# SCIENCE

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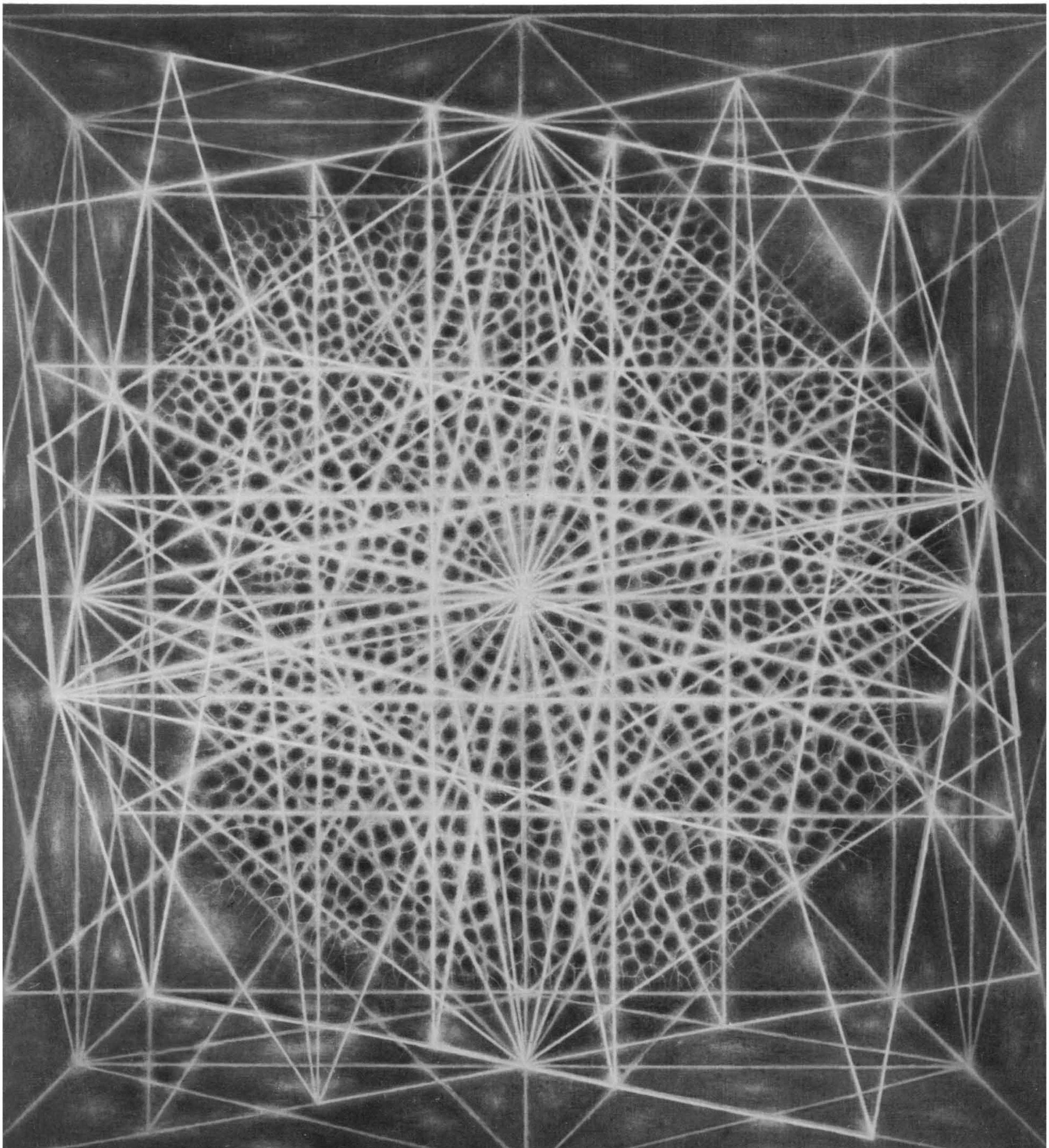
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



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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.

**COVER**

"Itinerary of Light," Pavel Tchelitchew, 1955. A network of organic form contrasted with a geometrical matrix whose linear regularity suggests the strict order of the inorganic, defining the space within which the web has been portrayed. This painting helps to illustrate the theme of the symposium, "Art and Science: The Analysis and Communication of Biological Form"; see page 1307. [Ruth Ford Collection, New York City]

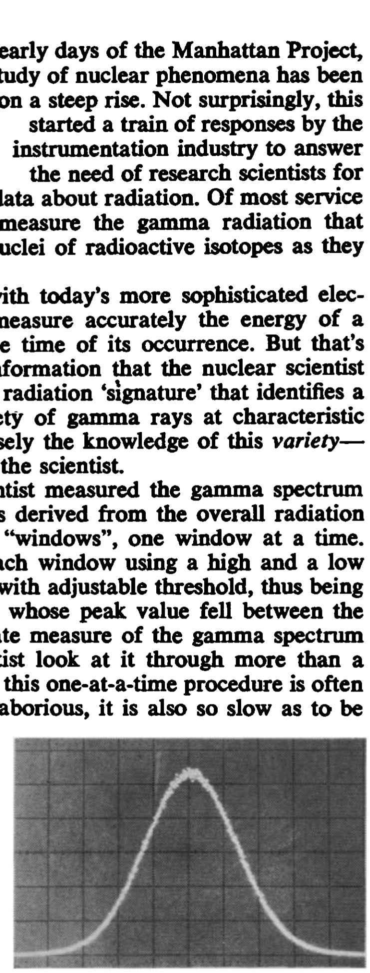
# Tame complex scientific data... produce useful information directly

## How to See Through 1000 Windows at a Time

Since the early days of the Manhattan Project, the study of nuclear phenomena has been on a steep rise. Not surprisingly, this started a train of responses by the instrumentation industry to answer the need of research scientists for analytical data about radiation. Of most service have been instruments to measure the gamma radiation that originates in the unstable nuclei of radioactive isotopes as they decay to stable states.

It's not really difficult, with today's more sophisticated electronic instrumentation to measure accurately the energy of a discrete gamma ray and the time of its occurrence. But that's only a small part of the information that the nuclear scientist needs to know. Usually the radiation 'signature' that identifies a material consists of a variety of gamma rays at characteristic energy levels, and it's precisely the knowledge of this *variety*—or spectrum—that interests the scientist.

Initially the nuclear scientist measured the gamma spectrum by looking at voltage pulses derived from the overall radiation through a series of energy "windows", one window at a time. He built the "frame" for each window using a high and a low voltage discriminator, each with adjustable threshold, thus being able to look only at pulses whose peak value fell between the two levels. Since an adequate measure of the gamma spectrum may require that the scientist look at it through more than a thousand different windows, this one-at-a-time procedure is often inadequate. Not only is it laborious, it is also so slow as to be useless where the decay rate (half-life) is very short.



*Probability density display of Gaussian noise*

Enter the multichannel analyzer (MCA), newest of which is the H-P 5400A. The MCA looks at gamma radiation through as many as 1024 windows, *simultaneously* sorting the pulses into as many amplitude groups. It counts and totalizes the pulses in each group and stores the results in memory for live or static display on the built-in cathode ray tube, for readout on a paper record or for input to a computer.

Speed, the essential characteristic of an MCA, reaches its peak in the 5400A. Employing a new analog-to-digital converter with a clock rate of 100 MHz, the 5400A sorts and digitizes input signals into one of 1024 categories in no more than 13 microseconds.

In its present state of refinement, the 5400A MCA has not only met the nuclear scientist's need for a gamma spectrum analyzer, but has also attracted the attention of analytical scientists in other disciplines. Biochemists for example have used it as a multichannel scaler to accumulate time/rate curves of activity for uptake/clearance studies in nuclear medicine. Design engineers have performed probability density analysis of continuous input signals with the 5400A to isolate signal and noise characteristics. Other solutions of complex measurement problems are described in the March 1968 issue of the *Hewlett-Packard Journal*, yours on request.

## Designing for the Electronics-Shy Analyst

Natural strangers to the complex world of electronics, chemists and other analysts have long since been trapped in it because of their seemingly insatiable appetite for analytical instruments that are essentially electronic creations. Both readily admit the impossibility of doing their analytical work at today's speed and accuracy standards without electronics. But upon introspection they also acknowledge a deep yearning somehow to exclude the whole complicated world of transistors, diodes and integrated circuits from their laboratories.

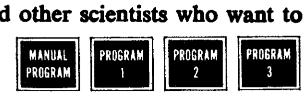
Yet exactly the reverse is happening: as the scientist uses more and more instruments in his quest for analytical speed, he produces greater and greater quantities of analog chart recordings, each of which he must laboriously interpret if he is to decode its analytical message. Bogged down in this task, the analyst once again has had to turn to the electronic designer . . . this time for a device which automatically interprets the *analog* output of such analytical instruments as the ubiquitous gas chromatograph, and translates it into *digital* data, the stuff of which quantitative analysis is made.

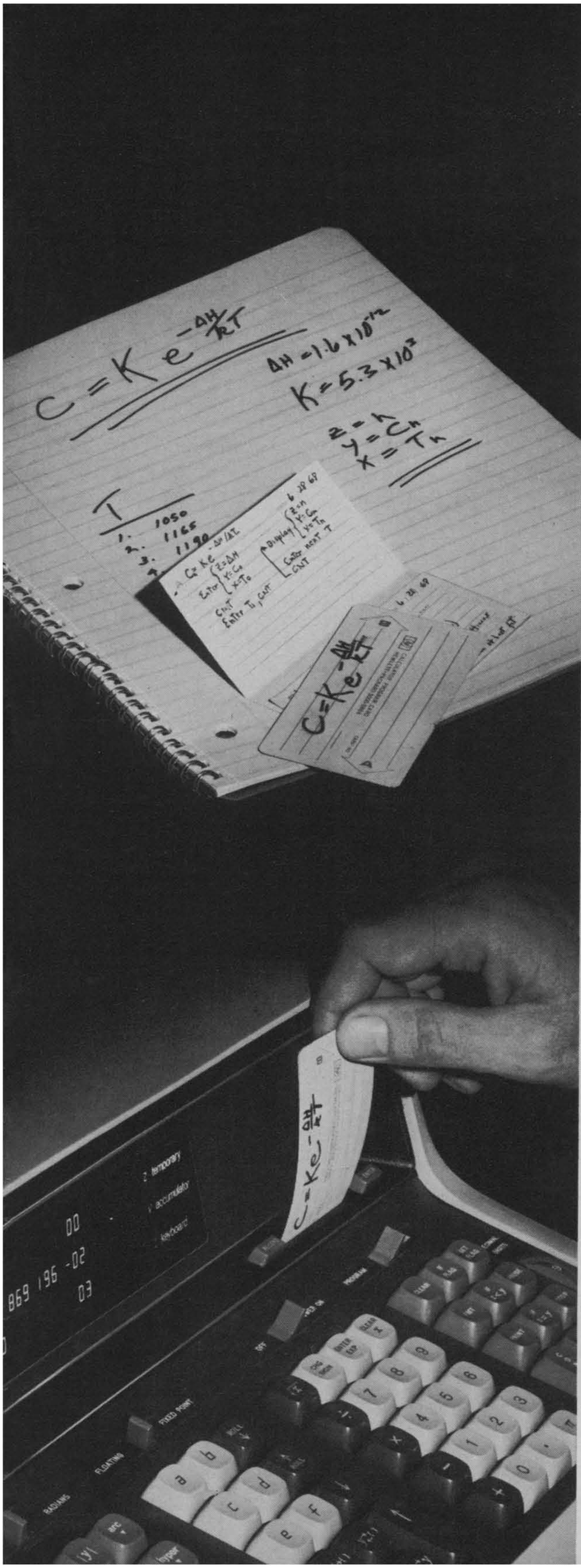
The device which does this job best—the digital integrator—employs even more complex electronic circuits than does the gas chromatograph. And it requires frequent adjustments of a dozen or more programming controls, each somewhat mysterious to the electronics-shy analyst.

For many, this is the last straw. Consequently they have refused to admit into their laboratories the one electronic device that, ironically, can do more than any other to speed their analyses and simplify their routine.

Aware of this problem in human engineering, a team of H-P chemists and electronic engineers together have recently completed the design of an integrator that can be programmed for an almost unlimited variety of analytical conditions just by pushing buttons. No longer must the recalcitrant analyst make the difficult choice of plunging into the strange world of integrator programming, or living in a world bereft of the benefits of digital integrators. The H-P 3370A lets him have the best of both worlds.

For electronics-shy chemists and other scientists who want to know how this was accomplished, we offer a new Bulletin 3370A, on request.






## Restoring the Balance Between Analysis and Computation

Time was when the scientist enjoyed sitting at his desk to manipulate the raw analytical data that he had accumulated while standing at the bench. Somehow complex computations with classical formulae created a pleasant interlude between creative sessions at the bench.

During the post-war period, this somewhat romantic attitude has gradually disappeared. Backed by a seemingly endless parade of new automatic instruments for analysis, the scientist has become such a prodigious producer of analytical data that the balance between his analytical and computational loads has been destroyed. One of the top technical management problems of the day is to release the scientist from the time-consuming drudgery of massive computations and return him to creative work.

Obvious solutions are not always satisfactory. The typical electronic desk calculator is simply not up to the job: many of the commonest mathematical routines of science and engineering are beyond its scope. On the other hand, the computer is often too imposing for the problem immediately at hand, too inconvenient of access or too expensive to justify, and always relatively difficult to program and use.

What is needed is a machine that combines the accessibility of the calculator and the capacity and speed of the computer. Such is the H-P 9100A computing calculator. It not only resembles but even surpasses the computer in its ability to handle very large ($10^{99}$) and very small ($10^{-98}$) numbers at the same time. In practical terms, for example, the 9100A allows the scientist to use Avogadro's number ($6 \times 10^{23}$) and Planck's constant ($6.6 \times 10^{-27}$) in the same computation without risk of overflowing its capacity, and without requiring the scientist to keep orders of magnitude in his head.

The 9100A also shares with the large computer the ability to solve complicated computations in fractions of a second. This stems from its ability to store as many as 196 program instructions, some of which may be decisions based on conditional branching and looping commands. But the 9100A is far easier to use than any computer because of two unique characteristics which bring it within easy reach even of the scientist who has no knowledge of computer programming techniques. First, all programming is carried out in English or common math symbols, not in special computer language. Second, even the most complex program can be stored on wallet-size magnetic cards and entered into the 9100A simply by inserting the card in a slot (as in the photo at left) and pushing a button.

As a result the 9100A can, for example, determine the straight line that best fits a set of experimentally obtained X-Y points in seconds. The scientist need only insert the appropriate program card and enter the data points on the keyboard. The 9100A then carries out the entire 'least squares fit' computation and displays the slope (m), intercept (b), and correlation coefficient (r). It will even plot the line itself when equipped with the forthcoming H-P X-Y plotter.

Yet the 9100A is no bigger and costs no more than a calculator. More important, it is as easy to use since all machine operations are in English or common math symbols. This includes single-key operation for log, exponential, trig and hyperbolic functions, and for coordinate conversions from polar to rectangular and vice-versa.

If you want to know how the 9100A can restore the balance between analysis and computation in your lab, get a copy of our new 22-page brochure. Write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe: 54 Route des Acacias, Geneva.

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ANALYTICAL INSTRUMENTS

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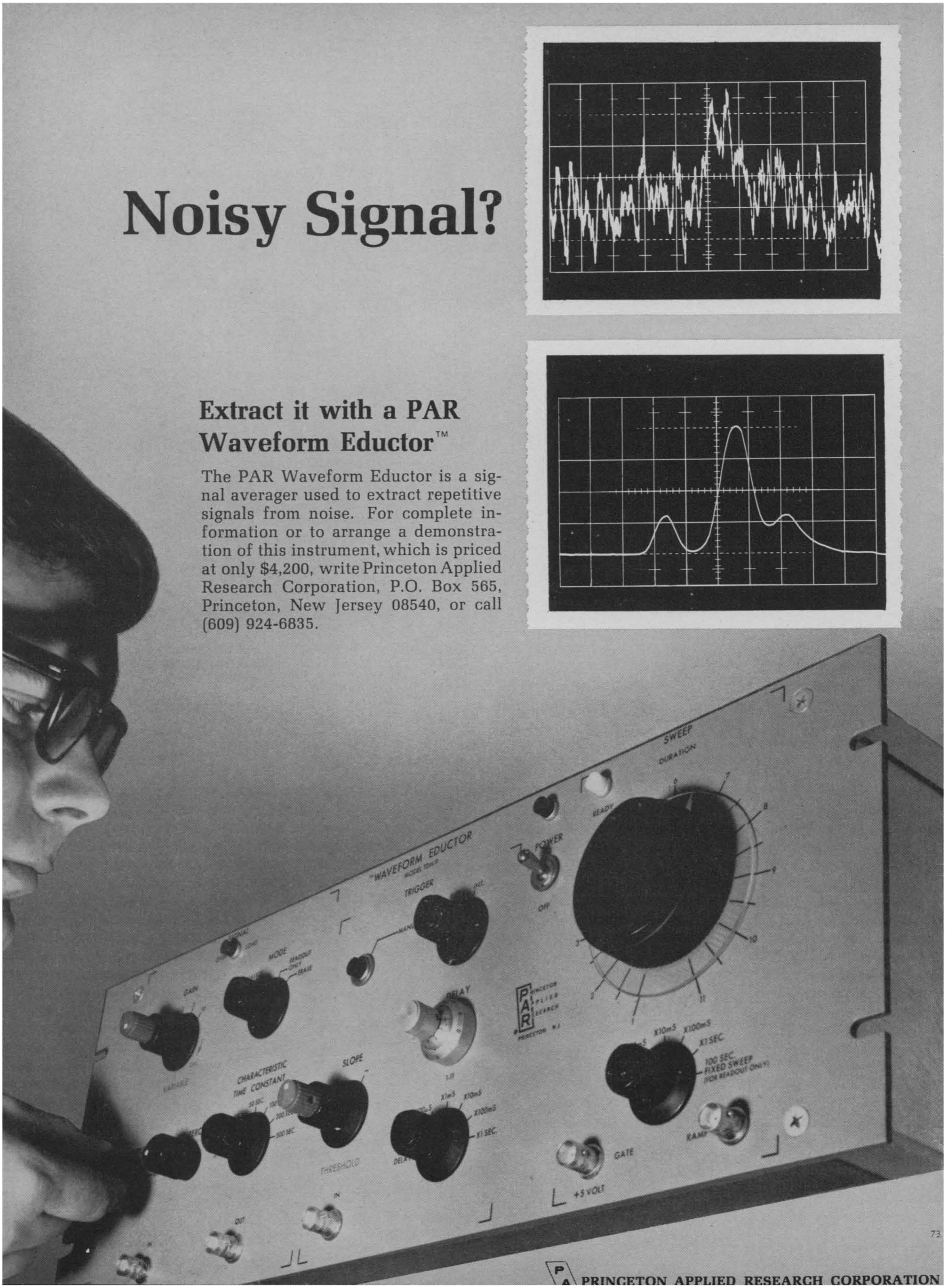

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atmosphere clean. In the late 40's I ran some large turbo-compound engines of this kind at Cornell as well as at Pratt & Whitney Aircraft and found surprisingly low levels of carbon monoxide in the exhaust during operation below 80 percent of full load at all speeds. In the early 50's, I witnessed the "Texaco Combustion Process" engine, which seemed unusually indifferent to octane rating. The engine ran on almost anything. My recollection is that I wasn't particularly impressed with the combustion chamber design and privately predicted nothing would come of it. Nevertheless, I recall that the design permitted a form of air-fuel mixing that promoted detonation resistance and might be worth another look from the standpoint of lowering atmospheric contamination from fuel additives, but I doubt whether the CO level would be reduced. This kind of engine design might be an example of the performance compromise that Fay and Keck so correctly anticipate. I agree with them that virtually every method for reducing pollution would introduce serious performance penalties.

I do not think that the automotive steam engine (even if somehow run condensing) would be especially attractive either in terms of economy or the instant response required of characteristic stop-and-go driving as well as of sudden accelerations as in high speed passing. Therefore I doubt whether there is a truly practical solution to the pollution problem without inordinate costs to the car operator.


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## Cultura Italiana

Some of Nicola Di Ferrante's comments (Letters, 20 Sept.) on the Italian academic situation bear some truth, but I cannot help feeling that he suffers from "Italophobia." It is not uncommon among Italians, especially those who emigrate to other lands to criticize excessively that very country and those institutions which prepared them, during the "green years," to attain success in life. Most remarkable, are not the shortcomings of the Italians, but the abilities of Italians to denounce their own shortcomings, without ultimately doing anything to resolve them. It is not unusual that they would even denounce themselves for sins which are either nonexistent or common to the entire human race, as Barzini (*1*) has involuntarily demonstrated by writing his book.

Everybody agrees that the university system in Italy needs complete overhauling, but for Di Ferrante to say that the new generation learns precious little and is well versed in the art of intrigue and academic politics goes beyond a fair and constructive criticism and creates the general impression that Italian students are ignorant lads whose primary pursuit is deception. Di Ferrante reassures us that he did not intend it as an accusation against Italian students and graduates, but in the meantime, for all practical purposes, the accusation has been made.

Regardless of how impractical the programs and system of teaching in Italian universities may be, most Italian students who reach the university have perhaps the highest general culture training among their counterparts in any country. The American public, even in the academic world, is not aware that the university in Italy, as in other countries in Europe, is in essence a graduate school. Before entering the university, the Italian student goes through 3 grueling years of *Liceo*, during which he practically "recapitulates" 3000 years of knowledge of the western world. He has to digest an impressive number of Latin and Greek authors in the original language, including translation, interpretation, and comment. The same is true for an endless list of Italian poets and writers, Dante's entire *Divine Comedy*, the philosophical work of German, English, or French authors, and works of art: painting, sculpture, and architecture, from Phidias to Frank Lloyd Wright.

To this, one has to add the chronological histories of each subject: history of Greek literature, history of Latin literature, history of Italian literature, history of philosophy, and so forth.

The humanities represent the major load, but the natural sciences are also part of the course of study. Division of subjects is conventional, with no fragmentation into a variety of courses with different exotic titles. A single word "Latin" defines a subject which may comprise everything that was written in Roman times.

The value of such training has been seldom pointed out or sufficiently emphasized. Rather, it has been minimized by the Italians themselves, at a time when many in America are crying for more humanistic training for scientists and engineers in order to produce more "complete, universal men." University reform and elimination of obsolete methods and practices is imperative in Italy, but international vilification of the *Mater universitatis* and her students and graduates is not.

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**Reference**


1. L. Barzini, *The Italians* (Atheneum, New York, 1964).


## Zond 5: Sketches and Guesses

While I generally agree with the uses of the Zond 5 class of (Soviet) spacecraft proposed by Davies and Murray (11 Oct., p. 243), their description of Zond 5 as being comparable in design to the Soviet Mars and Venus probes is, I think, wide of the mark.

The sketch in Dmitriyev's article (*Pravda*, 25 Sept.) does show three sections for the spacecraft in its parking orbit. However, it is easily seen that the section described by Davies and Murray as containing a midcourse rocket motor (that is, a rocket engine) is not that at all. It is, in fact, the upper stage of the booster rocket and its purpose is to inject the Zond 5 into its translunar trajectory. That upper stage adds some 10,400 feet per second (3120 meters per second) to the Zond 5 which at that point already has an Earth satellite velocity of perhaps 25,400 feet per second. Midcourse engines add only corrections of the order of hundreds of feet per second and often less $\Delta V$. The stage was ignited 67 minutes after the initial launching and discarded after burn-out, leaving only *two* compartments. All this is described by Dmitriyev and is shown in his sketches. He describes a sphere—the "descent vehicle"—and an instrument compartment as leaving the parking orbit.

Despite Dmitriyev's relatively detailed article, both Davies and Murray and myself will have to await photographs of the Zond 5 spacecraft comparable to those of the Venus 4 released by the Soviet Union. The latter were sufficiently detailed so as to permit counting of threads in the "plumbing," whereas the crude sketches of Zond 5 give rise to an extended guessing game, no less.

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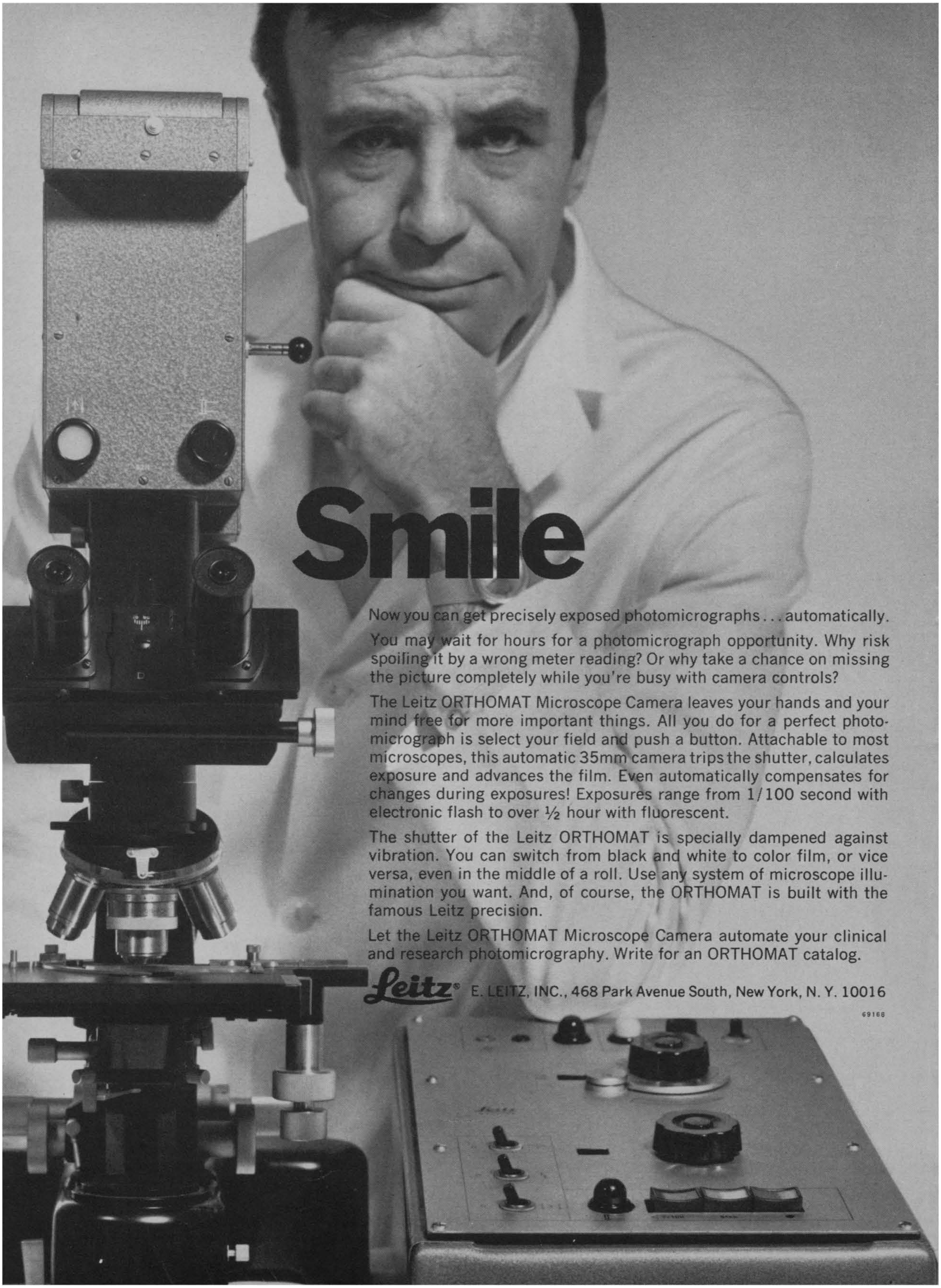
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SCIENCE



# Can Success Be the Cause of Failure?*

It is natural for us all to ask the age-old question: Are our educational policies and procedures really adapted to the world of today? The answer is always "No." Education is not for today; it is *of* the past and it is *for* the future. When, as in ages past, times are changing slowly, then the past, the present, and the future merge into one continuous pattern. In times of rapid change, however, the present appears to be a discontinuity between the past and the future, and no educational policy seems adequate to bridge the gap. Hence, turmoil would seem to be an inevitable characteristic of a rapidly changing world, and an educational system not in turmoil would be one that is surely dead.

The ghastly disruptions and grisly scenes of violence which have taken place on some campuses have been a searing experience for those who have devoted their lives to the development of excellence in American higher education. Despite its faults, our educational system gives more and better opportunities to more young people than any other system in existence—or in the history of civilization. Never, and nowhere, have the opportunities and the fruits of learning been so widely available, so widely utilized, and so widely appreciated.

One must inevitably conclude that the troubles of today are attributable not to the failures of our university system, but to its successes. It has brought higher education to 50 percent of our young people. Why not 100 percent? It has brought scholarly inquiry to bear on a host of areas of human concern. Why not on *all*? Scholarship and research have shed light on many problems which have puzzled the human intellect. Why are some problems still unsolved? Why is it we can understand the structure of the universe and not the structure of human society—or of the human brain or heart?

*Because* higher education has been so successful in so many areas, it is now said to be a colossal failure because success is not yet visible in *every* sphere of human concern. A few hundred years ago no one understood anything about the nature of the universe—and everyone was apparently happy. Today we are overwhelmed with knowledge—and we scream with pain because we don't know everything.

Once our colleges taught almost nothing except Latin, Greek, philosophy, theology, and jurisprudence—and they were regarded as the pinnacles of civilization. Today they teach everything that the human mind has learned—and are accused of living in the Middle Ages.

Success has thus led only to rising expectations and to mounting accusations of failure.

Or so it seems.

And yet—there are 6 million students now in college, and more are seeking admission each year. Americans are spending $15 billion a year on higher education, and—unless the calamity-howlers prevail—this will increase by 10 percent or more per year. More people want more education; more people want to teach in colleges and universities; the nation appreciates more (and demands more) of higher education in each successive year.

American higher education is in fact zooming ahead to new heights of achievement—even though a small minority of faculty, students, and citizens denounce its weaknesses and blame the universities for all the ills of a troubled world.

Imperfections there are. It is hard to keep pace with a rapidly changing world. These imperfections are going to be cured—not by wrecking but by improving the structure which carries the torch of learning, the torch of civilization, on to future generations.

—Lee A. DuBridge

* Adapted from "The President's Report and Reports of Other Officers, 1967/1968" (*Bulletin of the California Institute of Technology*, Pasadena, 1968).