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NSF ENGINEERING PROGRAM EVALUATION: PATENT STUDY

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By: Thomas P. Sheahen and Robert L. Stern

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National Science Foundation
Division of Grants and Contracts
BBS/MPS/STIA Branch
1800 G Street
Washington, D.C. 20550

SRI International Project No. 6432

DRAFT

SRI International®

333 Ravenswood Ave. • Menlo Park, CA 94025
(415) 326-6200 • TWX: 910-373-2046 • Telex: 334-486

NSF ENGINEERING PROGRAM PATENT STUDY

ABSTRACT September 1985

This report presents the findings of an examination of engineering research project grants funded by the National Science Foundation (NSF) between 1968 and 1977. The purpose of the study was to determine the extent to which these grants led to patented technology and to estimate the patents' economic value.

The names of principal investigators supported by NSF engineering grants were matched to the names of inventors on patents registered with the U.S. Patent and Trademark Office. SRI International staff technology experts then assessed the relationship of each grant to the matched patent or patents. In the cases in which the grant and the patented technology were determined to be linked, an independent estimate was made of the royalty income of each patent. Both SRI evaluations and licensing data obtained from patent assignees were used.

About 4,100 principal investigators (PIs) were awarded NSF engineering project grants between 1968 and 1977. About 10% (397) were named as inventors or co-inventors on 722 U.S. patents issued between 1975 and 1982. A sample of 248 of these patents associated with 149 PIs was investigated. Of that sample, 51 patents (or about 21%) were directly linked to NSF grants. Eighteen of these patents have produced or have the potential to produce royalty income, but only seven have been licensed; they have yielded royalties totaling nearly $680,000.

The total long-term royalty income from all 248 patents of the sample is estimated to be $8.5 million, and might be as much as $16 million if all the promising technologies are successfully pursued. The royalty income from all patents that have or will be issued to recipients of engineering research grants between 1968 and 1977 is estimated to be $52.5 million. When a particular technology is commercialized, the aggregate value to the U.S. economy could range between 10 and 20 times the royalty income, depending on the industry or industries in which it is used and the degree to which it penetrates the market.

One observation from this study is that a strong patent licensing program is valuable to universities, not only for the royalty income it produces, but also for the additional sponsored research funds it tends to attract from industrial firms.

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I INTRODUCTION

This report describes a study undertaken by SRI International (SRI) for the National Science Foundation (NSF) Office of Budget, Audit and Control to determine the number and estimate the value of patents issued to NSF principal investigators between 1975 and 1982 that resulted from work under NSF engineering research grants between 1968 and 1977. This study sought to establish whether there are unambiguous links between the university research NSF sponsors and commercially available technology (in the form of issued patents).

Links between technology and basic research efforts have been the subject of limited investigation. The NSF-commissioned TRACES study (IITRI, 1968) cited connections between basic research events and applications that confirmed the long-standing belief in the value of basic research. Another NSF study (Campbell and Levine, 1984) looked at ensembles of patents from several specific fields, particularly automotive technology, to identify emerging technology trends. At the popular level, the roots of entire industries were traced over centuries in Connections (Burke, 1973) and the British Broadcasting Corporation television series of the same name.

This SRI project complements an examination of NSF's Chemistry Division grantees between 1964 and 1977 and resulting patents issued between January 1975 and June 1981 (Marcy and Kosloski, 1982). It is another step in the development of a baseline for determining long-term technological and economic impacts of basic research.

The purpose of this study was to determine the extent to which the research supported by the NSF Engineering Program resulted in patented inventions and to estimate the economic value of these patents. The specific objectives of the study were to:

- Determine which patents issued to NSF grantees were linked to their grants (i.e., resulted from the grant research).

- For the linked patents, determine whether they have been commercialized and collect information about already realized, anticipated, or potential economic value.

- Estimate the aggregate potential economic value of the inventions derived from NSF engineering research grants awarded during the period investigated.

The study encompassed the 4,077 principal investigators (PIs) who received engineering research grants during the study period. Almost 10% were recipients of at least one of the 722 patents that were the subject of this study.

II APPROACH

Members of the staff of NSF's Office of Budget, Audit and Control compiled a list of 4,077* PIs known to have received one or more NSF engineering research grants between 1968 and 1977. Of these PIs, 397 were found to be named as inventors (or co-inventors) on 722 U.S. patents issued between 1975 and 1982. The U.S. Patent Office's information retrieval system was not able to provide an automated search for patents issued to such PIs before 1975.

The difference between the time period for the grants (1968-1977) and the time period in which patents were issued (1975-1982) is as much as 7 years; hence, the set of patents and grants made available to SRI for analysis suffers from the limitation that not all of the patents that may have been awarded to the PIs (before 1975 and after 1982, as well as in the period 1968-1975) were available for examination. A statistical adjustment was made to account in part for the difference in the two periods.

The NSF archives were searched to recover the grant jackets of the 397 PIs to whom patents had been issued. Grant jackets contain financial and administrative records of the grant, brief descriptions of the proposed work, and a summary of accomplishments. However, only 149 of the 397 were recovered from the archives and made available to SRI. Copies of the patents were also made available. A total of 248 patents were associated with the names of the 149 PIs. These 248 patents formed the data set that was evaluated by performing the steps shown in Figure 1.

A statistical analysis of the 149 grant jackets was made to determine whether the sample was representative of the entire population of 397. The analysis included tests of alphabetic distribution, engineering discipline, grant date, patent filing date, type of assignee (i.e., university or industry), and formal acknowledgment of NSF sponsorship in the patent. According to these tests, the characteristics of the set of 149 are similar to those of the 397. This result warrants confidence that the recovered grant jackets and their

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*The number of entries in NSF's list of PIs who had received engineering research grants during the period under study (1968-1975) was 4,711. However, close examination of the list revealed that some names appeared more than once in different forms (full names, initials, etc.). The frequency of duplication was estimated for the total population from an analysis of a 400-entry sample. The derived figure of 4,077 nonduplicated PIs is used throughout this report.

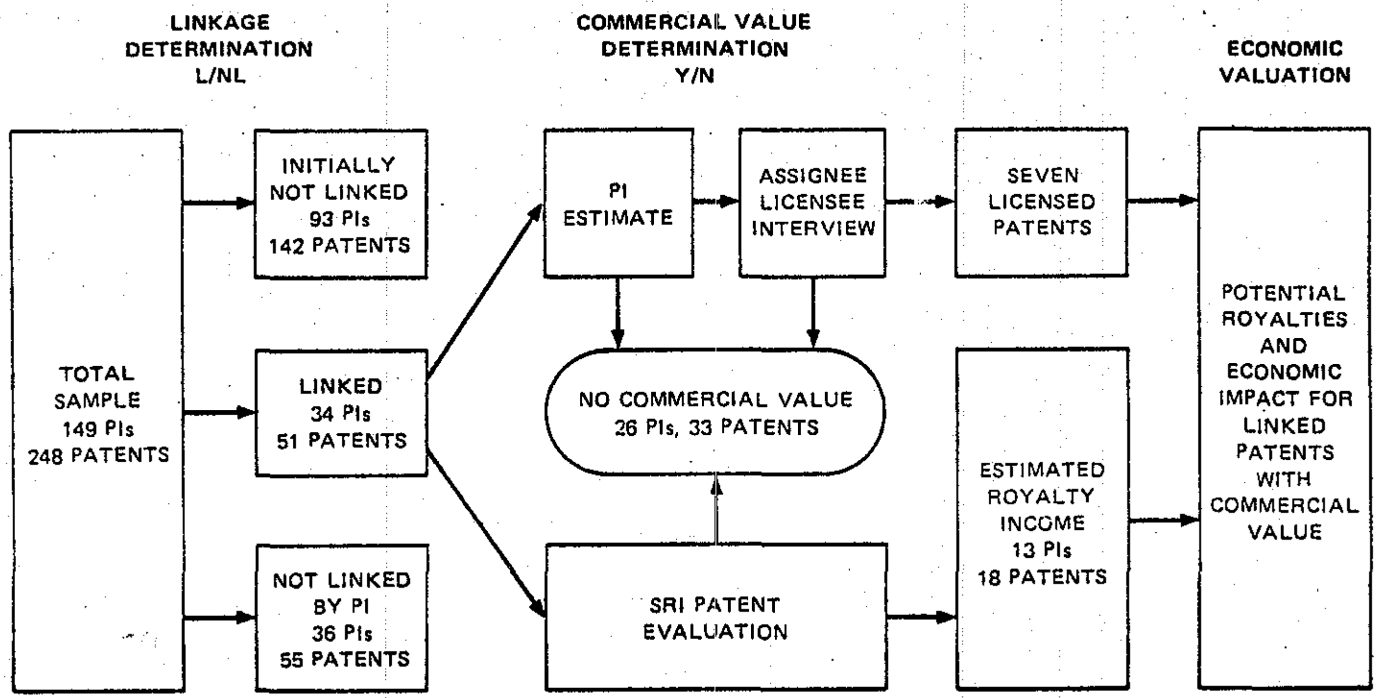

FIGURE 1 NSF ENGINEERING PROGRAM GRANT/PATENT STUDY FLOWCHART

associated patents are representative of the population from which they were drawn and that a statistical extrapolation of the results for the recovered grant jackets and patents to the full set of issued patents is reasonable.

Determination of Grant/Patent Links

The process for determining "linkage" between an NSF engineering grant and a patent or patents was designed to answer one question:

> Is the patent a result (an outgrowth or outcome) of the work done under the grant?

SRI's first task consisted of examining the information in the grant jacket and the patent to see whether the research described and conducted under the grant was a precursor of the teaching of the patent. The goal was to establish whether a particular patent was unambiguously linked to a grant. Criteria for linkage assignment were established at the outset of this study and employed consistently in the review of all grant/patent pairs.

For some of these pairs, the determination of linkage was trivial. For example, the start and end dates of the grant could be compared to the filing date of the patent. Furthermore, the grant report may mention intended future patent filings, or the patent text may specifically acknowledge an NSF grant as a basis of its teaching.

The primary determinant of the grant/patent relationship was the judgment of the SRI project staff based in Washington, D.C. At least one member of this group of three people read each grant and the associated patent or patents, and then provisionally classified the linkage between them. The classification could be "A/L" for "Acknowledged Link;" "L" for "Linked;" or "N/L" for "Not Linked." The grant/patent pairs provisionally classified as linked required further examination before they could be declared linked.

Factors that entered into the assignment of the "L" classification to a grant/patent pair were: the time interval between the grant and the date of patent filing; the similarity of equipment used in the grant to equipment used in reducing an invention to practice; similarities between ideas contained in the patent and suggestions for future research mentioned in the final report for each grant; and the SRI evaluator's professional knowledge of certain fields. This knowledge included an understanding of the similarities in the progress of research in allied fields and of the relationships between fields that superficially appear distinct.

It was important that the linkage analysis be performed in a consistent manner. As a test of consistency, a random sample of 18 grant/patent pairs was examined by each of the project team members, and the findings were compared. If any degree of linkage could be inferred from a thorough reading and analysis of the patent and the corresponding grant jacket, that grant/patent pair was designated as "provisionally linked."

Six of the 18 pairs in the calibration sample were independently deemed "Not Linked" by all three evaluators. In only one of the grant/patent pairs did all evaluators agree that there was a link. For the remaining 11 pairs, at least one of the evaluators felt that there was some evidence of linkage. After discussion among the evaluators, each PI was interviewed by telephone to obtain additional information and evidence of linkage. Subsequently, the evaluators who surmised a link concluded that 9 of 11 provisionally linked patents were not linked. In the remaining cases, the linkage was confirmed by the PI, although it was certainly indirect. This calibration is summarized in Table 1.

The most significant outcome of this step was that it indicated that the linkage analysis could be carried out consistently, regardless of which evaluator reviewed the data. The team continued to record "provisional linkages" that were not later sustained by the information obtained through interviews with the PIs, but it was more important to have a high degree of confidence that potential grant/patent links would not be overlooked.

After the evaluation criteria were established and the evaluation team calibrated, the body of grant patent pairs was divided amongst the three members of the SRI-Washington team to continue the search for linkages. The grant/patent pairs were assigned by subject matter to the team member with the strongest technical background in that field. On the basis of the linkage search process described here, it was concluded that, of the 248 patents issued to 149 PIs, 51 patents were linked to 34 PIs. This is the set of patents for which measures of potential economic value were sought.

Determination of Patent Value

Two independent paths were taken to quantify the potential value of the patents:

(1) An SRI-Washington team member interviewed the PI, his colleagues, and the associated university patent licensing office.

(2) The linked patent was reviewed by a technology expert from SRI headquarters for technical and economic value.

Table 1

LINKAGE ANALYSIS CALIBRATION

Data Set of 24 Patents Held by 18 PIs

Initial Review

7 patents held by 6 PIs were designated Not Linked*
1 patent held by 1 PI was designated Linked*
16 patents held by 11 PIs were designated Provisionally Linked**

Second Review

After subsequent investigation, including telephone interviews with the PIs of "linked" and "provisionally linked" patents:

7 patents held by 6 PIs were confirmed to be Not Linked
1 patent held by 1 PI was confirmed to be Linked

Of the 16 patents held by 11 PIs that were designated "Provisionally Linked":

14 patents held by 9 PIs were confirmed to be Not Linked
2 patents held by 2 PIs was confirmed to be Linked

Conclusion

In this calibration sample:

3 patents held by 3 PIs were designated Linked
21 patents held by 15 PIs were designated Not Linked

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*So designated unanimously by all 3 SRI-Washington evaluators
**So designated because at least 1 evaluator concluded there was a link.

To assure an unbiased valuation, the commercialization data from the interviews were not provided to the SRI evaluators.

The conclusions of the SRI project team are as follows:

- 18 linked patents held by 13 PIs are estimated to have some value.
- 9 linked patents held by 6 of the same 13 PIs are estimated to have no value.
- 24 linked patents held by 21 other PIs are estimated to have no value.

<u>Principal Investigator Interviews</u>

In addition to obtaining information on the linkage of patents to Engineering Program grants, the interviewers asked a series of questions to determine whether the patents had been commercialized or any plan for licensing had been made. (The interview records are included in the working papers of the project.)

Certain questions on the evaluation form, such as "Has the patent been licensed?" received a simple yes or no answer. Others, such as, "Have you obtained any indirect benefits because of the patent?" often led to considerable discussion.

In general, the PIs were cooperative and helpful in volunteering information about their research and the pursuit of patents. (They also contributed suggestions about how NSF might make better use of patents arising in this way.) Not surprisingly, patent holders tended to be optimistic about their chances for future royalties, even if no licenses had yet been obtained.

The frequent recital of the "success stories" of a few patents has obscured the very large number of "failure stories." The result is a common fantasy about the chance to strike it rich with a patent. A lingering faith in this possibility may help to account for the optimism expressed by the PIs. To offset such natural optimism, a separate determination of the value of each linked patent was undertaken by an expert from SRI.

<u>SRI Evaluation</u>

Any patent that was either acknowledged as linked or was judged to be directly linked (by either the PI or the SRI staff) was forwarded to SRI's Menlo Park headquarters for evaluation by a scientist active in that field. The SRI evaluator was not told of the results of the telephone interview with the PI. Appendix A is the text of the instructions given to the SRI evaluators. As a further means of assuring independent evaluations, the SRI evaluator was not selected by the Washington staff, but by a team member in Menlo Park with many years of experience in managing evaluations of new technologies.

Each SRI-Menlo Park evaluator considered the validity of the technical claims in the patent and how easily those claims might be circumvented. The SRI evaluator, having the understanding of an expert in the field of the invention, was also able to judge the strength of competing technologies and estimate the merit of the patent. Each expert's findings are included in the working papers of this study.

Although there are many components of the value of a patent (see Section IV), royalty income was used as the measure of patent value because it is the most direct and simple measure of the economic value of a patent. It establishes a minimum level of economic value without purporting to capture other economic value that is far more difficult to define and estimate. Royalty rates vary from industry to industry, but typically range between 5% and 10% of sales. Each SRI evaluator estimated royalty income by applying a royalty rate typical of that industry to an estimate of market size.

By far the most difficult part of the evaluation was estimating the potential market for an invention. In a few cases there is a known market. In others, the inventions had clearly been superseded by others. In some cases, however, the inventions apply to a technology yet to be applied. For example, the market for optical computers cannot be defined at this time with reasonable confidence.

Other Sources of Value Information

The results of the PI interviews and the SRI experts' evaluations were augmented by comments from university patent administrators and commercial patent developers.

University Patent Administrators' Views. Several major universities have a long history of patent administration. In addition to conducting the evaluation process for patents arising from NSF grants, the SRI team discussed patent practices with patent administrators at Case Western Reserve, the Massachusetts Institute of Technology (MIT), Stanford University, and the University of California.

Certain practices were common to all four universities. For example, the percentage share of royalties given to the inventor ranged from one-third to one-half; also, each university begins negotiating a license well before a patent is issued, often at the disclosure stage and usually before the application is even filed. Other practices were unique. For example, Stanford does a brisk business in copyrighted software, and Case is moving toward R&D limited partnerships as a means of patent commercialization. Other observations are included in the concluding section of this report.

For the purpose of evaluating individual patents, the perspective of the patent licensing office of each inventor's university was another source of valuable information. The enthusiasm of the inventor was often tempered by the experience of the licensing officer who had tried unsuccessfully to find a licensee. The statistical data covering thousands of patents that some offices had collected gave a profile of typical patent activity, and helped to refine estimates of future royalties for patents whose economic lifetime was just beginning.

Commercial Patent Developers' Views. The conditions for negotiating a license with an industrial organization are constrained at a university. University negotiators hesitate to take aggressive approaches in setting royalty rates, for example, when potential equipment gifts or graduate student employment may be at stake. Commercial organizations engaged in patent licensing can use a much broader range of negotiating tools than universities; they also have a different set of objectives, and patents have different values for them.

To augment what was learned about patent commercialization approaches and techniques at universities, representatives of five patent commercialization organizations were interviewed:

- o Research Corporation
- o University Patents
- o National Patent Development Corporation
- o PAT-LEX
- o REFAC.

Their respective approaches differ widely, as do their style, mood, pace, and type of executives involved.

From the 1930s to the early 1960s, Research Corporation (RC) was the organization to which many universities turned over their inventions (by actual assignment) for commercial development. However, RC is also engaged in the administration of its own research program based on income from its endowment (foundation). RC's prosecution of patent licensing was not sufficiently vigorous for some of its client universities, so they set up their own operations. Today, RC's practices and policies focus on the earliest possible contact with the university-inventor (i.e., in the disclosure stage), in part so that if the patent application stage is reached, RC can participate actively in the writing and prosecution. RC learned from its earlier experience the importance of assessing commercial prospects as a guide both for further research in the disclosed area and for investing wisely in the patenting process. The recent substantial increase in the cost of prosecuting and subsequently maintaining patents makes RC an even more selective organization. RC's patent evaluators are chosen from the same staff that makes its endowed research award judgments. RC also considers the difficulty of enforcing its patents, given the existence of other technology that could provide the same or similar functions.

University Patents is to some extent an outgrowth of the patent commercialization service offered by RC. Some universities preferred to deal with an organization exclusively devoted to university patent commercialization and unconstrained by its own research funding operation. Because University Patents has no supporting endowment, it makes a careful market assessment before it agrees to engage in significant developmental and promotional expenditures.

National Patent Development Corporation (NPDC) was established in the early 1960s with the intention of using privately raised capital to engage in the development of patents. The company's record has been variable. NPDC's major success, the licensing of soft contact lens technology, has overshadowed some costly and less profitable ventures. Currently, one of NPDC's well-advertised prospects is based on patented technology for porous glasses developed at Catholic University of America; a major prospective use for the glass technology is for the isolation of radioactive wastes from nuclear power reactors in porous glass matrixes, which can then be fused to reduce their volume prior to permanent disposal. The patent rights of the professors are, in this instance, not previously vested at Catholic University, but the university has already benefited from the additional contract support and research equipment that this venture has attracted to its Amorphous State Laboratory.

Both PAT-LEX and REFAC take a still different approach. They specialize in recovering income for clients whose patents are being infringed. They recover royalties from the infringers through legal recourse. As an example, PAT-LEX took a 40% interest in the Gordon Gould (Columbia University) laser patent in exchange for providing the funds to fight for the validity of the patent and to deal with its infringers. After an expenditure of more than $700,000 in legal fees, PAT-LEX obtained valid patents in 1979 (for an application that had been under review since 1975), and back-royalties of more than $8,000,000 have since been received.

The important point arising from this variety of patent commercializing organizations is that the choice significantly affects the nature and extent of the potential "worth" or value attached to the patent. The university patent and licensing offices operate within a different set of constraints and freedoms. Correspondingly, the value that can be obtained for a patent by a university is not the same as that which might be obtained by an outside organization.

Uniformity of Evaluations

Because the patents considered for this study spanned many disciplines, the SRI evaluators chosen to assess them were equally diverse. In general, the evaluators were consistent in the thoroughness with which they appraised the technical claims put forth in each patent. Evaluation by state-of-the-art practitioners yielded uniformly high technical performance in judging the relative strength of the claims, as well as the relative importance of the several claims in a patent.

The estimates of future market value were less consistent. Such estimations are highly speculative, and require an in-depth view of market factors comparable to the depth of technical evaluation performed. If a patent had no obvious value, it was so stated. For those patents with some potential value, the results were mixed. Several evaluators calculated potential sales after constructing a particular scenario for future market share. Others made only general statements about speculative futures. Based on the various inputs, estimates of "economic value" for all linked patents were developed, although some have accuracies only to an order of magnitude.

Resolving Disparities

In most cases, the inventor and the SRI evaluator agreed on the economic value of a patent, which was usually zero. When there were discrepancies, further evaluation was undertaken.

The data provided by the PI were compared with the SRI evaluation. For example, when it was obvious that an inventor was unaware of another development that had overtaken his idea, the SRI evaluator's value was accepted. If the inventor's expectations of future royalties were based on an unlikely future circumstance--such as crude oil prices of $60 per barrel--the more conservative estimate (often zero) of the SRI expert was accepted.

In other cases, a patent that at first looked valuable to an evaluator had already failed for subtle reasons known to the inventor. For example, good patents that were used for cross-licensing in the semiconductor industry were susceptible to overestimation by the evaluator. In such cases, the inventor's opinion overrode that of the SRI expert. On the other hand, if the inventor's favorable expectations were substantiated by licensing in progress, their values were used.

In two cases the organization that was handling the marketing of certain patents supplied an estimate of future worth. In both cases their reasoning and their evidence were convincing.

Influences on Patent Values

Because a patent represents a fixed technological accomplishment, it is tempting to assume that a single economic value can be associated with that patent. As this study progressed, however, its nature and central focus evolved toward a comprehensive meaning for the term "economic value" as applied to inventions.

In the legal world, a patent is classified as a "contingent asset." This means that it has no asset value until it is put to work. The value is as uncertain a variable as the future of the patent itself. In general, a patent does not have an absolute value independent of the context or time period in which it is brought to market.

Major variables on which the value of a patent depends are (1) competing technologies, (2) the comparative economics of the patented technology, and (3) the institutional setting of the inventor and/or assignee. Each of these were addressed separately, and expert advice was obtained from experienced university patent offices and commercial patent developers.

Competing Technologies

Although a patent can be said to represent a technological position frozen in time, other interacting and relevant technological events may be occurring contemporaneously and will continue to occur. Hence, a specific patent's value changes with time and with the inventory of technology with which it must compete at any particular moment. Important considerations are:

1. Can the technology of the patent be readily circumvented at modest cost (thereby avoiding liability for royalties), or is the patent so fundamental that it is unlikely to be circumvented at reasonable cost and time?

2. Is the patent "worth" circumventing; i.e., are potential users of its teachings tempted by excessive royalty terms and conditions to use alternative methods?

3. How much know-how created by the inventor and assignee accompanies the patent to enable its use in practice?

4. Are surrounding patents (a portfolio held by the same inventor that adds to the protected/defended area of technological and economic superiority) available?

5. How soon (or how far in the future) are attractive alternative methods likely to be available to achieve the effect/function described in the patent?

Because the answers to these questions change with time, the patent's value changes as well.

Proprietary Technology

The technology protected in a patent exists in an environment that is usually driven by economic considerations, which also change with time. The value of a patent is affected by both the perceptions and the realities of where the proprietary matter represents a marginal or revolutionary improvement over the preexisting state of the art and of the economics of competing approaches. The position of a patent on the evolution/revolution spectrum of technological development will also change with time.

Institutional Setting for Commercialization

Other factors affecting the value of a patent emerge from the institutional setting in which commercialization is attempted; i.e., a patent's value is not independent of the person or institution that seeks to capitalize on it. The value of a patent in the hands of an independent inventor is different from the value of that same patent in the hands of a large corporation. The value is again different in the hands of a university (and there will be additional differences between values at a state university and a private university), or a nonprofit organization, or a patent commercialization firm. Government rights to the patent will also have an effect on the patent's value.

Other determinants of value in this category include:

(1) The level of entrepreneurial talent and effort available to push the patent toward commercialization.

(2) The place patent commercialization holds in the value system of the patentor or assignee.

Particularly in university settings, the commercially realizable value of a patent is likely to be affected by: tradeoffs between royalties and further research funding at that university/department/unit; tradeoffs between royalties and industrial consulting contracts or prospects for graduate student employment with companies; and the ability to achieve commercialization at the university and in surrounding industry.

III RESULTS

To determine the commercial value of patents resulting from the NSF-sponsored research, it was first necessary to establish direct links between the sets of grants and patents. For patents that were found to be linked to NSF grants, SRI attempted to establish the value of each one by analyzing the technical merits of and the potential market for each invention. Because the value is directly related to the patent assignees' desire and ability to pursue commercialization of the technology actively (rather than taking an inactive role of waiting for a potential user to seek out the patent), a range of reasonable values was estimated for each linked patent. Figure 1 schematically illustrates the steps in the evaluation of the set of 248 patents.

The 248 patents and 149 grants from NSF that are the subject of this study are listed in Appendix B .

Linkage

Each patent is listed in Appendix B, with the status of its linkage to an NSF grant. The preliminary judgments of both the SRI evaluators and the PI, as well as the final linkage conclusion, are listed.

Of the 248 patents evaluated, only 51 patents held by 34 PIs were directly linked to NSF grants. The remainder were either deemed clearly not linked initially by the SRI evaluators or were eliminated after discussions with the PIs.

Of the 197 patents held by 127 PIs determined to be not linked to grant research, 142 patents held by 93 PIs were initially deemed not to be linked. An additional 55 patents held by 36 PIs were later added to the list of unlinked patents for several reasons. The most common reason for this later judgment is that many ideas that actually preceded grant applications were not prosecuted rapidly. Therefore, although the filing date followed the grant date, the idea actually predated the grant. This criterion for linkage was used consistently throughout the study. Individual inventors, on the other hand, had a variety of standards for calling a patent and a grant "linked;" for example, inventors who had been grantees of several agencies sometimes distinguished between projects worked on by different students.

Patent Licensing

After concluding which patents were linked to the NSF grant program, those linked patents were further evaluated to determine the extent of any commercial activity associated with them. Table 2 shows

Table 2

LICENSED PATENTS

Sequence	Institution	Patent Number	Royalties to Date	Topic	Comments
1306	University of Connecticut	4062237	Unknown	Ultrasonic Flowmeter	PI refused to quantify royalty
1389	Mass. Inst. of Technology	4186045	0	Epitaxial Growth Employing Electro-migration	Conflicting information whether the patent is licensed
1521	U. of California, Berkeley	4129863	620,000	A-D Converter by Weighted Capacitors	More royalties expected
1903	Purdue University	3991764	0	Plasma Arc Scalpel	Licensee terminated agreement; not actively pursued
2116	Stanford University	3875550	52,000	Focused Acoustic Imaging System	No expectation of future royalties
2116	Stanford University	4325257	5,000	Digital Acoustic Imaging System	5K per year until product development increases income
3361	University of Arizona	4263010	1,200	Crystallizer Process Control	No future royalties expected

that only 7 of the 51 linked patents have actually been licensed, and that 6 of these have received royalties. Three of these six are expected to produce additional royalties; the remainder are expected to be inactive in the future. These conclusions are based on the discussions with the PIs and their assignees, and on the merit of the inventions as determined by the SRI evaluators.

Potential Economic Value of Patents Examined

All 51 patents held by 34 PIs were analyzed to estimate the value of possible future royalties.

Table 3 lists 33 patents held by 26 PIs that were judged to have little chance of generating royalties, and consequently to have no value. As indicated in the brief comments on the table, reasons for these judgments given by the evaluators were related to a variety of technical, market, and business issues.

Table 4 summarizes the 18 patents held by 13 PIs that were judged to be of value (including 5 of those listed in Table 2). All are in different stages of development--some are already licensed, some are likely to find near-term markets, and others may have value far in the future. The potential royalty value ranges given in the table are based on the evaluators' assessments of the merits of the invention from the standpoint of breadth of applications, the size of the possible market and the invention's degree of penetration, the patent's vulnerability to other advancing technology, the invention's commercial lifetime, and a reasonable royalty rate.

If the patent is not actively pursued it will usually not generate royalty income. On the other hand, the number of application areas (different ways a patent can be used) and the market size and degree of penetration, as well as the patent's active lifetime and royalty rate plus any lump payment, will determine the total royalty yield.

Given the many interacting factors that circumscribe the commercial prospects of a patent obtained in a university setting as a result of an NSF grant, SRI's commercial value screening suggests that patents with a potential future value will have the following properties:

(1) The technology warrants further investment toward commercialization.

(2) An attractive prospective market application for the technology has been identified, and a group of potential sponsors appears to exist.

(3) The competitive technological advantage of the patent over current alternatives is significant.

Table 3

LINKED PATENTS WITHOUT COMMERCIAL VALUE

Sequence	Institution	Award Number	Patent Number	Comments
185	Mass. Inst. of Technology	K002534000	3904501	Other means available
211	Cornell University	K033848000	4161814	Needs development
331	Mass. Inst. of Technology	K028282x00	4292125	Fusion dependent
434	Stanford University	ENG7422234	4271041	Syngas price dependent
434	Stanford University	ENG7422234	4136062	Technical difficulties
656	U. of Wisconsin, Madison	K005043000	3899570	More expensive
918	U. of Wisconsin, Milwaukee	K032708000	4202051	No market
918	U. of Wisconsin, Milwaukee	K032708000	4275265	No market
1139	Oregon Graduate Center	ENG7622350	4283122	Technology surpassed
1306	University of Connecticut	K042114000	4307613	Part of another patent
1306	University of Connecticut	K042114000	4062237	Development cost prohibitive
1386	University of Delaware	ENG7622972	4294725	No market
1389	Mass. Inst. of Technology	ENG7622310	4011745	Simpler systems available
1521	U. of California, Berkeley	ENG7504986	4168440	Not fabricated
1521	U. of California, Berkeley	ENG7504986	4050031	Alternative methods available
1704	U. of Southern California	ENG7519335	4145671	Too expensive
1903	Purdue University	K003383000	3991764	Superceded
2036	U. of Michigan, Ann Arbor	K036519000	4040487	Not commercially viable
2106	U. of Wisconsin, Madison	K021218001	4150382	Superceded
2116	Stanford University	K024635000	3953825	Superceded
2116	Stanford University	K024635000	3944732	Not commercially viable
2177	Kansas State University	K041206000	3950789	Once licensed, not used
2256	University of Kansas	K024928002	3977203	Not reduced to practice
2501	U. of Wisconsin, Madison	ENG7615594	4101310	Limited application expensive
2630	Stanford University	ENG7502397	4253925	Expensive, superceded
2899	U. of California, Berkeley	ENG7621818	4361026	Small market satisfied by simpler devices
3061	Ohio State University	K014633000	4129974	In public domain
3361	University of Arizona	K016407000	4025307	Extremely high capital invest-
3361	University of Arizona	K016407000	4183729	ment required (both patents)
3971	Mass. Inst. of Technology	ENG7419999	4291390	Not viable
4108	Purdue University	GK40032000	4286142	Limited market, too specialized
4329	Rutgers University	K014075000	3972776	Superceded
4577	U. of Southern California	ENG7682560	4176326	Superceded

Table 4

LINKED PATENTS WITH COMMERCIAL VALUE

Sequence	Institution	Award Number	Patent Number	License	Royalties	Potential Royalty Value
185	Mass. Inst. of Technology	K002534000	4264750	In nego.	0	0-2M
1156	Northwestern University	ENG7414928	4101852	No	0	0-40K
1389	Mass. Inst. of Technology	ENG7622310	4186045	Yes	0	0-500K
1389	Mass. Inst. of Technology	ENG7622310	4080926	No	0	0-50K
1389	Mass. Inst. of Technology	ENG7622310	4076866	No	0	0-50K
1389	Mass. Inst. of Technology	ENG7622310	3879235	No	0	0-500K
1392	Georgia Inst. of Tech.	ENG0768170	4318581	No	0	0-40K
1438	State U. of N.Y., Buffalo	K003438000	3895958	No	0	0-25K
1521	U. of California, Berkeley	K005452000	4129863	Yes	620K	1M-5M
2116	Stanford University	K024635001	3875550	Yes	52K	52K
2116	Stanford University	K024635002	4325257	Yes	5K	5K-120K
2272	Mass. Inst. of Technology	ENG7505301	4144374	No	0	0-500K
2272	Mass. Inst. of Technology	ENG7505301	4076916	No	0	0-500K
2501	U. of Wisconsin, Madison	ENG7615594	4321086	No	0	0-5M
2860	Mass. Inst. of Technology	ENG7420857	4152676	No	0	0-100K
3361	University of Arizona	K016407000	4263010	Yes	1.2K	1K-10K
3618	Columbia University	ENG7603920	4331936	No	0	0-500K
4387	U. of California, Berkeley	K037774000	3970959	No	0	0-1M

In nego. = In negotiation

(4) The inventor and/or assignee is available and is interested in participating in efforts toward commercialization.

SRI's evaluators took all of the preceding factors into consideration in determining royalty potential. The resulting ranges of potential royalties reflect the inherent uncertainties in the evaluation process. The upper value is highly unlikely to be realized because it reflects a combination of ideal or near-ideal conditions, but actual royalties are highly likely to fall within this upper bound.

Of the 248 patents examined in this study, 51 (or 21%) were found to be linked to sponsored research. Eighteen of the 51 linked patents are considered to have "potential value"; 7 have already been licensed. Six of these 7 have yielded royalties totaling almost $680,000, although a single patent earned almost all of the total.

Potential Economic Value of All Linked Patents

As described earlier, the analysis of linked patents was limited by two conditions: (1) the difference between the period in which the grants were awarded (1968-1977) and the period in which the patents were issued (1975-1982), and (2) the lack of information about 474 patents known to be issued but for which grant information was not recovered. To reach quantitative conclusions about all linked patents issued to the grantees of interest, two statistical adjustments were made.

These two adjustments were made on the aggregate statistics of the patents examined. Considering the uncertainties of the evaluation process, this approach made it unnecessary as well as impractical to estimate the probability distribution of royalty income for each patent. Therefore, the midpoint of the range of potential royalties for each patent (Table 4) was used.

The sample of 248 patents showed that 92.7% of them had no value. The midpoint value of the estimated royalties for the remainder was found to be approximately lognormally distributed.

A Monte Carlo simulation yielded a best estimate of the potential royalties of the 474 patents of $23.0 million. Combining this figure with the midpoint of the estimated royalties of the 248 patents examined gives an estimated total of $31.5 million in royalties for all patents known to have been issued.

To adjust for the difference between the grant award and patent issue periods, the distribution of the time lag between grant award and patent issue was determined. From this distribution, it was estimated that 60% of the patents that have been issued to the grantees were issued in the period 1975-1982. Therefore, the total royalties for all patents issued or to be issued to the group of PIs studied was estimated to be $52.5 million.

Total Economic Value

The impact on the U.S. economy can be significantly higher than the royalty payments alone. Conventionally, royalties consist of a percentage of the total market and, in some cases, a lump sum payment. The percentage varies throughout the various industries and is, of course, affected by the perceived worth to the potential licensee. It is typically in the range of 5% to 10%. Thus, in those cases where the technology is successfully commercialized, its total economic value in the U.S. economy will range between ten and twenty times the royalty income.

IV ADDITIONAL OBSERVATIONS

University Patent Office Activities

Discussions with university patent administrators not only helped to refine economic evaluations in unclear cases, but also provided a wealth of general information about the nature and value of commercialization activities in a university setting. Furthermore, the specific cases that these administrators described provided insights into the variety of unpredictable technology and market factors that influence the commercial success of a particular invention.

A remarkable consistency exists among the viewpoints of patent administrators at the universities visited. These administrators have dealt with patents in many disciplines and with many sponsors; over a period of years, most have handled a few big winners. They reacted to the observed success rate in the SRI study without surprise, saying that it was consistent with their own experience.

At MIT, for example, the patent licensing office is expected to pay its own way (and has done so because of patents such as the ferrite core and synthetic penicillin). The office cannot afford to file for a patent on every disclosure that is submitted; some comparative evaluation of potential is required to select the most promising patent opportunities. The rapidly growing fields--biotechnology is a current example--have a strong appeal because of their more immediate potential for royalties, but long-term considerations such as the positive impact of an invention on society are not neglected. Food and nutrition patents are currently the largest sources of revenue at MIT, but its licensed patent base is quite broad, and patents deliver $1.8 million annually in royalties.

The question of how to balance the long- and short-term goals of a university was discussed in each visit. All the patent administrators we interviewed insisted on a subordinate role for patents. Figure 2 represents one university's concept of its major functions. Patent commercialization occupies a minor position in this view.

Of the university patent administrators interviewed, the one with the most seniority is Roger Ditzel of the University of California. His office handles patents for all nine campuses of the University of California system, which spends $800 million annually on research. In a typical year (academic 1983), this office processed 297 disclosures and 92 patent applications, and it derived royalty income totaling $2.2 million from 109 patents issued earlier. The technology transfer office has been very successful in the eyes of the university administration.

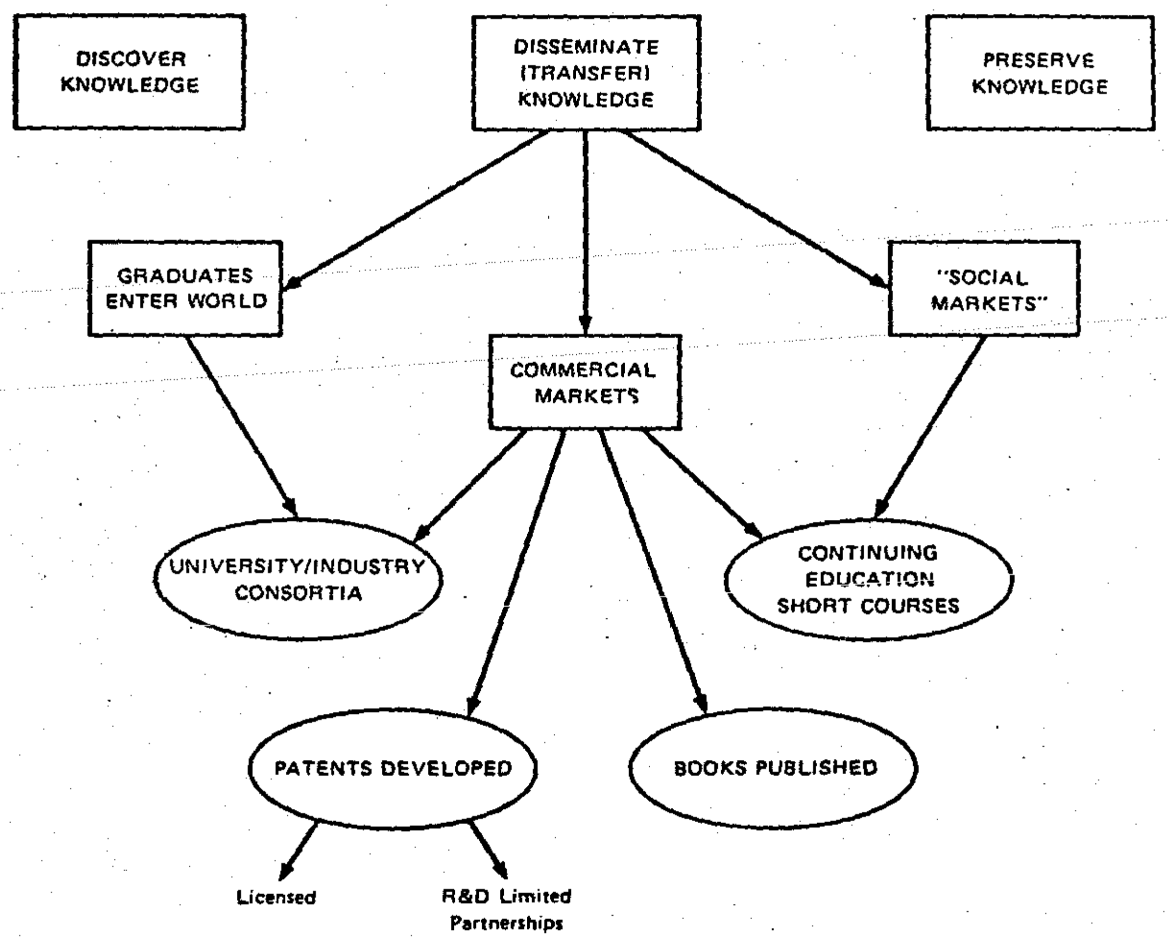

FIGURE 2 ROLE OF PATENT COMMERCIALIZATION IN A UNIVERSITY

However, Ditzel's criterion for success is not solely a financial one. He stresses the theme that the purpose of a university patent office is to transfer technology, not simply to maximize royalties.

All the universities visited had certain characteristics in common: (a) a large portfolio of patents, (b) entrepreneurial marketing skills, (c) no unrealistic expectation of short-term rewards, and (d) a conviction that securing royalties is not their primary objective. Some specific recommendations made by these experienced university patent administrators are included later in this section.

As this study progressed, it became clear that the value of patents in a university setting has much broader dimensions than simply royalties or future market sales. One merit of an active university patent program is the additional research funding it attracts from industrial firms.

Illustrative Cases

This section presents detailed discussions of certain patent cases, carefully chosen to illustrate points made throughout the study. Except for the circumstances surrounding the "Big Winner," the events described here were typical of those mentioned in several interviews.

A Big Winner: The CODEC Patent

Every inventor (and his university) dreams of striking it rich with a winning patent. In this study, one such winner was found. Its exceptional value warrants describing the patent in detail here.

In 1972, the Electrical Engineering Department of the University of California at Berkeley submitted a proposal to the NSF for funds to support research aimed at making an analog-to-digital converter on a silicon chip. NSF funded the project, and it was a success. A new method of A-to-D conversion based on switching a bank of capacitors (having values C, C/2, C/4,... C/256) was invented. On completion of the grant, a patent application was filed. In 1978, U.S. patent number 4,129,863 was issued for the CODEC. The text of the patent fully acknowledged the NSF grant that supported this research. Note that this was no serendipitous discovery, but was rather an example of the classical search for scientific insight into a difficult technical problem. What they accomplished was exactly what the grantees set out to do.

Because it is difficult to manufacture capacitances of C, C/2, ... C/128, C/256 precisely, it is necessary to calibrate this A-to-D converter using a known input signal. The inventors also devised a circuit to achieve this, but did not patent it because pursuing the first patent had been so difficult and time-consuming. With hindsight, they feel that the extra protection of a second associated patent would have strengthened their later negotiating position.

Recognizing that the grantees had a winner, the University of California patent office asked NSF for a waiver of NSF's rights in this patent, so that the university could reap the full benefits of commercialization. NSF agreed to grant the waiver, in keeping with a policy it had established some years earlier. Until the late 1970s, however, very few universities were aware of this NSF policy. (Later, in 1980, P.L. 96-517 was passed and codified this then exceptional NSF custom into a formal government-wide policy: Any university that is prepared to develop patents resulting from government sponsorship is granted the right to do so.)

In the intervening years, the University of California has successfully negotiated licenses with major producers of electronic equipment for use of this patent. The skills of the university negotiators must not be overlooked: most patents in the semiconductor field have only defensive value (for cross-licensing, in the tradition of the transistor patent). Had this patent belonged to an integrated circuit firm, it is doubtful that it would ever have produced royalties.

The A-to-D converter-on-a-chip has a promising future. Berkeley officials expect one in every car and one in every telephone by 1990, and total royalty income is projected to be in the tens of millions of dollars. What started in an NSF research project may become a commonplace part in consumer products.

Obviously, the CODEC met an important need in a unique and elegant way, and it is being carried along with the momentum of integrated circuit technology development. The question for this study is whether any general lessons can be learned from this success story, or whether it is an exception.

The statistics of this study show that any major economic return on a patent is an exceptional event. However, the CODEC story has certain characteristics that are common to profitable patents. They are: (1) the CODEC can be incorporated into widespread consumer products; (2) the patent was aggressively marketed by experienced negotiators; (3) the claims of the patent were carefully constructed and are difficult to circumvent; (4) the research was pursued diligently from start to finish; (5) the patent solved a technical problem that had stymied many earlier attempts following more conventional routes; (6) the research was based on a creative idea that took advantage of other contemporary developments in the field; and (7) the invention was applicable to a rapidly developing new industry.

<u>An Industrially Sponsored Laboratory</u>

Among the 75 PIs interviewed, a few had established formal links with industry, usually in the form of a consortium of industrial sponsors for research conducted under the PI's supervision. In the most successful of these arrangements, the industrial members pay a yearly fee of $20,000; in exchange for this fee, they receive the opportunity to interact closely with faculty and students of the program they sponsor. In a typical consortium, the members are given royalty-free licenses to use any inventions; not all sponsors want any given invention. The annual fee functions as a surrogate royalty--it is a payment for use of the inventions that may be created in the future. The members are the first to know about these when they appear.

When a discovery emerges that is of sufficient merit to warrant chartering a company to develop it, the consortium members have the first right of refusal to participate. One professor interviewed for this study had 25 patents, and 3 of these had formed the basis of new companies. No royalties were ever paid for these commercial developments, but no one would call these patents "worthless."

Inventions in the Public Domain

Several cases were found in which a patent covered a process or product that is now in use, but for which the inventor had no expectation of receiving royalties.

In the field of civil engineering, an improvement in I-beam technology followed from an NSF grant, and a U.S. patent was issued. Later, in pursuing a German patent, the inventor discovered that a very similar invention predated this one. The inventor, who realized how easy it would be to infringe his patent, gave several companies the right to use his technology, royalty-free. Still later, a leading civil engineering handbook recommended this method, and it is now expected to become standard practice. The benefit to the PI will be limited to the satisfaction associated with seeing his innovation being practiced.

In the semiconductor field, an electro-epitaxy method of growing crystals was invented in the mid-1970s at MIT. The patent acknowledged U.S. Air Force support; however, because an earlier NSF grant was also helpful, it was included in the "linked" set of this study. No license was ever issued, and the inventor expects no royalties because other technologies are used more commonly today. However, quite recently this process has been revived by NASA, which hopes that gallium arsenide crystals might be grown in zero gravity by the method described in the patent. A Joint Endeavor Agreement has been negotiated between NASA and a company set up to develop this zero-gravity activity. The possibility of later profitability (from an invention that had been written off) because of the availability of zero gravity clearly indicates the range of factors that can influence the future of an innovation.

A Technology Overtaken by Changed Economics

A university-based grantee in the early 1970s developed expertise in the control of particle sizes during crystallization of solids from solution. NSF grants for experimental and theoretical studies of the crystallization process nurtured the new capability in the late 1970s, the grantee obtained a patent that applied that control of crystallization, with the aid of a particle-sized measuring feedback system, to the operation of commercial-scale industrial chemical crystallizing equipment. A patent licensing firm was engaged by the grantee's university to develop income from the invention.

A license was negotiated through a process equipment firm. One royalty-bearing application was developed at a Canadian installation in the early 1980s; that particular plant used the process for the crystallization of potash (a fertilizer component) and sugar. However, the price of both commodities subsequently fell, and it became uneconomical to apply and operate the extra control system acquired to obtain the more uniform particle size distribution made possible by the licensed equipment. SRI's technical assessment of the patent confirmed that the prospects for the invention are now more dependent on the marketing skills of the licensee and on market economics than on the invention's technical superiority.

SRI's interview with the inventor revealed his continuing expectation of royalties, but his view seemed unrealistic in light of the comments from the patent licensing organization. Also, the market prices of potash and sugar have not improved. To summarize the current situation, the technical advantage of this NSF-linked patent is not sufficient to assure its success if the markets for the products the invention produces are characterized by declining or even stable prices.

A Patented Technology Under Negotiation

A professor of chemical engineering found in the 1950s that unusual or even unique chemical reactions might take place in high-frequency corona discharges (plasmas), and the design of experimental equipment was begun. Because of its growing promise and the increasing interest in it, the work was continued under various funding sources (industry and government). In the early 1970s, grants were awarded by NSF to pursue this field, specifically to examine the polymerization of carbon fluorides in plasmas. The result was production of polymerized materials with a thermal stability similar to that of Teflon. The plasma synthesis became the subject of various patent applications, and patents were ultimately issued.

Interest in the technology developed at Defense Department laboratories and at industrial companies. Licensing prospects in industry were pursued, but licenses were not issued. Instead, additional research funds were provided by both DOD and private firms that were interested in the high-temperature stability and lubricity of the compounds under high pressure.

The patents issued in the mid-1970s that are linked to the NSF-sponsored part of the plasma synthesis work have not been licensed to date, and their prospects are no longer being actively pursued because the technology has been superseded. However, research work has continued; a patent issued in 1981 and related patent applications that are still pending cover new derivatives and more attractive prospects.

The plasma synthesis of polyfluorocarbons in bulk (as described in older patents) did not prove economically competitive with the standard catalytic synthesis. However, more recent work shows that plasma synthesis could be practiced at the surface on much less expensive plastics such as the polyethelene types, and at high rates and cool temperatures. Such efforts are promising because it is usually only at the surface that the sought-after lubricity and chemical stability are needed. Furthermore, the plasma route seems to permit surface treatment to be highly customized. Potential applications extend to surface treatment for solvent-resistant plastics for automobile gas tanks--a large market. However, considerable funding is needed to develop commercial-scale processing and to determine its economical feasibility.

The university where this work has been continuing for more than 30 years is not as active in pursuing licensing prospects as the inventor might like. Also, the scale of the funding required for further process development is quite large; obtaining these funds may require the use of such potentially risky mechanisms as R&D limited partnerships, which are not normally acceptable in university settings. Negotiations involving the inventor, the university, and possible outside investors are currently under way, and the prospects for capitalizing on this long history of innovative technical achievements may be significant.

Qualitative Findings

The quantitative results of this analysis provided useful baseline data concerning the direct commerical returns from NSF engineering grants. In addition, the findings from this work, including the initial determination of grant/patent relationships, the interviews with 75 inventors, the detailed appraisals of patents, and interviews with university patent licensing officers provide additional valuable information. It is convenient to group this information into three categories: methods of evaluation, value of patents, and future expectations.

Methods of Evaluation

This study is part of an NSF research program intended to determine how NSF-sponsored research can best be evaluated. SRI was not asked to judge the worth of particular research grants; rather, the focus was on how data about patents can be used in the evaluation process. Thus, some findings are related to the methodology that was used.

It is possible, by applying experienced scientific judgment, to determine whether a patent is linked to a research grant. In this study, the primary SRI evaluation team consisted of three staff members whose skills spanned the chemical, civil, electrical, mechanical, and optical engineering disciplines. The two-step process of first making a tentative judgment of linkage and subsequently interviewing the inventor about the linkage worked quite well. The SRI team, acting alone, could not have correctly adjudicated every tentative grant/ patent linkage. Sometimes the interviews with inventors revealed the grant/patent linkage; at other times, the interviews with inventors revealed that the patent idea predated the grant (and in a few cases helped the inventor to be awarded a grant), but filing was delayed for various reasons.

There was little reluctance among inventors to acknowledge that NSF sponsorship had led to their patent. Indeed, many inventors praised NSF sponsorship for giving them their start, even though the patent was in a rather distant field and was awarded years later. The standard for calling a patent "unambiguously linked" to a grant necessarily led to the exclusion of some patents from detailed economic evaluation, but the intent was never to inflate the apparent worth of the patents in the sample.

Direct contact with inventors is a valuable source of information on commercialization activities. In general, the inventors were helpful and cooperative in providing information about the history and future prospects of their patents. Although inventors were usually more optimistic about the worth of technology, in very few cases did the inventor differ sharply from SRI's opinion of the patent's value. When licensing efforts had been made but had failed, the inventor's explanation of the surrounding circumstances was quite helpful in assessing the value of the patent.

The inventor's speculations about possible changes in the marketplace or in technology that could enhance the value of a patent were also helpful. Speculation about rapidly developing fields such as optical computers was particularly useful in determining "expected value" of future royalties.

Open-ended questions about indirect or nonmonetary benefits from an inventor's patents proved to elicit the most valuable information of all. None of the wealth of information obtained from this question could have been gathered without direct contact.

Whether or not a given idea is patented depends on a set of factors largely unrelated to research. In discussing patented inventions with their inventors, a wide range of attitudes toward patenting was discovered. Almost everyone likes to get one patent because it looks good on a resume. During the 1970s, it was relatively inexpensive to file a patent application. Also, certain research sponsors (especially the U.S. Navy) donated the time of patent lawyers. For universities that had a patent-development contract with an external firm (The Research Corporation, University Patents, etc.), the potential future value of the invention was an important consideration in deciding whether or not to file. These firms probably reduced the number of "vanity" patents. The great majority of the patents studied here were not handled by such firms, but were instead prosecuted by individual universities. Some universities with experienced patent development organizations (e.g., the University of California, MIT, Stanford) tried to act on the basis of judgments about future worth; not all others did so.

Inventors who held several patents and had not received royalties often had lost interest in any further patenting. The value of the time required to obtain a nonproducing patent was an important contributor to this disaffection. Other inventors, equally devoid of royalties, see the patents as an inducement for industrial sponsorship of their research, and continue to pursue patents vigorously. These inventors are a minority, and they tend to be located at universities with large, industrially supported laboratories.

A variety of motivations other than a desire for profit may determine whether ideas are patented, published in the open literature, or cast aside. The behavior of university inventors is not typical of the behavior of inventors employed by corporations; furthermore, the behavior of university inventors will probably change in the 1980s as the cost of obtaining a patent rises steadily.

Patents having little or no value can be identified by scientists who are skilled in the art of evaluation. The patent evaluators at SRI-Menlo Park who participated in this study are professional scientists who are active in research fields and interact regularly with the business community. Throughout the study, evaluators who called a patent worthless had sound technical reasons for this opinion. Knowledge of a competing technology that had surpassed a given invention was the most important aspect of an evaluator's expertise, but knowledge of market conditions also figured prominently.

The economic values of patents can only be estimated within about an order of magnitude. Such issues as the details of future licensing agreements, the entrepreneurial skills of the patent commercializer, and the market acceptance of the product will greatly affect the future royalties from patents that have some value. Uncertainties about such issues are partly responsible for the difficulty in estimating future royalties within a narrow range. There is also no way to be sure that some entirely new idea will not suddenly make a patent obsolete. On the other hand, a patented idea that is dormant today may become prominent tomorrow because of an ancillary invention.

In this study, the single most valuable patent has already received royalties of over $500,000. Its eventual potential may be $50 million; the characterization of its worth as $5 million ± 1 order of magnitude seems valid. For patents of less value, the same logarithmic range can be applied.

The values of patents that bear on as yet undeveloped technologies (e.g., optical computers) are even harder to estimate. Depending on the importance of other technologies and the speed with which change occurs, the value of such patents may range from negligible to $100 million.

Value of Patents

One goal of this study was to find the economic value of the set of patents derived from NSF sponsorship. The findings in this area are surprising.

Royalties do not measure the value of a patent. This statement differs from conventional thinking, and therefore calls for some explanation. First of all, this conclusion was not reached merely because so few royalty-generating patents were found in this study. There is evidence of several patents that led to the formation of new companies, even though no royalties were ever paid.

To measure economic value only through royalties thus seems unjustified. When a new company is formed and a product is made (even if the company eventually fails), there is an increase in economic activity. For example, during the early 1970s, NSF sponsored research in solar cells, and patents were derived from this work; but profitable production of solar cells has been an elusive goal. How can this economic activity be properly quantified?

When one invention points the way to others, and a new market develops, it is impossible to attach a numerical economic value to the initial invention. In one case in this study, the initial patent that led to formation of a new company never paid off, but subsequent related patents are making the company profitable.

A patent used defensively (e.g., in cross-licensing) has hidden economic value. Many examples could be mentioned, but the transistor patent is the outstanding case. No one would pretend that such patents are devoid of economic value simply because they deliver no royalties.

To a university, the value of a patent is determined by the amount of research support it generates. In our interviews with inventors, the most frequent recurring comment began with, "I didn't get any royalties, but I got...." The inventor then gave an account of another grant from elsewhere in government or from industry. When professors who have built research centers supported by industry were interviewed, they were quick to attribute their attractiveness to industry to their patents. The tenor of the inventors' comments is suggested by the following quotations:

> "If I get just one grant from the Air Force because of a patent, that alone far outweighs any royalties."

> "Companies sponsor us mostly in order to have the right to use our technology."

This form of remuneration to a university should not be overlooked. MIT, for example, receives $27 million in industrial sponsorship each year--a far larger amount than it receives in royalties from its patents. One MIT professor holds 25 patents and has started 3 new companies based on some of them, although his patents have received no royalties.

Pharmaceutical patents have the best odds of becoming valuable. (This result came from discussions with leading patent administrators at universities rather than from the data on NSF grants used for the study.) The pharmaceutical industry customarily respects patents, and over the last several decades a few universities have benefited greatly from certain pharmaceutical patents. However, until quite recently (with the passage of an extension of patent protection, signed into law in November 1984), the requirement for an 8-year period of clinical trials reduced the total time over which significant royalties could be earned. Now the 17-year patent lifetime starts after the clinical trials are complete.

In some fields, patents have only defensive value. In a 1956 consent decree, AT&T agreed to use its patent on the transistor only for cross-licensing. This agreement established a custom in the semiconductor industry that is still followed today. Circuit designers use the best available technology freely; if they are challenged for infringing on a patent, they will use their own patents to file a counter-challenge. The outcome of such conflicts is usually a cross-licensing agreement.

Patents in rapidly developing fields (e.g., optics) are superseded in a short time. The window of opportunity for many technologies is brief. Throughout most engineering disciplines, it is common for a promising technology to lose to some alternative technology. For example, several inventions in this study were applications of surface acoustic wave (SAW) devices, which had a brief period of ascendancy during the mid-1970s. Today, however, charge-coupled devices and other competing inventions have supplanted SAWs in all but a few applications. Another example from a different field is this: One of the licensed, royalty-bearing patents in this study served as the basis for a medical device that looked promising at first but never really succeeded in the marketplace.

The concept of optical computers is attractive at the moment, but its future is uncertain. Recall that the best engineering judgment at leading research laboratories once favored magnetic bubbles, and later Josephson junctions; neither appears promising today.

To an industrial firm, the patents held by a university provide a reason to support university research. In discussions with both inventors and research administrators, this comment was the most significant common theme. Independent studies by others (Cyert, 1985) have noted this condition as well.

Typically, a "center of excellence" at a university starts out with government support and gradually attracts industrial cosponsors. Over several years the industrial sponsorship becomes dominant and government support declines. Ideally, the professors maintain control over their research in this way, and do not risk being dominated by a single corporate sponsor.

For industry, this support of university research has several advantages. First, it allows a corporation's own scientists to maintain close working relationships with faculty members. Second, the graduate students emerging from these centers are an excellent source of employees. Third, sponsors receive prompt notification of research results, which enables them to stay ahead of competitors. This is the most important benefit of all, according to several of the PIs who were interviewed. Fourth, industrial sponsors are customarily given first right of refusal to license any patents that come out of the research they sponsor.

A good patent does not assure the success of a product. A desire to learn about new technology early is a major impetus for sponsoring research because being first in a field is a definite advantage. However, the power of a patent is limited. It protects manufacturers from obvious copying and gives them some leadtime--perhaps 2 or 3 years. However, competitors eventually will either find a way to evade the patent or will infringe it anyway while they negotiate for a license, hoping to reach an out-of-court settlement. The only real long-term protection for a product is the marketing skills of its manufacturer.

Future Expectations

Many universities are currently reevaluating their industrial relationships, often with the help of state governments that wish to foster high-technology industry in their states. In that reevaluation, the importance of patents to university research is an important topic. PIs as well as administrators addressed this issue in the interviews.

Legislative Changes. Before 1980, the commercial development of a patent derived from government-supported research was a rarity. It was widely believed that government-related patents were worthless, and this belief turned into a self-fulfilling prophecy because inventors (and their universities) did not vigorously pursue commercial opportunities.

Also, before 1980, various public agencies had separate policies governing patents received by grantees. NSF had a policy that would be termed "enlightened" by 1984 standards: Any university that could demonstrate the ability to negotiate a license for a patent was free to ask NSF for a waiver of the government's rights in that patent. NSF readily granted such waivers.

However, the policies of some other sponsoring agencies were more cumbersome and had the effect of discouraging attempts at licensing. Without a clear release of the government's rights, a patent holder would have great difficulty in limiting potential competition; because they recognized this, few companies were interested in licensing such patents.

The majority of the patents (and all of the grants) considered in this study originated in that legislative environment. Therefore this study provides baseline data on patent development in the 1970s, against which the effects of recent changes in the law can be measured. It is noteworthy that the single high-value patent found in this study is one for which the university requested a waiver from NSF.

A most important change in patent practices occurred in 1980 with the passage of P.L. 96-517, the "Bayh-Dole Act." This law corrected several deficiencies in the way government-based patents were handled. The law established the principle that rights should be vested in the inventor and his university in order to maximize the opportunities for development. This principle made infringement more difficult and gave universities a valuable enforcement tool. Second, the law required the government to create a uniform method of dealing with patents in all sponsoring agencies. This requirement simplified matters for universities and licensees alike. Third, the law allowed universities to give exclusive manufacturing rights to companies. To most patent developers, exclusivity is a vitally important characteristic of a license.

<u>Strategy for Universities</u>. Since 1980, a large number of universities have revised their thinking about patents. During the earlier period, when the likelihood of gain was small, it made economic sense for universities to neglect patents. Today, the opportunity for profit exists, provided that the technology and the market for the patent are strong. This circumstance has attracted the attention of universities, many of which are elevating the task of patent management to a more prominent role in their hierarchies.

In this transition period, universities should be aware that the probability of accruing wealth from patents is quite small, and any university patent office that depends on royalties to sustain itself is likely to find that it will be a struggle.

Certain major universities have maintained patent licensing offices for many years, and their experience is valuable for corroborating the data gathered from PIs in this study. During visits to a few established centers of licensing activity, the research team asked for their perspectives on the best way to license patents. These general themes recurred in their advice:

(i) Do not expect to make a profit on patent activities. The stream of income is much too uncertain to allow any form of budgeting or profit/loss accounting.

(ii) Expect to wait 10 years or more for a winner to come along. Major consumer products such as Gatorade and Warfarin illustrate the potential returns from university patenting activity, but such successes are rare and unpredictable.

(iii) Decide what role patents play in the overall structure of the university. The primary purposes of a university are to discover, preserve, and effectively transfer knowledge, and patent licensing activities must support these goals.

(iv) Patent commercializers must be entrepreneurs who respect the purpose of the university. Otherwise conflicts will eventually develop.

(v) The short-term goal of obtaining quick royalties conflicts with a university's long-term goal of maintaining freedom of research. When the attention of the university becomes focused on cash flow, a variety of distortions result; patent licensing activities are particularly susceptible to this pattern. If the university becomes dependent on marketplace activities, decisions about the allocation of resources will be affected.

(vi) Use patents to strengthen the university's base of industrial support. A research grant from industry, or a cooperative agreement, is well worth the likely small decline in revenue associated with giving a royalty-free license or the right-of-first-refusal to a participating company.

At a recent meeting, the National Council of University Research Administrators (NCURA) discussed the various ways that a university might manage its patent portfolio: contract it out to a patent development company, handle the activity in house, or follow some combined approach (NCURA, 1984). All three methods have merit, depending on factors such as the size of the portfolio, the university's in-house entrepreneurial skills, and the proximity of many different industries. The experience in this study echoes the views expressed at that NCURA forum. Each university must decide for itself what sort of patent licensing activity it wants to conduct.

One decision that each university must make is how royalty income is to be shared with an inventor. The data of this study are not broad enough to determine an optimal division between university and professor, but comments from both faculty members and patent administrators are worth reporting.

It is plausible to think that as the inventor's share of the royalties from a patent increases, the inventor would work harder to license the patent. This is only true up to a point. Indeed, when inventors receive less than 20% of the royalties, their enthusiasm for the patent is small. When the inventors receive about one-third, their interest in commercialization is great, and the university's patent office also has a substantial interest. In universities that give inventors more than 50%, the university provides less support to inventors. An inventor's lack of experience in patent marketing may then impair the transfer of technology that the patent was intended to achieve.

One common algorithm for dividing royalty income is as follows: "Give the inventor more of the initial royalties, then scale back for high-value patents." One embodiment of this principle is used at MIT: The inventor gets 35% of the first $100,000, 25% of the second $100,000, and 15% of further royalties. Although this policy no doubt encourages professors to keep their inventions associated with the university (rather than sheltering them in a corporation for which they consult), very few patents ever produce $100,000 in royalties, so the issue is usually irrelevant.

The university can ensure zero risk by leaving its faculty members on their own--offering no help, but demanding no percentage of royalties.

At a slightly higher level of risk, the university can turn over the entire patent licensing activity to a patent development company. The only risk for the university in this approach is that a professor disappointed in the outcome of that company's efforts will blame the university for not trying harder.

A university-affiliated foundation can be created to seek licensees and collect royalties. This approach keeps the university's risk fairly low.

A strategy with medium risk is to have an in-house office of commercialization that markets patents aggressively. This approach is being given serious consideration by many universities today. One tool that a university can employ is an R&D limited partnership to commercialize an invention.

Finally, the university could use its own money (e.g., endowment) as venture capital to start a new company. Clearly this is the approach that involves maximum risk, but it also offers the greatest potential rewards.

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Appendix A

INSTRUCTIONS TO SRI EVALUATORS

APPENDIX A

INSTRUCTIONS TO SRI EVALUATORS

MEMO

TO SRI Patent Evaluator

DATE February 6, 1984

FROM Tom Sheahen and Mark Gottlieb

LOCATION WDC

SUBJECT NSF Patent Evaluation Study

CC

This memo provides guidance towards evaluating a given patent from the NSF group of grants and patents. The central task for each patent is simply stated: determine its economic value.

However, there are subtleties hidden in that simple phrase. Scientists from a wide range of SRI disciplines are supporting us in this study, and we in Washington have to superimpose some consistency on the resulting ensemble of patent evaluations. The following comments provide guidance intended to bolster that consistency while making your task less formidable.

Each inventor will already have been contacted prior to you receiving the patent, to determine important information about licensing and the money received to date for each patent. In our initial experience, we have found that very few of these inventors have any notion of what the future might hold. Therefore, we ask you to emphasize the future value in your considerations (through the end of the 17 year patent life).

The basic subordinate questions are:

What is the market for this invention? Is it commercially viable? Does it have significant economic advantages over competing technologies? Is a competing product superior, thus making the patent obsolete? Can the claims be circumvented?

There are two ways to look at the future:

1) Conservative: determine the expected value of the patent under the status quo. (That is, no unexpected or dramatic changes in the market or any related technologies).

2) Speculative: We also solicit your insight into possible future changes in the market (or other changes) that could affect the value of this patent - in either direction. However, we'd like to know the assumptions underlying such possible future events. (For example, a wide variety of solar energy devices become economically attractive when oil hits $100/barrel, but that has a low probability.) Therefore, in order to help us make this study quantitative, please estimate when you expect such a change to occur (how many years away), and what is the probability of such a change. Please go as far as you can to state the economic value of the patent with these changes occurring.

SRI 2902 2/78

Appendix B

GRANT-PATENT LINK EVALUATION

Appendix B

GRANT-PATENT LINK EVALUATION

SEQUENCE	INSTITUTION	AWARD NUMBER	PATENT NUMBER	NUMBER IN SET	EVALUATIONS SRI	P/I	FINAL
28	Case Western Reserve U.	ENG7720750	4020690	1	NL		NL
107	Case Western Reserve U.	K018407000	4361641	1	L	NL	NL
141	U. of California, Davis	ENG7613146	4219776	1	L	NL	NL
166	University of Washington	K005501000	4273127	2	NL		NL
175	University of Washington	K019171000	4313439	5	NL		NL
185	Mass. Inst. of Technology	K002534000	3904501	1	AL	L	L
185	Mass. Inst. of Technology	K002534000	4264750	1	AL(D)	L	L
185	Mass. Inst. of Technology	K002534000	4111812	1	NL	NL	NL
195	U. of Houston, Central Campus	ENG7709592	4204041	1	NL		NL
195	U. of Houston, Central Campus	ENG7609000	4289853	1	L	NL	NL
211	Cornell University	K033848000	4161814	1	AL(D)	L	L
255	U. of Southern California	ENG7606231	4068920	1	NL		NL
285	University of Washington	GK43993000	4336811	1	L	NL	NL
300	U. of California, Berkeley	K004918000	4279723	1	NL	NL	NL
300	U. of California, Berkeley	K036495000	4094758	1	NL	NL	NL
300	U. of California, Berkeley	ENG7620284	4320219	1	NL	NL	NL
317	SRI International	ENG7500263	4081339	1	NL		NL
317	SRI International	ENG7500263	4199533	1	NL		NL
327	U. of California, Berkeley	K036179000	4162480	1	L	NL	NL
331	Mass. Inst. of Technology	K028282x00	4292125	1	L	L	L
360	U. of Rhode Island	GK27842000	3907180	4	NL		NL
434	Stanford University	ENG7422234	4271041	1	L	L	L
434	Stanford University	ENG7422234	4136062	1	AL	L	L
486	University of Florida	K027615001	3882274	1	NL		NL
495	Case Western Reserve U.	GK-4116000	4270937	1	NL		NL
533	Harvard University	K025997001	3873858	1	NL		NL
586	University of Connecticut	K003015000	4200310	1	L	NL	NL
623	University of Minnesota	K011289000	3873911	1	NL		NL
623	University of Minnesota	ENG7603679	3909708	1	NL		NL
638	Yale University	K004289000	4127329	1	L	NL	NL
656	U. of Wisconsin, Madison	K005043000	3899570	1	L	L	L
734	Rensselaer Polytechnic Inst.	ENG7602010	4000884	3	NL		NL
780	Mass. Inst. of Technology	ENG7620292	4330761	1	NL		NL
797	University of Texas, Dallas	ENG7406262	4053853	1	NL		NL
820	Mass. Inst. of Technology	K043782000	4332899	1	L	NL	NL
829	California Inst. of Tech.	ENG7413934	4334888	2	NL		NL
847	Lehigh University	K038188000	4016293	3	NL		NL
872	Pennsylvania State U.	ENG7510073	4027074	3	NL		NL
912	Rensselaer Polytechnic Inst.	ENG7422688	4093976	2	NL		NL
918	U. of Wisconsin, Milwaukee	K032708000	4202051	1	L	L	L
918	U. of Wisconsin, Milwaukee	K032708000	4275265	1	L	L	L
942	Texas A&M University	K038278000	4216751	1	NL		NL
965	Iowa St. U. of Science & Tech.	K034081X00	4290252	1	L	NL	NL

Appendix B (Continued)

SEQUENCE	INSTITUTION	AWARD NUMBER	PATENT NUMBER	NUMBER IN SET	EVALUATIONS SRI	P/I	FINAL
965	Iowa St. U. of Science & Tech.	ENG7417957	4362703	2	NL	NL	NL
989	Mass. Inst. of Technology	ENG7601369	4340617	1	NL		NL
1000	Virginia Polytechnic Inst.	K004747000	3879247	2	NL		NL
1012	Drexel Institute of Tech.	ENG7717823	4271370	1	NL		NL
1033	University of Florida	K040491000	4215918	1	NL		NL
1112	University of Idaho	K034413000	4310384	1	NL		NL
1139	Oregon Graduate Center	ENG7622350	4283122	1	L	L	L
1156	Northwestern University	ENG7414928	4101852	1	AL	L	L
1156	Northwestern University	ENG7414928	4059831	3	NL		NL
1192	U. of Central Florida	K035899000	4009575	1	NL	NL	NL
1206	Iowa St. U. of Science & Tech.	K038364000	4051435	1	L	NL	NL
1215	Illinois Inst. of Technology	K001903000	4275562	1	L	NL	NL
1268	Case Western Reserve U.	ENG7620186	4249527	1	NL		NL
1282	Mass. Inst. of Technology	ENG7609586	3953879	1	NL		NL
1282	University of Rochester	K004985000	4317043	1	NL		NL
1306	University of Connecticut	K042114000	4062237	2	L	L	L
1337	University of Detroit	K043298000	4096128	9	NL		NL
1360	University of Virginia	K034537000	3965261	1	L	NL	NL
1360	University of Virginia	K034537000	3975519	1	L	NL	NL
1360	University of Virginia	K034537001	4038144	1	L	NL	NL
1360	University of Virginia	ENG7712132	4046880	1	L	NL	NL
1360	University of Virginia	ENG7716358	4176179	1	L	NL	NL
1386	University of Delaware	ENG7622972	4294725	1	AL(D)	L	L
1386	University of Delaware	ENG7710177	4123379	1	NL		NL
1389	Mass. Inst. of Technology	ENG7622310	4186045	1	AL(D)	L	L
1389	Mass. Inst. of Technology	ENG7622310	4011745	1	AL(D)	L	L
1389	Mass. Inst. of Technology	ENG7622310	4080926	1	AL(D)	L	L
1389	Mass. Inst. of Technology	ENG7622310	4076866	1	AL(D)	L	L
1389	Mass. Inst. of Technology	ENG7622310	3879235	1	AL(D)	L	L
1389	Mass. Inst. of Technology	ENG7500521	4320247	1	L	NL	NL
1391	California Inst. of Tech.	K010136000	4081250	1	NL		NL
1392	Georgia Inst. of Tech.	ENG0768170	4318581	1	AL	L	L
1409	California Inst. of Tech.	K032456000	3942861	1	NL		NL
1438	State U. of N.Y., Buffalo	K003438000	3895958	1	L	L	L
1459	U. of Oklahoma, Norman	ENG7682943	4121176	1	NL		NL
1471	University of Illinois	GK-2775900	4069418	1	AL(D)	NL	NL
1480	Auburn University	K004903000	4040425	1	NL		NL
1503	Michigan State University	K004750000	4014633	1	NL		NL
1521	U. of California, Berkeley	K005452000	4129863	1	AL(D)	L	L
1521	U. of California, Berkeley	ENG7504986	4168440	2	L	L	L
1561	Purdue University	ENG7611229	4079221	1	NL		NL
1590	U. of So. Carolina, Columbia	K005408000	4364990	1	NL		NL
1616	Polytechnic Inst. of NY	K038549000	4241602	1	L	NL	NL
1631	Columbia University	K017023000	4151191	1	L	NL	NL
1670	University of Alabama	K005424000	3992327	1	NL		NL

Appendix B (Continued)

SEQUENCE	INSTITUTION	AWARD NUMBER	PATENT NUMBER	NUMBER IN SET	EVALUATIONS SRI	P/I	FINAL
1704	U. of Southern California	ENG7519335	4145671	1	L	L	L
1732	University of Washington	R028562000	3998711	1	L	NL	NL
1736	Rochester Inst. of Tech.	GK-7204185	3860494	1	NL		NL
1762	Polytechnic Inst. of NY	K002151000	4260553	1	L	NL	NL
1762	Polytechnic Inst. of NY	K002151000	4320030	1	L	NL	NL
1903	Purdue University	K003383000	3991764	1	AL	L	L
1913	University of Minnesota	ENG7605835	4298169	1	L	NL	NL
1919	University of Idaho	ENG7610910	4069149	1	NL		NL
1940	U. of California, Los Angeles	K032628000	4065351	1	NL		NL
1955	University of Vermont	GK-5542000	4277342	1	NL		NL
1960	University of Utah	K043124000	4020830	1	NL		NL
2036	U. of Michigan, Ann Arbor	K002085000	4116276	1	L	NL	NL
2036	U. of Michigan, Ann Arbor	K036519000	4040487	1	L	L	L
2039	University of Delaware	K034612X10	4260518	1	NL		NL
2106	U. of Wisconsin, Madison	K021218001	4150382	1	AL	L	L
2106	U. of Wisconsin, Madison	ENG7516174	4195262	1	L	NL	NL
2106	U. of Wisconsin, Madison	K021218001	4305153	1	L	NL	NL
2116	Stanford University	K024635000	3953825	1	AL	L	L
2116	Stanford University	K024635000	3944732	1	AL	L	L
2116	Stanford University	K040763000	3877982	1	NL		NL
2116	Stanford University	K024635001	3875550	1	L	L	L
2116	Stanford University	K024635002	4325257	1	AL	L	L
2134	Gulf South Research Inst.	K041824000	4244787	2	NL		NL
2151	Oregon State University	ENG7528502	4339945	1	L	NL	NL
2177	Kansas State University	K041206000	3950789	1	AL	L	L
2217	University of Detroit	ENG7611235	4288562	2	NL		NL
2235	Michigan Technological U.	K010988000	4355754	1	L	NL	NL
2235	Michigan Technological U.	K010988000	4241133	1	L	NL	NL
2256	University of Kansas	K024928002	3977203	1	L	L	L
2272	Mass. Inst. of Technology	ENG7102375	4187252	1	NL		NL
2272	Mass. Inst. of Technology	ENG7505301	4144374	2	L	L	L
2355	U. of Missouri, Columbia	GK-3476600	3925235	1	NL		NL
2364	U. of Michigan, Ann Arbor	GK-3163500	4118106	1	L	NL	NL
2426	U. of Wisconsin, Madison	K004528000	4010095	1	NL		NL
2429	Purdue University	GK-1507000	4004980	1	NL		NL
2431	U. of Maryland, College Park	ENG7419310	4079238	4	NL		NL
2493	Carnegie Mellon University	K013744000	4087840	1	NL		NL
2501	U. of Wisconsin, Madison	ENG7615594	4101310	1	L	L	L
2501	U. of Wisconsin, Madison	ENG7615594	4321086	1	AL	L	L
2630	Stanford University	ENG7502397	4253925	1	AL	L	L
2646	U. of Houston, Central Campus	ENG7513311	4276180	1	NL		NL
2746	Stanford University	K003736000	4285001	1	NL		NL
2748	Mass. Inst. of Technology	K040021000	4154585	2	L	NL	NL
2768	University of Delaware	GK-4330300	3938536	1	NL		NL
2787	Mass. Inst. of Technology	GK-0479300	3877463	1	NL		NL

Appendix B (Continued)

SEQUENCE	INSTITUTION	AWARD NUMBER	PATENT NUMBER	NUMBER IN SET	EVALUATIONS SRI	P/I	FINAL
2791	Princeton University	ENG7601460	4277170	1	NL		NL
2804	University of Utah	K005239000	3966461	4	NL		NL
2831	Mass. Inst. of Technology	K025141000	4113446	5	NL		NL
2860	Mass. Inst. of Technology	ENG7420857	4152676	1	AL	L	L
2899	U. of California, Berkeley	ENG7621818	4361026	1	AL(D)	L	L
2983	Mass. Inst. of Technology	K034094000	4243923	1	NL		NL
3026	University of Notre Dame	K029928000	4143468	1	NL		NL
3061	Ohio State University	K014633000	4129974	1	L	L	L
3086	Georgia Inst. of Tech.	ENG7610057	4135388	4	NL		NL
3099	Cornell University	K004769000	4115191	1	L	NL	NL
3122	Case Western Reserve U.	K038650000	3875400	1	NL		NL
3138	Stanford University	K002746000	4036637	1	NL		NL
3286	University of Texas, Austin	K032631000	4239041	1	NL		NL
3303	University of Michigan	K001913000	4229942	1	NL		NL
3361	University of Arizona	K016407000	4025307	1	L	L	L
3361	University of Arizona	K016407000	4183729	1	L	L	L
3361	University of Arizona	K016407000	4263010	1	L	L	L
3361	University of Arizona	K016407000	4294807	1	L	NL	NL
3392	Mass. Inst. of Technology	K003696000	4113446	1	NL		NL
3432	Pennsylvania State U.	K039205000	3897197	1	NL		NL
3618	Columbia University	ENG7603920	4331936	1	L	L	L
3643	University of Delaware	ENG7706078	4323482	1	NL		NL
3684	West Virginia University	ENG7413014	4272356	1	NL		NL
3700	U. of Illinois, Urbana	K042145000	4098690	1	NL		NL
3765	City College, CUNY	K004131000	3970587	1	NL		NL
3838	U. of Oklahoma Res. Inst.	K004613000	3951649	1	NL		NL
3908	U. of Illinois, Urbana	K012698000	4004896	1	NL		NL
3924	University of Iowa	K002567000	4240407	4	NL		NL
3925	Lehigh University	ENG7419318	4254002	1	NL		NL
3928	U. of California, Berkeley	ENG7521038	4231865	1	L	NL	NL
3971	Mass. Inst. of Technology	ENG7419999	4291390	1	L	L	L
3971	Mass. Inst. of Technology	ENG7419999	4290118	4	L	NL	NL
3984	U. of Missouri, Columbia	K017774000	4303536	1	L	NL	NL
4045	Princeton University	K017144000	4101287	1	L	NL	NL
4077	Polytechnic Inst. of NY	ENG7423908	3982810	1	NL		NL
4100	U. of Illinois, Urbana	K025076000	3866633	1	NL		NL
4108	Purdue University	GK40032000	4286142	1	L	L	L
4109	University of Delaware	K037424000	4296757	1	NL		NL
4114	Columbia University	K016649000	3875399	1	L	NL	NL
4219	Purdue University	ENG7509326	4174976	3	NL		NL
4262	U. of Wisconsin, Madison	K016708000	4347503	1	NL		NL
4318	U. of California, Berkeley	K037613000	4333815	1	NL		NL
4329	Rutgers University	K014075000	3972776	1	AL	L	L
4329	Rutgers University	K014075000	3843446	1	L	NL	NL

Appendix B (Concluded)

SEQUENCE	INSTITUTION	AWARD NUMBER	PATENT NUMBER	NUMBER IN SET	EVALUATIONS SRI	P/I	FINAL
4380	Mass. Inst. of Technology	ENG7518166	4293654	2	NL		NL
4387	U. of California, Berkeley	K037774000	3970959	1	L	L	L
4387	U. of California, Berkeley	ENG7503579		1	NL		NL
4402	University of Minnesota	ENG7303844	3994012	1	L	NL	NL
4404	Illinois Inst. of Tech.	K030028X01	4248686	1	NL		NL
4404	Illinois Inst. of Tech.	K030028X01	4224135	1	AL(D)	NL	NL
4450	Worcester Polytechnic Inst.	ENG7417599	4238418	2	L	NL	NL
4451	Johns Hopkins University	K012586000	4109113	1	NL		NL
4506	Stanford University	ENG7421752	4243935	3	AL(D)	NL	NL
4577	U. of Southern California	ENG7682560	4176326	1	L	L	L
4650	U. of California, Los Angeles	ENG7609932	3958188	1	NL		NL
4699	University of Pennsylvania	ENG7413043	4332157	1	L	NL	NL

U.S. DEPARTMENT OF ENERGY

memorandum

DATE February 26, 1986

REPLY TO ATTN OF Thomas P. Sheahen, ER-1

SUBJECT Value of Patents & DOE Rights in Patents

TO Richard Constant

Dean Helms told me that you have been working towards a new DOE Patent policy over the past year or so, since a task force first looked at the problem 2 years ago. Therefore, I am sending along a report that may be helpful in developing that policy.

Before coming to the Department of Energy, I worked for SRI (Stanford Research Institute) at their Washington office. While there, I conducted a study under contract to NSF to find out the value of patents that arose from NSF-sponsored research. Our report presents our findings, along with some interpretations as to what they mean for the NSF, and for Universities who obtain sponsorship from NSF.

There is, I believe, considerable application to DOE of what we found there. Foremost is the fact that having a patent is a lot like holding a lottery ticket. Indeed, you might be the fabled big winner. But there are many uncontrollable factors that stand between the patent holder and any riches - factors so random that it's a virtual lottery drawing to determine who the big winners will be.

When a government agency clings to its "rights" in the invention, holding out for a share of the royalties or even a nonexclusive license to anyone doing business with the government, the invention is virtually doomed. No one in the private sector will tackle the long task of commercializing a new technology (with all its attendant risk) unless exclusivity is assured at the outset. The government agency that wants 10% or 50% or whatever winds up keeping 100% of nothing.

Clearly, I'm on the side of having DOE formulate a very lenient and generous patent policy. I am there because of my experience leading to the writing of this report. I suggest that if we want our National Laboratories to be successful in transferring technology to the private sector, we have to adopt a patent policy that is as generous as that of the NSF.

Thomas P. Sheahen

Thomas P. Sheahen
Energy Research Advisory Board

New Laws Hobble Spread of Space Technology

To the Editor:

"Space Arms Scientists Selling Rights to Discoveries" (news story Nov. 4) was well researched, but a big issue remains: the commercialization of our government-funded research and development.

The article discussed two issues: that scientists are now "selling research" (which we taxpayers paid for) for their own personal gain, and that there is danger of conflicts of interest by the scientists between doing the government research jobs for which they are being paid and the pursuit of their own personal patent and trade-secret work.

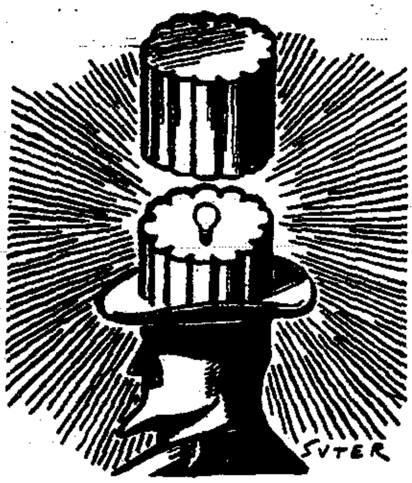
The estimated personal gain of some $2 million to $3 million per year spread out over 7,000 scientists on Federal laboratory payrolls is not the big issue, nor is the conflict of interest; the big issue is commercialization by the owners of the new technology spinoffs from $15 billion of research and development each year.

The new laws, including Public Law 96517 of 1980, President Reagan's Presidential memo of Feb. 18, 1983, and S.2171 of 1984, all of which gave patent rights on government-subcontracted technology to businesses and universities, have failed dismally in creating more commercialization by government contractors and in disseminating new technology for domestic use.

For in addition to granting first crack at patent rights to commercial and academic organizations, these laws removed the requirement to report innovations, inventions, improvements and discoveries to the Federal Government promptly. And in many cases, companies are not willing to spend the time and money on pursuing patents, which can often be a long and expensive process.

Since the legislation took the ownership rights to new technology away from the U.S. Government, the U.S. has suffered an irreversible loss of hundreds, perhaps many thousands of significant disclosures of patentable technological developments.

A typical case occurred with NASA. The key asset of NASA's charter, the 1958 Space Act — namely the ownership and dissemination of new technology — has been handed to the contractors and subcontractors and their employees. They may now use the technology for their own benefit (which they do not do) or not use it at all (the predominant mode), letting it go unreported, unrecognized, unpatented and unused.



Recent studies at the Jet Propulsion Laboratory and at Denver Research Institute have shown the crippling effects of the well-meaning but erroneous legislation since its enactment. The J.P.L., a NASA contract facility, has seen a 25 percent drop in new technology reports from its employees and a 75 percent drop from its subcontractors, along with 60 percent reductions in patent actions from each group. The trend shows more reductions ahead. Less patent activity and less dissemination of new technology adds up to a complete failure of the new legislation.

The reduction in patent activity also shows that the creators of the technology are not its potential best users, a historical truism, or they would have taken patent action and notified NASA of their intent.

The reduction in new technology reports from employees and subcontractors in turn curbs the dissemination activity by NASA to the 70,000 U.S. subscribers to its "Tech Briefs" for passing on the valuable information on processes, materials and innovations for use by these readers. Congressional corrective action is needed — and soon.

N.J. GOLDSTONE

Beverly Hills, Calif., Nov. 5, 1985

The writer is an engineering and aerospace consultant.

File w/ "Studies" NO