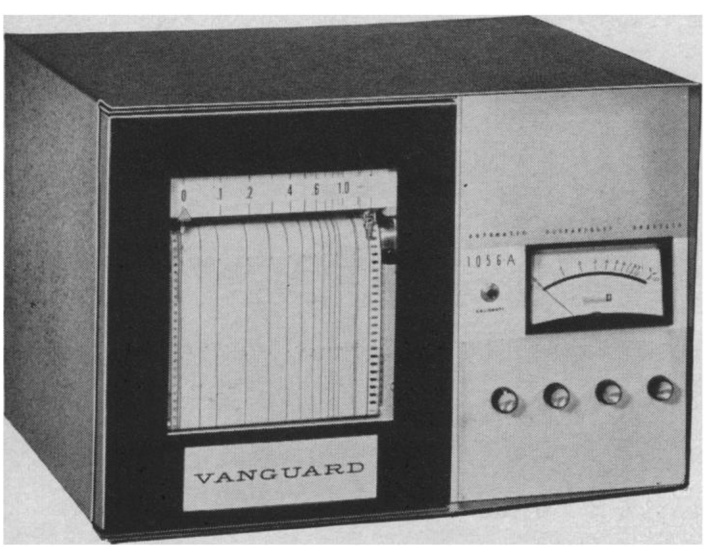

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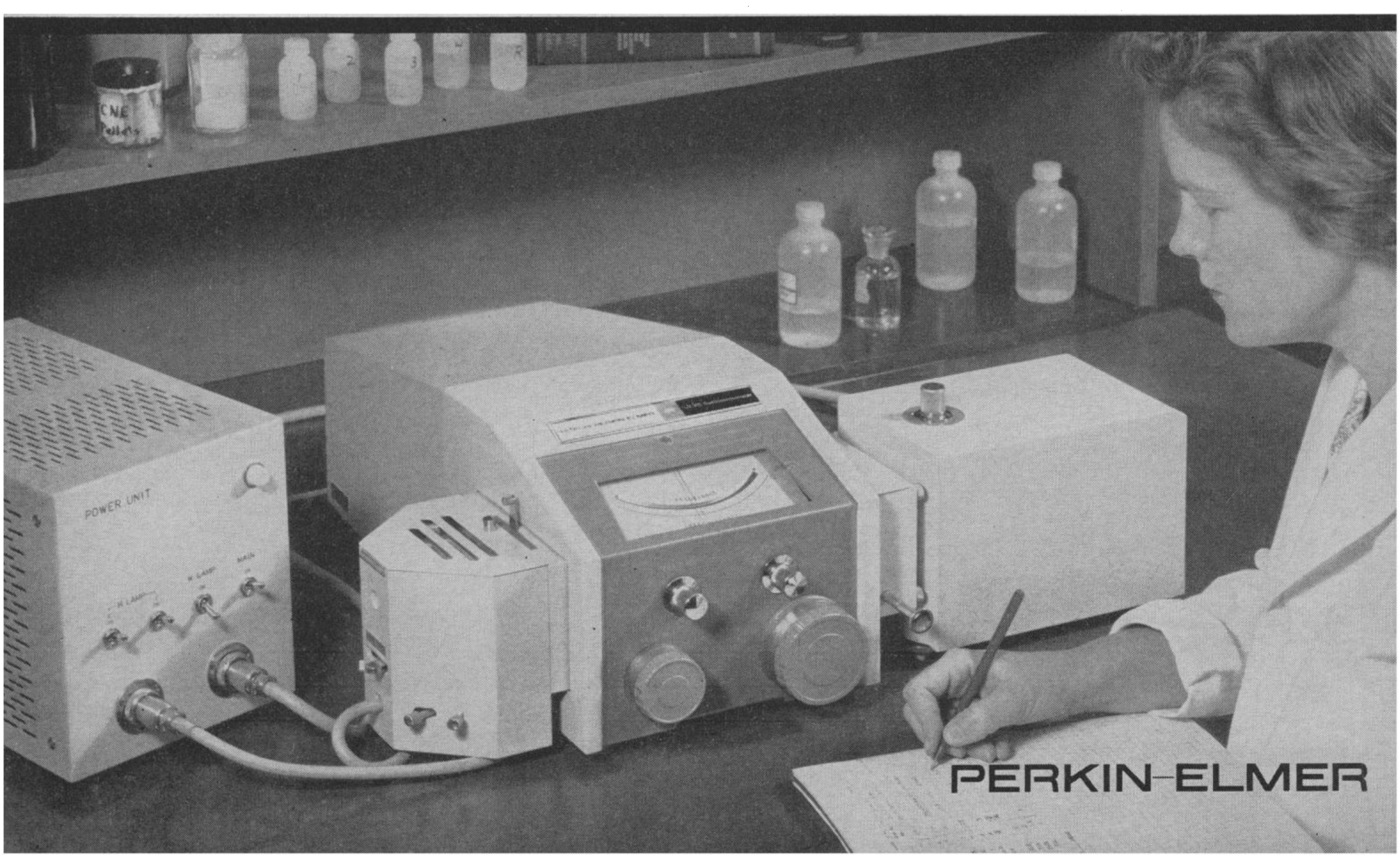

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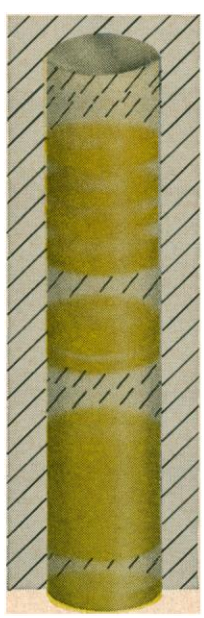

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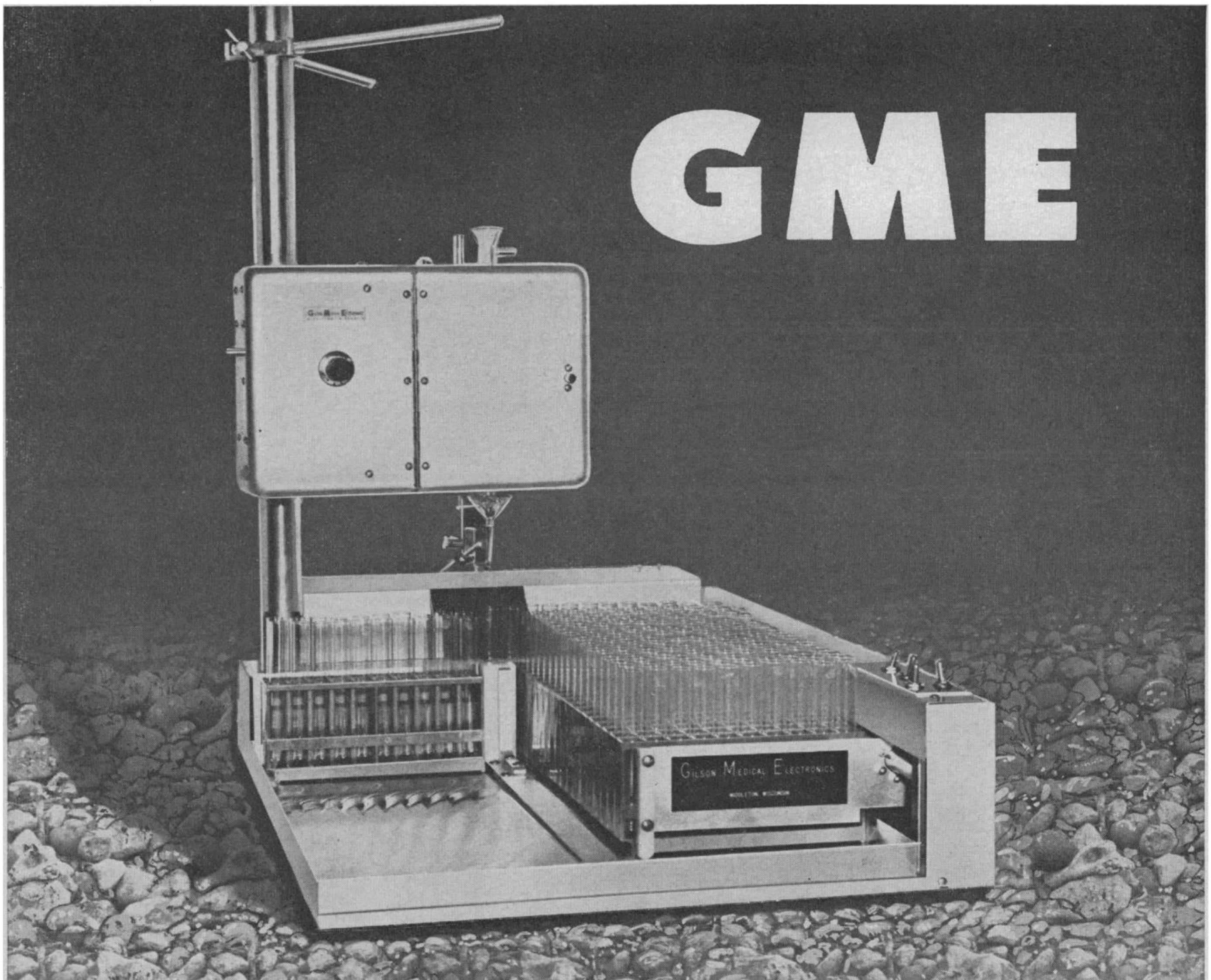
GME
GILSON MEDICAL ELECTRONICS

3 May 1963, Volume 140, Number 3566 SCIENCE

Technicians, Equipment, and Originality

Research mores are changing radically with the times. With the shift in attitude toward research from indifference to almost idolatry, there has come financial backing. And money has a powerful chemotactic effect, even on scientists. American science must "double and redouble" in size and strength, as several official reports have recently put it.

One reason for concern is the increasing growth of complexity, number, and cost of instruments and the growth in number, but decrease in capacity, of technicians. Instruments and technicians may, I suggest, reduce seriously the creativeness and originality of the young investigator. Before he has had the experience of being a naturalist, a man with his butterfly net, he is cast into a world consisting of a laboratory full of modern apparatus and two technicians who know how to do reliably almost nothing.

How can investigators keep the possibilities of fresh and creative approaches open for study? My suggestion is simple and, I am sure for many, simple-minded. When a young man starts his research, let him get his butterfly net out and put his thinking cap on. Sit down with the problem as it exists in nature—see and feel the problem—then decide how it can best be solved. With simple equipment and a clear plan, first he should try some preliminary orienting experiments with his own eyes and hands, not those of a technician. Then he should buy, or design, the necessary equipment and hire the technicians who may accelerate the work. Thus a problem might get solved, instead of just a paper being written.

Sir Alexander Fleming didn't have the benefit of modern instrumentation, a dishwasher, and a statistician to tell him what he had found. The latter, of course, could only tell him whether the results were "significant." I suspect Sir Alexander knew this already, don't you?

Am I trying to say that too much money is being spent on research? No, I am not. You must remember that research was a tenement-type operation just 15 years ago, and it takes time and money to clean out slums. Many laboratories need renovation, and many need rebuilding, and new ones need to be started. The total budget for research is still very small compared with items in the total budget of the United States, especially when you ruminate on how some of it is spent.

But the amount of money is not as important as how it is spent. I have touched on one problem. There are other problems such as the bigness of institutions, the tyranny of departmentalization, administrative rights, and responsibilities; the problem of expertness in mendicancy and problems of the ethics of science.

Neither scientists nor administrators have given much attention to the environment in which science is to grow. Until we are willing to give serious attention to these problems, we are not in a position to say "how much?" How much depends on what you have in mind. What I have in mind is to create a research environment in which originality thrives and technicians, equipment, and money are contributors—not roadblocks.—IRVINE H. PAGE, *Research Department, Cleveland Clinic, Cleveland, Ohio.*

SCIENCE AND ENGINEERING TELEVISION JOURNAL

The "Science and Engineering Television Journal" is televised weekly at 11:10 P.M. in cooperation with New York City's educational TV station, WNDT/Channel 13. These 1-hour telecasts are designed to supplement the traditional channels of communication among scientists and engineers. Plans are being considered which will make "Television Journal" recordings available to other ETV stations about the country.

2 May: **EXPLORATION IN SEMANTIC SPACE**—American Psychological Association. Chairman: Charles E. Osgood, President, American Psychological Association.

9 May: **CYCLONES**—American Meteorological Society. Chairman: Jule Charney, Professor of Meteorology, Massachusetts Institute of Technology.

16 May: **MODERN INFORMATION RESOURCES FOR TOMORROW'S ENGINEER**—Engineers Joint Council. Chairman: Eric A. Walker, President, Pennsylvania State University and President, Engineers Joint Council.

23 May: **BIOCHEMISTRY**—AAAS in collaboration with the Federation of American Societies for Experimental Biology. Chairman: William D. McElroy, Director of the McCollum-Pratt Institute, Johns Hopkins University.

30 May: **GEOCHEMISTRY: METEORITES AND THE EARTH**—American Chemical Society. Chairman: H. D. Holland, Associate Professor of Geochemistry, Department of Geology, Princeton University.

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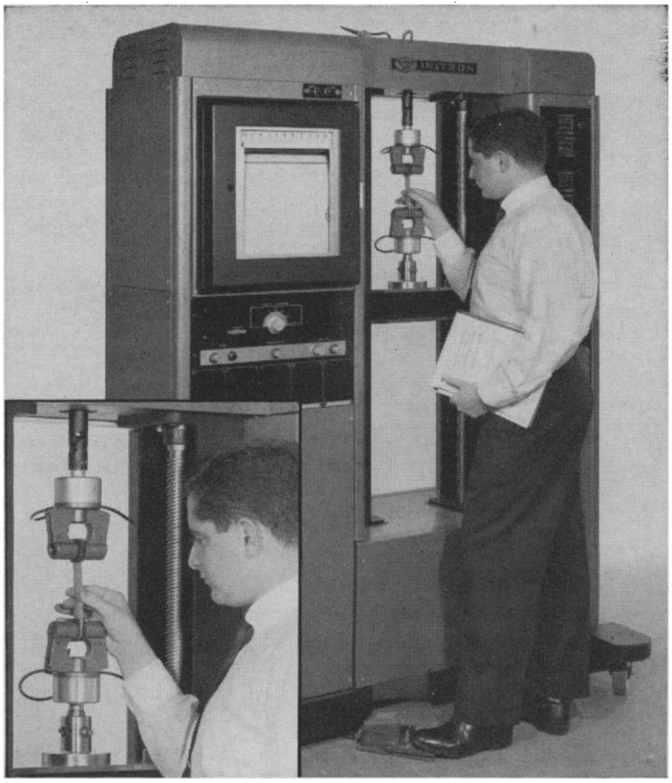

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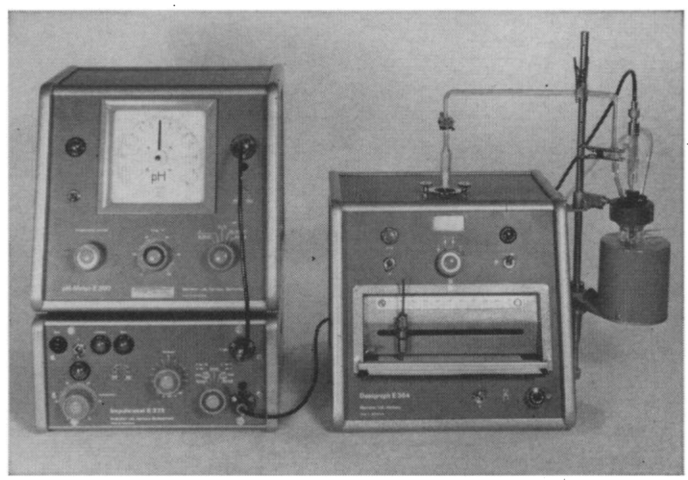

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Meetings

Thermal Imaging Techniques

The principle of focusing the image of the sun or an incandescent source onto the surface of a solid body in order to heat the surface to a high temperature has been known since ancient times. However, it is only in recent years that serious consideration has been given to the utilization of this heating technique in industrial and domestic applications and in research in high temperature chemistry and physics. Interest in such techniques has been stimulated primarily by the increased technological importance of the high temperature chemistry and physics of chemical substances. Atomic warfare has also brought with it the desirability of simulating in the laboratory the high heat fluxes which are encountered in the proximity of nuclear explosions.

Consequently a conference to review and assess progress in the application of thermal imaging techniques was held on 4 and 5 October 1962 at Acorn Park, Cambridge, Massachusetts. While the majority of discussants were from the United States, other contributors came from Belgium, France, England, and Algeria.

Early investigations of the potentialities of thermal imaging techniques were devoted almost entirely to solar furnaces. Such furnaces have the advantage that the sun is a constant temperature heat source. However, they generally require relatively massive optical systems, varying from 5 to 100 feet in diameter; it is only possible to operate them when the sun is well above the horizon; and the output from the sun is attenuated by varying atmospheric and meteorological conditions. Faced with these inconveniences, suitable alternatives to the sun have been sought. Among the alternatives and the most popular at the present time is the blown, magnetically stirred carbon arc which has a temperature of about 6000°K. This arc attains the same sample temperatures or heat fluxes as those obtained with a solar furnace, and the apparatus is reduced to proportions which can be conveniently contained in the average laboratory. Because this apparatus is now commercially available and the basic characteristics of the devices are sufficiently well known, the conference members concentrated on their applications and not on the details of their design.

Arc imaging furnaces suffer from their own shortcomings; for many purposes the arc is not sufficiently stable and its anode is usually consumed in less than 20 minutes. Because of these deficiencies, new sources are of continuing interest. The utilization of three such sources was described in talks on high pressure, graphite-resistor lamps (D. L. Richardson, A. D. Little, Inc.), the carbon vapor lamp (G. P. Ploetz, Air Force Cambridge Research Laboratories), and high wattage xenon and mercury vapor arc lamps (W. E. Thouret, Duro-Test Corp.). Although lasers were not formally discussed at the conference, it was felt that progress in the development of continuously operating solid state devices should be followed closely.

Two experimental problems restrict the application of thermal imaging techniques more than any others. These problems are associated with the uniformity and density of the energy flux incident on the sample and with the difficulty of measuring the temperature of and the temperature distribution over the heated surface. The uniformity of the flux distribution is partly a function of the quality of the optical surfaces of the apparatus. Both a new method of fabricating large diameter parabolic mirrors inexpensively and a simple technique for testing them for geometrical perfection were reported upon (T. S. Lazlo, Avco Research and Development Division). Techniques for finding a focus at the plane of maximum area with constant irradiance were also described and practically demonstrated (C. P. Butler, U.S. Naval Radiological Defense Laboratory). Other authors described ingenious calorimeters and flux redistributors used in measuring or modifying the incident flux distribution.

Calculation of the temperature of samples from a knowledge of the incident or emitted energy is hampered by a lack of knowledge of the spectral angular emission and absorption characteristics of substances. Definite progress has been made, however, in the development of instruments which permit average sample temperatures to be estimated from measurements of the incident, emitted, and reflected energy. L. Eisner (Barnes Engineering Co.) described two spectroradiometers which show promise of yielding reasonable accurate temperatures in the 1000° to 2500°C temperature range in spite of a 25 percent uncertainty in sample emittance. A technique for determining spectral reflectance and emittance of a sample in an imaging furnace was also described (M. R. Null, National Carbon Co.).

About half of the conference was devoted to a discussion of research applications. Arc imaging furnaces had in every case been used, and a wide range of properties of substances are now being investigated. For research purposes the advantage of the image furnace technique is that it permits experiments to be carried out at temperatures in the 1000° to 3500°C temperature range under extremely pure conditions or in strongly oxidizing or reducing atmospheres. The sparsity of data on the chemistry of systems under these conditions makes it profitable to obtain even qualitative information only roughly related to the International Practical Temperature Scale.

Four papers given at the conference were devoted to crystal growth. The presentation by R. Poplawsky (General Motors Corp.) was particularly impressive because it suggested that single crystals of high melting substances can now be grown and zone purified with a high degree of refinement and control by using imaging techniques. The qualitative usefulness of imaging techniques was also illustrated by several speakers who presented the results of studies of the thermal degradation of organic substances, of reactions between inorganic solids and gases, of solid propellant ignition, and of the ablation of solids. Two presentations described plans for utilizing imaging techniques in high temperature mass spectrometry.

Melting point and emissivity measurements have been attempted with promise of success and apparatus is being developed for the measurement of electrical and thermal conductivities at high temperature. It was also demonstrated that, with skillful application, precise quantitative measurements can be made by using arc imaging techniques (H. Prophet, Dow Chemical Co.). Results of measurements of the heat capacity of boron nitride and aluminum oxide over the temperature range of 1300° to 2200°K were shown to agree well with measurements made by conventional techniques over the lower portion of the range.

RAYMOND F. WALKER

National Bureau of Standards, Washington 25

Forthcoming Events

June

1–8. International **Electrotechnical** Commission, Venice, Italy. (American Standards Assoc., 10 E. 40 St., New York 16)

2–5. Society of **Aerospace Material and Process** Engineers, Philadelphia, Pa. (A. F. Feldbush, Box 613, Azusa, Calif.)

2–5. International Soc. for the Study of Diseases of the **Colon and Rectum**, 1st congr., Athens, Greece. (H. E. Bacon, Dept. of Colon and Rectal Surgery, Temple Univ. Medical Center, Philadelphia 40, Pa.)

3–11. **Space Science**, 4th intern. symp., Warsaw, Poland. (J. R. Beaulieu, COSPAR, 28 Nieuwe Schoolstraat, The Hague, Netherlands)

4–6. National **Electronic Packaging and Production**, conf., New York, N.Y. (J. McGrath, T. C. Gams & Associates, 250 Elizabeth Ave., Newark, N.J.)

4–6. Technical Assoc. of the **Pulp and Paper** Industry, 1st water conf., Cincinnati, Ohio. (H. O. Teeple, TAPPI, 360 Lexington Ave., New York 17)

4–7. European Federation of **Corrosion**, 3rd congr., Brussels, Belgium. (G. Biva, Société de Chimie Industrielle, 32, rue Joseph-II, Brussels 4)

4–8. Society of **Physical Chemistry**, 13th annual, Paris, France. (G. Emschwiller, Société de Chimie Physique, 10, rue Vauquelin, Paris 5)

4–10. Operating Experience with **Power Reactors**, conf., Vienna, Austria. (H. Storhaug, IAEA, Div. of Scientific and Technical Information, 11 Kärtner Ring, Vienna 1)

5–6. European Federation of **Chemical Engineering**, 46th, Frankfurt-am-Main, Germany. Secretariat, Deutschen Arbeitskreises Vakuum, 6 Frankfurt am Main 7, Rheingau-Allee 25, Germany)

5–7. International Symp. on **Zone Melting**, Karlsruhe, Germany. (H. Schildkrecht, Institut für Organische Chemie, Universität Erlangen, Fahrstr. 17, Erlangen, Germany)

5–10. **Documentation Research and Training** Center, 1st seminar, Bangalore, India. (A. Neelameghan, Documentation Research and Training Centre, 696 Cross Rd. 11, Malleswaram, Bangalore 3, India)

6–8. **Chemical** Inst. of Canada, 46th conf. and exhibition, Toronto, Ont. (J. R. Gray, Chemical Div., Shell Oil Co. of Canada, 505 University Ave., Toronto)

6–8. **Manufacturing Chemists'** Assoc., 91st annual, White Sulphur Springs, W.Va. (MCA, 1825 Connecticut Ave., NW, Washington 9)

6–12. **Hurricanes and Tropical Meteorology**, 3rd technical conf., Mexico City, Mexico. (M. A. Alaka, Natl. Hurricane Research Project, Room 517, Aviation Bldg., 3240 NW 27th Ave., Miami 42, Fla.)

9–13. **Air Pollution Control** Assoc., annual, Detroit, Mich. (A. Arch, 4400 Fifth Ave., Pittsburgh 13, Pa.)

9–15. International **Hospital** Congr., 13th, Paris, France. (J. C. J. Burkens, Intern. Hospital Federation, 24/6 London Bridge St., London S.E. 1, England)

9–15. National **Speleological** Soc., Mountain Lake, Va. (J. R. Holsinger, 115 W. Cameron Rd., Falls Church, Va.)

10–11. American **Vacuum** Soc., annual conf., New York, N.Y. (W. G. Matheson, P.O. Box 1282, Boston 9, Mass.)

10–13. German **Metallurgical** Soc., general assembly, Berlin. (Deutsche Gesellschaft für Metallkunde, Alteburger Str. 402, Köln-Marienburg, Germany)

10–14. **Health Physics** Soc., annual, New York, N.Y. (L. Gemmell, Brookhaven National Laboratory, Upton, N.Y.)

10–14. **Molecular Structure** and Spectroscopy, symp., Columbus, Ohio. (H. H. Nielsen, Dept. of Physics and Astronomy, Ohio State Univ., 174 W. 18th Ave., Columbus 10)

10–15. **Engineering** Societies of Western Europe and the U.S., 8th plenary assembly, Munich, Germany. (E. Hianne, Société Royale Belge des Ingénieurs et des Industriels, 3 rue Ravenstein, Brussels 1, Belgium)

10–21. **Analog Computation**, Washington, D.C. (B. P. Shah, Dept. of Mechanical Engineering, Catholic Univ. of America, Washington 17)

11–13. **Stimulus Generalization**, Boston, Mass. (D. Mostofsky, Boston Univ., 332 Bay State Rd., Boston 15)

12–14. **Heat Transfer and Fluid Me-**

chanics Inst., Pasadena, Calif. (J. J. Harford, American Rocket Soc., 500 Fifth Ave., New York 36)

12–14. **Stochastic Models** in Medicine and Biology, Madison, Wis. (J. Gurland, Mathematics Research Center, U.S. Army, Univ. of Wisconsin, Madison 6)

13–14. American **Rheumatism** Assoc., Atlantic City, N.J. (J. A. Coss, Jr., 20 E. 76 St., New York 21)

13–15. American Soc. of **Limnology and Oceanography**, Ann Arbor, Mich. (G. H. Lauff, Sapelo Island Research Foundation, Sapelo Island, Ga.)

13–15. **Endocrine** Soc., Atlantic City, N.J. (J. H. Turner, 1200 N. Walker, Oklahoma City, Okla.)

13–15. Great Lakes **Navy Research and Development Clinic**, Columbus, Ohio. (B. D. Thomas, Battelle Memorial Inst., 505 King Ave., Columbus 1)

13–16. International College of **Angiology**, 5th annual, Atlantic City, N.J. (H. E. Shaftel, ICA, 32 Broadway, New York 4)

13–17. American College of **Chest Physicians**, Atlantic City, N.J., (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

14–15. Institute of **Mathematical Statistics**, 95th Madison, Wis. (J. Gurland, Mathematics Research Center, U.S. Army, Univ. of Wisconsin, Madison 6)

14–17. **Instrument** Soc. of America, Los Angeles, Calif. (W. H. Kushnick, 530 William Penn Pl., Pittsburgh 19, Pa.)

15–16. Advancement of Private Practice in **Social Work**, 2nd conf., Denver, Colo. (P. Ledbetter, ACSW, Suite 1520, Medical Arts Bldg., Houston 2, Tex.)

16–19. Northeastern Section, **Botanical** Soc. of America, summer field meeting, Pittsburgh, Pa. (L. K. Henry, Section of Plants, Carnegie Museum, Pittsburgh 13)

16–20. **American Medical Assoc.**, Atlantic City, N.J. (R. M. McKeown, 510 Hall Bldg., Coos Bay, Ore.)

16–20. American **Nuclear** Soc., Salt Lake City, Utah. (O. J. DuTemple, 244 E. Ogden Ave., Hinsdale, Ill.)

16–21. American Inst. of **Electrical Engineers**, general meeting, Toronto, Ont., Canada. (R. M. Magee, Bendix Systems Div., Ann Arbor, Mich.)

16–22. **Medical Librarianship**, 2nd intern. congr., Washington, D.C. (R. MacDonald, Natl. Library of Medicine, Bethesda 14, Md.)

17–18. Learning, Adaptation, and Control in **Information Systems**, symp., Evanston, Ill. (J. T. Tou, Computer Sciences Laboratory, Technological Inst., Northwestern Univ., Evanston, Ill.)

17–19. American **Dairy Science** Assoc., Lafayette, Ind. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

17–19. Canadian Federation of **Biological Societies**, London, Ont. (A. H. Neufeld, CFBS, Faculty of Medicine, Univ. of Western Ontario, London, Ont.)

17–19. Hanford Symp. on Biology of **Radioiodine**, Richland, Wash. (L. K. Bustad, Biology Laboratory. General Electric Co., Richland)

17–19. Society for the Study of **Development and Growth**, Storrs, Conn. (W. A. Jensen, Dept. of Botany, Univ. of California, Berkeley 4)

17–21. American Soc. for **Engineering Education**, Philadelphia, Pa. (W. L. Collins, American Soc. for Engineering Education, Univ. of Illinois, Urbana)

17–21. **Gas Chromatography**, 4th intern. symp., Ann Arbor, Mich. (Instrument Soc. of America, 530 William Penn Pl., Pittsburgh 19, Pa.)

17–22. **Pacific Division, AAAS**, San Francisco, Calif. (R. C. Miller, California Acad. of Sciences, Golden Gate Park, San Francisco)

17–22. International Congr. of **Engineers**, 4th, Munich, Germany. (Deutscher Verband Technisch-Wirtschaftlicher Vereine, Prinz-Georg-Str. 79, Düsseldorf, Germany)

17–23. Nuclear Energy, 8th intern. congr., Rome, Italy. (Ufficio Congressi e Mostre CNEN, Via Belisario 15, Rome, Italy)

18–20. Chemistry and Biochemistry of **Fungi and Yeasts**, symp., Dublin, Ireland. (T. S. Wheeler, Dept. of Chemistry, University College, Science Bldgs., Upper Merrion St., Dublin)

18–22. American Soc. of **Ichthyologists** and **Herpetologists**, Vancouver, B.C., Canada. (J. A. Peters, Biology Dept., San Fernando Valley State College, Northridge, Calif.)

19–21. Joint **Automatic Control** conf., Minneapolis, Minn. (T. J. Williams, Monsanto Chemical Co., St. Louis, Mo.)

19–21. Metal Chelates in **Chemical Analysis**, natl. symp., Tucson, Ariz. (H. Freiser, Dept. of Chemistry, Univ. of Arizona, Tucson)

19–26. **World Petroleum** Congr., 6th, Frankfurt-am-Main, Germany. (U.S. Natl. Committee, 15 W. 51 St., New York, N.Y.)

20–21. Institute of **Mathematical Statistics**, 96th, Eugene, Ore. (D. G. Chapman, Dept. of Mathematics, Univ. of Washington, Seattle 5)

20–21. **Nutrition** Soc. of Canada, 6th annual, London, Ont. (E. V. Evans, Dept. of Nutrition, Ontario Agricultural College, Guelph, Ont., Canada)

22–23. **Ukrainian Medical** Assoc. of North America, Kerhonkson, N.Y. (R. W. Sochynsky, UMA, 2 E. 79 St., New York 21)

23–26. American Soc. of **Agricultural Engineers**, Miami Beach, Fla. (J. L. Butt, P.O. Box 229, St. Joseph, Mich.)

23–29. American Soc. for **Horticultural Science**, Caribbean region, 11th annual, Mexico City, Mexico (E. H. Cásseres, Calle Londres 40, Mexico 6, D.F.)

23–26. American Soc. of **Mechanical Engineers**, Ithaca, N.Y. (A. B. Conlin, Jr., 345 E. 47 St., New York, N.Y.)

23–28. American Soc. for **Testing and Materials**, 66th annual, Atlantic City, N.J. (ASTM, 1916 Race St., Philadelphia 3, Pa.)

24–26. International **Astrophysical** Symp., 12th, Liège, Belgium. (M. Migeotte, Institut d'Astrophysique, Cointe-Sclessin, Belgium)

24–26. American Soc. of **Heating, Refrigerating and Air Conditioning** Engineers, Milwaukee, Wis. (R. C. Cross, 345 E. 47 St., New York 17)

25–28. American **Home Economics** Assoc., Kansas City, Mo. (D. S. Miller, 3705 Van Buren Ave., Corvallis, Ore.)

(See issue of 26 April for comprehensive list)