Industry–university research programs

These joint efforts can benefit all participants, but must be carefully structured from the outset to protect the interests of both the industrial sponsor and the university.

Kenneth A. Smith

Cooperative research ventures between industrial sponsors and universities are attracting increasing attention, not only because they offer benefits for both parties, but also because they promise to improve technology transfer for the nation as a whole. Yet there are risks inherent in such arrangements, as much recent press coverage suggests. This press attention reflects a concern that the needs of industrial sponsors for proprietary secrecy and other competitive advantages may undermine academic traditions of open scientific exchange. I shall examine these issues in the light of our experience with joint programs at MIT. I am not presenting MIT as a paradigm for success in this area, but we have had, perhaps, more experience with these arrangements than any other campus (see table, page 27); also, these are the arrangements with which I am most familiar. Our experiences at MIT have led me to conclude that the incentives for both parties must, from the outset, be clarified and assessed, for they are key to the evolution of a strong and healthy partnership. I shall also discuss means we have found useful for resolving areas of innate conflict between the industrial and academic perspectives, and I shall identify the kinds of conditions we have found essential for the long-term success of these arrangements.

Incentives for universities

First, let us consider the possible incentives of the two parties. For the university, the money is certainly always important. But, even in the most optimistic scenarios, funding from industrial sources will be modest compared to that which universities already receive from Federal sources. There are limits to the ultimate growth of industrial funding; industry research budgets are simply not without bounds. At MIT in the fiscal year just completed, about 10 percent of our sponsored research was funded by industry. My own private guess is that this number might grow to something like 15 or 20 percent, but I think it is very unlikely that it will grow substantially beyond this. Also, industrial sponsors are likely to have areas of interest that are substantially different from those of the Federal agencies. Certain kinds of research in cancer, cognition, high-energy physics, plasma fusion and so forth are not likely to be of interest to the industrial sector.

I think the intellectual incentive is far more important. To a first approximation, there has not been an industrial presence on university campuses for three decades—students and faculty have had little exposure to industrial problems or to industrial motivations. Thus they've tended to adopt the values of their environment, which is the university, and of their sponsor, which has largely been the Federal government. This being the case, the universities have simply not been enriched by strong interactions with industry, despite the fact that most students seek employment in industry and despite the fact that industry is, after all, the agent through which the benefits of science and technology are usually transferred to the public. In this connection, it is certainly relevant to note that PhD physicists, for the last decade, have been increasingly employed by industry. We no longer hear the horror stories of the late sixties in which PhD physicists were seen fit only to drive taxicabs. The reason is not that the universities are employing more of the recent PhDs, but rather that the industries are.

Incentives for industry

So much for the universities. What are the incentives for industry? I think there are several. Particularly in quickly developing fields, affiliation with the university can minimize the inefficiencies and shorten the period associated with the early portion of the learning process. This is evident in the area of biotechnology, where much of the excitement about university–industry interaction has been focused.

In some cases, the motivation for the industrial cooperation is simply access to some outstandingly creative people, both faculty and students. In other instances, industries clearly want a window on an area of technology that may be of some significance to them, but to which they cannot commit major resources: The joint arrangement may be the most efficient way for them to maintain the role of an interested observer.

An enlightened self-interest is often at work as well: As an employer of university-trained people and as a user of university-generated knowledge, industry, too, is concerned about the value system of the university and knows that a *bona fide* relationship is essential if it is to have any impact on these values.

Finally, many industries have longstanding philanthropic interests in and commitments to universities; such historical ties are in themselves often valuable for an industry.

National interest

We also need to discuss the national interest in this kind of cooperation. This interest is usually not mentioned, but I think in some ways it is the most important one: If there is not a national interest in this kind of cooperation, joint efforts cannot survive in the long term. The national interest, in my judgment, hinges on whether stronger university–industry interactions can improve our ability to implement scientific and technological advances. Certainly our international competitors—for example, the Federal Republic of Germany and Japan—have not often succeeded in seizing the position of scientific leadership from us. However, they have often succeeded in superior implementation. It is this

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problem that can be addressed by a stronger connection between universities and industry.

This point is particularly relevant, given that the current Administration in Washington originally proposed that basic research should in fact receive strong Federal support, but that applied research should not receive strong Federal support. In the Administration's judgment, applied research was to be the business of business. This would leave industry-university cooperation in a somewhat precarious situation. If the Federal government ceased to fund some of the more applied research at universities, and if industry chose either not to fund such work at the universities or in fact to do it in-house, then the gulf between the universities and industry could increase rather than diminish. Fortunately, the Administration has now stated a clear appreciation of the unique role of universities *both* to develop talent and to perform research. For this reason, there is currently a heightened awareness of the contributions universities can provide in both the basic and the more applied areas.

Problems of cooperation

We have discussed the incentives. What, then, are the problems? The problems are many, and several of them have attracted great notice in the press. I think that there are five significant problem areas in all, the first two of which are seldom mentioned:

▶ The relevance of a proposed line of inquiry to the essential missions of the university and the industry—how to design a collaborative program that maintains balance between the university's pursuit of research as an integral part of the educational process, and industry's search for useful knowledge to be applied in the development of products, processes and services.

▶ The time frame for research efforts—how to organize a program that accommodates the different time constants of industry and the university. For instance, graduate students and their thesis projects, which at the doctoral level may stretch over several years, are intimately involved with the research effort, but industry is subject to the shorter-time pressures of the marketplace.

▶ The issue of proprietary rights versus openness—how to assure the protection of proprietary information provided by industry while meeting the statutory and ethical requirements of the university, which demand that research serve a broad public good, that it be conducted in an atmosphere of openness and free exchange and that results be available for distribution on a non-confidential basis.

▶ The issue of patents and copyrights—how to determine methods of licensing that will promote the progress of science and technology, assure that discoveries and inventions are used in the ways most likely to benefit the public and provide both adequate recognition to the inventors and appropriate financial support to the universities.

▶ The issue of conflict of commitment—how to assure that the primary allegiance of the faculty member remains with the university. This question becomes particularly serious if research funding is to be derived from a new venture in which the faculty member has taken an equity position.

Of these five problems, the first two—joint relevance and compatibility of time constants—are seldom mentioned, but they are in fact the most common problems. I find that when discussions with prospective industrial

Robot arm is adjusted by graduate student Kamel Youcef Toumi in research project under way at MIT's Laboratory for Manufacturing and Productivity.

sponsors begin, these are the first to emerge. Perhaps they have attracted so little attention because if resolution is possible at all, it is achieved by straightforward negotiation.

The last three problems, proprietary information, patent rights and conflict of commitment, have been the subject of intense discussion because they have the potential for influencing fundamental values of the university—its credibility as a free-standing independent institution, including the traditional obligation to disseminate information, and the quality of collegiality within that institution.

A case study

Given these problems, what has MIT's practice been? First, I think it's important to say something about MIT. It was founded in 1861 with the expectation of a close association with industry. It is a land-grant institution. Its charter commits it to efforts in what were then referred to as "the practical arts." Certain of these attitudes have continued to permeate MIT to the present and are responsible for the fact that our relationships with industry have been stronger than those of most other universities.

MIT has probably also been less perplexed by some of these new arrangements than many other universities. Indeed, we welcome them, in part, because we have in many cases previously encountered the issues raised by the arrangements. For example, the Institute has long had a very substantial involvement with the chemical and petroleum industries during their rapid development in the 1930s and 1940s and with the electronics and semiconductor industries during their very rapid development in the 1950s and 1960s. Therefore, in some ways, the current problems in biotechnology may seem more familiar to us than to some of our academic colleagues.

In addition, I think that preconditions for strong interaction with industry are favorable in other respects. Each of our departments is visited annually by a team we refer to as the Visiting Committee. That committee is charged with reviewing the progress of that department and reporting to the MIT Corporation, our governing body. The membership of these committees is commonly drawn largely from industry.

Moreover, we have a very strong industrial-liaison program that is meant to facilitate interactions and the transfer of technology. We have a strong continuing-education program. Perhaps most important, our faculty members are accorded the privilege of consulting one day per week; and, particularly in the school of engineering, this work is viewed as part of one's professional obligation. Faculty members do not usually take full advantage of this privilege. Ordinarily they do perhaps half the consulting they are permitted. Nonetheless, consulting is generally regarded as a way to remain current with industrial practice and concerns.

We have about 900 faculty in 23 departments and about 9000 students. The 9000 students are equally divided between undergraduate students and graduate students. In fiscal year 1983, our campus-sponsored research volume was about $200 million. Of that, about $20 million was industrially sponsored—that is, about 10% of our on-campus support is derived from industrial sponsors. About 81% is Federally sponsored. The remaining 9% derives largely from foundations. The figure of $20 million looms large compared to most other universities, but the figure of 10% is not extraordinary; the national average is about 4%.

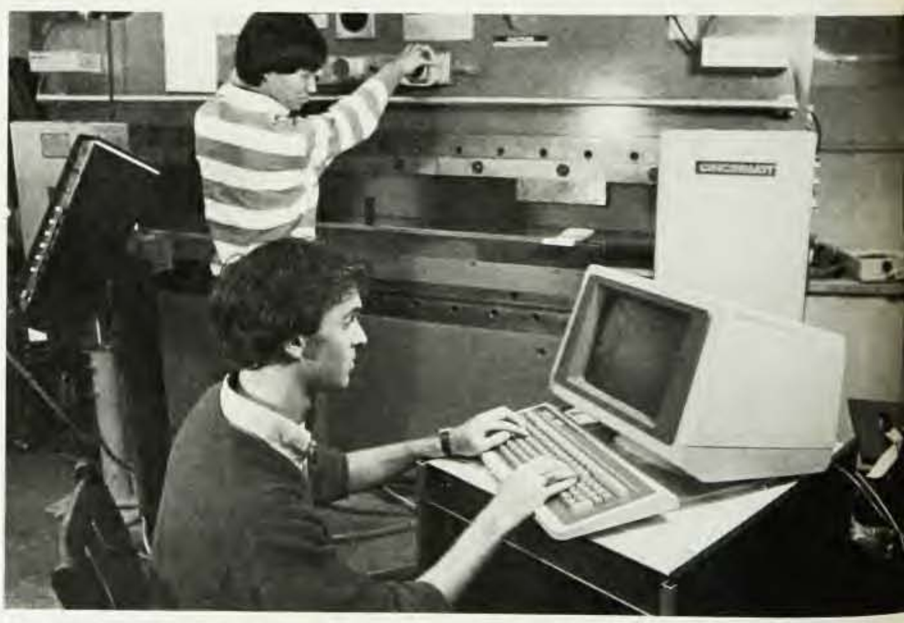
There are some important reasons why MIT came to have such a large share. The first is that it was not centrally raised. There was not a strong program by MIT's central administration to raise a lot of industrial money—quite the contrary. Almost all of it resides in relatively small projects, but very many of them, distributed all across the Institute and with funds largely raised by the individual efforts of individual professors, much as with Federal funding.

There are only two very large industrially-sponsored projects. One is the Exxon grant that attracted a good deal of attention when it was announced nearly four years ago. This grant allocates $8 million of funding over ten years for research in the area of combustion. Approximately two years later, we signed an agreement with W. R. Grace Co. for an amount that will probably total $7 million over the next five years. It is interesting to note that even though the Grace arrangement is for roughly the same amount of money in half the time span, the amount of attention it received when it was announced was almost negligible. I think this reaction indicates a change in the public perception of university–industry interaction—it is no longer considered unusual.

In addition to the large number of relatively small single-sponsor research agreements, I should also mention the emergence of a significant number of consortia. In each of these, the participating companies (typically five to ten in number) fund research jointly in a given area; this reduces the financial commitment required of any single company. One might think that such arrangements would be contrary to the anti-trust laws, but recent informal opinions from the Department of Justice have indicated that this is not a significant concern. Furthermore, the Administration is now supporting legislation that would eliminate any lingering doubts in this regard.

Policy guidelines

Let me turn now to the policy guidelines we have adopted at MIT for these various kinds of industry–university interactions. First, it must be remembered that we do not undertake proprietary research. All research results may be freely disseminated. But there



Machine for bending sheet metal—called a brake—is operated by students Bernard S. Chen (striped shirt) and Michael L. Agronin (foreground) at MIT's Laboratory for Manufacturing and Productivity.

are such ancillary issues as whether we should or should not receive proprietary information from a sponsor and hold that information confidential.

We recognize that there are times when it is very useful to receive this kind of proprietary information. Without it, the work may be difficult to motivate properly or we may proceed to retrace an unproductive approach that has already been explored by the sponsor. On the other hand, it obviously tends to run counter to the traditions of openness. As a result, we have adopted the position that a principal investigator may receive proprietary information from the sponsor, but that others may not. Students, for instance, should be able to discuss freely all aspects of their research, and therefore they should not have access to proprietary work and should not find themselves ever in the position of wondering whether what they are saying or doing is in any way bound by these kinds of strictures. In recognition of the fact that the principal investigator has received proprietary information, we grant the sponsor a 30-day delay in submission of any publication so that the sponsor can safeguard against inadvertent disclosure of proprietary information.

Another kind of intellectual property right is associated with patents and copyrights, and much the same kind of issue arises. On the one hand, there is the obligation for openness and the obligation to facilitate technology transfer and, on the other hand, there is the sponsor's view—often accurate—that the sponsor should have some prior claim on patents or copyrights generated by the work. The patent policy in this type of situation is still evolving. In all cases, MIT takes ownership of the patent, but various licensing arrangements have been used. The historically favored route has been a non-exclusive, world-wide license to any patents that emanate from the work; we will routinely grant that kind of right to any sponsor.

Frequently, however, the only sensible way to transfer the technology would in fact be through an exclusive license to the sponsoring company for a limited term. Otherwise the sponsor has no incentive to undertake the very large subsequent investments needed to commercialize the technology. There have, therefore, been many instances, although far from a majority, in which we have granted limited-term, royalty-bearing exclusive patent rights to sponsoring companies. But these arrangements have always been subject to march-in rights and performance milestones so that the company cannot simply sequester the technology and do nothing with it. In such an event, the march-in rights would allow

Examples of joint research programs at MIT

Sponsor	Project Description	Contract Total ($)	Effect Date	End Date
ALLIED CHEMICAL CORPORATI	CR DOPE GERMAN GARNET TUN LASER MATERIAL	200000	811001	831231
ALUMINUM COMPANY OF AMERI	IN-PROCESS STRAIGHTENING OF ALUMINUM EXT	60148	830901	850201
AMERICAN BUREAU OF SHIPPI	STRENGTHENING CRITERIA FOR NAVIG IN ICE	33028	810701	831231
AMERICAN CAN COMPANY	NONDESTRUCTIVE EVALUATION OF SEAM WELDS	22800	831001	840930
AMERICAN EDWARDS LABORATO	VASCULAR APPLICATIONS OF LASER CATHETERS	195000	830606	840120
AMERICAN ELECTRIC POWER S	ELECTRIC POWER SYSTEM	709735	661221	831231
AMERICAN HOSPITAL SUPPLY	ASSESSING BLOOD GLUCOSE CONTROL	60650	831101	840731
AMERICAN TELEPHONE & TELE	STRATEGIC VIEW OF INFORMATION SYSTEMS	20000	830112	840331
ANALOG DEVICES, INC	CHEM VAPOR DEPOSIT REFRACTORY METAL SILI	238580	820901	850831
ATLANTIC RICHFIELD COMPAN	POLYMER SCISSION AND DRAG REDUCTION	72440	820201	840131
AVCO CORPORATION	FILAMENT WETTING STUDY	35000	830115	831231
BEECH AIRCRAFT COMPANY	DAMAG TOLERANC COMPOSIT CYLINDRICAL SHELL	199728	830901	840831
BELL TELEPHONE LABORATORI	VISUAL AND AUDITORY PERCEPTION	1080000	520101	840930
BOEING	MILLIMETER WAVE MEASUREMENT	40950	821112	831231
BURLINGTON NORTHERN RAILR	ANSYSIS OF WHEEL AND RAIL PROFILE	23470	830115	840114
CANON	EFFECT OF PH ON PHASE TRANSITIONS	10000	830901	840831
COMBUSTION ENGINEERING, I	ELECTROSTATIC PRECIPITATOR DEV	107388	820101	831231
CONSOLIDATED EDISON	FLOW MEASUREMENT IN DISTRIBUTION FLOW	113000	810115	840331
CONTROL DATA CORPORATION	HEAD-DISK MECHANICAL INTERACTION	150000	830905	860930
COMPANIE GENERAL DE GEOPH	VERTICAL SEISMIC PROFILING	612500	820401	840331
COLECO INDUSTRIES, INC	EDUCATIONAL COMPUTING	500000	830901	850831
COLUMBIA PICTURES	STUDIES IN SATELLITE ALTIMETRY	8580	831020	840120
CUMMINS ENGINE COMPANY, I	INVESTIGATE TURBOCHARGER STALL	273942	800901	831231
DAIKIN INDUSTRIES LTD	ADVANCED ASSEMBLY ROBOTS	100000	820901	840831
DIGITAL EQUIPMENT CORPORA	AN INVEST OF FRICTION & WEAR	146520	800701	831231
DOW CHEMICAL COMPANY	MIT-DOW PROGRAM IN STRUCTURAL MATERIALS	342650	661201	831231
E I DU PONT DE NEMOURS	FUNDAMENTAL RESEARCH IN MECHANICAL ENG	243453	620701	831231
EG&G, INC	REACTOR SAFETY STUDIES	775000	791101	840930
ELECTROMAGNETIC LAUNCH RE	RESEARCH IN ELECTROMAGNETIC LAUNCHING	127767	830201	840103
E L F-BIO-RESEARCHES	SAFETY OF OFFSHORE STRUCTURES	15000	830301	831231
ENGINEERED PRECISION CAST	UNDERGRADUATE RESEARCH OPPORTUNITIES	4200	751001	831231
ENGLEHARD INDUSTRIES	DEVELOPMENT OF NEW PLAT COMPOUNDS	108286	830601	850531
ESSILOR INTERNATIONAL	STUDY OF ADAPTATION OF VARILUX 2 LENSES	30687	830301	850228
ESSO RESEARCH AND ENGINE	COMBUSTION	2746694	800301	840229
FAIRCHILD REPUBLIC CORP	FAIRCHILD-WRIGHT BROTHERS WIND TUNNEL	100000	810915	831231
FAUSKE AND ASSOCIATES	CORE CONCRETE INTERACTION MODELS	49919	820901	840115
FORD MOTOR COMPANY	SSM REGULATORY STUDIES	132596	790101	840630
FLOW GENERAL INC	TEST & DEVELOP OF LIVING SKIN EQUIVALENT	474724	790701	840131
FLOW MEADOX	BLOOD VESSEL PROSTHESIS PROGRAM	217455	820701	840131
GENERAL MOTORS CORPORATIO	COMPUTATIONAL PROCED FOR INITIAL DESIGN	305835	830701	850630
GENERAL TELEPHONE AND ELE	MOSSBAUER SPECTRA	2000	820901	831231
B F GOODRICH AND ELE	BIOTECH PROCES INDUSTRIAL WATER TREATMENT	30098	830901	840831
GOUGEON BROTHERS	COMPOSITE WIND TURBINE BLADES	25000	830715	831231
GOULD INC	INVEST MAGNETIC INFLUENCES JOSEPHSON DEV	30000	821101	840115
JOHN HANCOCK INSURANCE	PEDESTRIAN WIND JOHN HANCOCK TOWER	58981	820501	840331
HITACHI RESEARCH LABORATO	HIGH STRENGTH-HIGH TEMPERATURE CERAMICS	200000	781231	831231
HYCOR	MEASURE STABILITY FINNED BLUNT CYLINDER	15100	831101	840131
INTERNATIONAL BUSINESS MA	NMR TOMOGRAPHY-INSTRUMENTATION	1442439	820101	840630
KANSAI ELECTRIC POWER COM	ENERGY SITUATION & ELECTRICITY	30000	820301	831231
KURZWEIL ALPHA SYSTEMS, I	UNRESTRICTED RESEARCH GRANT SUPPORT	20000	830609	840608
LIFELINE SYSTEMS, INC	BEDSIDE ARRHYTHMIA MONITOR (BAM)	224818	820318	840314
LOCKHEED MISSILES & SPACE	MEMBRANE REFLECTORS	155000	800901	831231
MARTIN-MARIETTA CORPORATI	ARTIFICIAL INTELLIGENCE	25000	820201	840630
MEDTRONIC, INC	REAL-TIME ARRHYTHMIA ANALYSIS	665995	790426	840401
MICROGRAVITY RESEARCH ASS	ELECTROEPITAXIAL GROWTH OF GA AS IN SPACE	245080	830501	840430
MILLIPORE CORPORATION	MEMBRANE SURFACE	99890	820701	840131
MINNESOTA MINING & MANUFA	STUDY OF MICROSLIP DURING SLIDING	112400	830701	850630
MITSUI INTERCOMPANY RESEA	MECHANO-CHEMICAL TRANSFORMATION	10000	830401	840331
MOBIL TYCO SOLAR ENERGY C	SILICON-SHEETS	7394	831101	831231
MONSANTO CORPORATION	TECHNOLOGY TRANSFER	200000	820101	831231
MULTI GROUP SPONSOR	INTEGRATED ENERGY SYSTEMS PROGRAM	50000	830831	840830
MULTI SPONSORED PROJECTS	FULL-WAVE ACOUSTIC LOG INTERPRETATION	957495	820401	850331
MULTI SPONSORED PROJECTS	SOLUTION OF FLUID FLOWS INTERACTIONS	190000	820101	841231
NEW ENGLAND NUCLEAR CORP	IRRADIATION OF SULFUR TARGETS	17590	830101	831231
NIPPON ZEON COMPANY LTD	PHASE TRANSITIONS IN POLYMER GELS	40000	821028	841027
ORTHO INSTRUMENTS	GEL MICRODROPLETS FOR MICROBIOLOGY	210512	810201	840131
OWENS/CORNING FIBERGLASS	ENERGY EFFICIENT BUILDINGS	15000	830601	840531
TETROFERM, USA	CHARACTERISTICS OF EMULSION FUELS	30000	830201	831231
PLASMEDICS	UNDERGRADUATE RESEARCH OPPORTUNITIES	2500	830101	831231
POWER REACTOR & NUCLEAR F	MIXED CONVECTION TESTING AND ANALYSIS	182000	811001	840930
RADIATION MONOTORING DEVI	CADMIUM TELLURIDE DETECTORS	50000	830101	831231
RESEARCH CORPORATION	STIMULATED BRILLOUIN SCATTERING	15600	821201	840430
SANDIA LABORATORIES	ECONO RISKS OF NUC POWER PLANT ACCIDENTS	146218	820401	840401
SALOMON ET FILS	BINDING RELEASE & INJURY STUDIES	3015	830301	831231
SCHLUMBERGER-DOLL RESEA	ACOUSTIC WAVE PROPAGATION STUDIES	215000	780415	840115
SEMI CONDUCTOR RESEARCH C	CENTER OF EXCELLENCE	628653	830601	840531
SOLAR ENERGY RESEARCH INS	THEO INVESTIGAT ORIGIN METASTABLE LIGHT	49952	830901	840831
STANDARD OIL CORP OF OHI	CIVIL AND OCEAN ENGINEERING	400000	830901	840831
TECHNOMARE S.P.A (ITALY)	CONTROL OF UNMANNED UNTETHERED INSP VEH	50000	831001	840330
TELEDYNE COMPANY	FRACTURE TOUGHNESS OF TOOL STEELS	10000	780601	831231
UNITED AIRCRAFT HAMILTON	MULTISTAGE COMPRESSOR II	424346	810101	831231
UNITED PARCEL SERVICE	IMPROVED ANALYTIC METHODS	110397	830601	840531
VARIAN ASSOCIATES	INTENSITY MICROWAVE IN AIR	28000	830701	831231
WESTINGHOUSE ELECTRIC COR	PREDICTION OF TEMP AND VELOCITY FIELDS	55000	830930	840930
YANKEE ATOMIC ELECTRIC CO	METHODS OF SEISMIC HAZARD ANALYSIS	33000	830401	831231

Selected entries from a computer printout of the more than 300 joint programs currently sponsored at MIT by industrial concerns. No more than one program is listed for any one sponsor. IBM, for instance, sponsors 22 ongoing programs.

us to reclaim the patent license.

One of the most difficult parts of the negotiation is the fact that it is almost impossible to foresee in advance what reasonable patent terms will be—what would be a reasonable royalty rate, what would be a reasonable duration of the license and so on. We have often left these terms to be negotiated at a date subsequent to issuance of the patent. But this procedure will not work unless there is good faith on both sides.

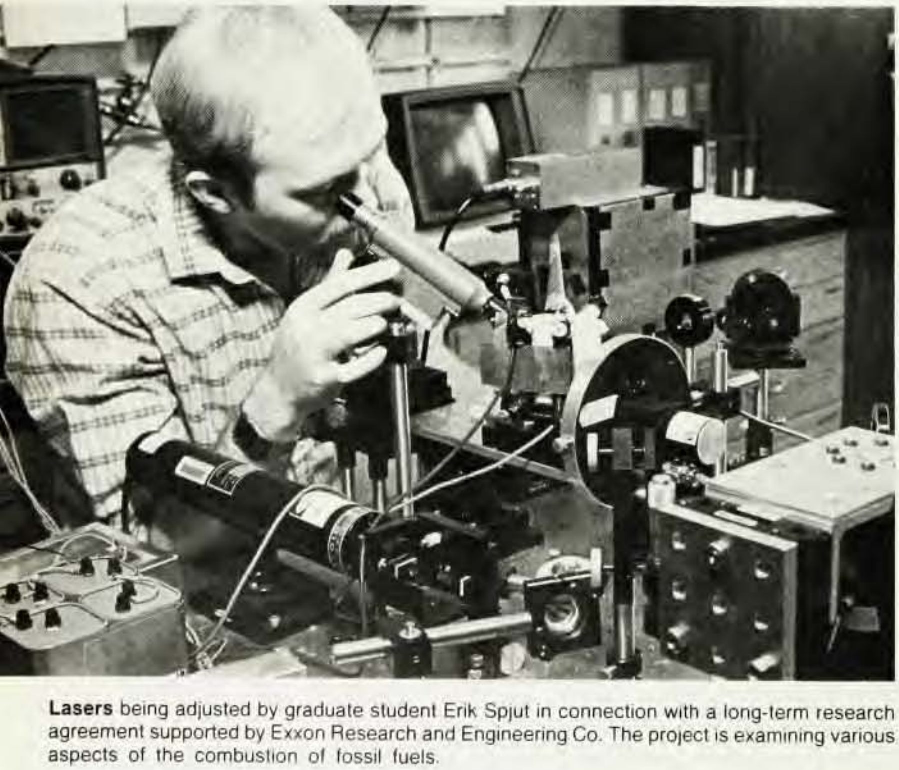
To protect information that is potentially patentable, we have had the same kind of arrangement that we use to identify any inadvertent disclosure of proprietary information supplied by the sponsor. We have been willing to grant a sponsor a right of 30-day review prior to publication. In the contract we will usually recognize the possibility of an additional 60-day extension if there should in fact be information that should be submitted for patent.

Conflict of commitment. In this area, we have established some rules governing faculty behavior and the elements of good citizenship. By and large, I think these rules have served us well. Perhaps the first rule is that each faculty member annually disclose all consulting and other outside activity to the department head. It is not necessary that the fees received be disclosed. But the individual must disclose whether compensation was in the form of a fee or in the form of an equity interest and, if the latter, how substantial an interest is involved. If, upon reviewing these reports, the department head should conclude that there may be a problem, the report is referred to the provost for further review. The fact that there is a mechanism for this kind of annual review means that faculty activity is subject to a measure of openness that militates against the kind of behavior that might cause concern.

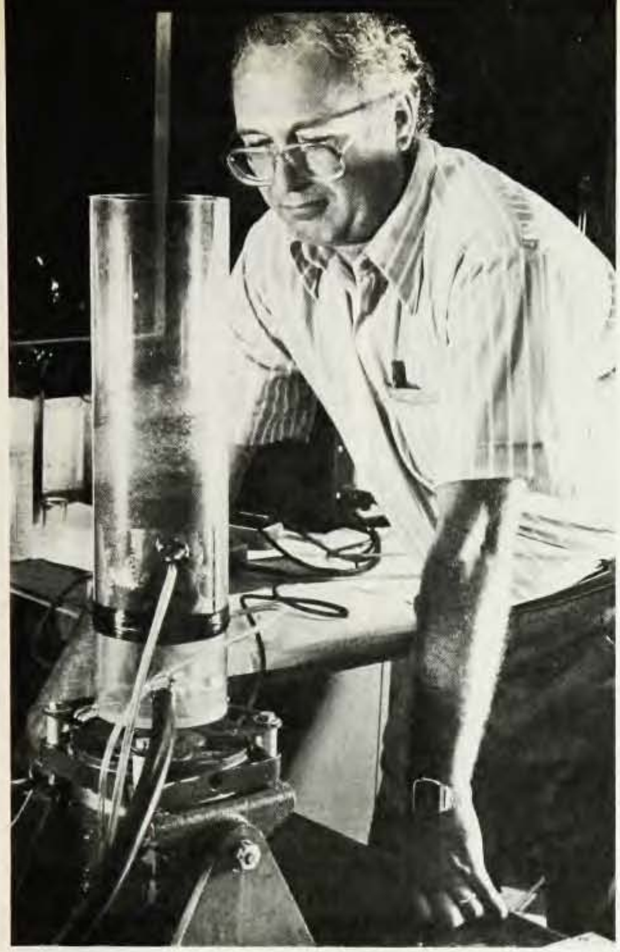
In addition, it is generally understood that a faculty member should not have a line responsibility in any outside firm. The one exception is that we will grant a leave of absence for periods of up to two years, during which time the faculty member can be committed full-time to an outside position. At the end of the leave period the individual must decide either to return to the university and change the relationship with the firm (so that it is no longer a managerial responsibility) or to leave the university and join the firm. The clear intent here is that the faculty member's obligation and first commitment should be to the university, not to someone else. Yet we want to make it possible for faculty members to interact with industrial firms. Therefore we do not view leaves of absence for this purpose very differently than we view leaves for government service or for the conduct of research in a different setting.

Finally, and perhaps of most concern in a number of contexts, we have felt that industrial relationships that do not involve equity interests or direct financial gain by the faculty member, but that *do* involve other kinds of arrangements that provide the sponsor special access to the university, can create a conflict of commitment. For instance, there have been industrial sponsors that have wanted a right of first refusal to any continuing work from a given laboratory. Indeed, at other institutions there have been sponsors who have wanted the right to be the sole industrial sponsor of a particular laboratory. We have felt that either of these kinds of arrangements would eventually lead to a conflict of commitment on the part of the faculty member, and would indeed lead to a rather unhappy kind of Balkanization in which laboratories become the special preserves of special sponsors. This kind of situation is not compatible with the aims of a university.

One might ask how the above considerations have applied to the highly visible arrangements reported in the press between industrial firms and universities in the area of biotechnology. The biotechnology arrangements are largely motivated by the peculiar circumstances in which we find ourselves—a quickly developing technology whose associated skills, for historical reasons, happen to reside in the universities, at least temporarily. There has been, at least until recently, a general sense of the prospect of huge profits in this business. The combination of these factors has led, I think, to a very transient but rather frenetic kind of activity, with various types of companies trying to develop special liaisons with pockets of university expertise. These non-representative problems are going to solve themselves but, nonetheless, they are responsible for much of the feeling of unease about industry–university ties. An example of this emphasis upon biotechnology is provided by the well-known Pajaro Dunes conference. Delegations attended from Stanford University, Caltech, the University of California, Harvard and MIT, with Stanford serving as host and convener. Each of the five university presidents was present, and for each university there were, in addition, approximately three administrators, two faculty and two industrialists present. The purpose was to focus on the problems of university–industry interaction. Of the total of ten industrialists, six were chosen by these particular universities from Syntex, Genentech, Applied Biosystems, Cetus, Damon and DuPont. So it was a meeting set largely in the context of biotechnology. It had been decided to have the meeting closed to the press, based on the assumption that the universities would feel more comfortable talking about their problems off the record. In retrospect, we should have invited a few highly respected members of the press. Such



Lasers being adjusted by graduate student Erik Spjut in connection with a long-term research agreement supported by Exxon Research and Engineering Co. The project is examining various aspects of the combustion of fossil fuels.



Test of vented compression molding technique, developed under the sponsorship of Martin Marietta Corp. This technique permits ablative materials used on the exterior fuel tank of the Space Shuttle to be molded more reliably and easily than was previously possible. Work began at MIT–Industry Polymer Processing Program.

coverage would have gone a long way toward reassuring the more paranoid members of the community who sued the University of California to force disclosure of everything associated with the meeting and who had *Sacramento Bee* photographers with telephoto lenses stationed outside the seminar center as though we were attending a conference of the mob. This reaction was unfortunate, and I believe peculiar to the biotechnology area. The high visibility of that field and its possible application to matters of health accord it a special position.

What, then, do we see as the keys to the long-term viability of these industrial–university relationships? Because the Exxon program I mentioned earlier is one that I consider well-run, I would like to quote from a statement prepared about a year ago by one of my colleagues, A. F. Sarofim, who is a participant in that arrangement. In this statement, he summarizes the way in which the program has been working after about three years of existence:

> ... The topics supported under the program are selected by a committee consisting of two representatives from Exxon, and the MIT principal investigators. The procedures are usually for the MIT principal investigators to suggest topics of interest, and the committee then to select those to be funded on the basis of the following criteria:
>
> ▶ potential for significant contribution to science and technology
> ▶ breadth of applicability
> ▶ relevance to long-term Exxon and national interests
> ▶ potential for interaction between MIT and Exxon researchers.
>
> Once the topic is selected, there is a commitment to maintain support for it until the students working on the topic have graduated, even though, as has happened in several cases, changes in priorities at Exxon may have resulted in loss of interest in the general topic within Exxon. The committee meets approximately every six months and copies of the minutes of meetings are sent to the Office of Sponsored Programs. The committee has broadened the objectives of the program from combustion to high-temperature reactions associated with fossil-fuel conversion and utilization. This has enabled us to select problems from the related areas of combustion, gasification and pyrolysis. There are currently eight tasks being supported in general areas of carbon and hydrocarbon reactions, gas–solid reactions, reaction engineering, and new experimental methods.

These tasks are then listed, and he goes on to say,

> We have nine students working toward their PhDs under the Exxon program, and in addition have supported seven Master's students, two at present, and have on average about 12 UROP students working on the program at any time. [UROP is an MIT acronym for Undergraduate Research Opportunities Program, and represents a development at MIT over the last decade to involve undergraduates in research. I think it is interesting and reflective of one of the benefits of these kinds of collaborations that one of the things that Exxon has most enjoyed has been the exposure to the undergraduates.]
>
> We have derived benefits from the Exxon support additional to the obvious financial ones; being able to offer topics supported by industry is an asset in recruiting graduate students, since the majority of our graduates end up in industry [my colleague is referring to chemical engineering here]. Our students have also been stimulated by the interest shown in their work by their counterparts at Exxon working on similar problems. We have valued the long-term nature of our support, which has enabled us to undertake the development of sophisticated equipment that would not usually be possible with the short-term support from mission-oriented government agencies. The provision of discretionary funds under the contract has also proven to be very valuable in developing new research topics.

I should explain that the "discretionary funds" Sarofim referred to above derive from a feature of the Exxon contract that specifies that a sum equal to 20 percent of the funds expended under the program is allocated to MIT to be spent in an entirely discretionary way. This same feature appears in several of our other agreements.

What, then, do I glean from the Exxon experience as to conditions for long-term viability? The features it clearly incorporates are, first, a commitment to stability. In addition, the intellectual connections have been real. The sponsor has respected the academic traditions and has been flexible with respect to the direction of the work. And finally, the university has been sensitive to Exxon's motivations and has focused on work consistent with those motivations.

We find these same conditions in many other successful projects, and I am hopeful that there will be still many more. □