SCIENCE

27 October 1967

Vol. 158, No. 3800

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

TRIPLANAR ROTATION

The key word about PDP-10 General Purpose Time-Sharing is Simultaneous

PDP-10 General Purpose Time-Sharing (GPTS) is an advanced software system which can handle multiple unrelated:

- Real-time simulation and control jobs
- Conversational jobs
- Batch-processing jobs

All at once!

For example, a system that's been operating nearly two years interfaces a Digital Equipment Corp. computer with three analog computers forming a hybrid system. The GPTS system is configured to handle the three real-time simulations *simultaneously*.

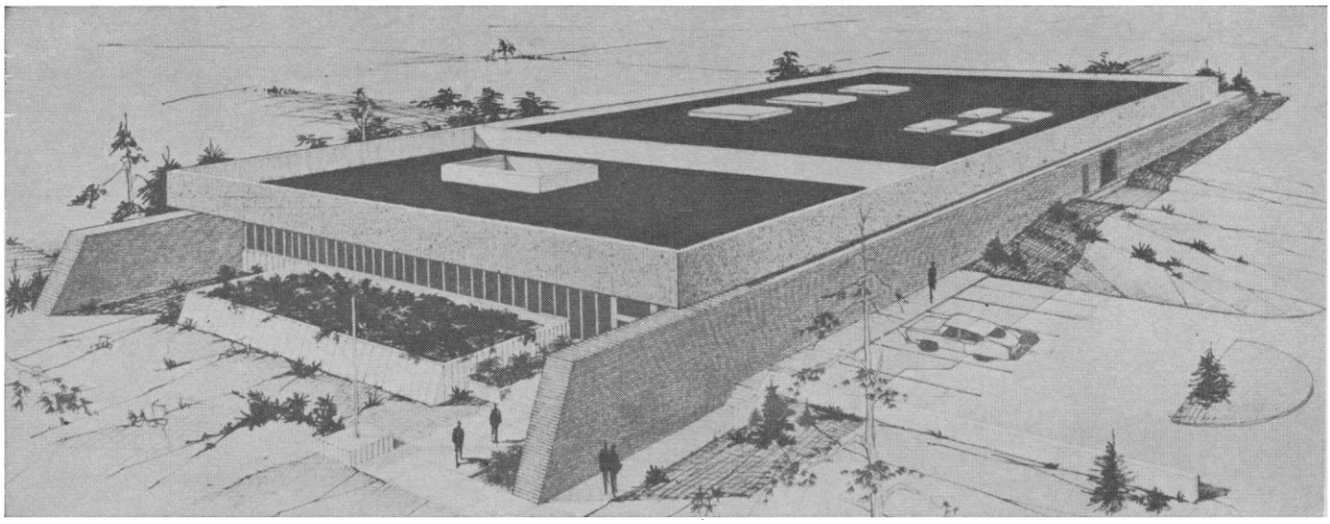
At the same time the real-time programs are running, individual programmers have direct access to the central processor and its associated peripheral equipment from teletype consoles. From these teletype stations, programmers may write, debug, edit and run their own programs. This feature makes it possible for a user to debug application programs for real-time systems without costly and inconvenient shutdown of the real-time systems.

Using the PDP-10 time-shared batch-processing system, individual users can initiate their own batch stacks or submit jobs to a system background stack which is available to all users. Jobs are placed in the system batch stack through a simple Teletype command. Batch control programs run as ordinary time-shared jobs at the same time as real-time and conversational jobs.

DEC's time-sharing software has been field-proven at numerous installations throughout the world. *True* GPTS is available today with the surprisingly low-priced PDP-10. Why settle for less in your installation?

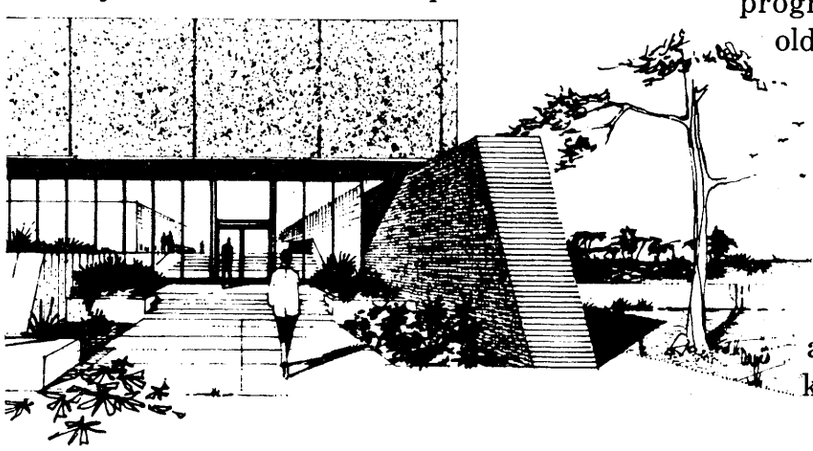
digital
MODULES · COMPUTERS

DIGITAL EQUIPMENT CORPORATION, Maynard, Massachusetts 01754. Telephone: (617) 897-8821 • Cambridge, Mass. • New Haven • Washington, D. C. • Parsippany, N. J. • Princeton, N. J. • Rochester, N. Y. • Long Island, N. Y. • Philadelphia • Huntsville • Pittsburgh • Chicago • Denver • Ann Arbor • Houston • Albuquerque • Los Angeles • Palo Alto • Seattle • Carleton Place and Toronto, Ont. • Montreal, Quebec • Reading, England • Walkden Manchester, England • Paris, France • Munich and Cologne, Germany • Noordwkerhoot, Holland • Sydney and West Perth, Australia • Modules distributed also through Allied Radio



NBCo. keeps building to serve you better.

Just look at the way things are growing at NBCo. Things like another fine new building. The one you see here. And things like service that's better than ever. With our greatly expanded facilities, you'll get even faster delivery. Your orders can be processed with greater efficiency. We'll have even larger inventories of our more than 3000 items with space for the development of plenty of new ones.



Yes, we'll keep building and changing. That's progress. We'll also keep many of our old ways of doing things. That's dependability. You'll still get the purest biochemicals at the lowest possible prices. You can still expect speedy 24-hour delivery anywhere in the continental U.S.A.; 80-hour delivery anywhere in the world. And you can always count on us to fill your order accurately. As we said, NBCo. keeps building to serve you better.

NUTRITIONAL BIOCHEMICALS CORPORATION
26201 Miles Road
Cleveland, Ohio 44128 U.S.A.
Phone 216-662-0212

27 October 1967
Vol. 158, No. 3800

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., N Washington, D.C. 20005. Now combined with **The Scientific Monthly**®. Second-class postage paid at Washington, D.C. Copyright © 1967 by the American Association fo Advancement of Science. Annual subscriptions $8.50; foreign postage, $1.50; Canadian postage, 75¢; single copies, 50¢ (back issues, $1), except **Guide to Scientific Ins ments,** which is $2. School year subscriptions: 9 months, $7, 10 months, $7.50. New rates effective 1 January 1968: Annual subscriptions $12.00; foreign postage: Americas overseas $5; single copies, 50¢ (back issues, $1), except **Guide to Scientific Instruments,** which is $2. School year subscriptions: 9 months, $9; 10 months, $10. Provide 4 wee 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

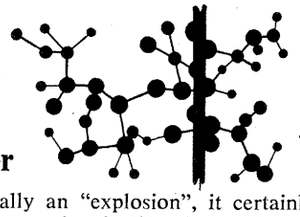
COVER

Sphere rotating in three planes, each plane perpendicular to the other two. Unconnected lines at the bottom are reflections of the sphere. The purpose of the machine is to equalize the effect of gravity on all sides of a germinating seed. Under such equitropic conditions, the seeds grow faster with a less organized cellular pattern than the controlled seeds, thus suggesting that tropisms act as inhibitors. [Time exposure by J. Garrett Whitney, Bartlesville, Oklahoma]

Who else in the pH business

A close look into analytical efficiency... from polymers to pesticides

In Pursuit of the Polymer



So widespread is the pursuit of the polymer molecule by so many scientists in so many laboratories that Sunday Supplement writers will soon be calling it the polymer explosion. Even if it isn't really an "explosion", it certainly is an expensive pursuit because so much scientific time is involved . . . hence a growing demand for instruments to replace the tedious and time-consuming classical methods heretofore used by the polymer chemist.

For some, it may seem curious that these demands come from analytical and micro-chemical sources as well as from the polymer chemist . . . but polymer chemistry is a complex field that involves all these chemical disciplines. It will be more curious to others that Hewlett-Packard, a company generally known for its achievements in electronics, is also deeply involved with things chemical, including polymer research.

Molecular weight determination, a chief factor in polymer characterization, provides examples. Hewlett-Packard offers no fewer than four types of molecular weight instruments now considered by many as standard laboratory apparatus because of their proven efficiency: the Model 302 Vapor Pressure Osmometer for determining number average molecular weight in the range of 100 to 20,000; the Series 500 Membrane Osmometer for the same type of measurement up to 1 million; the Model 701 Light Scattering Photometer for determining weight average molecular weight from 500 to 5,000,000; and the Model 5901B Auto-Viscometer for determining viscosity average molecular weight.

When reminded that polymer characterization is a case of establishing molecular weight by *all* rather than just *one* of these methods, and that molecular weight determination via classical routes is expensive, complex, and time-consuming, the efficiency of one or all of these Hewlett-Packard instruments is considerably more beneficial than might otherwise be apparent. For a full description of these instruments, write for Data Sheets 3020, 5000, and 7010.

Granted that molecular weight counts heavily in polymer chemistry, there are several polymers (and many more co-polymers) whose characterization would be incomplete without CHN analysis (determination of carbon, hydrogen, nitrogen proportions). Unfortunately classical CHN analysis tends to defy efficiency, requiring lengthy procedure, costly equipment, and an environment-controlled balance room, all resulting in a somewhat classic laboratory fee.

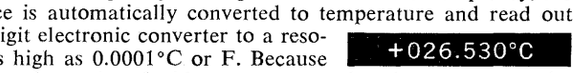
To the extent that H-P's Model 185 CHN Analyzer streamlines traditional CHN analysis it is a boon to all concerned. For the bench chemist, no more than this need be said of the 185's capability: one sample, one weighing, ten minutes per determination, with reliability well within the traditional 0.3% allowable error. For the managing chemist, a more direct comparison might be in order: CHN analysis is valued on the order of $15.00 per hour, with the classical approach requiring about one hour per determination. The 185 makes determinations at the rate of six per hour. Or a value of $90.00. Or an improvement over the classical of $75.00 per hour. The calculation of how long it would take the Model 185 to pay for itself will be left to others. The instrument costs $6,000.00. It's fully described in Bulletin 1850.

Frequency in Degrees C.

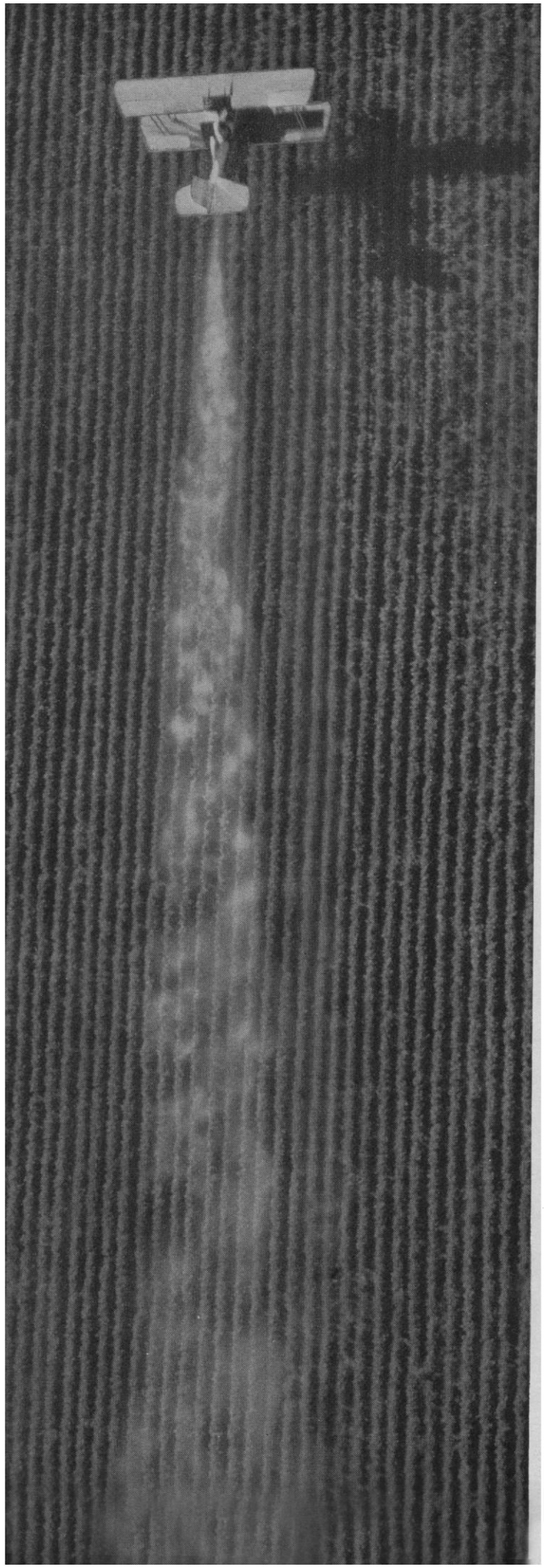
If the CHN Analyzer strays from the classical, H-P's Model DY-2801A Quartz Thermometer (hereinafter called the QT) departs radically. Platinum resistance thermometry has always been looked upon as the best (if not the most practical) means of making sensitive laboratory temperature measurements. This view will likely soon change in the direction of quartz thermometry, which in the QT has been developed to such a fine state that there's a breakthrough in the offing—both a technological and a practical one.

The new technology lies in the precise angle of cut of a quartz crystal wafer, which gives the QT a linearity of ±0.05% vs ±0.55% (−40 to +250°C) for platinum resistance devices. The new practicality can be traced to H-P's electronics design capability, which has given the QT direct digital readout in degrees—no bridge balancing, no conversion tables. Together they make for a very gifted instrument: the QT is ten times more linear and conservatively that many times more convenient to use than anything else available.

The QT operates on the basis of the variation of the resonant frequency of its quartz crystal due to temperature change. The crystal wafer is mounted in a small probe and connected by cable to its oscillator circuit. When the probe is placed in a test environment, oscillator frequency is compared to a reference frequency, the difference is automatically converted to temperature and read out on a 6-digit electronic converter to a resolution as high as 0.0001°C or F. Because the QT can be equipped with one or two probes, it can measure the temperature of either probe or the difference between the two. It can also double as a highly accurate 300 kHz electronic counter.



In application, the Quartz Thermometer can be depended upon to improve determinations in just about every popular area of temperature analysis. This is apparent in the field of differential thermal analysis—qualitative characterization and quantitative identification of a material by measuring the temperature difference between its sample and an inert reference—where the superiority of the QT can again be laid to its superior linearity. Discussions on how to use the QT in calorimetry and molecular weight determinations can be found in Application Notes 78-2, 78-3.

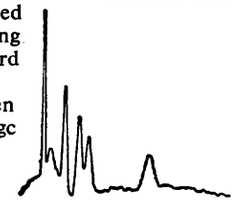


Garden Variety Pesticides

"For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death. In the less than two decades of their use, synthetic pesticides have been so thoroughly distributed throughout the animate and inanimate world that they occur virtually everywhere." RACHEL CARSON—*Silent Spring*

The determination of precisely how much contact human beings do have with synthetic pesticides is currently a very active scientific pursuit, and a bit more difficult than Miss Carson's statement might reveal. In fact, never before in the field of chemical analysis has it been necessary to detect such minute amounts of such unstable compounds, whose presence is so greatly clouded by the natural samples in which they exist.

While the men engaged in pesticide detection are many and far flung, instrumentation for this sensitive work falls almost solely on the gas chromatograph. On this basis much research effort at Hewlett-Packard's F & M Scientific Division is directed at pesticide analysis with the aim of perfecting both instrumentation and technique. In regard to the former, it is interesting to note that although pesticide detection is still most often recorded in the nanogram range, an F & M gc —more than two years ago—separated a laboratory pesticide sample at the picogram level ($1x10^{-12}$, or .000,000,000,001 gram).



Most of this chemical detective work is being performed on the F & M Model 402 High-Efficiency Gas Chromatograph—an instrument perfected especially for this and other biochemical research. H-P's pesticide analysts prefer to use this instrument equipped with an electron capture type of detector. The latter employs a radioactive tritium source to produce electrons whose capture by the pesticide molecules is a direct measure of their presence. Recently, H-P chemist-designers have perfected a new electron capture detector that employs a radioactive Ni^{63} source that is more stable at higher temperatures, thereby holding out a promise of more searching pesticide detection than the older tritium type can accomplish.

Sometimes the inherent difficulty of pesticide analysis is resolved by improvements in technique rather than hardware. A case in point is an H-P developed procedure that aids in the identification of elusive eluted pesticide peaks by running the same sample through two dissimilar gc columns. When the suspected pesticide has the correct retention time in both columns, identification becomes more positive; conversely its presence is ruled out if it doesn't have the correct retention time in either column.

This work was first recorded in H-P laboratories using samples of a domestic and an imported marmalade. The first column indicated that the domestic sample was free of pesticides but that the imported one showed the presence of Endrin. Those partial to imported jams should feel free to eat them anyway since the presence of Endrin was ruled out on the second column.

H-P chemists have developed similar techniques for the analysis of pesticide residues in many foodstuffs, and sample extraction techniques for the analysis of bovine and human milk.

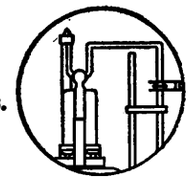
If you care to pursue this subject in depth, ask for Applications Lab Report 1003. Write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304.

HEWLETT hp PACKARD

ANALYTICAL INSTRUMENTS

first automatic pH stat titrator with all-digital volume indicator and quick-change burets

With the superb craftsmanship that is synonymous with their country, Metrohm of Switzerland brings you the Combititrator-3D—an automatic titration apparatus of unparalleled quality and versatility. It features a pH meter, a controller, and a recording motor buret. The latter is offered with the first bayonet-mounted burets for instantaneous exchange of all glassware components. (SEE CIRCLED AREA IN PHOTO.)



The Combititrator-3D can be set up to perform virtually any common or unusual titration: automatic potentiometric with recording; automatic potentiometric to an endpoint; constant-potential with recording of reagent volume against time (pH stat titration); pH and mV measurements; acid/base, redox, precipitation, non-aqueous, or complex titrations.

The Combititrator offers high operating accuracy, eliminates errors resulting from manual procedures, and provides reproducible results. All the operator has to do is prepare the sample solutions.

The most complete line of accessories is available including titration vessels with capacities ranging from micro to macro quantities, with and without thermostatic control.

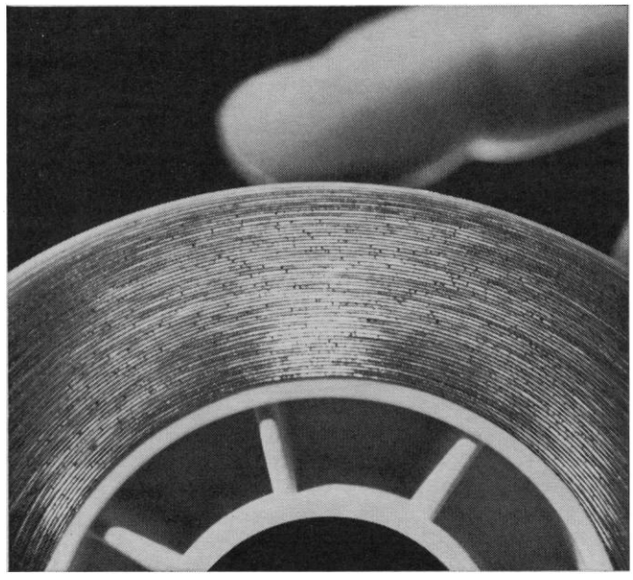
Measuring accuracy is 0.01 pH or 10 mV; the chart recorder drive incorporates a 4-speed gearbox; and titrant volume can be read on an all-digital counter (if recording is not required).

For detailed information about all Metrohm automatic titrators write to:
Metrohm Division
Brinkmann Instruments, Inc.
Westbury, New York 11590

Combititrator-3D accuracy versatility compactness

Metrohm of Switzerland

The hope of doing each other some good prompts these advertisements



Film for 50Å to 4000Å, with rails

You are looking edgewise at a reel of a new type of film for the ultraviolet down to 50Å. The specks are polystyrene beads embedded to protrude from a raised strip of gelatin along each edge of the film. The apparent simplicity of the invention detracts nothing from our pride in it. The structure provides a reliable pair of 150μ-high rails to keep the photographically active surfaces from touching. Sensitivity below 2000Å forbids burying silver halide crystals in gelatin for the usual protection. Therefore density can result from mechanical contact instead of from radiant energy.

Over the years we have learned ways to endow these bare crystals with far more uv sensitivity than when Victor Schumann first proposed sticking them out free of the uv-absorbing gelatin. A certain film imported from Kodak-Pathé in delicately packaged strips 35mm x 7 inches has represented the high mark in sensitivity. Still, its touch-me-not nature continued to impose awkward constraints on design of equipment. No more, provided enough interest can be aroused in new domestic KODAK Special Film, Type 101-01.

Now Eastman Kodak Company, Industrial Photo Methods, Rochester, N.Y. 14650 awaits word on length, width, and perforation requirements from anybody who can afford the price.

Liquid crystals: breadth of choice now, purity later if needed

For some time now we have been busily adding more and more items to the list of mesomorphic compounds we offer, particularly those of cholesteric habit with its enormous optical rotation power and circular dichroism. Further possibilities are suggested by work reported in *Physical Review Letters 18:393;* it seems that the random alignments available in cholesteric "swarms" can simplify the generation of second harmonics from Q-switched lasers. Meanwhile, some who are less interested in basic optical principles use "liquid crystals" to depict slight but significant temperature anomalies in the skins of people or airframes. Those concerned with the latter tell us we are doing a good job in making them what they want.

In serving the optical investigator with liquid crystals, the chemical talent we have invested might have been devoted to higher purity for fewer compounds. Instead, we reasoned that once his investigations establish a need for higher purity in a given compound and it happens that purification overtaxes his own chemical facilities, we would be happy to see what we can do for him.

To check on current offerings and prices in cholesteric, smectic, and nematic compounds, write Eastman Organic Chemicals Department, Distillation Products Industries, Rochester, N.Y. 14603 (Division of Eastman Kodak Company).

The way into print

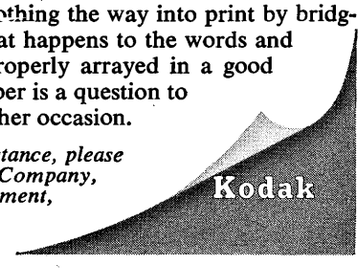
Publish or perish. The doctrine still holds sway despite bitter words spoken against it over ethanol after midnight. For validity one's work must be consecrated by a typesetter. Only after ink has been applied to paper by a decent number of revolutions of a metal cylinder can a piece of scholarship be considered accomplished. This is the custom. It dates from a day when learned men with news to spread were few, which is no longer so.

Now that myriads of learned men and women have to get into print and get into it frequently, the technology by which this is done had better be improved. On top of Gutenberg's 15th century concept of movable type and Mergenthaler's 19th century concept of casting liquid metal into lines of type, photography now further facilitates the printing of the printed word. This involves us.

Companies that built typesetting machines around a pot of simmering Pb-Sb-Sn alloy now build them around computers and certain light-sensitive litho plates of our manufacture. The neatness with which the characters are arrayed on the page—which has come over the centuries to signify commitment and authority—is attended to by the computer. With less asked of human judgment and fingers, the flux of words and symbols onto our plates can be maintained at superhuman levels. As the plates emerge from the machine, they are dunked in solutions that change them to actual printing plates, ready to run on offset presses in certain printing applications today and probably more tomorrow.

Dunking sounds like a bottleneck, and it is. This very year that bottleneck, too, is being broken. To the printing establishments prepared to cope best with the publishing needs of the day we are supplying another machine (called KODAK VERSAMAT Plate Processor, Model 1-N). It sits beside the typesetting machine, smoothing the way into print by bridging the dunking step. What happens to the words and symbols thus at length properly arrayed in a good black on a respectable paper is a question to be disposed of on some other occasion.

If we can be of any assistance, please inquire of Eastman Kodak Company, Graphic Arts Sales Development, Rochester, N.Y. 14650.



individuals who have indicated their willingness, 127 have Ph.D. or M.D. degrees, 30 have Masters, 19 have Bachelors, and 3 have no degree; 17 are in medicine, 75 in the physical sciences, 54 in biological science, 17 in social science, and 16 in engineering. The areas represented are: Northeast, 35; Middle Atlantic, 54; Southeast, 17; Middle West, 29; South, 10; Mountain States, 5; Pacific Coast, including Alaska, 26; and 3 from abroad.

We have made no plans for action as yet. Suggestions have been made that we make studies on pacification, on health problems, and on biology, and the anti-infiltration barrier. I suggest that we be called "The V.N. Emergency Science Group." Clearly we face problems of placement, of briefing, and of budget. We are starting to consider means of meeting these problems.

Of the 17 letters which opposed my views, there were those who abused me; those who believed that if I were to read Senator Fulbright and *Ramparts* magazine I would reform; and those who asserted that all terrorism in Vietnam is committed by the United States. The few unsigned letters were discarded.

If I were to attempt to summarize the comments, other than the many expressions of gratitude, I would say that they concluded that dissent has gone too far and the secondary effects of dissent are now more important than the primary goals of the dissenters.

It is abundantly clear from the letters that those who replied are thoughtful, earnest, and deeply involved. I began this action because my conscience would not leave me alone! I had many misgivings. I now have great pride that I have been able to serve as a focus for these individuals. The schism among scientists caused by the present situation is latent with profound tragedy. If our group can so perform as to lessen that tragedy, the letter to *Science* will have served a great purpose.

ERNEST C. POLLARD
Department of Biophysics, Pennsylvania State University, University Park 16802

In response to Pollard's call to improve the U.S. position in Vietnam, I make the following suggestions:

1) To reduce terrorism, we can stop bombing, quit burning villages, provide no support for any terrorist activities, and make any scientific techniques to counteract terrorism available to all people.

2) To make food available to a people who were never short of it before our arrival, we can refrain from fighting in the Mekong Delta rather than be concerned about how better to "hold" it.

3) To "permit humble people . . . to choose their way of life without fear," we could back only those elections in which all organized political groups, rather than just those that meet our approval, are represented on the ballots.

4) Finally, to make the best single improvement in our position in Vietnam, we can remove all of our armed forces and supporting personnel and make our technology available to help rebuild where we have left ashes, both North and South.

As Pollard implies, there appears to be less university-scientist support for this war than for World War II. This seems to be related to the substantial difference in political and moral realities between the two wars.

WILLIAM F. PROKASY
Department of Psychology,
University of Utah, Salt Lake City 84112

. . . I hope you will give a hearing to those who feel that American scientists are already far too closely identified with that military adventure. Far from suffering from a lack of scientific support, our invasion of Vietnam has involved an unprecedented mobilization of scientific resources. Scientists developed the gas which drives civilians and guerrillas alike from their shelters. Scientists developed the napalm and phosphorus and pellet bombs with which we wipe out the villages suspected of sheltering the Vietcong. Scientists developed the crop-destroying agents with which we are creating artificial famine. And scientists are now perfecting "counter-insurgency techniques"—the methods which are to make certain that a military dictatorship, if once established, can never be overthrown.

WILLIAM PALMER TAYLOR
416 Ross Avenue,
Hamilton, Ohio 45013

. . . when [Pollard] says that the nub of our position is "that we seek to nullify terrorism," I wonder if he is referring to the terrorism of napalm, crop destruction, and scorched earth tactics.

ROBERT B. KELMAN
Department of Mathematics and Statistics, Colorado State University, Fort Collins 80521

N.V. Uitgevery Wistik
announces publication of:

"THE FOUNDATION OF EMPIRICAL KNOWLEDGE"

with a theory of
artificial intelligence
by Pieter J. van Heerden

Information theory is an important intellectual byproduct of the great field of electronic engineering. It has stimulated and challenged the thinking, not only of engineers, but also of scientists, mathematicians, and philosophers. This is quite analogous to the impact of mechanical engineering, in the seventeenth century, on the thinking of scientists like Galileo, which led to Newtonian mechanics. It is true that Newtonian mechanics was never a great help to the inventors and engineers of engines, guns, cars and aeroplanes in the following centuries, because they had of course always applied its principles intuitively. It only set a limit of efficiency. On the other hand, it did open a path towards the understanding of the motion of the planets and the atoms and electrons, and so led to totally new fields of engineering.

Information theory deals with information as dynamics deals with motion. So far, its influence has been threefold: In the first place it describes how to improve the detection of weak signals in random noise. In the second place, Shannon's theory has shown that all communication channels have a given capacity in bits per second, and how in principle they may be used more efficiently. Finally, in the widest sense, computers are subject to information theory. It describes how any mathematical computation, any piece of logical reasoning, or any set of instructions, can be carried out by computers faster and more accurately than humans could ever do it.

Just the same, there are vital elements missing in information theory as it is today, as some examples will show: A good chess player plays much better than a computer, despite the fact that chess is a strictly logical game, and the efforts to program machines for such games have clearly reached an impasse. One might say that people use judgment, and that judgment is something quite different from logic. Another example, this one related to channel capacity, is when a radio announcer says: "The next hour will bring you Hamlet by Shakespeare." These few bits give more information about the time series in the next hour than all statistics of letters and words in the English language could ever supply.

Do such examples indicate that information theory can never be made into an all encompassing conceptual framework for information as mechanics is for motion? **Does it mean that judgment, common sense and intuition are the assets of human intelligence which will forever escape the boundaries of an exact basic formulation?** That would clearly be a scientific paradox! We know today that, physiologically speaking, a man's decisions are made as a consequence of information processing in his brain, which therefore must be subject to information theory. It would be against the basic tenet of science if these activities of the brain, resulting in intelligence, would not follow from a few clear and basic concepts.

To formulate such a complete foundation of information theory is the first objective of the present book. The fundamental question to be answered is this: Let all my information received in the past be given in the form of books, films, magnetic tapes or any other physical records; what are my rational expectations of the future? Please notice: a basic theory does not have to give a concrete answer in every complex situation. Newtonian mechanics has never even resulted in an exact solution of the three body problem! The requirement for a fundamental theory is that it is simple, intuitively satisfying and that it completely and exhaustively characterizes the solution of every individual situation which may present itself in reality. Very important is that the theory is operational, which means that it only speaks in terms of operations which can actually be carried out in the real world.

This basic problem of rational prediction, once put in this general form, and once we know that there must exist a general theory, **is readily solved.** This is done by generalizing commonsense analyses of specific, real situations in which the rational prediction is intuitively obvious. The general and simple mathematical formulation then follows naturally. Formulated in words, the universal principle of prediction is: **"Whatever in the records is found to be constant in time in the immediate past, we will expect to remain constant in the immediate future."** (Notice the analogy with Newton's first law of motion!)

Once this main goal is achieved, one can realize that this general result had already been anticipated by philosophers and scientists. The philosopher Hume, around 1740, arrived at the conclusion that this was the ultimate foundation of all human knowledge. Although nobody has ever been able to refute his idea, it remained mostly ignored, apparently because it is so unpleasant to admit that all our rational knowledge of the future, and the past, is ultimately based on so simple-minded a principle. The language of information theory however gives his idea an authority which will be hard to ignore. It leaves little doubt that **information theory now replaces speculative philosophy as an ultimate foundation of human knowledge.**

Furthermore, it turns out that the very fundamental uncertainty relations in physics, formulated by Heisenberg around 1930, now can be looked upon as a consequence of information theory. While up till the present these wave-particle aspects of Nature had to be considered as mysterious and even paradoxical, they become perfectly natural if we assume that physics does not deal with reality, but only with information about reality. In a previous book, "The Foundation of Physics," the author has discussed this new point of view and shown that **it leads logically to a new and promising mathematical formulation of quantum mechanics.**

Having arrived at the solution for the basic problem of information theory, which is how to predict the future rationally, one can turn to the general problem of intelligence. Human intelligence is defined as follows: **"To be intelligent is to try to satisfy one's psychological needs by all available rational means."** It is the power of well formulated basic principles that they make things easy which looked highly mysterious and abstruse before. The new foundation of information theory allows one to translate this simple and scarcely contestable statement into a rigorous and precisely defined form of information processing. **One thereby has solved the problem of intelligence.** The information processing required to achieve significant intelligence turns out to be truly enormous. It amounts to a search through all the stored information for the one piece that most closely matches the information presently received. However, it turns out that a simple model of the brain makes this process quite feasible. **Information theory therefore provides a general blueprint for understanding the operation of the human brain.** One could hardly expect less from a basic theory.

Artificial intelligence is the field of engineering which tries to construct machines, able to perform tasks, which at present can only be done by living intelligent beings, humans or animals. On the basis of the present theory of intelligence, **it is shown in detail how artificial intelligence, comparable to that of living beings, lies within the reach of present day technology.**

The prerequisites for this book are: a good college course in mathematics and the maturity to trust one's own common sense. Order the book now, since we can offer it at a special price if your order is received before the book goes to press. This will also ensure your receiving it at the earliest possible date.

Special price, if your order is received before December 31, 1967 is $3.50. Special edition sold in Europe only is Nfls 10.00 (hard cover resp. $6.00 and Nfls 15.00).

After December 31, the price will be $6.00; special edition for Europe Nfls 15.00 (hard cover resp. $8.00 and Nfls 20.00).

Also available, "The Foundation of Physics," by the same author. Price $5.00; special edition for Europe Nfls 12.00 (hard cover resp. $7.00 and Nfls 18.00).

The books can be ordered directly from us for prompt delivery. For this purpose, copy and fill out form below. Send it with personal check or postal money order enclosed for the proper amount. No shipping charges.

Fill out:

To: N.V. Uitgevery Wistik
P.O.B. 1003, Wassenaar, Netherlands

Please send:

"The Foundation of Empirical Knowledge," C. 140 pages, ☐ soft cover, ☐ hard cover.
"The Foundation of Physics," x + 100 pages (Sept. 1967), ☐ soft cover, ☐ hard cover.

Check/money order in the amount of: _____ enclosed.

Name: _____

Street: _____

Town: _____

Country: _____

27 October 1967, Volume 158, Number 3800 **SCIENCE**

EDITORIAL CORRESPONDENCE: 1515 Massachusetts Ave., NW, Washington, D.C. 20005. Phone: 202-387-7171. Cable: Advancesci, Washington. Copies of "Instructions for Contributors" can be obtained from the editorial office. ADVERTISING CORRESPONDENCE: Rm. 1740, 11 W. 42 St., New York, N.Y. 10036. Phone: 212-PE 6-1858.

Student Unrest

In several panel discussions at the recent annual meeting of the American Council on Education, faculty members, administrators, trustees, representatives of public agencies, and students debated the conference theme: "Whose Goals for American Higher Education?" Most of the students used shock treatment ("objectivity is no good," or "the American student has lost faith in the leadership of our colleges and universities"), and some went little further. Others offered positive suggestions. And a plea for faculty cooperation in meeting student complaints is presented in *Champaign Report*,* a recently published summary of a 1966 seminar of 11 student leaders, from as many different campuses, some of whom were participants in the ACE meeting.

It is easy to fault *Champaign Report* and some of the student presentations at the ACE meeting on such grounds as inconsistency, incompleteness, and bias. Moreover, the student authors and participants represent a minority of all students. Nevertheless, it is useful to understand what a group of bright, articulate, committed, influential, activist student leaders want: (i) they want freedom—they complain that mature interests are offered juvenile opportunities; (ii) they want to be treated as individuals, not as types—an ideal long supported by older critics of educational practices; (iii) they want to learn how to learn instead of being fed information—another ideal long held by older critics; (iv) they want educational priorities and practices changed to give emphasis to what they currently consider important; and (v) they want part of the power in "all policy-making functions," including admissions, budget, hiring and tenure, degree requirements, building and construction, and others.

Which of their complaints are legitimate and which demands should be met? Analysis is required along three lines.

1) The appropriate roles of students and others in establishing and enforcing rules and policies should be defined more explicitly. Students should no more have the same kinds of responsibilities in every area of decision than faculty members, presidents, or trustees have.

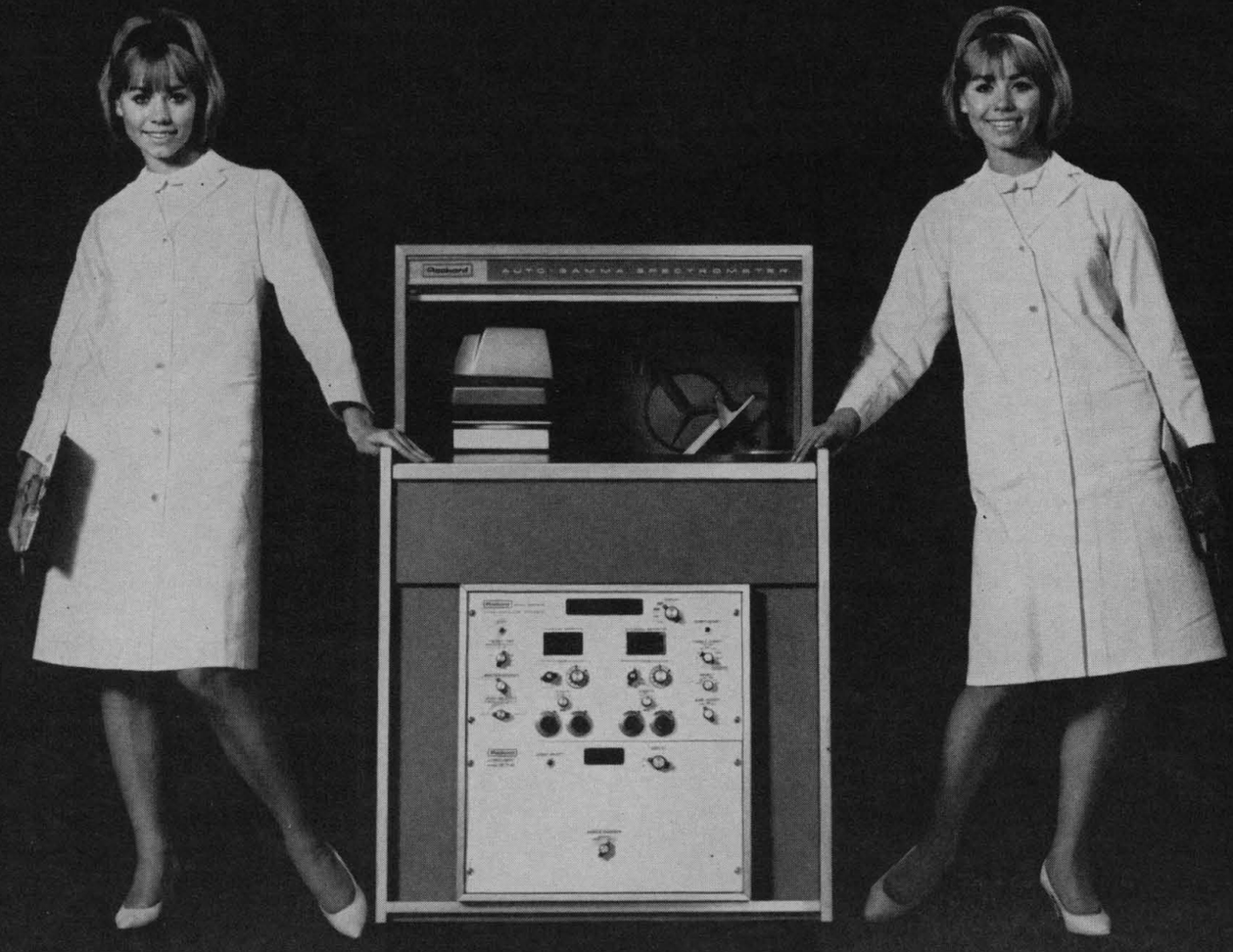
2) Rules and procedures should be examined to determine which are truly relevant to the attainment of educational objectives. The legal decision in the "filthy speech movement" at the University of California offers help in this regard: "state universities should no longer stand *in loco parentis* in relation to their students . . . the university has the power to formulate and enforce rules of student conduct that are appropriate and necessary to the maintenance of order and propriety, . . . where such rules are reasonably necessary to further the university's educational goals."

3) Opportunities for constructive student involvement in activities they consider important should be encouraged. Students can bring energy, idealism, and innovation (as they have in the Peace Corps and VISTA) to work on social and educational programs in city ghettos and with underprivileged groups. One of the student participants in the ACE meeting put it this way: "Thirty Columbia students running a Study Club for second graders is not going to solve New York City's educational problems, but for the people involved, it is as educational an experience as there can be . . . the *involvement* is something that many undergraduates feel is as vital to their education as their classes. It is a time for students to test themselves in ways that are important to *them*, rather than in ways important to their parents and teachers. Any college interested in more than the strictly academic success of its students can support this type of activity without hesitation."—DAEL WOLFLE

* P. Danish, in *Champaign Report*, E. Schwartz, Ed. (U.S. National Student Association, 2115 S Street, NW, Washington, D.C. 20008); 50¢.

NEW DUAL CHANNEL AUTO-GAMMA® SPECTROMETER

Now you can get two-channel gamma operation at the single-channel price



Model 5212 is a unique, automatic gamma counting system for either single or double-labeled samples. For two-channel analysis the system is automatically programmed to count each isotope sequentially, using a single scaler. Samples are changed automatically, and the data for each channel is recorded by a digital printer. Low, constant backgrounds are ensured by a patented 100-sample automatic changer. ■ Though it has two-channel capability, Model 5212 is modestly priced . . . costs less than you would expect to pay for Packard's single-channel system. It is an ideal instrument for the laboratory where analysis of double-labeled gamma samples is becoming increasingly important, but volume of counting does not justify purchase of a full two-channel system. ■ Model 5212 is one of Packard's complete line of gamma counting instruments, which range from manual, single-channel instruments to automatic, 400-channel systems for the most sophisticated analysis. Your Packard Sales Engineer can recommend a system exactly suited to your needs. Call him, or write for Bulletin 1064U to Packard Instrument Company, Inc. 2200 Warrenville Road, Downers Grove, Illinois 60515, or Packard Instrument International S.A., Talstrasse 39, 8001 Zurich, Switzerland.

Packard

ference Hq., 330 S. Wells St., Chicago, Ill. 60606)

13–15. American **Petroleum** Inst., 47th annual mtg., Chicago, Ill. (American Petroleum Inst., 1271 Ave. of the Americas, New York 10020)

13–16. **Engineering in Medicine and Biology**, 20th annual conf., Boston, Mass. (Professional Assocs., 6520 Clayton Rd., St. Louis, Mo. 63117)

14–16. American Federation of **Information Processing** Societies, fall joint computer conf., Anaheim, Calif. (Executive Secretary, 211 E. 43 St., New York 10017)

14–17. American **Acoustical** Soc., fall mtg., Miami Beach, Fla. (J. Steinberg, Inst. of Marine Science, Univ. of Miami, Miami 33149)

14–18. **Air-Conditioning and Refrigeration** Inst., annual mtg., Miami, Fla. (1815 N. Fort Myer Dr., Arlington, Va. 22209)

15–18. American Society of **Tool and Manufacturing Engineers**, semi-annual conv., Dearborn, Mich. (The Society, 20501 Ford Rd., Dearborn 48128)

16–18. American **Physical** Soc., New York, N.Y. (W. W. Havens, 538 W. 120 St., New York 10027)

16–19. National Soc. for **Crippled Children and Adults**, annual mtg., Los Angeles, Calif. (K. Bauer, Director of Public Relations, 2023 W. Ogden Ave., Chicago, Ill.)

17–18. **Computer Applications in Clinical Electrocardiography**, postgraduate program, Washington, D.C. (J. S. France, Assistant Director, American College of Cardiology, Bethesda, Md. 20014)

19–21. International College of **Surgeons**, 5th Western regional mtg., Las Vegas, Nev. (F. M. Turnbull, Jr., 1127 Wilshire Blvd., Los Angeles, Calif. 90017)

19–22. Association of **Military Surgeons** of the U.S., annual mtg., Washington, D.C. (Brig. Gen. F. E. Wilson, AMSUS, 1500 Massachusetts Ave., NW, Suite 132, Washington, D.C. 20005)

20–22. Society of **Economic Geologists**, New Orleans, La. (J. O. Kalliokoski, Dept. of Geology, Princeton Univ., Princeton, N.J. 08540)

20–22. American Physics Soc., annual **Fluid Dynamics** mtg., Bethlehem, Pa. (P. S. Klebanoff, Natl. Bureau of Standards, Connecticut Ave. at Van Ness St., NW, Washington, D.C. 20234)

20–22. **Geological** Soc. of America, annual mtg., New Orleans, La. (G. E. Murray, Texas Technical College, Box 4680, Technical Station, Lubbock, Tex., or Miss D. Curtis, Shell Oil Co., Box 60193, New Orleans 70160)

20–22. **Geochemical** Soc., annual mtg., New Orleans, La. (E. C. T. Chao, % U.S. Geological Survey, Washington, D.C.)

20–22. **Mineralogical** Soc. of America, New Orleans, La. (G. Switzer, % U.S. National Museum, Washington, D.C. 10025)

20–22. **Paleontological** Soc. of America, New Orleans, La. (R. L. Langenheim, Dept. of Geology, Univ. of Illinois, Urbana)

26–29. American **Medical** Assoc., clinical conv., Houston, Tex. (W. E. Burmeister, Director, Convention Services Dept., AMA, 535 N. Dearborn St., Chicago, Ill.)

26–30. American Inst. of **Chemical En-**