SCIENCE

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COVER

Gray kangaroo doe (*Marcropus major*) with young in her pouch. The pouch life of the gray kangaroo is one of the longest known in the marsupials, and can last more than 300 days. See page 1221. [W. Brindle, Australian News and Information Bureau]

Scientist or statistician? Some new computer developments are changing things for the better

To the laboratory scientist, the promise of the computer is relief from a growing burden of rather boring statistical work. He is much less interested in the computer's nanosecond-speed and the bit and word-size of its memory than in its ability to accumulate data, plot graphs, make long calculations and generally perform the non-creative tasks that increasingly are reducing his effectiveness as a scientist.

Given the chance, the computer can live up to its promise. But in all too many laboratories, the computer doesn't even stand the chance of a trial because it creates new problems that some scientists consider to be worse than the old. Chief among these is the complexity of putting the computer to work in the laboratory—programming it, mastering the instrument-computer and the man-machine interfaces—which, to the scientist, is often a greater drudgery than the manual data gathering and calculations that the computer eliminates.

Two more or less recent advances in technology will make the computer more readily acceptable to the reticent scientist. The first is the small, instrument-oriented digital computer, a relatively low-cost ($10,000-$20,000) machine with easy-to-use controls, often pre-programmed to do a specific job . . . as in the lunar sample analysis experiment described later. Second is the growing popularity, at lower and lower cost, of shared-time computer leasing, which reduces the physical presence of the computer in the lab to nothing more complex than a typewriter-like keyboard. When coupled with the availability of packaged programs developed by instrument manufacturers for a specific analytical purpose—as in the simulated distillation article described next—shared-time computers will satisfy increasingly larger numbers of scientists.

In both cases, the scientist can capture the advantage of the computer without suffering its complications. Use of the computer requires nothing more complex than answering a computer-initiated dialogue in English and mathematical terms that are already familiar to the analytical technique in question . . . and entering the answer on a keyboard that requires no more than a "hunt and peck" typing skill.

Shared-Time Computer Helps GC Simulate Distillation

A far cry from the alembic used by the 16th century alchemist, the artful glassware used by the modern oil chemist for True Boiling Point (TBP) distillation nevertheless employs the same basic technique: boil and condense. To this day, TBP distillation remains the only accepted way to establish the basic marketing specification of petroleum products . . . and it leaves a lot to be desired. Those who refine petroleum products don't like it because it takes so long: TBP distillation of a wide-boiling distillate can take as long as 100 hours, and the results are useless in controlling the operation of a refinery. Those who buy petroleum products don't like it because the method is not very reproducible, especially as it applies to the initial and final boiling points. Those who perform the distillation don't like it for both of these reasons and because the procedure itself is a long and boring task.

A group of scientists at HP's Avondale Division have devised a completely automatic method that employs gas chromatography (GC) to simulate distillation and produces boiling point distribution data more precisely and in much less time—about 10 minutes—than TBP distillation. The new method employs the HP 7600A Chromatograph System which is capable of automatic unattended operation from sample measurement and injection through GC analysis and digital readout of integration data.

The recipe for simulated distillation with the 7600A is relatively simple. After installing a non-polar column of limited efficiency (most of the methyl-silane silicone rubber phases are satisfactory), set the GC for a linear program of 6 to 10°C/minute starting at −20°C, load the sample tray with as many as 36 different calibration and analytical samples, even of widely diverse boiling ranges up to 1000°F . . . and push the *start* button: the rest is automatic.

The 7600A automatically injects the samples and prepares a punched tape record of the GC retention time and area measurements at precise time intervals. Complete sets of programs provided with the 7600A enable any of the principal time-sharing computer services (including the HP 2000A Time-Shared System) to read the punched tape data, determine the initial and final boiling points of each sample, assign boiling temperatures to each data point and print out the analysis report of boiling point distribution of each sample at 1% increments.

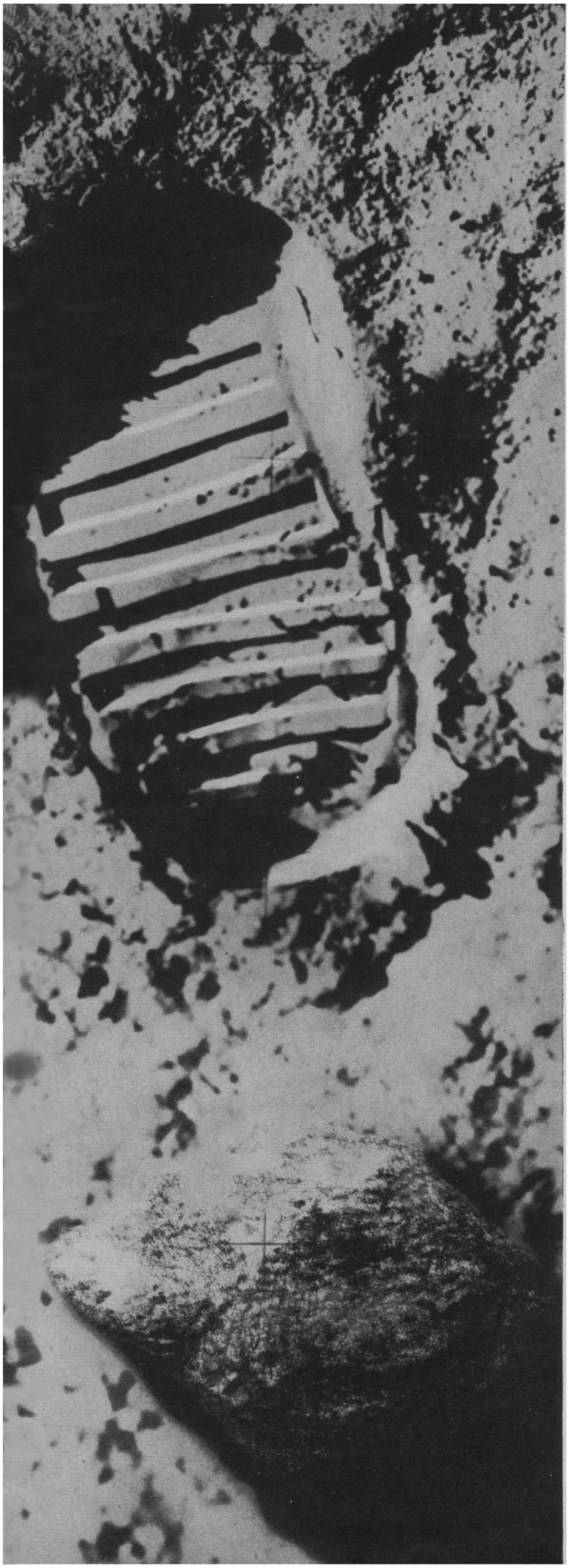
No knowledge of computer programming is required by the analyst. At each stage of the computer-performed calculations, the computer asks for the information it requires and the operator answers by typing the requested number or word on the time-share terminal keyboard.

The precision of the 7600A Simulated Distillation method with wide boiling range samples is greater than is possible by any distillation method. Its speed—an average of 10 minutes per sample—completely outclasses distillation methods.

This new automated Simulated Distillation method is examined in much more meaningful detail in Vol. 2, No. 3 of *Analytical Advances.* Request your copy today.

Dedicated Computer Extracts hidden information from Lunar sample

Some of the most respected scientific teams in the U.S. and eight foreign countries are performing analytical investigations on the lunar material returned to earth by the Apollo 11 crew. Among the 100-odd investigations scheduled by NASA, a nuclear magnetic resonance (NMR) analysis will be conducted by a Jet Propulsion Laboratory team headed by Dr. S. L. Manatt. Its goal is to characterize hydrogen nuclei in lunar material and attempt to establish whether any of it can be traced to free or crystalline water molecules presently on the moon's surface. The JPL scientists will also be on the lookout for heavy hydrogen whose presence will allow some conclusions about the history of the moon's surface and about the effect of the solar wind. A study

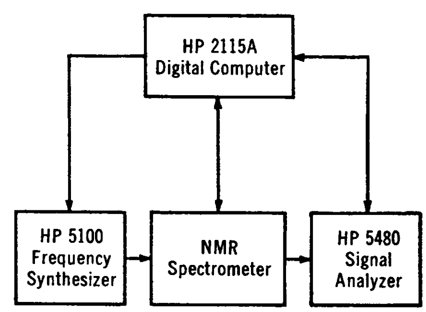


of oxygen-17 may give them important clues about the current chemical environment of the moon (from surface samples) and about the presence of a lunar sea or ocean in the distant past (from core samples).

Present-day commercial NMR spectrometers are capable of accomplishing, unaided, the work assigned to the JPL team with a creditable degree of success. But when you're analyzing samples that cost about a million dollars a gram to acquire, you're not satisfied with anything short of the best possible performance from your analytical instruments.

In the JPL team's quest for enhancing NMR sensitivity, they devised a system that combines the NMR spectrometer with a frequency synthesizer and signal analyzer under the control of a small digital computer, the HP 2115A, dedicated to this task alone.

The computer-controlled system extracts very weak NMR signals from heavy noise, enhancing instrument sensitivity as much as 100 times. It also performs fast Fourier Transforms of the NMR signal, converting it from time to frequency domain, for a further increase in sensitivity of another order of magnitude.



Here's how it works: the computer digitally sweeps both the frequency synthesizer and signal analyzer through programmed frequencies. Synthesizer output excites the NMR spectrometer which develops noise-covered resonance spikes for each nucleus in the lunar sample; under computer control, the frequency synthesizer also shifts NMR excitation between the resonance and transition frequencies of the nucleus under observation, thereby permitting measurement of relaxation or resonance decay times: The NMR output signal is fed to the signal analyzer which extracts the data from the noise and presents a calibrated display of the average signal at all times. The computer then processes the waveform, converts it from time to frequency domain by Fourier transformation and displays the result immediately in analog as well as digital form. End results of computer-controlled signal averaging and Fourier Transform is to increase spectrometer sensitivity as much as a thousand-fold. (Photo courtesy of NASA.)

Detailed information on HP Signal Analyzers and Computers is available on request. Write to Hewlett-Packard, 1507 Page Mill Road, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT PACKARD

ANALYTICAL INSTRUMENTS

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LETTERS

Two-Way Benefits of Defense Research

Like many scientists in the New York area, I was gratified to read the editorial in the *New York Times* (13 Jan.) on the funding of academic research. It is most encouraging that a subject of truly national importance, which has been surrounded by a great deal of irrational and partisan debate, should have been brought to public attention.

The *Times* article which pleaded for "orderly transfer" of nonmilitary Pentagon research to other federal agencies overlooks the harsh reality of research budget cuts everywhere; cuts in research funds at this time are likely to undermine many universities' financial structure. To eliminate defense funding without facing up to real needs is to replace expedience with neglect. A sharp delineation between basic, nonmilitary, and mission-oriented research is not possible and research is not a supply line than can be turned on or off at will.

Scientific contributions to man's knowledge have always been in the service of all of man's needs including (rightly or wrongly) his armory. From Archimedes to Leonardo da Vinci to this day, science in war and peace provided the potential from which military inventiveness designed its hardware. If the present law stipulates that cooperation by universities be limited to areas of evident military application, this violates the basic mission of universities and excludes true academic participation. The cooperation between the Department of Defense and universities is far from a one-way affair, on the financial or the intellectual level. The vast storehouse of factual information at the disposal of DoD is of very great value to the academic man who in turn can prevent DoD from becoming insulated from the trends of the day or from investing in dubious causes. In any case, to undertake to decide beforehand which piece of scientific inquiry is going to be useful to the military is trying to chart the unknown. Therefore, apart from the facts pointed out in the *Times* editorial that the new congressional rule can only serve to reduce seriously the support for scientific inquiry in this country, it must be emphasized that diluting the military-university partnership is not only bound to cause serious delays in transmission of new knowledge, but will impair the building of a force of academic men who have the necessary defense background in case of emergency. If the British had delayed the development of radar by only 6 months, if France had not insisted on butter before guns between the wars, or if Hitler's politics had not interfered with the development of nuclear physics at a time when all the trumps were in his hands, history would have taken another turn. In times when the next war may come undeclared and be over in a few hours or days, we are flirting with catastrophe to stifle the military-university interchange.

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Campus Computer Costs

Mark Oberle's article entitled "Campus computers: Federal budget cuts hit university centers" (26 Sept., p. 1337) failed to consider what we believe to be a major inequity in regard to the use of university computer facilities by government research projects on campus. He states that "The Bureau of the Budget requires that all users of a computer that handles government-sponsored projects be charged the same rate for the same service." However, this is not necessarily true. Under some circumstances the government requires that the cost to university users not funded by government contracts or grants must be greater than the cost to university users who are government-supported.

This situation arises because the government refuses to recognize interest charges (on money borrowed to purchase, rather than lease, a computer) as an allowable cost to government contracts and grants. Although the interest expense which is included in the lease price of a computer by the manufacturer or by a third party is an allowable expense, the university is not always given the option of leasing. Should the lease payments on a system exceed what would have been the annualized amortization of that system's purchase price, the government can disallow lease costs in excess of that depreciation figure. Since many universities plan to retain their systems for beyond that break-even point, they are in a sense "forced" to purchase their computer equipment. Economic considerations may also point toward a purchase decision. However, it is often necessary to borrow money in order to purchase a major computing system today. This is particularly true in view of the current financial straits of most universities. Yet, the government will not permit its users to pay their fair share of the interest charges on the funds used to purchase the computer, requiring instead that the university-funded users pay not only for their own share but for the government-sponsored users' share as well. The magnitude of the inequity becomes apparent when one considers that the interest costs for a $3-million computer system amortized over 5 years amounts to more than $780,000 at today's interest rates.

It is easy to understand how the government policy of not allowing interest expense came into existence. Where commercial profit-making organizations are involved, the government can validly argue that profit is defined to include return on capital investment as well as rewards for risk-taking and accomplishment. Thus it would neither be fair nor in the government's interest to permit a contractor to exercise high leverage through debt rather than equity financing, recover the interest cost of borrowed capital and obtain a profit on it while other contractors, using invested capital, must pay their capital costs from profits alone. Therefore, no cost allowance is permitted for "interest" computed on invested capital, for dividends on equity capital, or for interest paid on borrowed capital. The source of capital is not of concern, and the contractor is expected to pay the cost of capital from profits. In the case of nonprofit educational institutions, however, it is clear that the above factors are irrelevant.

Private colleges and universities operating under the Internal Revenue Service regulations for nonprofit institutions cannot very well sell stock to raise capital, so borrowing from the bank must be the avenue for financing equipment acquisitions. Even if an institution were willing to invest endowment capital in a new computer, the loss of endowment income would represent a real cost to the institution, equivalent to the payment of interest. Yet, when such an institution performs work for government-sponsored users, it is allowed neither profit nor interest recovery regardless of the fact that a capital cost is incurred. One must then conclude that the government is adversely discriminating against colleges and universities in the handling of computer costs.

Further, the policy of not allowing interest expense can also result in government funded users paying more for computer usage than they would if the interest expense of nonprofit organizations were allowed. For example, a nonprofit contractor often elects to lease computers from the manufacturer or from a third party (interest on the capital being included in the lease price) for shorter periods of time than they otherwise would so that cumulative lease costs are less than purchase price. Yet, the purchase price plus the interest expense less the residual salvage value of the equipment at the end of the period will frequently turn out to be less expensive than the cumulative lease payments over the period.

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New Ringmaster—Same Circus?

The article by Carter (26 Dec., p. 1603) records the departure of Yannacone as general counsel of the Environmental Defense Fund (EDF) and states the scale of compensation which furnished the incentive for his cross-examination of scientific witnesses. Wurster [*BioScience* **19**, 809 (1969)] has extolled Yannacone's courtroom tactics as furnishing the "acid test of relevance and competence" for obtaining information on DDT. Yannacone was described in *Science* (22 Dec. 1967, p. 1552) as without "formal training in ecology."

The bizarre tactics employed by Yannacone at the Wisconsin hearings, according to the hearing examiner, included "histrionics and badgering witnesses." I have hoped that the material in those hearings might some day be reexamined in a more orderly scientific atmosphere, but this seems doubtful: EDF's new general counsel boasted in the hearings at Seattle on 16 October of his lack of training in biology. My prediction for the EDF is: same traveling circus, different ringmaster.

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Chance, or Human Judgment?

For some kinds of decisions, chance may be better than human judgment. Adoption of the policy of selecting draftees by a random drawing of birth dates has been widely commended as the most democratic method available when the number of men who must be drafted is only a fraction of the number of men available.

If risk should be allocated by lot, perhaps benefit should be also. The Federal City College (the new land-grant college in Washington, D.C.) had many more applicants than could be admitted to its first class. Selection on the basis of grades or test scores was inappropriate, for the institution was intended to be an "open door" community college. A lottery solved the selection problem. In December, the arts and sciences college of the University of Illinois used a lottery to choose its quota of 3350 new students from among 4200 well-qualified applicants for admission in the autumn of 1970. In this case, the 850 losers were less impressed with the democratic fairness of a lottery than were the 3350 winners; public pressure, including pressure from parents of rejected applicants, persuaded the university to reconsider, and to accept all 4200 qualified applicants. The university has, however, announced that, if necessary, it will use random selection for 1971.

There are other selection decisions that could be made by chance. Traditionally, the best medical care has been available to the affluent, and in some places also to the indigent. If excellent medical care is not available to everyone, would not allocation on a random basis be more equitable?

A general principle can be stated: when the number of eligible people exceeds the number who must bear a particular burden or who can receive a particular benefit, the most democratic, equitable, and moral basis for allocation is by chance.

* * *

The use of a lottery to decide who will receive a benefit that cannot be granted to all or who will bear a burden that need not fall on all is a denial of rationality. Under an earlier method of selecting draftees, local draft boards could take into account the particular circumstances of individual men and the particular needs of the country or the communities in which they lived. Errors and biased decisions no doubt occurred, but the system honored the rational judgment of a group of one's fellow citizens, not the luck of the draw.

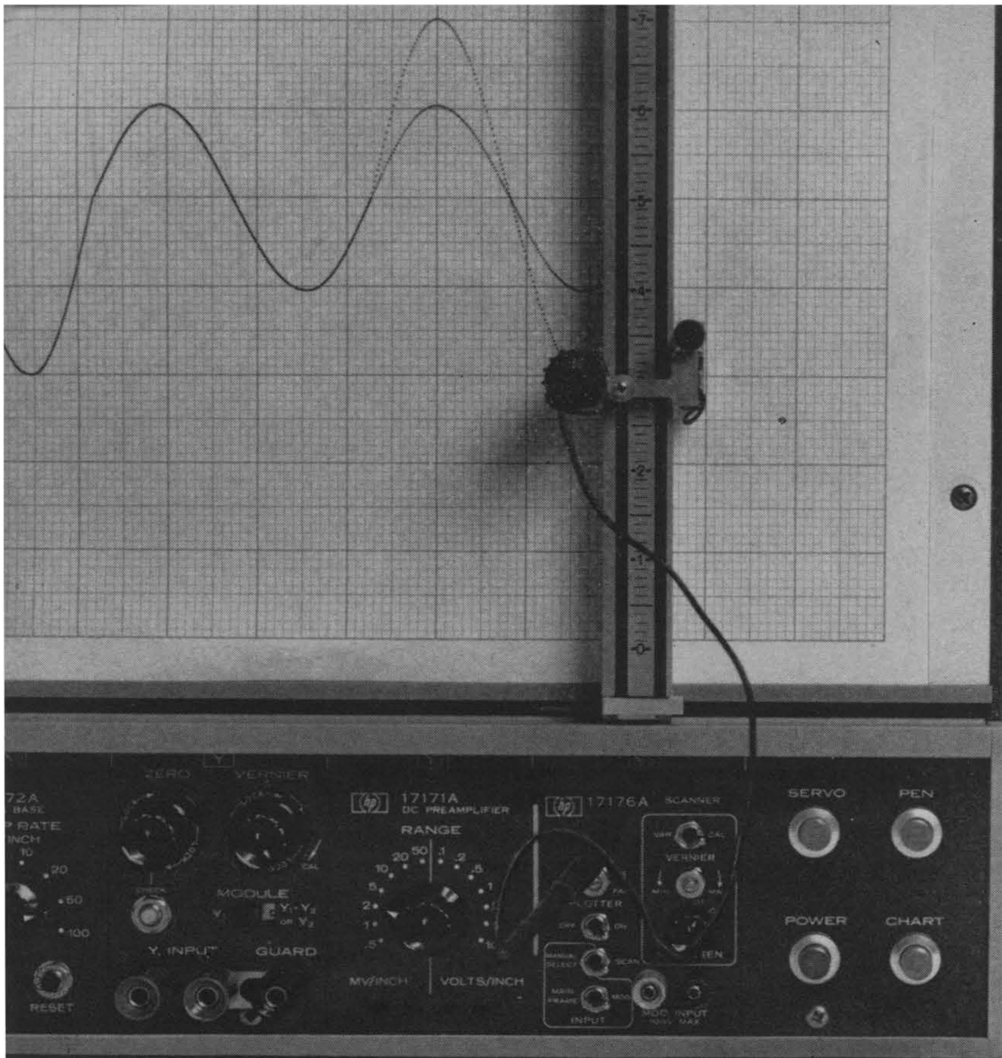
To choose students by a random process is to deny the ability of the faculty to select those applicants who show greatest promise or who appear most likely to benefit from higher education.

In times of battle or catastrophe, a triage officer selects the ill and wounded who most need, and who are most likely to respond favorably to, prompt medical attention. A physician is surely more competent than a pair of dice to make such decisions and to determine which patients should be given access to limited medical resources.

To use a lottery to allocate risks or benefits is not only a denial of rationality, it is also a denial of man's humanity; each man is reduced to a cipher, distinguished from other ciphers only by the uniqueness of the combination of digits that identify his records in a growing number of office files.

* * *

Should Judgment wear a blindfold, or should she be required to see the persons judged?—DAEL WOLFLE



Two in one

Hewlett-Packard now offers you a new extra advantage in X-Y recording – the 17176A Dual-Trace unit – a new accessory for the world's first truly "plug-in" recorder, the 7004A. It lets you plot, with a standard recorder, two variables against a third – without the expense of a two-pen system.

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Price, too, is part of the new plug-in's uniqueness: $300. The 7004 X-Y Recorder costs $1395. The 17012B Point Plotter, $95. Additional plug-ins for either x or y channels start at $25.

To find out how you can get double your money's worth in an X-Y recorder, call your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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