# SCIENCE

5 May 1967
Vol. 156, No. 3775

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



# ...see how the Beckman Blood Measurement System stacks up

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*At the bottom a new variable temperature control*

*In-between modules and electrodes to measure $Po_2$ and $Pco_2$*

From a performance standpoint, the Model 160 gives you what you need: stable, accurate measurements. For convenience of use, and versatility for research, nothing else quite stacks up to it.

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If you plan to buy instrumentation for making precise blood gas and pH measurements, we'd like to have the opportunity to demonstrate the 160 System for you. Write on your letterhead, including information about your application, to the Physiological Product Manager in Palo Alto. For literature only, ask for Data File 160-5.

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**New!** This programmed text beautifully clarifies the kinetics of enzymatic reactions and transport mechanisms. It gives the student a basic understanding of how a substrate "saturates" an enzyme and how an analog inhibits its action. Steady-state approximation is presented before equilibrium assumption; the general case of the competitive inhibitor that undergoes reaction is presented before the special case where it does not undergo reaction. The plot of the absolute velocity versus the relative velocity is presented on an equal basis with the Lineweaver-Burk plot.

**124 pp. Illus. $3.50. Soft Cover. New—Published January, 1967.**

### Patton: Biochemical Energetics & Kinetics

**By A. R. Patton, Ph.D., Colorado State Univ.**

This supplemental volume is designed for the student with a limited background in mathematics and physics who needs a practical understanding of the laws of thermodynamics and kinetics. The equations, formulas, and integrations essential for understanding modern biochemistry are reduced to more simplified algebraic notations. These equations are then related to functions of energy, heat, and mass in chemical systems. Dr. Patton gives careful coverage to such topics as: electrochemistry, chemical potential, chemical distribution and osmotic pressure, Gibbs-Donnan effect and Gibbs adsorption equation, and reaction kinetics.

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The **New (3rd) Edition** of this highly readable text provides a clear picture of the structural and functional changes that underlie and accompany disease states. Dr. Robbins includes a brief review of normal organs, understandable explanations of pathologic mechanisms, and a concise outline of clinical implications. He gives particular attention to the pathogenesis of disease and to clinical correlations. Virtually every line of this edition has been checked and up-dated. You will find entirely new chapters on genetics in diseases, diseases of immune origin, and diseases of the aging. Sections on neoplasia and cellular injury and repair are also substantially revised.

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5 May 1967
Vol. 156, No. 3775

# SCIENCE





SCIENCE is published weekly on Friday and on the fourth Tuesday in November by the American Association for the Advancement of Science, 1515 Massachusetts Ave., NW, Washington, D.C. 20005. Now combined with **The Scientific Monthly®**. Second-class postage paid at Washington, D.C.  Annual subscriptions $8.50; foreign postage, $1.50; Canadian postage, 75¢; single copies, 50¢ (back issues, $1), except **Guide to Scientific Instruments**, which is $2. School year subscriptions: 9 months, $7; 10 months, $7.50. Provide 4 weeks' notice for change of address, giving new and old address and zip codes. Send a recent address label. SCIENCE is indexed in the **Reader's Guide to Periodical Literature.**

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

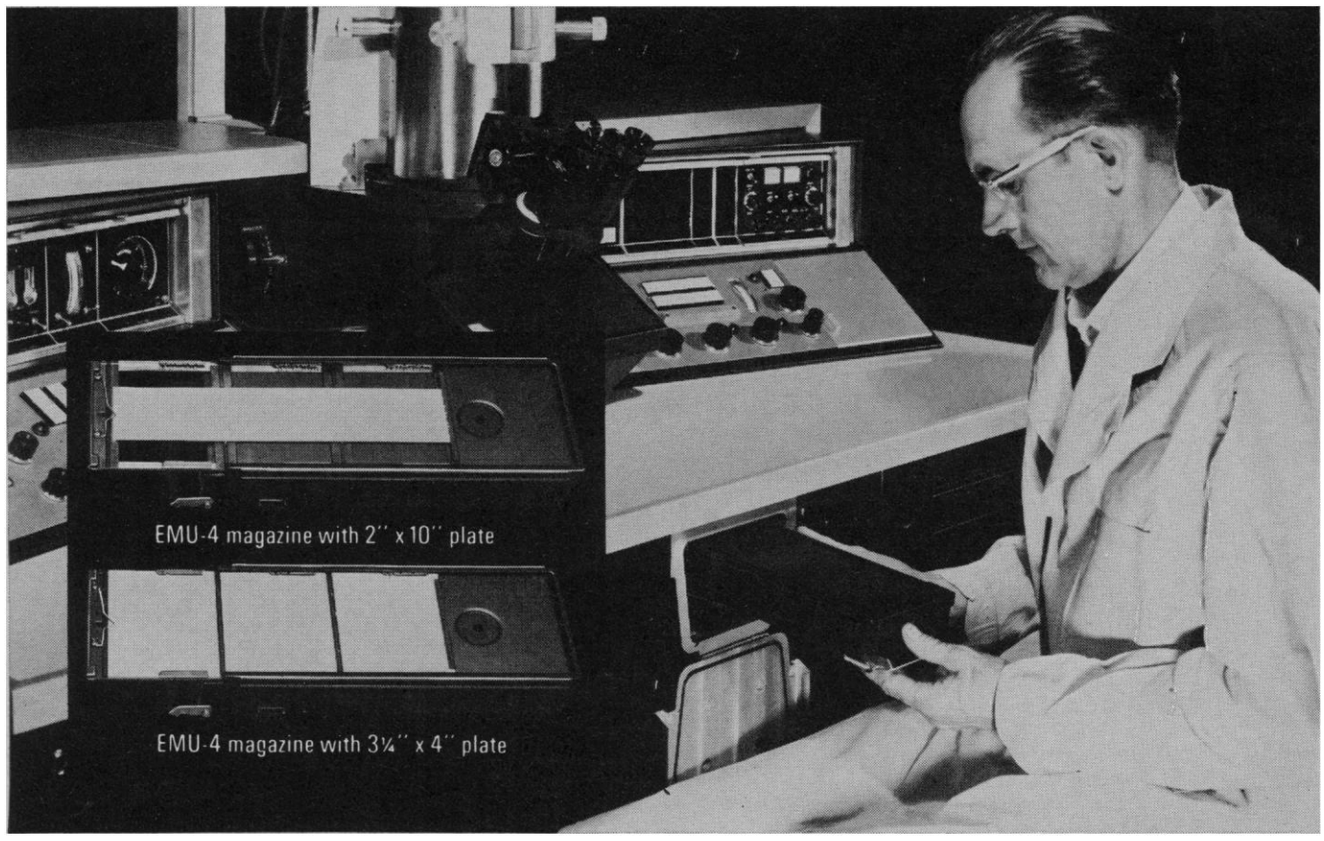




**COVER**

Inner surface of mammalian myocardial cell. The projections represent the broken stumps of the invaginations which form the transverse tubular system. (Freeze-etching and electron microscopy, × 40,000). See page 656. [D. G. Rayns, Medical Research Council of New Zealand; F. O. Simpson, University of Otago Medical School, Dunedin, New Zealand; and W. S. Bertaud, Department of Scientific and Industrial Research, Lower Hutt, New Zealand]

## *EMU-4...The "New Look" in Electron Microscopes*




**Front-loaded magazine holds 6 cassettes**

# Which plate size is best for electron micrographs?

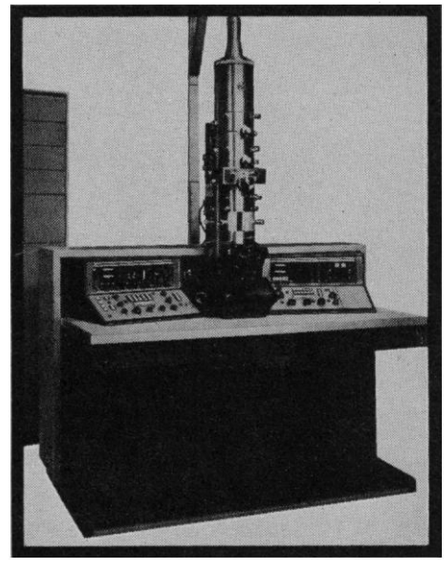
The best plate size is a *standard* size, for only a standard size gives you a selection of emulsion characteristics, is easily and quickly available in local supply and demands no premium in price.

The EMU-4 plate cassette—there are six in a magazine load—is designed with those thoughts in mind: They accommodate—interchangeably—the standard 2" x 10" spectroscopy plate or the standard 3¼" x 4" projector-slide plate or cut film in 4" x 10" pieces (which is precisely one-half of a standard 8" x 10" piece of sheet film).

Since they are universally available, these plates are competitively priced, offer wide choices of emulsion types and are usually stocked at local supply houses.

Using standard-size photo materials is but one of the many features of the new EMU-4. Among the others are: transistorized, modularized electronics; an almost-impossible-to-contaminate objective aperture; a truly universal specimen chamber; a quick-change specimen airlock and many others.

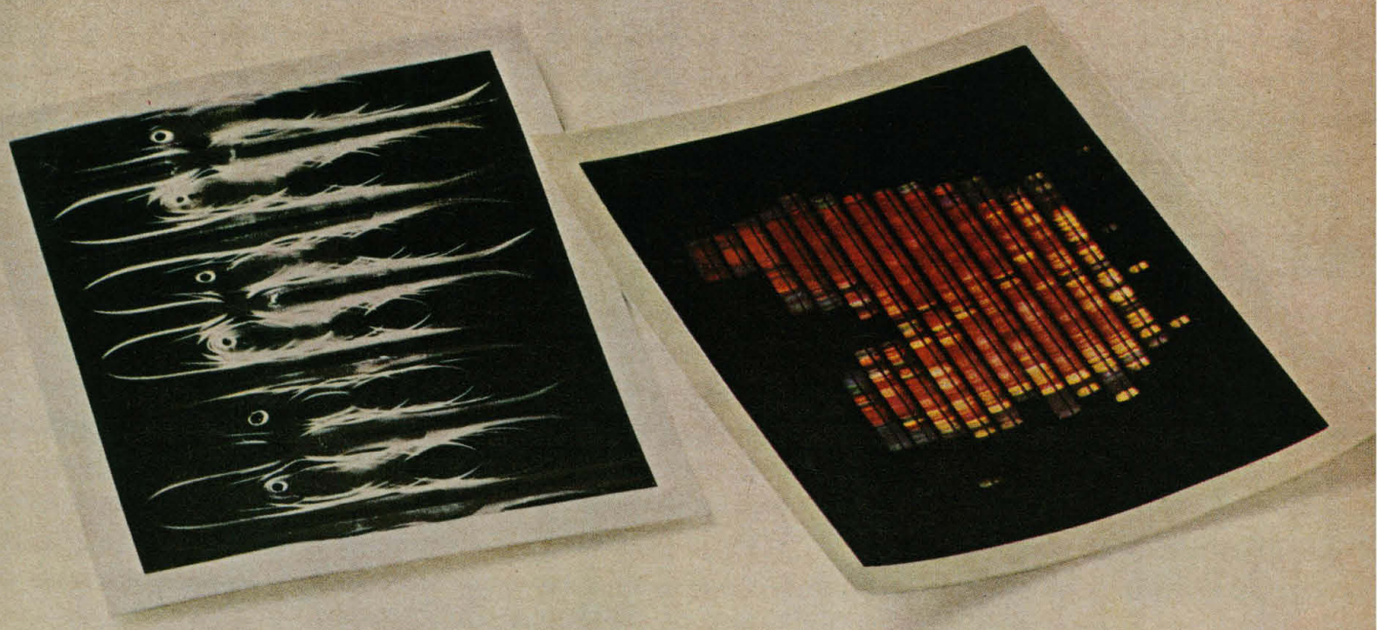
For additional information, write RCA Scientific Instruments, Bldg. 15-5, Camden, N. J. 08102. In Canada: RCA Victor Co., Ltd., Montreal. Overseas: RCA International Division, Clark, N. J. 07767.



**Nationwide maintenance service available from RCA Service Company.**

**The Most Trusted Name in Electronics**

# It takes time to get a good lab photograph.



15 seconds for B&W

1 minute for color

It's not hard to see the advantages that go with getting pictures this fast.

Polaroid Land photography can give you immediate visual documentation for your research notebook (like the immunoelectrophoretogram on the left). Or fast diagnostic results (like the radiological scan of the thyroid, on the right).

And you're always sure of your picture. If you goof on the first one, you'll know immediately and you can take another right away. You never risk having to repeat a time-consuming setup later.

Now, is there a choice of films, and what kind of results do you get without waiting?

Polaroid color film is available in three formats: roll, pack, and 4 x 5 packets. (The roll and pack films produce 3¼ x 4¼-inch prints.) It gives you everything you want in a color recording: accurate color rendition, excellent contrast and sharpness.

There are three black and white emulsions. One is a 3000-speed film—sensitive enough for virtually all laboratory assignments. It comes in roll, pack, or 4 x 5 packets.

Another black and white film, a 200-speed roll film, produces a fine-grain print with exceptional quality in detail and tone. (A similar emulsion, a 400-speed film, is available in 4 x 5 packets.)

Our third black and white film (only in 4 x 5 packets) gives you a sharply detailed print, and a true film negative which can be enlarged 25 times without losing detail or picking up grain. This one develops in 20 seconds.

We also have an infrared film which gives you a high-contrast infrared recording in 15 seconds. Film speed is 800 without filters—and that's three times faster than conventional infrared film.

Have any more questions? Send them on to us. The minute-or-under men. Polaroid Corp., Dept. 75, Cambridge, Mass. 02139.

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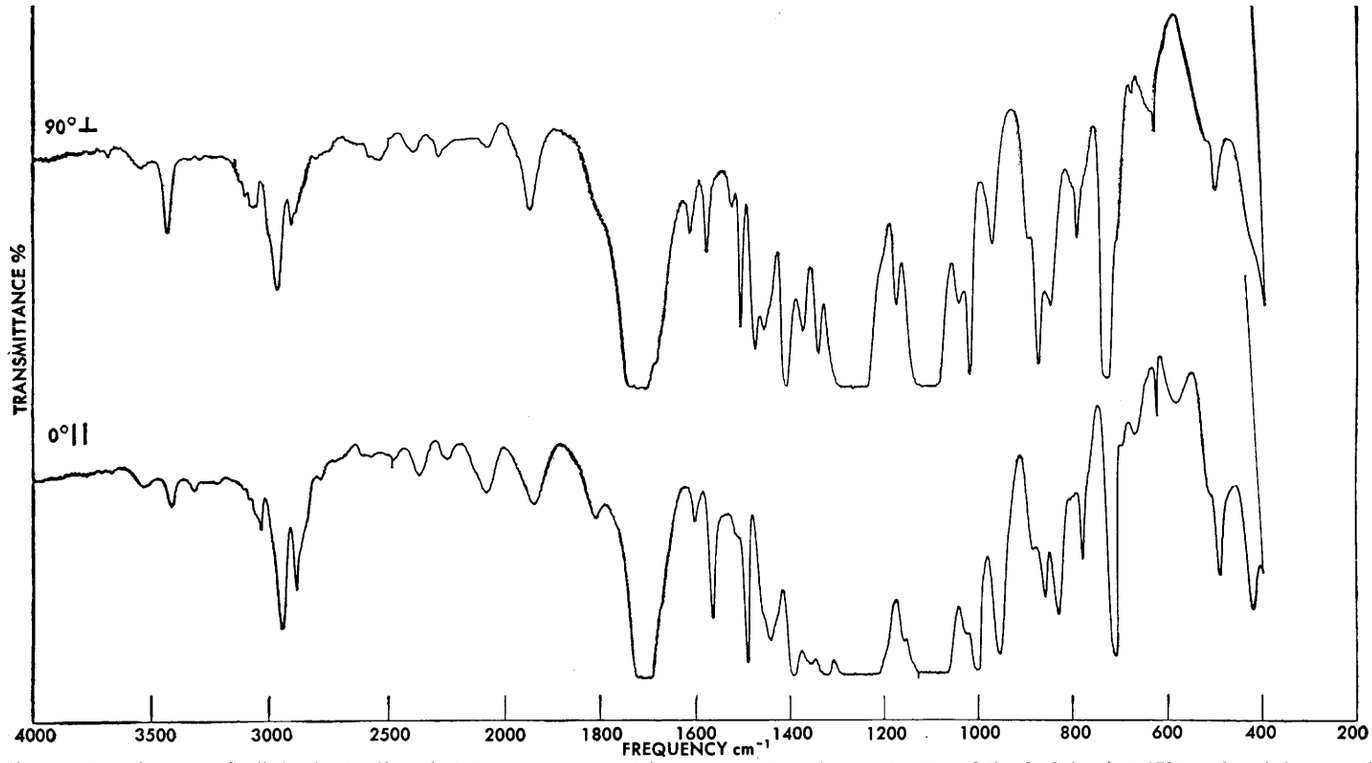



These spectra, of a piece of rolled polyester film only 1.5 mm square, were taken with the aid of two P-E accessories: a wire-grid polarizer and a 1 X 4 refracting beam condenser (see illustration). They show how polarized radiation can be used to obtain fundamental information on even the smallest polymer samples. From the dichroic behavior of two absorption bands, it can be seen that the polymer chains are preferentially aligned parallel to the machine, or rolling direction. Here's how: the two spectra were taken with the wire grid polarizer at orientations 90° apart. The relative intensities of the C=O band at 1725 $cm^{-1}$ and the aromatic carbon-hydrogen bending vibration at 1500 $cm^{-1}$ can be used to determine the relative orientations of the transition moments associated with these vibrations. The 1725 $cm^{-1}$ band has its maximum intensity when the polarizer is oriented to transmit radiation perpendicular to the machine direction of the film: i.e., the band exhibits perpendicular dichroism. On the other hand, the 1500 $cm^{-1}$ band shows parallel dichroism. The Model 621 makes this kind of analysis easy to do.

# HERE'S A NEW DIMENSION IN MICROANALYSIS

Our Model 621 IR Spectrophotometer lets you work with the smallest of samples. You can record good spectra with less than 0.1 microliter of liquid—or even as little as 50 nanograms of solid.

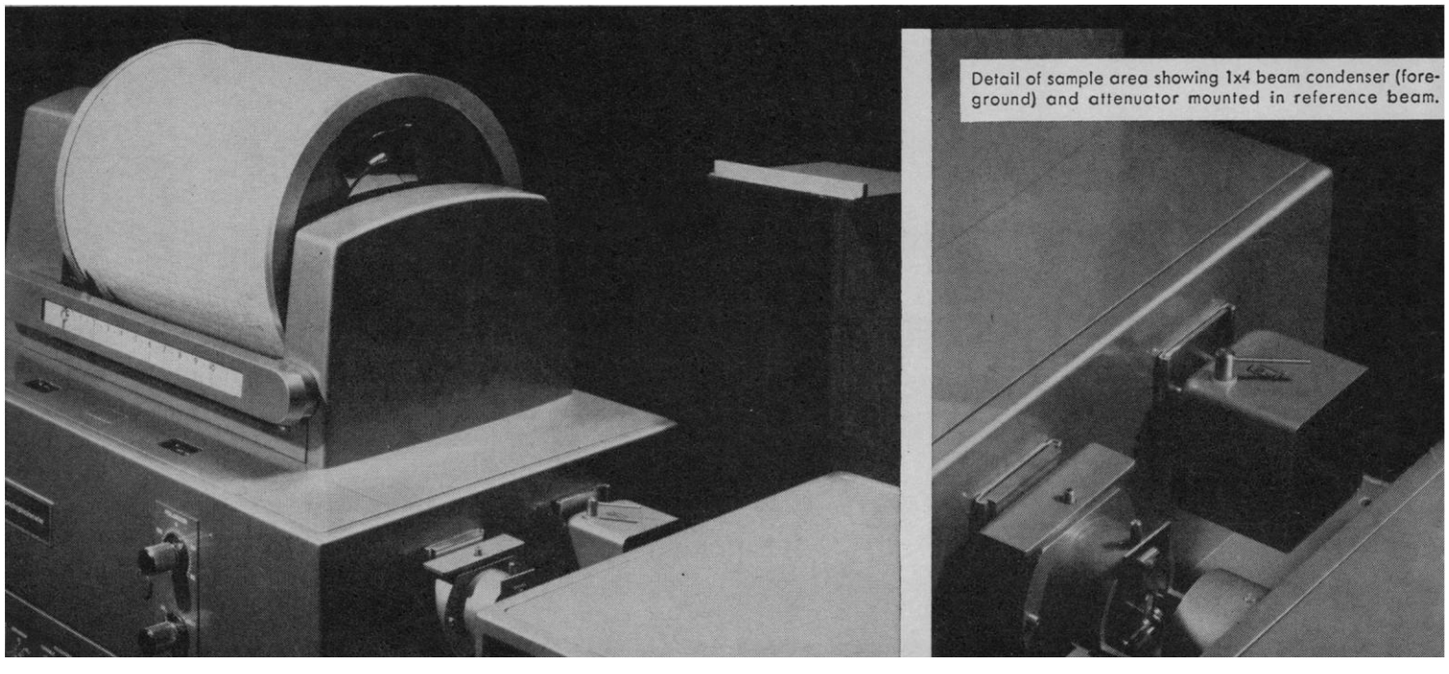
The unique micro-capabilities of the Model 621 result from its fast f/4.5 optical system, folded, compact optical path and small sample aperture. We use aspheric optics for the most efficient transfer of energy and precise imagery. The shorter optical path makes it easier to purge water vapor and carbon dioxide from the sealed instrument.

We've designed special accessories to give you optimum micro-performance. We offer a microcell and beam-condenser combination, an ultra-micro 6X beam condenser, and a microspecular reflectance attachment. The spectra show how a new Perkin-Elmer accessory, the Wire Grid Polarizer, is used in conjunction with a beam condenser to reveal orientation of the functional groups in a polyester film.

The unique power of this instrument in the micro-sampling range also makes it ideal for analyzing chromatographic fractions. But it hasn't been designed for microanalysis alone. We've built in every possible convenience and technical improvement for rapid, precise work. You can also handle ordinary samples faster and easier. The Model 621 gives you unparalleled sensitivity over its entire range.

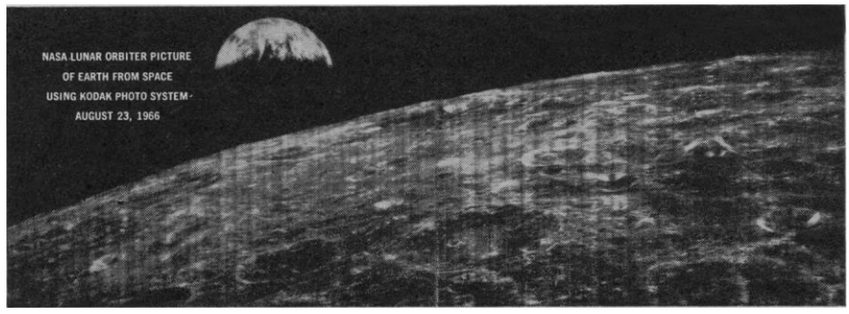
Write for our 16-page brochure on the Model 621. We'll also send you a brochure describing the many accessories available. Address: Instrument Division, Perkin-Elmer Corporation, 723 Main Avenue, Norwalk, Conn. 06852.

PERKIN-ELMER



Detail of sample area showing 1x4 beam condenser (foreground) and attenuator mounted in reference beam.

# The hope of doing each other some good prompts these advertisements



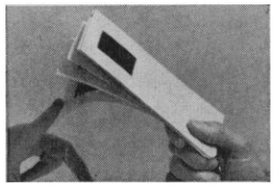

## Earth photography: what to do with it

When we displayed this now familiar photograph in 18 x 60-foot size in New York's Grand Central Terminal, more than one scurrying commuter was overheard speculating as to which was the moon and which the earth. In stimulating widespread thought about questions like that, the picture was fulfilling a purpose. For the moment it also fixes one end of the scale for available photography of the earth's surface. For such other purposes as urban and agricultural planning, photogeology, ecological studies, resource assessment, and all the rest, photography of a less majestic scale is also available and more serviceable.

As the camera gets closer and detail becomes easier to resolve, another problem presses in: the sheer physical volume of film to keep track of. More and more of the earth's surface is being photographed in finer and finer detail for more and more purposes.

For those perversely glad that coverage is not more complete because theirs is the responsibility of making sure that existing coverage is available for use, there is still time to take steps while the men in airplanes assiduously fill more warehouse space with more long rolls of aerial negative.

We can help. We hereby announce a new service. We are prepared to move in on a collection of aerial negatives and convert it from the ancient scroll format in which



it emerges from the camera into far more accessible modern unitized form on the familiar aperture cards, such as nowadays carry engineering drawings for storage and retrieval. At last we have the right film for the job, which is more demanding photographically than the microfilming of drawings. It processes to deliver a negative directly, like the negative it sees. Eliminating the positive saves one step of degradation. Positive prints projected back from the small negative have fooled experts asked to distinguish them from those contact-printed from the original camera negative.

To keep that kind of reproduction quality, we suggest that the mechanical sorting from data punched on the card be done from a "slave deck" that's just as easy to generate at the time we prepare the card that carries the microfilm negative to a file drawer, where it awaits retrieval by a nimble-fingered lady.

*Consultation can commence now with Eastman Kodak Company, Business Systems Division, Rochester, N. Y. 14650. Ask about* RECORDAK *Air-Photo Microfilm Service.*

## Mars photography: what to do it on

Film for photographing the face of the earth is mighty big business, but plates for photographing Mars are mighty small business. This does not excuse us from doing our best for the Mars photographers (or at least so we choose to interpret our obligations).

Mars photographers have been at it for a long time; their pace slackens not, but quickens. For this year's opposition, the Observatory of New Mexico State University is photographing the planet in six spectral bands every two hours. The most fluctuation in appearance and the most bafflement to explain it occur in the band centered at 550m$\mu$. For this band Dr. Bradford A. Smith, the observatory's director, has chosen KODAK "Spectroscopic" Plates, Type III-G, which establish the long-wavelength limit of sensitivity at about 600m$\mu$, have high speed for the job, and are not too grainy to show detail in the 1 to 3-millimeter image of the planet's disk formed by the observatory's 30-meter focal length instrument.

Elsewhere other astronomers maintain a watch on Mars also, whatever arrangements the space travel agencies have in mind for closer looks than the one that earthbound astronomers will be given at the midsummer '69 opposition and the considerably closer one of September, 1971. After that there will be a 15-year wait for another really close opposition.

Dr. Smith's need has pulled Type III-G plates out of the limbo to which we had prematurely abandoned the type. Astronomy with feet firmly planted on the ground still has vigils to keep photographically.

*Inquiries about specialized photographic plates for scientific purposes should be directed to Eastman Kodak Company, Industrial Photo Methods, Rochester, N. Y. 14650.*

## Contributions gratefully transmitted

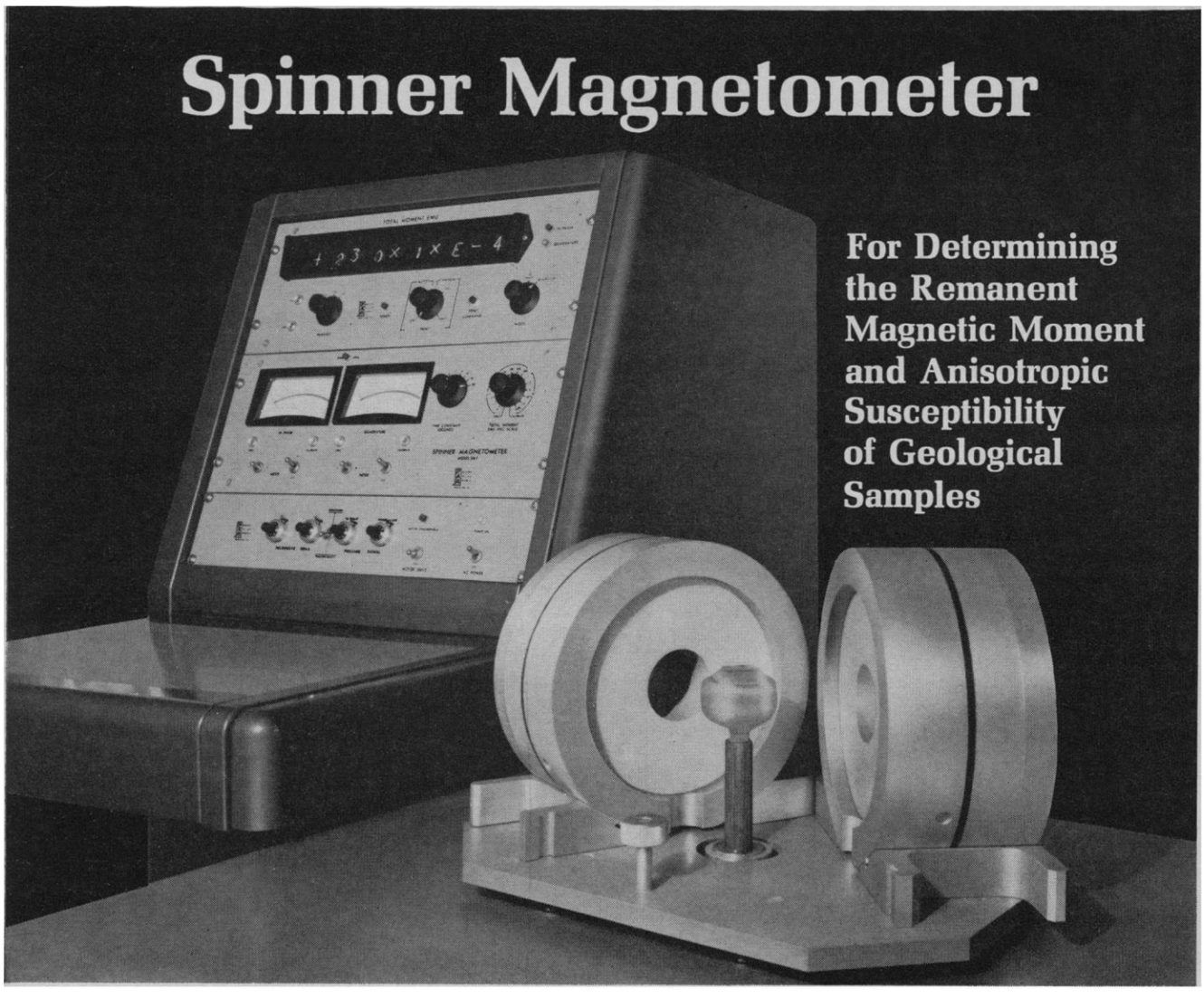
Tetraheptylammonium Chloride (EASTMAN 9505) in chloroform or ethyl acetate solution quantitatively extracts anionic lipids from water. The animal kingdom's favorite detergents and solubilizers, the salts of the glycine and taurine conjugates of bile acids, can be thus extracted. Try it also for extracting alkaloid conjugates, bile pigments, steroid sulfates or glucosiduronates, alkyl sulfonates or sulfates. Few other solvents offer favorable partition coefficients for liquid-liquid extraction of these compounds.

We did not discover this use of EASTMAN 9505. We haven't even confirmed it experimentally. All we do is make the compound. The discovery and demonstration of its usefulness have been a contribution to science by a physician who likes to work at the interface between physical chemistry and sick people. He published it in the *Journal of Lipid Research* for January, 1967.

His paper mentions that the compound as obtained from us is a yellow, viscous oil, that while a colorless preparation of the same compound can be made from Tetraheptylammonium Iodide (EASTMAN 7630), the further elegance is unnecessary. This is worth knowing. For a scientist to report on the usefulness of a commercially available product is as much a service to his fellows as to the manufacturer. For the manufacturer to lift that report out of the scientific literature and give it wider currency through commercial communications like this may be as much of a service as manufacturing the chemical in the first place.

*The helpful hints are also delivered to us in person, by phone, and by mail. When told that we are free to pass them along, we do so as best we can. This communicators' role has been sort of bestowed on us as a result of the position occupied by the* EASTMAN *Organic Chemicals catalog. A copy of the latest edition, List No. 44, can be obtained from Distillation Products Industries, Rochester, N. Y. 14603 (Division of Eastman Kodak Company).*

# Spinner Magnetometer



## For Determining the Remanent Magnetic Moment and Anisotropic Susceptibility of Geological Samples

Recent results in paleomagnetic research have pointed out the importance of remanent magnetic moment studies in dating events in the Earth's history. This new application of remanent moment measurement together with earlier uses in drilling core orientation and studies of continental drift, polar wandering and magnetic anomalies have greatly increased interest in this technique. To facilitate work in these fields, PAR is making available its Model SM-1 Spinner Magnetometer. This instrument, which incorporates the results of PAR's wide experience in small-effect measurement and weak signal processing, has been designed to increase measurement sensitivity to the limits imposed by the thermal noise of the pick-up coils.

The Model SM-1 simultaneously measures and displays two orthogonal components of the magnetic moment in the spin-plane of the sample. Operation is simple and straightforward, and can be carried out by non-technical personnel. Low noise and freedom from drift and spurious pick-up allow quick and accurate measurement of samples having very weak moments. Earth field-canceling Helmholtz coils are included on two axes to eliminate problems associated with anisotropic susceptibility. These coils also allow the determination of the anisotropic susceptibility of the sample.

**Brief Specifications:**

*Minimum Detectable Signal:* Will detect changes in magnetic moments smaller than $7 \times 10^{-9}$ EMU/cc.

*Sensitivity Ranges:* 21 full scale ranges calibrated in TOTAL MOMENT from $0.5 \times 10^{-6}$ to 5 EMU in a 1, 2, 5 sequence.

*Calibration Accuracy:* The system is factory calibrated to within $\pm 0.5°$ phase and within 1% magnitude.

*Sample Size:* Cylinder 2.54 cm diameter, 2.28 cm length. Slightly larger or smaller samples can be accommodated.

*Sample Rotational Speed:* 105 Hz (52.5 for anisotropic susceptibility measurements).

*Price:* $8,000 for complete system; with automatic digital readout (as shown in the photograph) to monitor the orthogonal components of the moment alternately, $9,750. Export price approximately 5% higher, except Canada.

Write for Bulletin No. T-133 to Princeton Applied Research Corp., Dept. G, P.O. Box 565, Princeton, N. J. 08540. Telephone: (609) 924-6835.

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See us at the Physics Show, Booths 8, 9, and 10

community to print such biased partisan propaganda as this brings serious discredit upon it. . . . I view Reagan as a breath of fresh air and common sense in a country gone tragically awry. You should be thankful that we can still produce such men and recognize them by placing them in positions of authority. It's dirty business to print such snide distortions of the facts as you have in this article. . . .


WILLIAM B. ELMER
*113 Pinckney Street,*
*Boston 14, Massachusetts*


Langer is an excellent reporter, although I don't always agree with her judgments, but she performs an important journalistic service for those of us who live here. Our newspapers are so bad that I have to wait until *Science* arrives in order to learn what our local situation actually is.


ROBERT H. SOMERS
*Department of Sociology,*
*University of California, Berkeley*
*94720*


I am very distressed about the implication that we here at the University of Southern California have been unresponsive to the problems at the University of California. The following excerpts from a resolution of the Academic Senate of USC, approved and passed on 15 February, truly reflect the feeling of the faculty here. The delay in this resolution was due to the fact that this was the first university senate meeting after the events at the University of California.

The University Senate of the University of Southern California wishes to thank Clark Kerr for his contributions to higher education in California and the United States.

The University Senate of the University of Southern California conveys to the Universities of California support in their fight for academic freedom and excellence in education.


WALTER WOLF
*School of Pharmacy,*
*University of Southern California,*
*University Park, Los Angeles 90007*


Langer's report implied that Governor Reagan's ill-advised attack on higher education in general and the University of California in particular somehow originated, was motivated, or at least, was condoned by the University of Southern California. This, of course, is totally untrue (I know because I earned my Ph.D. there). The "local cognoscenti" quoted in her article, whoever they may be (although I can't help but think that they are from UCLA), are obviously attempting to find someone to blame for a situation which has been generated in part by the total lack of attention to undergraduates at UCLA (I know because I earned my B.S. there).


JOSEPH ARDITTI
*Department of Organismic Biology,*
*University of California, Irvine 92664*


## Humanitarianism and CBW

The three letters (10 Mar.) defending chemical and biological (and, by implication, nuclear) warfare employ essentially similar justifications. Alpert confesses "this issue" [of university research on CBW] "is muddy in my mind"; I find all the authors' logic likewise. Their viewpoints are egocentric or narrowly nationalistic based on the unwritten premise of the right of American intervention in Vietnamese affairs.

First, they ignore the fact that, in contrast to all previous wars, warfare today is no longer a question of the extermination of a clan, a walled town, a religious group, or a nation, but involves the existence of the entire human race. The ultimate escalation could occur with explosive suddenness. It should be obvious that we must take every reasonable step to avoid the experiment of finding out whether 50, 10, or zero percent of humanity can survive an all-out war. The first step would be not to make wars on nations far or near but to negotiate the peaceful end of those now in progress.

Second, the writers of the aforementioned letters justify CBW by reference to the legitimate needs of defense. But defense today is a word that includes aggression! Is it really necessary to destroy the ecology of Vietnam in order to protect American lives—lives of people who do not have to be there anyway—and to defend the faraway folk in America? It may, of course, be difficult to understand the immorality of ruining a "rich biological area" and starving its population when the individual himself, or his son, is an actual or potential combatant. But there are those who are able to transcend this subjective view and, fortunately, some who act accordingly.


ROBERT V. SAGER
*6 West 77 Street,*
*New York, New York 10024*

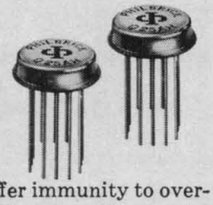
# Philbrick...

## the source for things Analog

Philbrick is the top-value supplier of analog instrumentation components, software, and related accessories for modeling, measuring, manipulating . . . and much else. We offer the widest variety of advanced-technology analog products available . . . and the best in total value — which includes price, plus applications assistance, plus field service, plus stock delivery . . . and Philbrick's 2-year warranty. *Only at Philbrick* can you obtain all six of the analog product types described below.

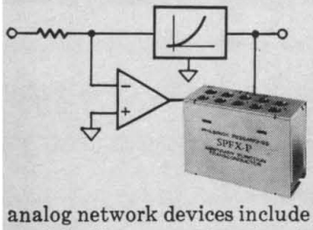
### DISCRETE-COMPONENT OPERATIONAL AMPLIFIERS

Philbrick Operational Amplifiers are, in the simplest terms, high-gain, low-drift amplifiers designed for use in stable feedback loops to provide precise, predictable operations on one or more input signals. In addition to linear applications, a wide variety of nonlinear functions and operations can be performed using them with passive nonlinear elements or with Philbrick Transconductors.



### IC OPERATIONAL AMPLIFIERS

Philbrick MICRO-HYBRID Operational Amplifiers combine the best of two technologies — linear monolithic chip and discrete microminiature components — and offer immunity to overloads, shorts and supply-voltage stresses. They provide superior electrical performance and mounting and assembly advantages. There are no equivalents, particularly in high-reliability applications. Philbrick ISOLITHIC* Operational Amplifiers are state-of-the-art monolithic amplifiers, superior electrically and mechanically to present monolithic chip amplifiers. *Trademark.

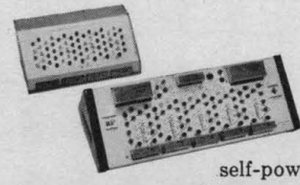


### TRANSCONDUCTORS

Philbrick Transconductors are plug-in analog system components for linearizing or embodying nonlinear functions. These analog network devices include natural continuous function and straight-line approximation (piecewise-linear) types. Philbrick transconductors include networks that accurately exhibit logarithmic, trigonometric, and quadratic behavior.

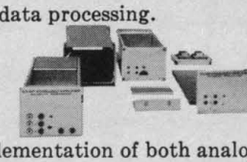
### REGULATED DC POWER SUPPLIES

Philbrick power supplies are precisely regulated and are essentially noise-free. Typical regulation (including drift) is of the order of 100 PPM, noise and hum less than 1 PPM; and recovery (to within .001%) from a step-change in load is accomplished in microseconds. Philbrick power supplies are available in rack, cabinet, modular, plug-in or built-in models.



### OPERATIONAL MANIFOLDS

Philbrick operational manifolds offer a new "breadboarding" technique. These all-in-one self-powered analog instruments virtually eliminate wiring problems; components and jumper leads plug into prewired panel jacks. Model MP (with 4 amplifiers) and Model RP (with 5 amplifiers) simplify experimentation, simulation, and instruction in the practical application of feedback techniques, and employ all-silicon solid-state operational amplifiers. Their many uses and habitats include industrial process control, physics and electronic laboratories, educational institutions, as well as in-line analog data processing.



### MODULAR ANALOG COMPUTING INSTRUMENTATION

Philbrick equipment for the implementation of both analog and hybrid computers, simulators and analyzers includes: arbitrary function fitters, universal linear operators, multiplier-dividers and manifolds. Components may be formed into systems by mounting them on Philbrick unique Q3-series modular front panels, chassis, adaptors and accessories. Completely-wired modules for amplification, multiplication, and other analog operations are available individually as self-powered instruments or for integral systems use.

### TECHNICAL SUPPORT SERVICES

For prompt, competent applications engineering advice, call Philbrick in Dedham or one of Philbrick's worldwide Engineering Representatives. Our engineers welcome opportunities to help you apply analog techniques and products in such areas as industrial and scientific instrumentation, process and quality control systems, in-line analog data processing. You are welcome to write to us for technical literature on the product categories of interest. Philbrick Researches, 25M Allied Drive at Route 128, Dedham, Massachusetts 02026

**ELECTRONIC ANALOG COMPUTING EQUIPMENT for MODELLING, MEASURING, MANIPULATING and MUCH ELSE**

PHILBRICK

5 May 1967, Volume 156, Number 3775 **SCIENCE**



## Public-Private Organizations

President Johnson's committee to review Central Intelligence Agency support of private organizations that operate abroad submitted two basic recommendations: that covert support of educational and private voluntary organizations be stopped, and that a public-private mechanism be developed to provide open governmental support of overseas activities of selected private organizations.

The President's committee concentrated on overseas activities, but the question of public support of private organizations that work for the public good is a wider one. In the 1966 annual report of the Carnegie Corporation, Alan Pifer advocated governmental support of selected scholarly and professional associations, health and community action agencies, nonuniversity research and educational institutions, defense advisory organizations, and agencies providing technical assistance. There is little doubt that it is desirable to have strong, independent organizations of all these types, but financing is a problem. Their own resources are often inadequate. Foundations cannot supply permanent help. Project-by-project support endangers independence. Pifer concludes that continuing government support is the only solution: "If we want to avoid an ever more extensive and powerful Federal Government, it would seem that we must now, paradoxically, use federal money to ensure that we have a viable alternative—a network of vigorous, well-financed nongovernmental organizations ready to serve government but able, in the public interest, to maintain their independence of it."

In response to his committee report, the President has now appointed a new committee, under the chairmanship of Secretary Rusk, to study ways of achieving the proposed mechanism for using public funds to assist private organizations that serve public purposes.

The provision of open and continuing support of organizations that operate overseas, as the President's committee recommended, or of a wider range of agencies, as Pifer proposed, presents a problem which Great Britain has solved more satisfactorily than the United States has. "It is no longer a bishop or a queen or a merchant-prince, but the little man in the street, who is the patron of learning. The little man in the street is very powerful. He is liable to exercise what de Tocqueville called the despotism of the majority." Sir Eric Ashby wrote these words about universities, but they apply as well to the institutions Pifer and the President's committee had in mind. That the despotism of the majority has not been exercised over British universities, Ashby continued, is due "to a very simple but remarkable device which has been invented in Britain for subsidizing intellectual activity without endangering its independence. It is a political invention of the first importance. It is simply this: Parliament entrusts financial control of science and other intellectual activities to bodies of men whose sympathies and interests lie less with Parliament than with those whom they are controlling."

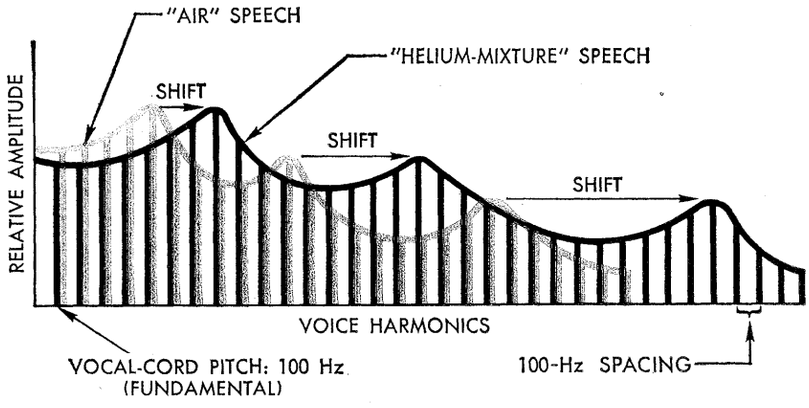
This political invention is exemplified in Great Britain by the University Grants Committee and the British councils, and in several other countries by comparable institutions. A U.S. example is the peer system of evaluating research proposals submitted to government agencies. Pifer and the President's committee want to extend the principle so that we may avoid the dangers of covert support and government control while we gain the advantages of strong, independent nongovernmental organizations that serve the public interest.—DAEL WOLFLE

Report from

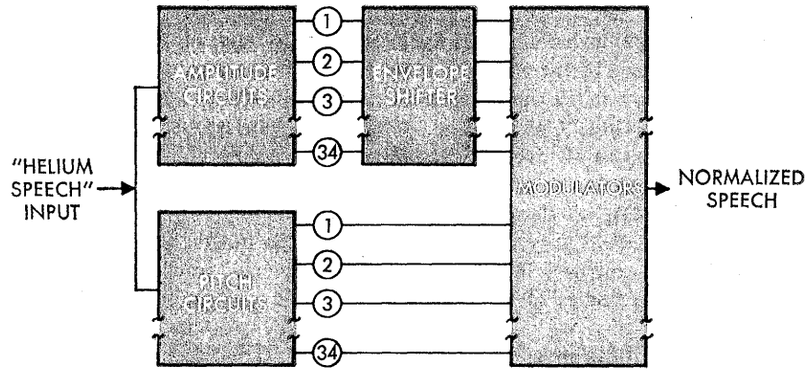
**BELL LABORATORIES**

# Making voices from the depths sound deeper

Bell Telephone Laboratories has had a long-term interest in speech research—tracing back, indeed, to the work of Alexander Graham Bell. It was for this reason that the U. S. Navy asked us to investigate a problem encountered in Sealab II. To prevent "bends" and nitrogen narcosis, the divers breathe a pressurized mixture of oxygen, nitrogen and helium, but the helium gives their voices an unnatural, squeaky, Donald-Duck-like quality. As a result, voice communications between divers and people on the surface are seriously impaired.




**Fundamental pitch and harmonics (vertical bars) for normal "air" voice sound (color) and "helium speech" sound (black). Note that the frequencies of the fundamental and harmonics do not change very much, whereas the envelope of the amplitudes shifts toward the right. Note also that the magnitude of the shift increases with increasing frequency.**




**Block diagram of system for restoring helium speech to normal voice quality. Helium speech is fed to amplitude and pitch circuits. In the pitch circuits, the frequencies of the 34 lowest harmonics are determined. In the amplitude circuits, the power levels within each of 34 150-Hz intervals of the speech spectrum are determined. The amplitudes are shifted and applied to harmonics of lower frequency. In the modulators (right), these power levels control the loudness of the 34 harmonic frequencies... thus producing a pattern or envelope closely corresponding to the envelope of normal speech.**

THE MAJOR PROBLEM is that the velocity of sound in the helium mixture is much higher than in air. This does not appreciably affect vocal-cord frequency, but does strongly affect the acoustic resonances of the vocal tract—which give the voice its characteristic sound quality. So, though fundamental voice pitch remains approximately the same (about 100 Hz in men), the amplitudes or loudness values of the various harmonics change markedly. Specifically, the pattern of these resonances (the envelope) shifts toward the higher frequencies (see graph), and voice timbre is grossly distorted.

THE SOLUTION to this problem was found at Bell Laboratories by research scientists M. R. Schroeder, J. L. Flanagan, and R. M. Golden. The distorted "helium speech" is separated into harmonic frequencies and their amplitudes are measured (see diagram). Then the envelope of the harmonic amplitudes is shifted back toward the more normal or low-frequency condition. In other words, the amplitudes of the harmonics are adjusted to match a more normal envelope.

As a test, the technique has been used on recordings of helium speech made in the U. S. Navy's Sealab II. The processed voices are readily understandable and sound enough like the speaker's "air" voice to be identifiable.

**Bell Telephone Laboratories**
Research and Development Unit of the Bell System

*15–17.* **Chemical** and **Petroleum** Instrumentation Symp., 8th natl., Instrument Soc. of America, St. Louis, Mo. (S. A. Young, Honeywell, Inc., 2146 Hampton St., St. Louis 63139)

*15–17.* **Biomedical Sciences** Instrumentation Symp., 5th natl., Instrument Soc. of America, Albuquerque, N.M. (The Society, 530 William Penn Pl., Pittsburgh, Pa. 15219)

*15–17.* **Radioecology**, 2nd natl. symp., Univ. of Michigan, Ann Arbor. (F. C. Evans, Dept. of Zoology, Univ. of Michigan, Ann Arbor)

*15–17.* **Technical Literature Abstracting** and **Indexing**, 3rd annual institute, Washington, D.C. (Director, Center for Technology and Administration, American Univ., 2000 G St., NW, Washington, D.C.)

*15–18.* Mid-America Symp. on **Spectroscopy**, 18th annual, Chicago, Ill. (W. K. Baer, Nalco Chemical Co., 6216 W. 66 Place, Chicago 60038)

*15–18.* Society of **Plastics Engineers**, 25th annual technical conf., Detroit, Mich. (R. D. Forger, The Society, 65 Prospect St., Stamford, Conn. 06902)

*15–19.* Society of **Photographic Scientists** and **Engineers**, annual conf., Chicago, Ill. (R. J. Mazor, Nugent-Williams Studies, Inc., 120 N. Pulaski Rd., Chicago)

*15–20.* **Space Technology** and **Science**, 7th intern. symp., Tokyo, Japan. (S. Nozawa, ISTS-Tokyo, 1967, Japanese Rocket Soc., Yomiuri Newspaper Bldg., 1, 3-chome, Ginza-Nishi, Chuo-ku, Tokyo)

*15–26.* Workshop in **Heat Transfer Computer Programs**, Univ. of California, Los Angeles. (Engineering Extension, Room 6266, Boelter Hall, Univ. of California, Los Angeles 90024)

*16–18.* National **Telemetering** Conf., San Francisco, Calif. (L. Winner, 152 W. 42 St., New York 10036)

*16–19.* Society for **Experimental Stress Analysis**, Ottawa, Ont., Canada. (B. E. Rossi, The Society, 21 Bridge Sq., Westport, Conn. 06882)

*16–20.* **Solid Inorganic Phosphates**, intern. colloquium, Toulouse, France. (Secretariat du Colloque International sur les Phosphates Mineraux Solids, Dept. de Chimie Inorganique, Faculté des Sciences, 38, rue des Trente-Six Ponts, 31-Toulouse)

*17–22.* **Fresh Water from the Sea**, 2nd European symp., Athens, Greece. (A. A. Delyannis, P.O. Box 1199, Athens-Omonia)

*18.* **Washington Acad. of Sciences**, mtg., Washington, D.C. (R. P. Farrow, Natl. Canners Assoc., 1133 20th St., NW, Washington, D.C. 20006)

*18–19.* Midwest Symp. on **Circuit Theory**, Purdue Univ., West Lafayette, Ind. (B. J. Leon, School of Electrical Engineering, Purdue Univ., West Lafayette)

*18–19.* Southern **Textile Research** Conf., Hilton Head Island, S.C. (A. L. Smith, Chatham Manufacturing Co., Elkin, N.C. 28621)

*20–24.* Recent and Ancient **Deltaic Deposits**, seminar, Louisiana State Univ., Baton Rouge. (J. M. Coleman, Coastal Studies Inst., Dept. of Geology, Louisiana State Univ., Baton Rouge 70803)

*21–24.* American Inst. of **Chemical En-**

**gineers**, mtg., Salt Lake City, Utah. (F. J. Van Antwerpen, The Institute, 345 E. 47 St., New York 10017)

*21–26.* **Nondestructive Testing**, 5th intern. conf., Montreal, P.Q., Canada. (Conf. on Nondestructive Testing, P.O. Box 95, Verdun 19, P.Q.)

*22–24.* Conference on **Frequency Generation and Control for Radio Systems**, London, England. (J. L. Regan, Inst. of Electrical Engineers, Savoy Pl., London, W.C.2)

*22–25.* Institute of **Electrical** and **Electronics Engineers**, joint technical conf., Cleveland, Ohio. (Office of Technical Activities Board, The Institute, 345 E. 47 St., New York 10017)

*22–25.* New Aids for **Management Decision Making**, Washington, D.C. (Director, Center for Technology and Administration, American Univ., 2000 G St., NW, Washington, D.C.)

*22–25.* **URSI–IEEE**, spring mtg., Ottawa, Ont., Canada. (R. S. Rettle, Natl. Research Council, Ottawa 2)

*22–26.* **Drug Metabolism**, 2nd workshop, George Washington Univ., Washington, D.C. (Dept. of Pharmacology, School of Medicine, George Washington Univ., 1337 H St., NW, Washington, D.C. 20005)

*22–26.* **Radiosterilization of Medical Products**, symp., Intern. Atomic Energy Agency, Budapest, Hungary. (J. H. Kane, Conferences Branch, Div. of Technical Information, Atomic Energy Commission, Washington, D.C. 20545)

*23–25.* National **Tuberculosis** Assoc. and American **Thoracic** Soc., annual mtg., Pittsburgh, Pa. (NTA, 1740 Broadway, New York 10019)

*23–31.* **Water for Peace**, intern. conf., Washington, D.C. (R. C. Hagan, Dept. of State, Room 1318, 2201 C St., NW, Washington, D.C.)

*24–26.* Fourteenth Canadian **High Polymer** Forum, Laval Univ., Quebec City. (J. F. Henderson, Research and Development Div. Polymer Corp. Ltd., Sarnia, Ont., Canada)

*24–27.* **Teratology** Soc., 7th annual mtg., Estes Park, Colo. (M. D. Runner, Inst. for Developmental Biology, Univ. of Colorado, Boulder 80302)

*25–26.* **Drug Information** Assoc., 3rd annual, Philadelphia, Pa. (P. de-Haen, The Association, 11 W. 42 St., New York 10036)

*26–27.* **Surface Physics**, 5th annual symp., Washington State Univ., Pullman. (E. E. Donaldson, Dept. of Physics, Washington State Univ., Pullman 99163)

*29–1.* **Special Libraries** Assoc., New York, N.Y. (B. M. Woods, The Association, 31 E. 10 St., New York 10003)

*29–2.* Congress of **Canadian Engineers**, Montreal, P.Q., Canada. (Office of Technical Activities Board, Inst. of Electrical and Electronic Engineers, 345 E. 47 St., New York 10017)

*31–2.* American Soc. for **Quality Control**, 21st annual technical conf. and exhibit, Chicago, Ill. (R. W. Shearman, The Society, 161 W. Wisconsin Ave., Milwaukee, Wis. 53203)

*31–2.* **Instrument Soc.** of America, 13th natl. analysis instrumentation symp., Los Angeles, Calif. (The Society, 530 William Penn Pl., Pittsburgh, Pa. 15219)