letters

More physics on Saturday morning

In his recent letter (September, page 11), Leon Lederman described Fermilab's Saturday-morning physics classes designed to "rekindle the flame among bright high-school science students." I share his concern with the quality of teaching of math and science in American high schools and the need for other institutions to augment those efforts if we are to reverse a trend which threatens our nation's well-being.

I hope the following descriptions of three Caltech programs for high-school students will help stimulate discussion of potential initiatives by research institutions aimed at increasing interest in science.

The first of these is a Saturday-morning science and math project for secondary-school students, similar to Fermilab's program. The program offers more than 20 October-to-May classes in subjects such as astronomy, geology, oceanography and physics, taught by Caltech undergraduate and graduate students. Some 378 students from the Los Angeles area are enrolled in the 1982–83 program.

The second program is a monthly after-school lecture by a Caltech faculty member for high-school students and their teachers. The first lecture this fall, on the population "bomb," attracted 120 attendees.

Our third program is a four-days-per-week, seven-week summer school conducted on campus. Participating high-school students select a single class in molecular biology, chemistry, physics/trigonometry or physics/calculus. There is no admission charge and no admission requirement except a math prerequisite (according to program director Lee Browne, "any student who is willing to give up seven weeks of vacation to be in class five hours a day and then have a couple of more hours of homework is self-selecting").

Although primarily intended for students from the Los Angeles area, this past summer's 372 participants included students from 12 states, Canada, France and Ivory Coast. Like the Saturday-morning classes, summer classes are taught by Caltech students. Faculty members give occasional guest lectures (Richard Feynman spoke to both physics classes this past summer). No credit is granted by the Institute, but we recommend that local school districts give credit to those students who earn an *A* or *B* grade.

Incidentally, many Caltech students have opted for teaching careers as a result of their experience as instructors in the Saturday-morning and summer programs.

Living in a world of limited resources demands the most creative use of science and technology. And public issues increasingly require both scientifically enlightened leadership and scientifically literate citizens. Thus, I hope more and more institutions will join Fermilab and Caltech in mounting pre-college science education programs.

MARVIN L. GOLDBERGER
California Institute of Technology
10/82 *Pasadena, California*

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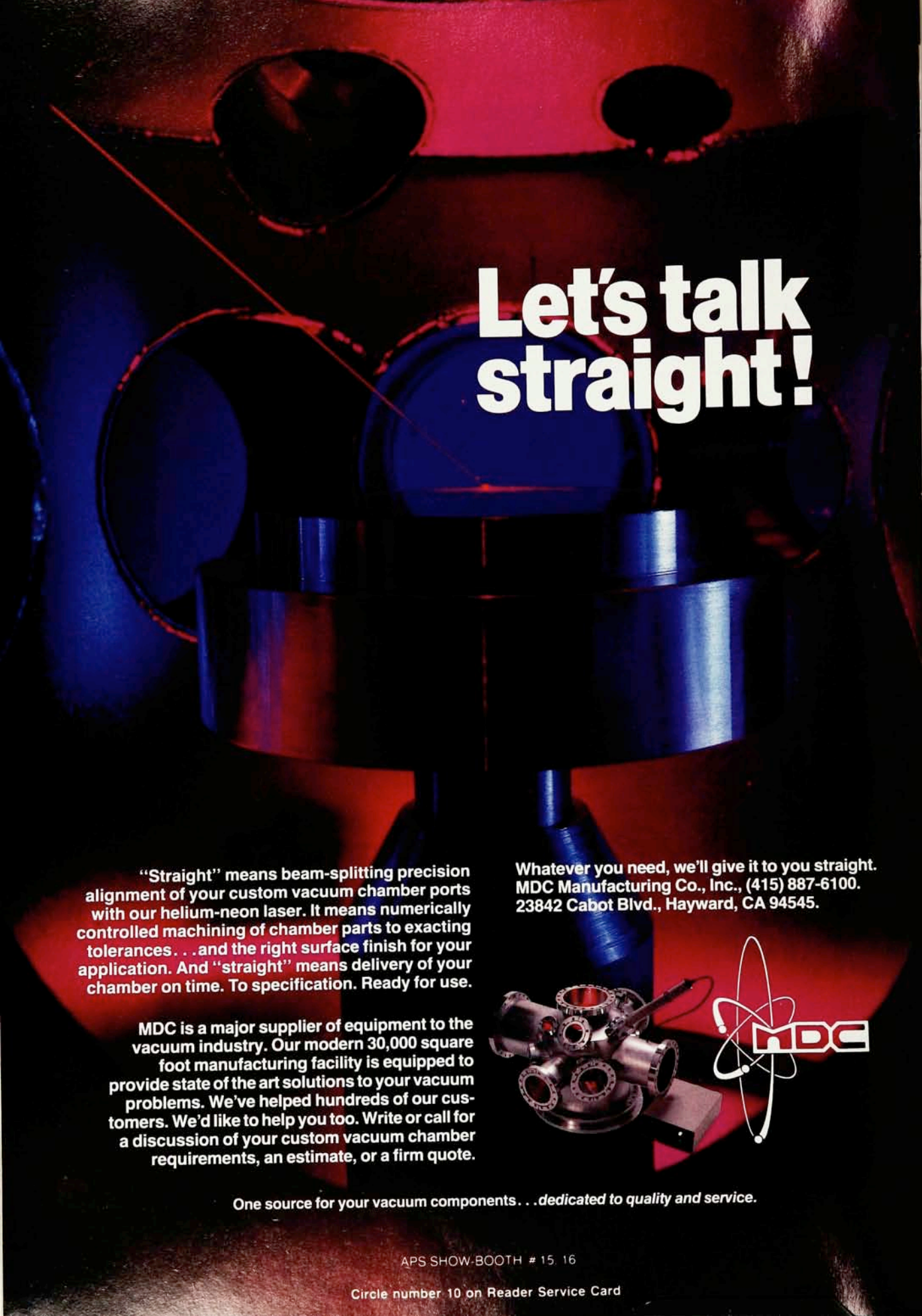
The recent letter from Leon Lederman describing a Saturday-morning program for high-school students struck a resonant chord at Yale. We have been running a very similar program for the past ten years and we have made contact with some 2000 students during that time. We agree wholeheartedly that such programs can make a significant contribution in raising scientific awareness in high schools.

The Yale program differs in a number of respects from that at Fermilab, and our experience may be useful to others contemplating a similar venture. First, our program is not restricted to topics in physics, as one can see from the partial list of lectures we have offered in recent years (see table). Discussions with small groups of students following the lectures have shown that the topics closest to physics are, generally, the hardest for them to understand, and that physicists have to be especially careful not to assume too much prior knowledge from their audiences. Even in a highly selected group of high-school students, only a few will have any real grasp of physics, while a significantly greater proportion seem comfortable with topics related to biology, chemistry or computers. How-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ever, even with computers we were surprised to find that a relatively large number of high schools still do not offer students any instruction or facilities. If one is to aim at a reasonable cross-section of students, one must be careful to interest them without overwhelming them. Needless to say, one must be even more careful to avoid talking down to them.

One device which we have found very useful in reaching students is to encourage all lecturers to use as many live demonstrations as possible. The sight of the "real thing" will often make a point when a careful explanation will not.

Early on, we also recognized that it was probably more important to *interest* the students than to *instruct* them, and we decided, therefore, to offer a wide range of essentially unrelated topics in the hope that at least some of them would stimulate the students' thoughts. The variety of enthusiastic responses seems to have justified this expectation.

Each lecture is followed by a break for donuts and soda, during which the students can ask questions and examine the demonstration equipment. They are then divided into groups of 25, which are taken by guides to visit three or four different laboratories where there are again demonstrations. We have found it useful to give the students written or printed hand-out material, particularly for the laboratories where it is hard to take notes. Students are readily impressed by complex arrays of equipment, but it is easy for them to forget what they have seen.

We also arrange some informal "rap" sessions with small groups of students, and in these we have tried to get them to understand something of the life of a scientist, as a professional and as a student, and we have found some interesting misconceptions. Most students seem to believe, for example, that being a scientist is essentially a lonely occupation, and they are surprised to hear about collaborative efforts and the other interactions we enjoy. We also discuss with them the role they see for women scientists, noting that about fifty percent of the participants in our program are female. Surprisingly, few seem to express any problems in this area and one cannot help wondering

Saturday morning lectures

for high-school juniors

Selected Topics 1972–1982

Signals and systems in engineering
Controlling the Unknown: A systems approach
Molecular beams: Order from chaos
Lasers
Holography and its applications
How do bacteria sense and respond to information about their environment
Very low temperature: The long road to absolute zero
Artificial intelligence
Electron and laser microscopes
The technology of computation
Color filters in eyes of insects
The beginnings of chaotic behavior in systems
When electrons collide with molecules
Plasmas: Ionized gases in our world
Organic reactions in super-acids
Chemical reactions: How fast can we make them go?
Catalysis: The selective acceleration of chemial reactions
Applications of liquid crystals
Structure of biological molecules
Chemical reactions in organic solids
Enzyme catalysis: A new tool for chemical engineers
Will the Universe expand forever?
Diagnostic ultrasound: Probing the human body with sound
Recognizing patterns in images
Solar energy
Energy and society
Nuclear energy and coal as near-term options
Thermal and materials problems of manned space shuttles
The sense of taste: Why things don't always taste the same to everyone
New directions in physical sciences
The computer as a research tool
Past, present and future of Long Island Sound
Sound reproduction: The decibel and you
Gene function in higher cells
Nonlinear phenomena: good and bad
Aerodynamics of automobiles
Growing the crystals we need
Electrochemistry: Engineering with electrons
Engineering and medicine: Career preparation and collaborative possibilities
Information: What is it and how do you handle it?
Medical imaging technology: present and future
Microelectronics: Science, technology and applications
What is the source of solar energy?
Natural radioactivity: tracers and chronometers on Earth
Concorde: Problems and future of supersonic air transportation
The physical ideas of modern optics
Air pollution levels in New Haven and their effect on health and well-being
The glassy state of matter: engineering and applied disorder
Understanding and engineering the chemical gasification of solids
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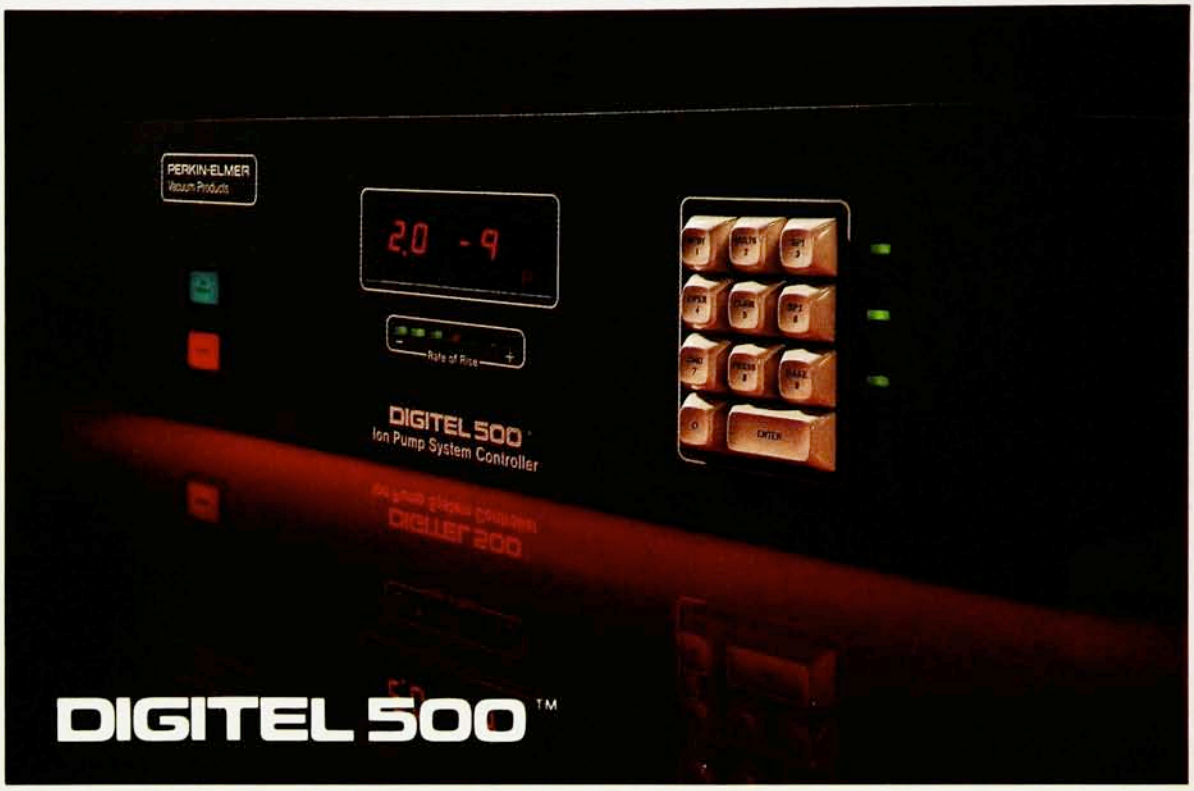

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why more of them do not end up in our ranks.

While we feel that programs such as ours and the one at Fermilab are important in establishing some contact with the schools, there are other, perhaps more far-reaching efforts that should also be made. One of these is to counteract the "science-phobia" that grips the *majority* of the college students in this country. The idea that science is hard and only for scientists pervades school boards, legislatures and even some science faculties in our universities. Carefully designed college courses for non-science majors can be very effective in alleviating this problem, and we have been very successful with a number of such courses at Yale. Copious demonstrations and illustrations are again the key, as is a recognition of the fact that these students want to *understand* science and technology but not to *do* it themselves. It will take some time, but if more of the general population of this country had a better appreciation of science, the disastrous trend in our schools would begin to receive the attention it needs.

In the meanwhile, all efforts to reach this goal should be pursued, and we would like to join Fermilab in offering to exchange ideas with anyone working on this important problem.

WERNER P. WOLF
Yale University
10/82 *New Haven, Connecticut*

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We read with great interest and pleasure the recent letter by Leon Lederman about the Saturday physics program at Fermilab for high-school science students. At the Westinghouse R&D Center in Pittsburgh, we are in our twenty-sixth year of sponsoring the Westinghouse Science Honors Institute, nicknamed Saturday Science, which has been operating in a manner almost identical to the Fermilab program. The institute is staffed and operated by scientists who volunteer their time and effort out of the conviction that it is our professional responsibility to promote the cause of science in this fashion, and sponsored by Westinghouse out of respect for that conviction. Our annual series consists of 12 lectures (profusely embellished with working demonstrations) but is not limited to physics. Because of popular demand in recent years, we broadened the scope to encompass the life sciences. While most of the lectures are given by scientists from Westinghouse, we have found it desirable from time to time to include guest lecturers from local universities. In any case, we have not attempted so much to balance the program as to have outstanding speakers who may inspire students to consider careers in science. Each of our sessions is offered to 250 seniors (the capacity of the R&D Center auditorium) from about 55 high schools in the Pittsburgh area, chosen for their ability and interest. A recent very successful addition to our program is the granting of two summer internships each year to the top scorers on an optional examination based upon the 12 lectures. These students, working largely independently but under the supervision of scientists at the R&D Center who enjoy the challenge and stimulation of very bright young people, have consistently turned out excellent, professionally done projects that have been a credit to themselves and the laboratories.

Our experience with the Westinghouse Science Honors Institute over the years is that it is greatly respected and appreciated by the local community and considered by a number of schools to be a part of their academic year. We have been a strong positive influence for promoting scientific literacy among many who do not follow science careers, as well as giving some direction to the most scientifically talented among our students. We applaud Fermilab for devoting a small part of their resources to reach out to our best high-school students and expect they will find as much satisfaction in doing so as we have.

MILTON GOTTLIEB
PAUL SLADE
Westinghouse Science Honors Institute
11/82 *Pittsburgh, Pennsylvania*

Ice age in physics

The simulated-annealing statistical mechanical approach to complex optimization problems (May, page 17) is highly intriguing. With a bit of forgiveness for loose thinking, it might be adapted to modeling of the scientific process itself. The traveling-salesman problem ("optimally" to link up a given set of nodes), for instance, is suggestive of thematic links or idea-sharings that connect nodal subsets of minds engaged in the attempt to describe nature. All too often, a social phenomenon analogous to too-rapid cooling occurs, by which very strange ideas indeed (for example, quarks, black holes) freeze out of the "melt" and are perpetuated. Associating a "temperature" with the intellectual climate, one observes that in fundamental physics a sort of "ice age" seems to have set in, beginning during the second quarter of the twentieth century. Given a strong application of "heat" to agitate the neurons,

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