letters

Masters in instrumentation

In response to your October news article (page 85) on future prospects for jobs in physics, we in the physics department at the University of California, Santa Barbara would like to describe our successful six-year-old experiment in graduate education at Santa Barbara: the Master of Science in Instrumentation program. We wish to suggest to other departments that such a program stands to benefit from recent developments in technology as well as changing attitudes about the purpose of graduate education.

GUEST COMMENT

by David F. Nicoli
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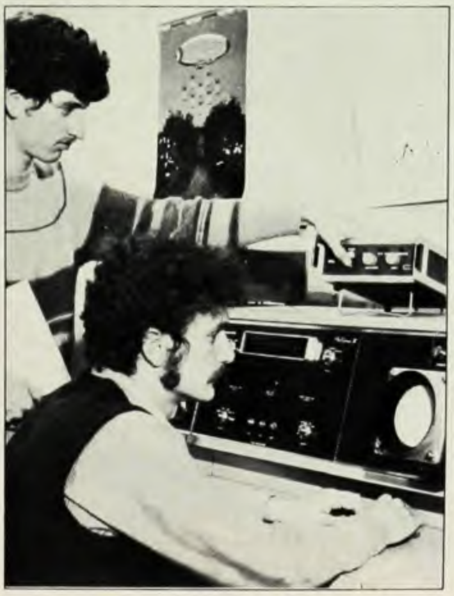
The motivation for creation of the MSI program by Vincent Jaccarino and Virgil Elings in 1972 was to provide intermediate-level graduate training for the sort of person research laboratories seemed to be crying out for: namely, a "master of instrumentation," who is able independently to translate ideas relating to a scientific measurement into the design *and* construction of a professional-quality electronic instrument.

The MSI program is popular at UCSB; its yearly average of ten entering students accounts for roughly half of the total entering physics graduate-student population. The opportunity to receive "hands-on" training in a vital applied area with a commitment of only two years appeals to an increasing number of capable students who have rejected the alternative of seeking a PhD degree—which is several years down the road and too ambiguously linked to future goals given present-day employment trends.

These MSI students become active participants in the revolution that is microelectronics. Ironically, such a program can return some of the excitement and "action" of solid-state electronics back to a physics department where, of course, it all began two and three decades ago. The revolution in large-scale integrated electronics is notable not only because it provides such astounding tools at exceedingly low cost but especially because it has made this technology more accessible to *non-specialists*.



The admissions policy of UCSB regarding MSI applicants has been to determine, primarily from grades, whether in the past a given student has applied himself and done well with whatever he has attempted. Prior knowledge of electronics is not a requirement. An extreme emphasis is placed on individual work in the laboratory. It is where projects are discussed, designed and constructed. It is in the laboratory alone that there occurs that moment of truth for every MSI student: can he make something *work?* For most students this is the first time that such a demand has been made of them, and for some it clearly provides a rude awakening from the spoon-feeding of most undergraduate experiences.

The first year of the program is devoted to work on a series of projects of typical duration two to three months. The students are largely responsible for finding these ideas from within the department or from other science faculty on campus. The projects must have real "clients"—those who have a vested interest in the timely and successful completion of the project.

The second year is devoted mainly to a single large-scale project. It must be original and challenging and be fully documented upon completion. One exciting aspect of microelectronics is that the resulting "intelligent" instruments may be easily redesigned to meet altered specifications, often by simple software changes. The emphasis, again, is on the conceptual design rather than the tedious details of hardware and circuitry, from which the "new" electronics has largely liberated us. Some past instruments include ultrasound cardiac dimensioning, light scattering immunoassay, a sensitive gravimeter, speech display for deaf children and a thermal-dilution cardiac output computer.

Perhaps not surprisingly, the graduates of MSI and UCSB are finding a variety of attractive employment opportunities. A number of them have accepted offers from university research groups, mainly in physics, biology and medicine. Others have taken positions in industrial research labs, often in the semiconductor area. These include Stanford Research Institute, Hewlett-Packard, TRW, IBM and National Semiconductor. Indeed, for a good student the MSI degree may produce a wider spectrum of employment options than would a PhD in applied physics.

Obviously, instrumentation expertise is vital for any serious experimental research effort. Hence, it can be argued that a physics department can itself benefit from such an in-house degree program in instrumentation.

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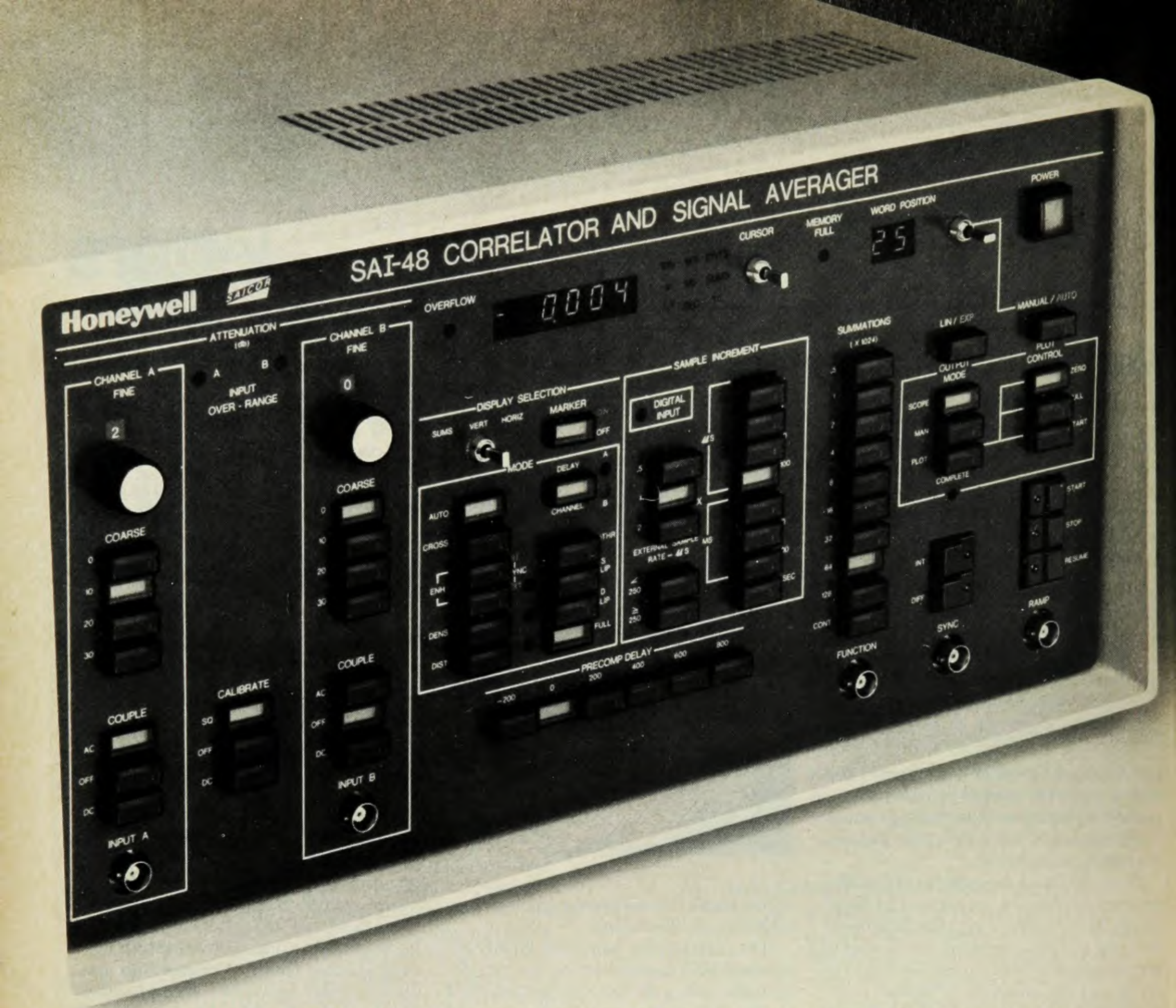
Index to astronomy articles

The huge breadth of topics encompassed by modern astronomy and astrophysics makes it almost impossible for the instructor of an introductory astronomy course to be sufficiently knowledgeable about every topic he must cover to be able to field every question his brighter students may raise or to discuss current problems in the light of the most recent results. This problem is also encountered in many other fields of physics. The series of "Resource Letters"[1] published by



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the AAPT was one attempt to alleviate this problem by collecting lists of important references (with annotations) on various subjects of current interest. The AAPT Selected Reprint series is a similar attempt. Recently, A. Fraknoi published a "Subject Index to Astronomy Articles in *Scientific American* Magazine (1960–1976)" in *Mercury*,[2] a publication of the Astronomical Society of the Pacific. Although this contribution was aimed at enlightening lay people and amateur astronomers, it will nevertheless be extremely useful to students and teachers of astronomy as well. Following the lead of Fraknoi we have compiled a subject list to astronomy articles in PHYSICS TODAY.

This index is comprehensive in that it contains references to every astronomy-related (including astrophysics, astronautics and geophysics) feature article published in PHYSICS TODAY during its first thirty years of publication (1948 through 1977). It does not, however, include book reviews, letters, or brief reports in the "Search and Discovery" column. The compilation is extensively cross-referenced and is organized by subject headings that correspond closely to those employed by Franknoi. Thus this index will complement his.

References

1. Anonymous, *Am. J. Phys.*, **38**, 1053 (1970).
2. A. Fraknoi, *Mercury*, **6**, no. 1, 20 (1977).

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Readers may obtain copies of Harney's subject index by writing to PHYSICS TODAY enclosing $2.00 in check or money order for each copy.
The Editor

Opposes MBO

Thomas M. Tobin, in his letter on management by objective (February, page 83), used a phrase in his third paragraph that indicates the real source of trouble in applying MBO in a research laboratory. The phrase is "delegation of responsibility." Any ROTC student learns that one can delegate authority but not responsibility. The two concepts are radically different in meaning. All too often it seems that bench scientists have responsibility for everything and authority over nothing. Accountability is little more than harrassment if the person who is held accountable does not have the discretionary authority and support in securing the resources to accomplish his objectives.

Advocates of MBO presume some sort of idealized environment in which supervisors are visionary and competent, in which organizations are willing to take suggestions from the bench, and in which there is a willingness to take risks and fail. It is also presumed that those who apply MBO know the difference between planning an investigation and predetermining success. (It would not be research if it were possible to program a successful result.) The inclusion of the Peter Principle into the consideration may lead one to question the efficacy of MBO. MBO becomes an instrument by which those who have the least say in what they do (and the most responsibility) become bullied into becoming scapegoats by those who have retained all of the authority.

The real-world misapplication of MBO leads to a decline in innovation. The bench scientist, who is made ultimately responsible, learns early that there is no room for failure. If he manages to keep his job past his first failure, he learns that success or, at least, the *illusion* of success is required. Extend these attitudes to a larger scale and one will see only "safe" projects being taken, risk and failure avoided, and real progress disappearing.

It is a remarkable coincidence that the advocacy of MBO has occurred while many scientists have been and continue to be underemployed and unemployed and, at the same time, the leadership of American science has been evaporating. Maybe it is time to discard useless management systems like MBO and hire people to do *science*.

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Catastrophe theory

Schulman's review (January, page 75) of two "catastrophe theory" books is excellent in the main, but I would take issue with one assertion: that optical caustics as catastrophes "do not represent an application of Thom's theorem because that theorem applies only to finite dimensional 'state' spaces." They do represent such an application, by way of a rigorous, finite-dimensional treatment of oscillatory integrals. (The most complete technical account is in J. J. Duistermaat, *Comm. Pure Appl. Math.* **27**, 207 (1974).) My point in the essay cited was that a version of Thom's theorem valid in infinite dimensions would give a natural way of seeing at the ray-theoretic (or classical-limit) level why caustics "should" be catastrophes, though the physical information or "quantum flesh on the classical bones" available by the existing method would be missing. Moreover such a version would be applicable to a wide range of other problems.

Since "Thom's theorem" actually represents a cluster of results, an infinite-dimensional version naturally appears piecemeal. The main results on truncation of Taylor series and insensitivity to