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OAK RIDGE NATIONAL LABORATORY

UNION CARBIDE

Evaluation of the Energy-Related Inventions Program

Volume II: Case Studies of Supported Projects

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Regional and Urban Studies Section
Energy Division

EVALUATION OF THE ENERGY-RELATED INVENTIONS PROGRAM

VOLUME II: CASE STUDIES OF SUPPORTED PROJECTS

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for the
U.S. DEPARTMENT OF ENERGY

EVALUATION OF THE ENERGY-RELATED INVENTIONS PROGRAM
VOLUME II: CASE STUDIES OF SUPPORTED PROJECTS*

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Marcia L. Gradt
Edward Jonathan Soderstrom

ABSTRACT

The Energy-Related Inventions Program (ERIP) was established as part of the Federal Non-Nuclear Energy Research and Development Act of 1974. The program is designed to stimulate innovation in the field of energy-related products and processes by providing financial assistance and other support to independent inventors and small businesses that enables them to further develop their inventions.

As part of an evaluation of the ERIP, 30 case studies were conducted on inventors who received grants from the Department of Energy to further develop their inventions. Inventions ranged from turbine rotors capable of operating at high temperatures to an all-plastic solar collector. This volume contains summaries of each case study. Each case study provides information on the inventor's background, background on the invention, the inventor's experience with the ERIP, the current status of the invention and impact of the ERIP on the development of the invention.

This second volume serves as an appendix to the data aggregation and analysis contained in the first volume of this report.

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PREFACE

This report is submitted to the Department of Energy, Energy-Related Inventions Program, in partial fulfillment of the requirements set forth in Contract No. DE-AC03-80CS15032. The purpose of the work performed during the contract period has been to implement an evaluation of the Energy-Related Inventions Program.

The Energy-Related Inventions Program (ERIP) was established by Public Law 93-577 in 1974 as a joint Department of Energy and National Bureau of Standards (Department of Commerce) program. The National Bureau of Standards (NBS) was charged with evaluating energy-related inventions submitted to it and recommending promising inventions to the Department of Energy* (DOE) for support (financial or nonfinancial). The legislation clearly states that special emphasis is to be placed on inventions submitted by individuals and small businesses.†

In 1979, the ERIP chiefs contracted for the development of an evaluation methodology and in 1980 for the implementation of the evaluation.

One task of the evaluation was to conduct a series of case studies of participants in the program who had been recommended for funding to the DOE. The purpose of these case studies was to gather qualitative information by which to assess the overall performance of and outcomes resulting from the implementation of the Energy-Related Inventions Program. The case study included the following subtasks:

- Interviewing a select number of program participants supported by the Energy-Related Inventions Program.
- Interviewing National Bureau of Standards and Department of Energy, Energy-Related Inventions Program personnel.
- Developing case studies from those participants interviewed.

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*Formerly known as the Energy Research and Development Administration (ERDA).

†A detailed description of the program and its development and the evaluation are contained in Volume I.

- Meeting with consultants and conducting field work in order to discuss results, problems, selections, and potential recommendations.

- Developing a final report.

Volume I of the final report contains a program description and the synthesized and aggregated data, as well as conclusions and recommendations. Volume II (this volume) contains the individual case studies.

In order to develop the cases contained in this volume, a team of consultants with expertise in evaluation, entrepreneurship, venture financing, economics, invention and innovation, and small business development was recruited to conduct the field work and write the cases. Because of the time constraints on this project, only highly qualified individuals with specific areas of expertise were added to the basic evaluation team. The following is a list of the team members conducting the field work:

Lois Martin Bronfman
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Marcia L. Grad
M. L. Grad Consultants
Chicago, Illinois

Gregory Grapsas
Systems & Applied Sciences Corporation
Riverdale, Maryland

Herb Kierulff
Kierulff Associates
Seattle, Washington

Hal Livesay
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia

Sumner Myers
Institute of Public Administration
Washington, D.C.

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Art Ramseur
Arthur Ramseur Consultants
San Antonio, Texas

Al Shapero
Shapero-Huffman Associates
Columbus, Ohio

Jerry Udell
Gerald G. Udell and Associates
Eugene, Oregon

Bill Wadsworth
Systems & Applied Sciences Corporation
Riverdale, Maryland

The list of interviewees for the case studies was developed cooperatively by the Energy-Related Inventions Program personnel and M. L. Grad, who coordinated the field work. The sample was selected on the basis of time, budget, and geographical constraints. Out of the 185 participants recommended to DOE for funding by 1981, 30 cases were finally selected for interviewing. Of the 30 cases, 29 had received funding and one had not; of the 29 funded cases, 25 had completed their work statements with the DOE and 3 were still finishing at the time of the interview.

After selecting the cases, a briefing meeting was held in September 1981 to acquaint the consultants with the program and evaluation data requirements. Interviews were conducted during September and October. By the first week in November the cases were completed and a debriefing meeting was held. This meeting's purpose was to discuss individual cases as well as general results of the field work, problems identified during the field work, and program and policy issues that emerged from the data. The cases have been reviewed by interviewees, Marcia Grad, and the evaluation team leaders, Jon Soderstrom and Lois Martin Bronfman. The finalized cases are presented on the following pages.

The reader will note that writing styles vary from case to case just as experience and expertise of the consultants vary. Each author brought specific expertise to this project, which has substantially enriched the final product. Personal comments are restricted to the case section titled "Interviewer Comments." The cases are organized to describe specific projects supported by the Energy-Related Inventions Program; judgments concerning cases individually and collectively are contained in Volume I of this report.

Several acronyms are used in this volume:

- ERIP — Energy-Related Inventions Program
- NBS — National Bureau of Standards, Department of Commerce
- DOE — Department of Energy (formerly Energy Research and Development Administration).

ACKNOWLEDGMENTS

The authors wish to thank the Energy-Related Inventions Program grantees who participated in this effort. Often they made special arrangements to accommodate the timing of our field work. And they took the time and made the effort to review and comment on each case, which resulted in an improved product.

A special thanks also is extended to Glenn Ellis and David Mello, who helped us identify and find both people and documents, and who contributed their time to respond to a series of questions that enabled us to round out our interview data.

In addition we are grateful to George Lewett, Chief of the Office of Energy-Related Inventions at the National Bureau of Standards, Pat Donohoe, past Chief of the Inventions Program at the Department of Energy, Harold Devoe, past Acting Chief, and Randolph Stephens, current Chief, of the Small Scale Technology Branch, Energy-Related Inventions Program, Department of Energy for their continuing support.

PARTICIPANT: Joe Agar (72)
2215 Bauer Drive
Houston, Texas 77080

CASE TITLE: Utilization of Waste Gas for Boiler and Furnaces in Refineries and Petrochemical Plants

FUNDING LEVEL: None

CASE STATUS: The project had been approved for funding by the DOE. However, Mr. Agar sold his company to Redland Automation, which decided not to pursue the grant.

INTERVIEWER: Arthur Ramseur
Arthur Ramseur Consultants
12615 La Bahia
San Antonio, Texas 78233

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Mr. Joe Agar has a bachelor of science degree in electronics and a master of philosophy in physical chemistry.

He owns his own company (Agar, Inc.), which employs four full-time employees and manufactures oil skimmers and viscosity monitors for use in the petrochemical industry. At the same time he submitted his invention to the Energy-Related Inventions Program he owned Agar Instrumentation — a multinational firm engaged in research and development, manufacturing, and installation of measurement instruments for the petrochemical industry. The company employed 60 people. He sold that business in May of 1979 to Redland Automation — a subsidiary of Redland, Limited, which is a major multinational corporation with headquarters in England. He considers himself an engineer, inventor, and entrepreneur. He has been working in the instrumentation field since 1959.

Mr. Agar holds six U.S. patents, primarily in the energy conservation and pollution control fields. He reports working with several different individuals at the National Bureau of Standards (NBS) in technical evaluation and testing of some of the instruments developed by his companies over the last ten years. As an example he cited working with the Cryogenic Laboratory at Boulder, Colorado, on some supercold temperature measurement and control instruments. Other than this experience with NBS, he has not received any state or federal assistance.

Description of the Technology

Mr. Agar describes his invention as a control system rather than a single device. Its purpose is to allow oil refineries to use waste gas and/or oil as well as natural gas and/or heating oil in the boilers used in the refining process. Mr. Agar estimates that 30% of the crude oil energy input into a refinery is used in the refining process (i.e., refining is an energy-intensive process). He feels that 2% of this can be saved by using waste gas and/or oil that the refinery now flares or burns. In the final technical review by NBS, Mr. Tom Coultas describes the process as follows:

> Existing sensors are used to measure the density and flow of "waste" gas from a refinery or related plant that would ordinarily be vented and flared. This information is then used by a microprocessor to determine fuel gas density, BTU content, mass and volumetric flow and pressure. In turn this information could be used by a control system to regulate the fuel mass flow to assure proper air/fuel ratio operation of the burners in the plant boiler. Mr. Agar has subsequently incorporated other boiler control into the system, but those facets, burner temperature and burner balance, were not evaluated, and do not form a portion of this recommendation.
>
> ...One of the most difficult problems encountered in evaluation of this invention was to determine the bounds of the invention. Several evaluators believed the invention was a density meter or a flow meter. In either case there seemed to be little energy-related novelty. At the other extreme, and noted to some extent in the second-stage evaluation the invention is assumed to include all sensors, computers, actuators, etc., necessary to completely control the boiler in a refinery or petrochemical plant. Either of those interpretations may be correct, but this recommendation is for a system to control air/fuel ratio to the boiler, does include the flow and density meter, but does not include the boilers steam side instrumentation nor the individual boiler burner controls or sensors.

Mr. Agar feels that his invention was the complete control system, including the boiler instrumentation, rather than the more limited view of the invention taken by Mr. Coultas.

The system is not patented. According to Mr. Agar, it is proven expertise rather than patents that convince major companies to incorporate new ideas into their production processes.

Mr. Agar reports evolving the idea over the three decades he has worked with oil refineries. He estimates that he had invested two to three man-years of time in development which would equate to $140,000, prior to submitting the process to NBS.

He felt most of the technical problems had been solved prior to submission. The major nontechnical problem was finding a refinery that would participate in testing the idea due to both safety and monetary reasons.

He felt that this process was in a concept development stage at the time he submitted the idea to the ERIP and that the major application of the technology would be in the oil refining industry.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

He recalls reading about the ERIP in one of the technical or trade magazines, but he doesn't remember which one.

He first submitted the process to NBS on March 8, 1976, in order to obtain technical assistance from the NBS, a stamp of approval for his program from a recognized agency, and funds to incorporate the system into an existing refinery.

He expected the NBS to provide a thorough evaluation of his idea. He already had some commercial interest in the concept from refineries but needed a respected outside opinion to persuade refinery management to conduct the test. Some downtime of the refinery might be required to install and test the equipment.

He recalls receiving an initial letter from NBS within three weeks. During the first stage of the evaluation, he remembers some phone calls and letters. He recalls the second-stage evaluation taking a very long time and not hearing the status of his evaluation for rather long periods. The process was recommended by NBS to DOE for funding on June 28, 1978, in the scaled-down mode referred to previously.

Mr. Agar feels that the greatest benefit of the NBS evaluation was having a second opinion that his idea was feasible from a respected disinterested party. He feels the worst problem encountered with the NBS evaluations was the time required to complete it. Based on his other experiences with NBS evaluation (Cryogenic Laboratory at Boulder, Colorado), he felt that this evaluation took too long. Overall he would rate his experience with the NBS as very satisfactory.

Experience with the DOE

When the process was recommended to DOE by NBS, Mr. Agar expected the DOE to participate actively in testing the process by making funds available, by monitoring the progress of the test, and by making the process widely known in the refining industry if it proved successful.

During this time period he was negotiating the sale of Agar Instrumentation to Redland Automation. In May 1979 the sale was consummated, and on June 22, 1979, Redland notified DOE that they were still interested in the grant. Mr. Richard C. Wisler, Regional Vice President of Redland Automation in the Houston, Texas, office, was interviewed, and he reported that during the ensuing month, Redland Automation decided not to accept the grant for several reasons as follows:

- Redland Automation was in the sensor and monitor business and not the boiler control business. To go into this business would have meant engaging in competition with some of the company's major customers.
- Redland Automation was not prepared to assume the possible liability and safety problems associated with the experimentation of an unproven system in a major refinery.
- Redland Automation was a subsidiary of a billion-dollar-a-year multinational corporation and did not need the grant money for the project.

Thus on August 5, 1980, Redland Automation officially turned down the DOE grant, and the grant for the project has never been awarded.

According to Mr. Agar, he is still interested in pursuing the grant.

Participant's Assessment of the ERIP

Mr. Agar would recommend speeding up the evaluation process — perhaps by funding the evaluator to travel to the inventor.

Mr. Agar reports the best thing about the program was both NBS and DOE giving an opinion that the process is feasible.

Mr. Agar believes the time required by NBS to evaluate the idea and then the additional time required by DOE to evaluate the grant (three years in total) is too long.

OUTCOMES

Current Status of the Case

The grant was not awarded.

Mr. Wisler reports that Redland Automation has continued independently to develop a microprocessor unit (their FCD/T900) which is able to calculate both energy and volume flow and which could be used as an accurate measuring device for someone else's boiler control system.

Mr. Agar is apparently interested in pursuing the development of this process further. Redland Automation is apparently not interested in developing the full system (including the boiler controls).

Tangible Outcomes

Redland Automation continued on their own (and probably would have without the ERIP) to develop a feed-forward set-point microprocessor device to measure volume flow and energy.

Intangible Outcomes

Mr. Agar reports the government "seal of approval" (DOE/NBS) of his idea as helpful.

INTERVIEWER COMMENTS

This project provides an interesting contrast between the individual entrepreneur/inventor/innovator (Joe Agar) and the large multinational corporation (Redland, Limited). The individual inventor has less to lose (although it may be everything he has) should the project fail and cost the customer or test-bed user significant funds.

PARTICIPANT:	Robert Arthur (47) Arthur Technology 548 Prairie Road Fond du Lac, Wisconsin 54935
CASE TITLE:	Wastewater Aeration Power Control Device
FUNDING LEVEL:	$58,200
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Marcia L. Grad M. L. Grad Consultants 3930 North Pine Grove Avenue Chicago, Illinois 60613

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Mr. Arthur earned a bachelor's degree in mathematics and a master's degree in civil engineering from Northwestern University, a master's degree in environmental engineering from Harvard University, and a doctorate in environmental engineering from the University of Iowa. He is also a registered professional engineer.

Prior to establishing this company, Mr. Arthur taught for 16 years at Rose Polytechnic Institute in Indiana. He founded and is president of Arthur Technology, which has 18 employees and is organized into three divisions:

- A.T.I. Consulting Engineers, which performs engineering design services for municipalities and industries,

- Contract Services, which conducts laboratory testing, operator training, and research and development under contract to the government and industry,

- Tech-Line Instruments, which designs, manufactures, and markets control instruments for wastewater treatment.

Arthur currently holds four U.S. patents in addition to the one submitted to the ERIP, has another in preparation, and has applied for one other. Interestingly, one invention (not patented) is for a ski wax measurement device. He identifies himself as an engineer who spends half of his time as an administrator and half performing R&D.

Arthur Technology has had a great deal of experience in obtaining funding from government agencies, including the Environmental Protection Agency, National Science Foundation, and the Department of Energy (Appropriate Technology Program and various research divisions). All of these projects have focused on wastewater treatment. In addition, he has submitted two other technologies to the ERIP (one is an energy minder and one is a waste treatment instrument).

Description of the Technology

The technology funded by the Energy-Related Inventions Program is an on-line process control laboratory instrument designed to measure the amount of oxygen required to metabolize the organic matter being processed in a wastewater treatment plant. The NBS recommendation report contains the following description of the invention:

> The purpose of this invention is to reduce the power consumption utilized to supply oxygen to the microorganisms during the metabolism of the organic matter in wastewater in biological water pollution control plants. Oxygen is usually supplied by electrically powered compressors or aerators which can be controlled by the invention to fluctuate with the oxygen demand.

The problem Arthur addresses with the technology is that presently the amount of oxygen introduced into a wastewater plant is sufficient to treat a maximum load of waste rather than the amount actually being processed. This results in about a 50% waste of oxygen which must be pumped through the system (i.e., a waste of energy). The respirometer designed by Arthur is unique because it determines the amount of oxygen that will be needed and regulates its introduction into the system.

Arthur first worked on this problem and got the idea for this technology while working on his dissertation. The technology was further developed as Arthur consulted on wastewater treatment problems. Overall, Arthur has devoted the major part of 20 years to solving the problem, has drawn on the expertise of patent lawyers in obtaining the patent, and has invested between $50,000 and $100,000 of his own money. The first-generation respirometer was licensed to Badger Meter, which invested $200,000 and the cost for six people to work on it. This company paid Arthur about $50,000 in royalties which he plowed back into R&D.

Arthur's greatest problem in developing the respirometer was determining how to market it and acquiring the capital to continue developing it. He notes he did not encounter many technical problems.

The technology submitted to NBS is considered a third-generation respirometer which is submersible in the waste. It is noteworthy that the first- and second-generation instruments were being manufactured and sold at the time of submission. He stated the technology submitted was in a preliminary planning stage.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Arthur learned of the ERIP through the *Wisconsin Business Advertising Newsletter*, published by a local office of the U.S. Department of Commerce. He decided to submit the invention for evaluation because he needed funding to continue his R&D.

His expectation was that the NBS would perform a technical evaluation. He was surprised that an outside consultant was used as an evaluator rather than a peer as in the evaluation of an NSF proposal.

Arthur is specific about the fact that he received no technical assistance during his contact with the NBS. He also believes that there was not enough communication from NBS. The invention was submitted in February 1977, and in July he was contacted by the second-stage evaluator, who, Arthur believes, knew little about the wastewater treatment field. The invention was recommended to the Department of Energy for funding in November 1977. Arthur also stated that the technology did not change as a result of his contact with the NBS.

When queried about benefits and problems in dealing with the program, Arthur did not identify benefits but did state that delays in the evaluation process caused him a great deal of frustration because he wanted to begin work quickly. He also felt that he should have been kept informed of the invention's progress through the evaluation.

Arthur rates his personal contact with the NBS internal staff as very satisfactory. The time required for evaluation, clarity of evaluation form, and tone and wording of correspondence are rated as satisfactory. The technical content and quality of the evaluation as well as its helpfulness are rated as less than satisfactory. He did not respond to the confidentiality query since his patent had been applied for and he knew he was protected.

He has submitted two other energy-related inventions for evaluation. One was rejected and subsequently dropped. The other was rejected, reconsidered, and rejected; Arthur noted that the evaluators have requested more information than he can provide without performing costly

R&D. Indeed, he stated that the latter invention was submitted in order to obtain funding to generate such information. He is not pursuing this project.

Arthur is unsure if he would submit other inventions to the program for evaluation. He is disappointed that so much information was required to move his second invention through the evaluation process and feels that if such information is required of all inventions (i.e., if this is a new policy), submission is a wasted effort. With respect to recommending the program, he responded that he sympathizes with an inventor who must wait for the results, and therefore he is not sure he would recommend the program.

Experience with the DOE

All Arthur expected from the Department of Energy was direct funding, and he states that was all he needed. In addition to the funding, he indicates that he received information assistance in the form of marketing contacts and an invitation to display his invention at the Dr. Dvorkovitz "Tech Ex" and that he was included in the MIT study contracted by the NBS.

The best thing about the program, for Mr. Arthur, is Glenn Ellis; the second best thing that happened to him was being included in the MIT study subsequently published in *Technology Review*. His worst experience with DOE was waiting for the contract to be issued from October 1977 to June 1978. Overall, Arthur indicates he would elect to go through the DOE process again because he would have the funding to look forward to.

During the funding period, Arthur notes he sold one respirometer, which is being tested at a nearby plant.

Participant's Assessment of the ERIP

The following is taken directly from the final report:

> Technologically, Arthur Technology has received great benefits from the award of the Grant. It has had a significant impact on our goals and motivation and has created a new spirit in our employees. It has given us time to

> analyze our basic instrument and to think about its potential as an energy saving device. Frankly, it would have been impossible to do this without the Grant.
>
> In addition, Mr. Glenn Ellis has been most helpful in going out of his way to provide us with contacts which have been of benefit to us. He never failed to come up with a name when we needed help. Mr. Ellis has given us a good feeling about our relationship with this program.
>
> Of most significance was the lack of "red tape" associated with this Grant. The contact with the staff of DOE has been kept to a minimum which is decidedly different than our experience with other Grants.
>
> At this stage of our marketing it is difficult to determine how the company will benefit financially from this project. The $42,500 invested by Arthur Technology may not be recovered for some time.

In the interview Mr. Arthur reported that one of the best things about the program was that it "gave me the opportunity to view my technology (i.e., invention) from a new perspective." Mr. Arthur also noted that "learning the true costs of developing and commercializing a new product is a painful experience."

OUTCOMES

Current Status of the Case

At this time, one more unit has been sold, and Arthur recognizes the need to perform an energy-savings analysis. He is increasing his marketing efforts.

Three new applications have been developed:

- As an early warning device to stop or pretreat waste material that cannot be treated before it reaches the first settling tank.
- To regulate the fermentation of alcohol in gas production (e.g., methane, liquid alcohol).
- A portable submersible respirometer for use in evaluating oxygen transfer efficiency of aeration devices; that is, it would measure the amount of oxygen in air that will go into solution in a specific environment. The result is improved efficiency and, therefore, reduced energy use.

Tangible Outcomes

Arthur has identified the following tangible outcomes:

- A technician has been hired to work on the technology.
- Arthur spends about one-third of his time working on it.
- He obtained a loan of $100,000 from the Small Business Administration (at a high interest rate), which he is using for operating capital; the SBA liked the fact that he had received a DOE grant.
- Arthur sold two units at $4000 each.
- More proposals have been written to obtain support for additional R&D.
- A patent has been granted.
- He has developed a business plan.
- Without the grant, Arthur would have developed a mechanical unit and would have viewed control of the instrument by microprocessor differently. His question now is: Is it necessary to automate the unit?

Intangible Outcomes

Arthur has identified intangible outcomes that center on an increased understanding and knowledge of the new product development process. As noted previously, learning the lessons was painful for him, and he now feels he is better able to estimate the cost of commercializing a new product. Also, he would get expert development advice earlier in the new-product development process. He also notes that publicity and visibility (e.g., the MIT study) are very important in establishing the credibility needed to commercialize a new product. He believes that he received a Five Star Award from the magazine *Pollution Engineering* for his invention earlier because he had the development funds from the ERIP.

INTERVIEWER COMMENTS

Mr. Arthur is a sophisticated grantsman with experience in proposal writing and working with federal agencies. The length of time required to process the grant through DOE, in addition to that required by NBS, makes the total evaluation period 18 months, which is quite long. From the chronology provided by Mr. Arthur, it appears that the process broke down at DOE between November 18, 1977, and April 4, 1978. Arthur submitted his statement of work on the former date and received notice of an incipient award on the latter — nearly five months later.

Mr. Arthur made several suggestions to improve the program:

- Ask the submitting inventor to identify ten peers who could be used as second-stage evaluators; these persons should be from public and private organizations. The NBS would make the final selection from this list.

- Someone should be more involved in identifying the market potential of an invention ... in general, evaluators and other program personnel should be more aware of the marketing needs for *new* technologies (i.e., "quantum leap" as opposed to incremental); funding should be available for developing marketing strategies.

- The NBS, in particular, should take a greater initiative in keeping the inventor informed of the invention's status.

- The DOE contracting procedure needs improvement to speed up the system.

- The DOE program officers should work with funded inventors in developing contacts with other government agencies that can use the technology or recommend its use. Do not leave the inventor hanging at the end of the project.

- A better understanding of timing in the commercialization process is necessary for ERIP program personnel.

PARTICIPANT: James A. Bagby (91)
P.O. Box 569
Greenville, Kentucky 42345

CASE TITLE: Bagby Brattice

FUNDING LEVEL: $62,664

CASE STATUS: In progress

INTERVIEWER: William Wadsworth
Systems and Applied Sciences Corporation
6811 Kenilworth Avenue
Riverdale, Maryland 20840

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

James Allen Bagby has received little or no formal education. His education consists only of high school. Bagby is a coal miner who currently works in a Kentucky coal mine. His job in the coal mine involves building brattices (a brattice is a wall by which a mine tunnel is sealed against the passage of air or other gases; it is used primarily for controlling air flow during mine ventilation). Bagby is not a professional inventor and had no inventions prior to his ERIP submission.

Description of the Technology

The technology used in the Bagby brattice is predicated on the idea of using aluminum as a building material (to allow the brattice to bend in squeeze situations) and utilizing a telescopic post and shear pin (which provides a strong but flexible framework).

The device was originated and developed during 1974-1975 as Bagby worked in the mine as a brattice builder. Bagby still works in the mine as a brattice builder as of 1981. At the time of the interview he was receiving Workmen's Compensation because of his bad back. He gradually developed a basic configuration, which was patented (after a one-year delay) in 1976.

Technical problems in the development of the invention were those of experimentation with the framework, fasteners, jacking supports, roof supports, sealants, etc. This experimentation was continuing as of the time of the interview.

Potential applications for the brattice are rather far-reaching in the mining business, with an estimated market in excess of $90 million. It can be used in all types of copper, coal, salt, etc., mines to improve mine ventilation. The invention was originally designed for small (6 feet or less) heights. It is currently being reconfigured to accommodate larger (15 feet high or more) stoppings.

Other applications for the brattice involve related uses based on the telescoping rods. Specific possibilities are metal roof supports for mines and stoppings for subway construction. The brattice may also prove beneficial as a warning device to miners since it has the capability of carrying a sound alarm indicating roof or floor movement in a given mine location.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Bagby's contact and experience with the ERIP was beneficial to the continued development of his invention. He has stated that without the ERIP his invention would not be enjoying the limited success it now has.

He heard about the ERIP through two sources. At about the time that he read about the ERIP in a *Time* magazine article in 1977, he received a suggestion from the University of Oregon that he apply to the program.

The invention was submitted so that Bagby and his company would know whether their work was worth all the time and effort necessary for continued development. Bagby was under the impression that he had made a novel contribution to the field of mining and mine ventilation but was not certain that the brattice was as unusual as he hoped.

He therefore submitted the brattice to NBS in the expectation that NBS would consider and test the invention. If they felt the brattice was revolutionary, then he would try to market the brattice on a larger scale.

Bagby's expectation that NBS would test and evaluate his invention was realistic since it involved a desire that NBS produce an evaluator who could either confirm or deny Bagby's claims.

According to Bagby, the NBS evaluation had an enormous impact on his invention. This impact can be attributed to the exceptional quality of the evaluator chosen for the second-stage evaluation and the fact that the evaluator, Dr. Ernest M. Spokes, is an articulate and respected authority in mine ventilation who is known both academically and commercially as an expert or an authority. Spokes's comments in the second-stage evaluation report supported Bagby's claims and were later used (along with comments by Howard Robb of NBS and those of the DOE appointed tester) in a brochure generated by Bagby and his company. This brochure highlights Dr. Spokes's comments on the effectiveness of the brattice and quotes his report at length. Bagby is convinced that Dr. Spokes and his evaluation provided his company with the necessary support so that other mines (notably those in the West) were more likely to order his product.

Experience with the DOE

Bagby's experience with DOE parallels that with NBS. He expected DOE to help him to test the brattice through a series of formal tests. DOE personnel were able to accomplish this by securing the necessary funds for a test by a Peabody Coal ventilation engineer (Jerry Tien). The statement of work for Bagby's grant stipulates that he will manufacture 25 brattices, install them in a mine, and have them tested. A scale model was also to be built. The DOE coordinators (D. Mello and B. Bell) made sure that the test was conducted properly and, more important, served as friends, advisors, and confidants for Bagby and his group.

Bagby's general assessment of DOE is favorable. DOE enabled him to secure a Kentucky specialist in ventilation who is known in the area and who provided the brattice company with approval and recommendation that had some impct in Bagby's geographic area. Tien proved to be an exceptionally good choice since he also wrote an articulate, intelligent, and clear recommendation of the brattice which appeared in the April 1981 issue of *Coal Age*.

Participant's Assessment of the ERIP

Bagby is a strong supporter of the ERIP. He states that without the program, he would not be as far along with the invention as he is today.

The best thing about the ERIP, in Bagby's opinion, was the excellent second-stage evaluation conducted by Dr. Spokes. Dr. Spokes's recommendation gave the brattice a needed credibility and was instrumental in generating interest, if not actual sales, from the mining community.

Bagby only had minor problems with the ERIP. He feels that the greatest problem with the program involved the lack of coordination between the ERIP and other federal agencies, notably the IRS. It seemed to Bagby that while DOE/NBS was trying its utmost to help him start, or at least maintain, his company, the IRS was doing its best to hinder him in developing the invention. Communication with NBS and DOE's slow procurement process can be improved.

OUTCOMES

Current Status of the Case

The invention did make limited progress during the ERIP phase. When the invention entered the program, it was in the testing phase; by the time the project had nearly terminated (it is still in progress), the invention had entered a limited production and marketing phase.

Currently, Bagby is awaiting receipt of the final grant funds so that new design modifications can be implemented. Bagby has completely redesigned and improved all the components of the brattice. Other items (notably an alarm system linked to the shear pins) that are in the design process will expand the brattice's market.

Plans for future development of the brattice or the technology behind the brattice are rather extensive. Besides having reworked many of the details of the brattice and adding improvements, Bagby is working on a telescopic roof support and larger brattices.

Tangible Outcome

The tangible outcome of this case can be summarized as helping him establish a degree of credibility in the mining community (primarily through the comments of Dr. Spokes and, to a lesser degree, Jerry Tien). This credibility has resulted in interest in the brattice from and/or sales to some of the Western mining companies.

Intangible Outcomes

Intangible outcomes are those of allowing Bagby to continue work on the brattice. Bagby insists that if the evaluation had been unfavorable, he would not have continued work on the project. Once the brattice was tested and supported by both Dr. Spokes and Jerry Tien, Bagby renewed his efforts to develop and market the brattice. The various evaluations by Howard Robb, Spokes, and Tien also gave his company the necessary support and credibility to enter limited production.

INTERVIEWER COMMENTS

Bagby appears to be one of the best of the inventors who have entered the program. His invention is simple, effective, easy to install, and easily transportable. Although sales at present are sporadic, Bagby appears to have succeeded in moving from the testing phase to a limited production phase. The prognosis for further production is excellent, and the inventor has received inquiries in Kentucky, from the Western mines, and from foreign delegations. Bagby's claim of huge cost savings to the coal industry appears to be no exaggeration. Bagby is, therefore, unusual in that he is a "successful" inventor among the funded inventors.

Despite the inertia in the coal industry, the brattice has achieved limited success. This limited success is attributable in part to the NBS and DOE evaluation and to the fact that the brattice received the support of a recognized authority in the ventilation field from the Rolla School of Mines as well as that of a ventilation specialist from the Peabody Coal Company. Both experts were instrumental in gaining respect and recognition for the brattice.

The brattice tests prove its effectiveness and, in all probability, it would have surfaced in new mines within the next 20 years as transportation costs for concrete block and labor costs continue to rise. The ERIP, however, ensured that the invention received early support and accelerated the time period during which the brattice will come into common usage.

While the final result of the brattice will not be known for several years, the ERIP also proved to be of inestimable support to Bagby and his company. Bagby's invention, if it does come into widespread use, will seriously affect concrete block manufacturers with contracts for brattices. While they have not mounted any campaign yet, there is a possibility such a campaign will be undertaken in an effort to retain their profits. Bagby and his company have thus won some time in which to develop and to solidify their market before such a campaign begins. Unlike Joe Willis Fowler (one of the other inventors interviewed as a part of this evaluation), Bagby should have a better than even chance to succeed when he tries to compete with the large established concrete block manufacturers.

The ERIP has bought Bagby time in other areas as well, notably the time to refine the brattice design and manufacturing technique so as to withstand competition from competitors. The Peabody Coal ventilation specialist who performed the evaluation signed a statement in which he agreed not to use the brattice design for his or Peabody Coal's uses. A possible competitor was thus neutralized and transformed into an advocate of the invention.

A final, albeit intangible, result of the project also involved time. Bagby has used the needed respite provided by the grant to further develop the brattice and explore other brattice-related ideas. He and his company now have a more precise idea of what they are and where they are going. The DOE's unbiased advice and assistance have helped Bagby meet other inventors like himself.

All of the above factors have provided Bagby with an important time advantage in marketing his brattice. It is conceivable that without the advantage of the grant, Bagby would not have progressed beyond the testing stage as rapidly as he did. Moreover, it is likely that the brattice's impact on U.S. mine operations would have been delayed for a number of years.

It should be noted, in closing, that Bagby is unusual in that the invention was patented in one year and progressed rather rapidly through the NBS evaluation (December 14, 1977, was the original submission date; second-stage evaluation was completed in November 1978; the invention was recommended on December 19, 1978). DOE then awarded a grant in August 1979.

Bagby has, since beginning to work on his invention, been fortunate or wise enough to work very closely with Rees Kinney. As a lawyer, Kinney has ensured that Bagby has patented the invention correctly, that contracts he signs are to his and the company's best interest, that the invention is adequately protected from unwanted competition, etc. The technical know-how of Bagby coupled with the legal expertise of Kinney and the credibility provided by NBS and DOE evaluators have brought Bagby to the point at which he is today. The Bagby brattice is an excellent example of a case in which the government intervened successfully to allow the inventor a much-needed chance to continue to improve and to expand his marketing capabilities.

Operationally, Bagby's invention appears to have moved very quickly through the system with a minimum of difficulty. The problems encountered were all of a minor nature.

The policy decision to have Bagby's invention evaluated by Peabody Coal proved to be fortunate. Instead of attempting to block the invention's development, Peabody Coal provided some much needed support.

This approach could be successfully applied to other inventors. Continued advice or support to Bagby would also be advisable.

Otherwise, there appear to be no other policy issues with regard to the grant to Bagby. This project is a classic representation of the program's goal to support small businesses in order to advance an invention into the market place.

PARTICIPANT:	Dan Ben-Shmuel (66) Heat Extractor Corp. Box 268 St. Johnsville, New York 13452
CASE TITLE:	Heat Extractor
FUNDING LEVEL:	$125,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Harold C. Livesay History Department Virginia Polytechnic Institute and State University Blacksburg, Virginia 24061

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Dan Ben-Shmuel is a latter-day Renaissance man — metal sculptor, poet, real-estate operator, inventor, and now entrepreneur. Ben-Shmuel's case constitutes a success story for the ERIP.

Ben-Shmuel has no formal technical training whatsoever. A self-taught metal sculptor, his artistic work required him to learn a steadily widening range of skills: welding, stainless steel welding, metallurgy, stress mechanics, and so on wider and deeper into the range of knowledge necessary to construct large, heavy metal sculptures and complex equipment. He has, he says, an "intuitive sense" of things mechanical, can sense what's possible and what isn't, then consults scientifically trained people to optimize his designs and ideas.

Self-employed through all of his life, Ben-Shmuel worked as a sculptor and managed his own real-estate holdings prior to his invention of the heat extractor, which he submitted to the ERIP.

Before he became interested in energy-related inventions, Ben-Shmuel had a successful history of inventing in the field of small and large textile machinery and the machine tools required to produce them. He held some 30 patents on these inventions, which constituted a rewarding and lucrative sideline and familiarized him with the patenting process.

Description of the Technology

The heat extractor uses water or an alternative fluid in direct contact with industrial stack gases to extract heat from the gases. The heat is then removed from the coolant by means of a secondary heat exchanger. The secondary heat exchanger performs the dual function of cooling the working liquid, which then recirculates through the stack gases, and transferring the heat into an external system, which carries the energy to alternative uses, such as the heating of buildings, chemical processes, or any other applicable energy requirement. In addition, the working liquid removes a large percentage of particle pollutants from the stack gases. These pollutants can then be removed by filters or other suitable means. The heat extractor thus raises the efficiency of combustion boilers (or other combustion processes) while reducing the pollution associated with such processes.

Ben-Shmuel developed the original crude heat extractor in reaction to rising heating costs in his own real-estate properties. A friend heard of his success and asked Ben-Shmuel to install a similar unit for his factory. The unit functioned well as an energy saver but soon sprang myriad leaks as a result of the corrosive effect of industrial stack gases. Ben-Shmuel felt he had to tackle this problem, since he had undertaken in good faith to help out a friend and had been paid for his work. In solving the corrosion problem, Ben-Shmuel developed the prototype from which the current heat extractor directly descended. Having solved this principal technical problem, Ben-Shmuel encountered the usual obstacles of capital and credibility. He needed capital to promote and manufacture his invention and persuasive scientific test results to persuade prospective customers to try his invention. He succeeded in placing one unit at a New York State hospital, where a computer recorded the energy savings, and another at a Scott Paper Company plant, despite a last-minute decision by the New York State Department of Energy to withdraw its support. By the time he approached ERIP, Ben-Shmuel had placed 10 or 12 units, but he had five years and $100,000 invested and had reached the limit of his resources.

Obviously the heat extractor has widespread potential for adoption in any industrial or large residential unit that consumes significant quantities of energy in a combustion process. Its pollutant-removing capacity makes it particularly promising for use in coal-burning power plants.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Ben-Shmuel's son told him about ERIP (where his son heard of it Ben-Shmuel didn't know), which seemed like a message from heaven, given that Ben-Shmuel had nearly exhausted his resources trying to make and market the heat extractor. From NBS, Ben-Shmuel wanted two things: the endorsement necessary to get a DOE grant and the added credibility associated with such an endorsement.

He had, prior to submission to NBS, worked out all the technical problems with the assistance of Phillip Zacuto, a physicist. He neither needed nor expected technical assistance from NBS.

Essentially the only service provided was the endorsement of the heat extractor's practicality and the recommendation to DOE that a grant be made. Ben-Shmuel says that he never talked to any of the NBS evaluators (both stage II and stage III evaluations were made by T. A. Coultas of NBS) and that the evaluations merely confirmed what he already knew and had proved through site trials.

Ben-Shmuel speaks very positively of NBS. Naturally, since the NBS evaluations substantiated his own claims, he thinks the evaluators had a lot on the ball. He speaks highly of NBS personnel, their behavior, and their attitudes. He does, however, think the process took an unreasonable amount of time (11 months), considering that his proposal was endorsed at each stage and no modifications to the invention were required.

Experience with the DOE

Ben-Shmuel wanted a grant to subsidize a trial of the heat extractor by the Mohawk Paper Company, and he agreed to pass the $50,000 involved through to Mohawk. In addition to this $50,000, Ben-Shmuel got something more from DOE: the opinion of Professor Y. T. Li, an MIT emeritus who came, looked at the heat extractor, said he couldn't suggest any improvements, and "went his merry way." More important, he got some crucial advice from Pat Donahoe, who urged him to test the effectiveness of the heat extractor as an antipollution as well as an energy-saving device on coal-fired boilers. The DOE grant included (in addition to the $50,000 Mohawk money) $75,000 to conduct such tests at Ben-Shmuel's plant. Together these trial runs generated data demonstrating the heat extractor's effectiveness.

Ben-Shmuel thinks highly of the DOE. He found its personnel knowledgeable, dedicated, and willing to help within the limits of their mandate. He also thinks the DOE people highly committed and was surprised by the personal interest they took in his project.

Participant's Assessment of the ERIP

Ben-Shmuel thinks the program excellent in concept, effective but slow in execution at the NBS stage, effective and supportive at DOE, but crippled by the limited mandate of the program as a whole. He says neither NBS nor DOE could or would help him move toward commercialization. The one-shot nature of the program limits its effectiveness, which he thinks could be expanded significantly by DOE providing grants to discount the costs of installation by industries. The money thus invested could later be recovered by recapturing energy savings. Despite these criticisms, Ben-Shmuel waxes enthusiastic about the program, would go back to it if he could, thinks it gave him an indispensable shot in the arm at a critical time, and recommends it to other inventors.

The best thing about the program for Ben-Shmuel was that both the test results and the implied endorsement by NBS and DOE enhanced the heat extractor's credibility. The greatest impediment of the program was the time factor. Ben-Shmuel couldn't have survived until the grant came through if he hadn't had other resources to fall back on.

OUTCOMES

Current Status of the Case

The progress attributable to the ERIP grant was the installation at Mohawk and completion of the specified tests there and at Ben-Shmuel's factory, both of which produced results highly favorable to the heat extractor. During that time period, Ben-Shmuel continued making minor technical improvements on the process and specific adaptations necessary to particular installations, but none of this had anything to do with ERIP.

The Heat Extractor Corporation has become a going concern, with about 250 employees, doing $25 million a year in business in the United States and abroad. Ben-Shmuel says, however, that the company's survival and its future hinge on the general state of the economy, since purchasing a heat extractor requires a major capital investment, which businesses are reluctant to make, despite the certainty of recouping the investment in time. Consequently he often has to make installations on a savings participation basis, at enormous (for him) outlay of capital.

Ben-Shmuel plans to concentrate on the antipollution aspects of the heat extractor, since he thinks it becomes more attractive as a pollution preventive as coal grows more important as a fuel. He also has plans to use some aspects of heat extractor technology to develop industrial use of a new fuel, but he declined to specify what this involves.

Tangible Outcomes

Tangible outcomes in this case are:

- The test results
- Sales grew from the initial 10-12 units to an annual $25 million employing 250 persons
- SBA loan for $400,000

Intangible Outcome

The intangible outcome for this project is that Ben-Shmuel learned to deal with the federal bureaucracy.

INTERVIEWER COMMENTS

No doubt about it, this is a success story, at least so far. Ben-Shmuel is an impressive guy, full of ideas and energy, troubled by problems of cash flow and capital, but utterly convinced of his ability to solve any technical problem. In his mind, ERIP helped him move "one step closer," and, in time, that one step may prove to have been the critical one. His views, however, reinforce the impression gained in all my interviews that the principal difficulties these inventors face are not technological difficulties nor manufacturing problems but the problems of commercialization — cracking the market with a promising but unknown and relatively untried product.

To Ben-Shmuel, as to my other interviewees, it makes no sense to invest public money bringing an invention one step closer to technical maturity without some follow-up program to help push the product into the market. The political implications of these criticisms naturally enough don't carry much weight with frustrated inventors. Whether they can somehow be subsumed by the overarching need to conserve energy presents, I presume, a problem that only the politicians, not the staff at NBS or DOE, can resolve.

PARTICIPANT:	Mr. James L. Chill (98) Marion Bronze Company 404 Executive Blvd. Marion, Ohio 43202
CASE TITLE:	Process Development to Conserve Energy and Material by Cold Working, Roll-Forming, and Stamping Leaded Bronze Plates and Strips to Manufacture Bearings and Bushings
FUNDING LEVEL:	$123,994
CASE STATUS:	Project completed; final report still to be accepted
INTERVIEWER:	Albert Shapero Shapero-Huffman Associates 2342 Dorset Road Columbus, Ohio 43221

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

The formal education of the inventor, Mr. James L. Chill, ended with high school.

Mr. Chill has spent 45 years in the bronze business. His experience combines all aspects of the business, including tooling, production, time study, methods engineering, inspection, sales, product development, and management. He began his working career with the Johnson Bronze Company in Pennsylvania, one of the largest companies in the bronze business. When an opportunity arose, Mr. Chill and two partners bought the Marion Bronze Company with an initial combined capital of $20,000. The Marion Bronze Company, which now has 100 workers and which at its peak had 200, is one of five major suppliers of bronze bearings and bushings of all types and sizes in the United States. Though bronze is one of the oldest metals to be used by man, it is a small industry made up of relatively small producers.

As one of the three owners of Marion Bronze until it was sold a couple of years ago, Mr. Chill functioned across the board in sales, production, and development. At the present time he is officially retired but is still listed as vice president of the company. He received $5500 a year as a consultant to the company (the maximum he can earn without jeopardizing his Social Security status) plus expenses. The new owners of Marion Bronze, a Chicago company, seem to be letting the business run down; nevertheless, Mr. Chill has an office and the use of all company facilities. His present efforts include sales, consultation to production, and development.

Mr. Chill is a man with a great and active curiosity. He has always taken a great interest in the technology of manufacturing bronze, and his interest continues into his very active retirement. His office is full of trade and professional journals, and he continues to follow the technology by attendance at trade and professional meetings. Throughout his working career he has received much personal support and technical guidance from his brother-in-law Louis G. Klinker, a metallurgist, recently retired from the Army, where he was a colonel in ordnance. The brother-in-law has continuously served as an informal consultant and teacher, guiding the inventor in his technical interests.

Though the inventor has spent a good deal of his career working on improvements in production and operations, his formal invention record consists of the invention he submitted for evaluation. He holds one patent and has applied for one patent.

Description of the Technology

Mr. Chill's invention is classified as an industrial process. More specifically, it is a process for the continuous casting of bronze alloy in the form of a strip of any width and thickness desired. The resulting strip, which can be kept to very close tolerances and good surface finish, can be rolled and welded to form bushings or bearings. The cold working of the strip gives it a structural strength that up to now has only been achieved by adding hardening agents such as tin to the bronze.

Until now, leaded bronze bearings and bushings have been produced by means of sand castings or limited batch continuous castings. In both of these methods there is a requirement for a great deal of machining to achieve the final form and surface condition desired, losing 60% of the metal in the process. Further, current casting methods result in differential cooling of the casting, with a consequent differential in characteristics at different points through the thickness of the casting.

The invention submitted for evaluation by Mr. Chill evolved over a ten-year period prior to his contact with ERIP. It originated in his continuous interest in finding ways to improve the working of bronze. He cannot think of a singular "Aha!" experience or revelation that resulted in any significant part of his invention.

To some extent, Mr. Chill's metallurgist brother-in-law is crucial. He made the inventor aware of processes being used with other metals and guided his reading. The invention is a classic case of a series of increments, small deltas, a series of cut-and-try efforts to overcome problems encountered in the casting and working of bronze, such as wastage of metal, machining costs, health hazards in the form of lead fumes from the heated alloy, and energy inefficiency. In the invention process, the inventor experimented with classical sand casting techniques and vertical batch casting techniques. He continuously asked questions such as Why not continuous flow? Why not horizontal flow? Why not a completely enclosed process? Why not casting to close tolerance? each of which led to another incremental improvement. As Mr. Chill puts it with a sly grin, "I wasn't educated so I didn't know what couldn't be done."

Many technical problems were encountered during the ten years that the inventor worked on the process prior to submission to ERIP, but almost all of them were solved through cut-and-try methods. However, one major problem was and still is present, and that is gaining acceptance of the products. Diffusion of the continuous casting process to current and potential producers of bronze products is a slow process, requiring time as well as the establishment of the technical worthiness and credibility of the process. Bushings and bearings produced by the process are being sold today with no difficulty.

The most obvious potential application of the process is to the production of bushings and bearings, where it is already demonstrating that it can produce technically good products at far less cost, with far less wastage of metal, and with far less machining and consequent use of energy. Since the bronze alloy strip resulting from the process can be cold worked to obtain far greater structural strength than is now possible with leaded bronze alloys, it makes available applications and markets not now open to bronze. As will be pointed out below, bronze strip produced by the invented process is now being seriously considered as a replacement for copper in ammunition and also for use in claddding steel.

Because the process is completely enclosed, with the metal entering and exiting cold, the process appears to be the only one available that can meet all of the safety requirements of OSHA with regard to lead fumes.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

The inventor is not aware that there were two agencies involved in ERIP. As far as he is concerned he was dealing with one program and agency throughout, "the Energy Department." Therefore it is difficult to separate experiences related to NBS as differentiated from DOE.

The inventor heard about the program through his brother-in-law, the Army colonel of ordnance, who was serving in the Pentagon at the time the program was announced. The brother-in-law called Mr. Chill's attention to the program and encouraged him to submit his invention for evaluation. Since ERIP offered a way for the inventor to obtain funding and the kind of credibility that would allow him to concentrate on establishing the invention's validity, Mr. Chill submitted it for evaluation.

The inventor had no experience with government programs, but his expectations were realistic in that he expected nothing more than the possibility of getting funding to support his work. He did, however, obtain "services" in the form of contact with one of the technical evaluators at the University of Maryland (it is assumed that this was through NBS, though the inventor cannot differentiate between NBS and DOE), whom he visited and who gave him useful advice.

The inventor has only the highest regard for the program. He can think of no negative aspect and many positive ones.

Experience with the DOE

Again, Mr. Chill sees the program as being carried out by a unitary agency, which, in itself, is a comment on his inexperience with government. His only expectation was that he might receive some funding to help him with his invention. During the DOE phase, the inventor was invited to take part in a program "Tech Ex" in Atlanta, which resulted in many inquiries about his invention from potential foreign buyers of his process. Though none of the foreign contacts has resulted in sales to date, the experience was important for the inventor in terms of encouragement.

Participant's Assessment of the ERIP

Financial support and encouragement were the two outstanding contributions of the program, according to the inventor. The inventor had been working on the process for ten years, taking advantage of the time he could spare and the times when shop equipment and manpower were available. The program provided the inventor with the money and the "contractual obligation" to concentrate on completing his invention and, most important of all, the validation provided by tests run under the imprimatur of a respected technical organization, Battelle Memorial Institute. The latter provided the inventor with the wherewithal to go into the marketplace with confidence.

As far as Mr. Chill is concerned, there were no impediments to participating in the program. Though he commented on the length of time it took to get a response, he explained that away in terms of the newness of the program.

The inventor has demonstrated his positive assessment of the program by submitting a second invention for evaluation and by urging other inventors to apply to the program (one of whom has successfully done so).

OUTCOMES

Current Status of the Case

Though the final report has as yet not been accepted, the program provided the funding to have Battelle Memorial Institute provide assistance to:

> ...optimize the rolling-pass and heat treatment schedules, establish and compare the performance characteristics of the prototype bearings with those made by current methods, evaluate cylindrical bearings with and without a seam weld and investigate performance of prototypes containing only 3% tin.
>
> (from work statement)

The work done by Battelle and the very action of funding by ERIP provided the inventor with the data and credibility required by potential buyers of the process and of the outputs of the process.

The technology has essentially been proved. The next steps are concerned with selling both the process and the use of the process for new applications of bronze. There will be a need to develop specific equipment for special products.

As has been mentioned above, the technology is proven as far as the manufacture of bearings and bushings is concerned. Future development is taking the form of developing products using the metal strips produced by the technology. Army ordnance people are now considering the use of bronze produced by the inventor's process for ammunition in order to overcome problems of "coppering" now encountered in the barrels of guns and in the release of noxious and toxic fumes in gun emplacements. The Vickers Company is considering the use of bronze strip produced by the process for the cladding of steel. Currently, there are tests going on using a method of cladding developed by Texas Instruments which uses very little heat — another incidental saving of energy that was not anticipated.

Tangible Outcomes

The most tangible outcomes are the bearings and bushings being produced and sold by Marion Bronze that are being produced by the process. Other tangible outcomes are the serious consideration being given to use of products of the process by the Army and by the Vickers Company and the testimony given at OSHA hearings by Mr. Chill.

INTERVIEWER COMMENTS

Mr. Chill's background, combining as it does shop experience, methods engineering, tooling, sales, production management, and general management, is one that is rather unusual today compared to what one might have found up to and including World War II. Because of his background, Mr. Chill is able to carry his invention all the way into the marketplace. Though it will take time until his invention diffuses into more general practice, it is very market-oriented and has every possibility for being successful.

The inventor's background in methods engineering, work simplification, and time study highlights something that has been discarded in the university education of engineering and business students, with a consequent loss to inventiveness in the United States. Mr. Chill's invention is a product of the methods-engineering-work-simplification preception of the work place. It is a viewpoint that generates a continuous flow of small improvements (inventions) that often result in large changes in the processes.

The invention considered here is an industrial process invention that can have a far greater impact than most product inventions. As has already been pointed out, the invention is making possible new products that were not considered before.

PARTICIPANT:	Paul Cromwell (108) Cromwell Metals, Inc. 1875 Sheridan Drive Buffalo, New York 14223
CASE TITLE:	Recovery of Aluminum Metal from Aluminum Drosses
FUNDING LEVEL:	$158,029
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Marcia L. Grad M. L. Grad Consultants 3930 North Pine Grove Avenue Chicago, Illinois 60613

THE ENERGY-RELATED INVENTIONS PROGRAM

Program Participant's Background

Paul Cromwell's college education consisted of a "year and a half playing football" on a scholarship to St. Lonaventure University. His knowledge of the aluminum industry is a result of his 30 years of working in the field.

After serving in the Air Corps during World War II, Cromwell was unable to get a job flying for a commercial carrier, so he went to work at North America Smelting Company in 1947 unloading railroad cars and "learning the business from the ground up." In subsequent years he became especially interested in learning how to put aluminum dross to better use. Cromwell's career is heavily entrepreneurial. In chronological order, he:

- Started his own company and sold it to a larger company.
- Acquired 17% of a Cleveland-based firm in return for building and operating an aluminum chloride plant in Canada, where he eliminated the competition in Canada and the U.K. by manufacturing industrial aluminum chloride using aluminum dross as a raw material. Shortly after the firm was sold to Canadian citizens, Cromwell resigned.
- Negotiated a deal with Combustion Engineering to acquire its aluminum dross processing plant. Cromwell leased the plant with an option to buy it; Combustion Engineering agreed to supply all of the capital needed, in the form of a ten-day balloon note in an effort to turn the business around.
- Decided, with his cousin, to form a new company which would exploit his idea for processing aluminum dross. This company is now a publicly held company, which will be detailed later.

Mr. Cromwell identifies himself as a "technical entrepreneur" and holds one foreign patent for manufacturing aluminum chloride ($AlCl_3$) in addition to the U.S. and foreign patents for processing aluminum dross which have been assigned to Cromwell Metals, Inc. He has neither sought nor received previous assistance from a state or federal agency.

Cromwell's higher education consists of 1-1/2 years of college education. He has developed and patented a mechanical process for recovering aluminum metal from aluminum drosses.

The U.S. aluminum industry has grown dramatically since World War II. Prior to the War, there was only one producer in the United States (i.e., ALCOA); when it became apparent that the War was a real possibility Reynolds Metals entered the industry with substantial federal government financing and support. Kaiser Aluminum entered the field after World War II by acquiring War surplus Defense Plant facilities at a fraction of their original cost. The industry grew as new uses for aluminum were developed. During the Korean War, President Eisenhower asked the industry to expand to meet the needs of the War effort plus consumer products. The government guaranteed to purchase at the market price any excess aluminum produced. It was not until 1975 that the huge government stockpile acquired under this agreement was finally disposed of. Aluminum production consumes 8-10 kWh per pound of metal produced and in 1973 with the rapid increase in energy costs, the manufacturing costs of aluminum soared, also raw material costs (i.e., bauxite, carbon caustic soda, etc.).

This made it obvious that any aluminum metal was important to recover and recycle. The recovery of clean aluminum scrap was and is a very simple operation, but the recovery of poorer grades of scrap becomes increasingly complicated. Using "Webster's" definition, dross means waste from the manufacture of aluminum. Dross is the poorest grade of aluminum scrap and therefore is the most difficult to process for metal recovery. Over the years there has been little or no interest in recovery of aluminum from dross because of the huge surplus on the world's markets. It's obvious then that aluminum producers have little or no knowledge or experience in processing aluminum drosses.

Cromwell has been involved with reclaiming aluminum from dross for over 23 years and was constantly searching for improvements over existing technologies. Over a period of years, the process, now known as the Cromwell Process was taking shape in his mind. The research and development work was done in Ashtabula, Ohio and an actual prototype plant was constructed.

A patent on the process was granted in November 1978. Between the time Cromwell began to work on the process (1976) and the time it was submitted to the ERIP (1978); he drew on the following resources to continue his work:

- $500,000 cash plus income from the shoestring plant operation,
- three technical people,
- a plethora of patent and corporate attorneys,
- an accountant who bought a small part of the business,
- capital invested by his cousins and, subsequently by 25-30 investors.

Each day was an adventure in survival.

The major problem Cromwell encountered during the development of his process was a lack of capital for research and development. The technical problems were identifying appropriate materials to use in the seals and bearings (metallurgy problems) and the overall design of the mechanical system. It was necessary to ensure that all of the system's components worked properly, both individually and as a total system. Cromwell indicated that developing this process was really like conducting a classical laboratory experiment in which each component has to be developed and tested and then tested as part of the system.

Cromwell did not and does not see any other applications for his process outside of the aluminum industry. At the time of submission to NBS, the invention was characterized as a working model which was used in limited production of product (the income was then plowed back into further development of the process).

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

A part owner of Cromwell Metals, Ron Fiddler, read an article in the *Buffalo Evening News* about a Pittsburgh-based inventor funded by ERIP. Fiddler contacted the inventor, who referred him to the National Bureau of Standards for additional information.

Mr. Cromwell's only interest in the program was to obtain the financing necessary for him to continue developing his invention. He had no expectations of the NBS and states that he did not expect the NBS evaluation would tell him anything he didn't already know. He did mention that it took a long time to complete and submit the forms.

The only direct contact Cromwell had with the program came via a second-stage evaluator (Professor G. Durgie, from Carnegie-Mellon University) who visited the plant, observed the process in operation, and then submitted his report to the NBS. Cromwell and Durgie also talked on the phone two or three times. Mr. Cromwell conveyed the impression throughout the interview that he dropped the NBS evaluation application into a void from which it emerged, eventually, and was funded. He had no experience in dealing with the federal government and did not expect anything to happen but was delighted when it did.

Cromwell was unwilling to comment on his experience with the NBS because of this attitude. He notes that he made improvements in the process during the time NBS was evaluating the technology but that they were not as a result of his contact with the program.

Cromwell rates his personal contact with the NBS, clarity of the evaluation form, and attention to confidentiality as very satisfactory. He rates the time required for evaluation as average and did not comment on the technical evaluation, helpfulness of the evaluation, or correspondence because he had no experience with them and, therefore, was neither positive nor negative.

Mr. Cromwell has not submitted any other inventions to NBS for evaluation because he has no others. He would recommend the program to others because of the high potential yield, although he has had no opportunity to do so yet. He sees the potential benefits as money and a great deal of credibility when the technology is reviewed and approved by Carnegie-Mellon and the NBS. In fact, he has used the evaluation report submitted to DOE to establish credibility with potential investors.

Experience with the DOE

Cromwell reiterated that he had no expectations of the DOE or the government. He couldn't believe that anyone would give him money to continue working on his invention.

He received money from DOE. He did not receive technical assistance and states that he did not want any. Furthermore, he has been visited twice by Glenn Ellis, who has made valuable suggestions he will use in the future. Finally, the inventor states that the process of developing a work statement helped him clarify and prioritize the steps necessary to achieve commercialization.

The statement of work included in the grant specified the following tasks:

- construct a research-sized furnace to test the design and complete modifications, if necessary,
- acquire a used impact mill and define an appropriate design appropriate to modify standard production models,
- develop improved metallurgy for hammer mill bearings to increase their life span,
- determine optimal exit screen mesh size in order to regulate the length of time the dross remains in the mill,
- develop improved metallurgy for hammer mill hammers in order to prolong hammer mill life and the life of its hammers,
- purchase and test four sets of crusher rolls to determine the metallurgy most resistant to aluminum dross abrasion, thereby increasing the life of the rollers,

- perform additional R & D to determine best configuration of rollers and screens to loosen the dross/oxide coating.

This work has been completed and a final report submitted.

Participant's Assessment of the ERIP

Cromwell emphatically stated that Glenn Ellis is the best thing about the program. He is specific about the fact that he is near the end of the commercialization process and that his planning is better as a result of participating in the program.

Cromwell is clear about the difficulty of enduring the length of time between notification of the grant award and receipt of the grant funds. He minimized this criticism by indicating he lacks knowledge of the government procurement process.

Cromwell is very pleased with the ERIP and the fact that it helped him stay afloat long enough to complete the financial arrangements for opening the plant. In describing his relationship with the ERIP, Cromwell writes:

> It is obvious that two factors are missing in a situation like this, funds are not available in sufficient amounts and equally important is the lack of credibility, which is related to funding because with money credibility can be established. It was at this point that we contacted the Office of Energy-Related Inventions of the Department of Energy and in particular a Mr. Glenn K. Ellis, of that office. With their help, in the form of a grant of $158,000 and the credibility established by their office, Cromwell Metals is now building its first commercial plant. I can truthfully say, that without the help of the DOE office, it is extremely doubtful whether Cromwell Metals would have ever gotten off the ground.

OUTCOMES

Current Status of the Case

During the grant period, Cromwell developed a business plan for use in a private stock offering, negotiated a loan package with the city of Buffalo and the Small Business Administration, applied for about 15 foreign patents on his process, and obtained three orders in the form of letters of commitment, any one of which would completely utilize his plant capacity for one year. In addition, construction on the plant has begun and is expected to be completed in January 1982.

At the time of the interview, Cromwell estimated it would take three months to complete the construction and another three months to get through the plant start-up phase, so that at the end of six months, the plant should be generating real profits. About 3,000,000 to 6,000,000 lb of dross can be processed per month; primary aluminum plants can produce about 100,000,000 lb of dross per month; thus Cromwell concludes that about 20 plants could effectively be licensed in the United States. It would cost about $5,000,000 to build a plant and initiate production. Cromwell will also consider acting in a turnkey capacity for a primary producer of aluminum.

Tangible Outcomes

Cromwell identified several tangible outcomes:

- He has orders in hand valued at $750,000 per month for one year.
- He has leased a building and land for $75,000 per year with an option to buy.
- He has completed his negotiations with the city and Small Business Administration for a total of $700,000.
- The building is being renovated.
- He has raised about $450,000 in private capital.
- He has obtained a $200,000 line of credit from a local bank.

Intangible Outcomes

Several intangible outcomes were identifed:

- Cromwell has a new invention in mind and will not hesitate to submit it to the ERIP; he is convinced that it will be easier for him to deal with the system and that he will be more responsive to the needs of the system.
- He has established a good relationship with the financial community and believes he would find it easier to obtain financing for other endeavors.
- Last, but certainly not least, he would plan any future venture more thoroughly -- as he was forced to do in developing his work statement.

INTERVIEWER COMMENTS

This case represents the typical path followed by an entrepreneur who commercializes an invention growing out of his on-the-job experience. Mr. Cromwell spent his entire working life in the aluminum industry, and much of that experimenting with methods to recover aluminum dross. At the same time, he was responsible for establishing and managing aluminum plants for larger companies. When he submitted his invention to the ERIP, both his entreprenurial and inventive skills had combined in the establishment of Cromwell Metals, Inc.

It is noteworthy that timing is of the essence for those involved with the ERIP. Mr. Cromwell had disengaged himself from a venture at about the same time that most of the bugs had been worked out of his aluminum dross recovery process. (The reader may wish to refer to Shapero's theory of the displaced entrepreneur.)

He was able to liberate sufficient cash (from his relations and an existing shoestring venture employing the unperfected aluminum dross recovery process) to continue developing his process and establishing Cromwell Metals. The ERIP provided the necessary seed capital to speed completion of the R&D necessary to begin full production. The serendipity of these events and the time at which they occurred may be bewildering to those attempting to provide useful assistance. However, Cromwell's attitude is simple, straightforward and pragmatic: he would have reached full production by himself sooner or later *but* the ERIP shortened the time required to do so. From a policy perspective this may be one of the most important contributions of the ERIP to inventors.

Another important point made by this case is that ERIP provided cash for specific work to be performed (i.e., the negotiated work statement) without a great deal of government supervision and reporting. This "hands off" attitude resulted in timely completion of the work and recognition by the grantee that planning, as required in developing the scope of work, is critical to successful venturing. As a result, Cromwell is likely to be successful in any further attempts at commercialization.

PARTICIPANT:	Jay Dornier (56) 3308 Tulane Avenue Suite 312 New Orleans, Louisiana 70114 William P. Boulet (Inventor) 3601 Rue Nadine New Orleans, Louisiana 70114
CASE TITLE:	Flexaflo — the Wet Fuel Dryer
FUNDING LEVEL:	$111,220
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	James Petersen Center for Informative Evaluation P.O. Box 17600 Tucson, Arizona 85731

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

The inventor of the Flexaflo — the Wet Fuel Dryer is Mr. William P. Boulet. Mr. Boulet issued a license to manufacture the dryer to Quality Industries, Inc.; Mr. Jay Dornier, the interviewee, has been responsible for its development and commercialization. Mr. Dornier received a B.A. degree in mechanical engineering and has 20 years of experience in the petroleum, sugarcane, and marsh equipment manufacturing industries. He describes his 20 years of work experience as having been extremely diverse, with several quite different employers. His skills are primarily the result of working in various jobs. He identifies himself as a petroleum and mechanical engineer.

Mr. Dornier has been employed by Quality Industries for the past ten years. Prior to that he functioned as an engineer for firms in the petroleum industry. Quality Industries, which employs 100 persons, is one of the world's largest designers and manufacturers of marsh equipment. At Quality, Mr. Dornier is the new project development engineer, and although not a partner, he is clearly one of the executive staff. In addition to his intimate involvement in the design of all Quality's products, he is responsible for manufacturing and quality control, shop management, sales, marketing, and whatever else needs to be done. In large part, Mr. Dornier is an innovator with regard to marsh equipment.

Mr. Dornier, although not the inventor of this invention, has designed and invented several products. Some of these products are patented, but, in general, he does not believe that it is always necessary to patent an invention. His inventions are primarily in the petroleum and marsh equipment fields.

Description of the Technology

The technology, an industrial and commercial product called Flexaflo — the Wet Fuel Dryer (Patent No. 3,976,018), was invented by William P. Boulet of New Orleans. The most succinct functional description of the invention is contained in the NBS second-stage evaluation; it describes the invention as primarily an "energy savings device using boiler flue gas to dry combustible process residues of fiber, pulp, etc., such as bagasse from sugarcane processing to improve its burning characteristics, increase its fuel value and make it more useable as boiler fuel."

The idea for the Flexaflo came to Mr. Boulet while he was consulting to the city of New Orleans, according to Mr. Dornier. Mr. Boulet recognized that inefficiencies existed in the traditional method of drying and using wet bagasse as fuel in processing sugarcane. Essentially, in order for bagasse to be used as a fuel, auxiliary fuel such as gas and oil must be used along with it. Mr. Boulet became intrigued with the idea of improving the efficiency of the traditional drying system used by the industry.

Apparently the inventor reasoned that if wasted stack gas energy from boiler furnaces could be diverted and used to dry and pretreat bagasse, an energy saving could be accomplished.

In order to dry the bagasse efficiently in the Flexaflo dryer, the wet fuel and hot stack gas from the combustion furnace are entered into the top of a large cylindrical container. The bagasse is dried by the hot gas as it drops from the top of the dryer to the bottom. Inside the cylindrical container is a center shaft that incorporates inner and outer cones. This system ensures the slow movement of bagasse as it moves downward in the dryer and, therefore, optimal drying. The dried fuel exits the dryer through a hole at the bottom and moves onto a conveyor belt system. The conveyor belt dumps the dried fuel into the boiler furnace, and the cycle is repeated.

Before submission of the technology to NBS, two sugarcane mills had purchased three Flexaflo dryers. Quality built and installed the dryers prior to the beginning of the processing season, and when finally tested in a real application, several serious technical design problems were immediately observed. As a result, the dryers were turned off, and eventually Quality returned all the money to the purchasers.

According to Mr. Dornier, these technical problems occurred because the system (prototype) was never tested adequately during the developmental stage. He stated that the prototype should have been tested at peak capacity and for prolonged periods of time; it wasn't. The inventor was described as testing the prototype under less than optimal circumstances and minimizing the significance of potential problems. If adequate testing had been conducted, the serious problems discovered after the product was purchased might have been identified and solved. It is possible that NBS would never have received a proposal from the grantee had a production prototype been built and tested prior to sale to the sugarcane industry.

Three specific problems were discovered once the invention was operated at capacity. The most serious problem was the production of bagacillio (dried miniscule pithy particles) and dust. These particles caused both a health and a waste disposal problem.

Second, problems were experienced in the positioning of feed and discharge conveyors. Pumps and motors broke down as a result.

Third, the flow of dried material into the furnace was irregular, which caused problems in the maintenance of constant furnace temperatures.

The application of this technology was intended for the sugarcane industry, initially. The developers believe that there are applications to any industry which uses or could use wet waste material in furnaces if it was dried sufficiently. Industries such as wood paper pulp, rice, grain processing, garbage disposal, etc., would be appropriate for this technology.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

The manufacturer can't remember how he heard about ERIP; however, he suspects he saw it in some printed material which crossed his desk. Quality Industries and Mr. Boulet submitted a proposal to ERIP because they ran out of money and were unable to obtain funding from anyone else. Quality Industries invested close to a million dollars in the commercialization of this invention. When they discovered that the invention wouldn't operate as planned, the company could not afford to invest more money to solve the problems because of a slump in the sugar industry. ERIP seemed like the last alternative.

Mr. Dornier's expectation of NBS was straightforward; he wanted a positive recommendation to DOE to fund their project. He did not expect, nor did he receive, much technical assistance. In fact, Mr. Dornier couldn't recall very much technical assistance or contact with NBS. What NBS did do, he felt good about, particularly because they were positive in their recommendation for funding.

Overall, the greatest benefit of his experience with NBS was the positive recommendation. On the negative side, Mr. Dornier was dissatisfied with the amount of time (11 months) it took to get the NBS approval. His assessment of the NBS evaluation process was total satisfaction with their attention to confidentiality and satisfaction with the technical content and quality of the evaluation and the helpfulness of the evaluators. He was neither satisfied nor dissatisfied with the personal contact with NBS and the clarity of the evaluation form.

The proposal submitted by Quality Industries and Mr. Boulet was not rejected by NBS at any time; however, both the first- and second-stage evaluators recommended not funding the project.

As of this date, Quality Industries only submitted one technology for evaluation. Basically, Quality's inventions are not in the energy-saving areas, and consequently no additional request for funding was thought to be appropriate. However, should an energy-related invention be developed in the future, Quality would only consider submitting a proposal to NBS if they needed money. While they have not recommended the program to others, they would do so if the opportunity arose.

Experience with the DOE

In terms of expectations for DOE, Mr. Dornier stated that he expected a fair review and a fairly rapid decision-making process. He believed that these expectations were realistic. He felt that he did get a fair review, but the process of receiving the money took too long.

Once the contract award was made, he had only one major expectation, and that was to receive the money. He thought that he might receive some management assistance; however, he said it wasn't a very strong expectation. His expectation regarding the money was fulfilled. He didn't receive any management assistance from DOE, but he discovered that the funding by DOE, in itself, was very valuable in marketing the invention. In addition, the article written by the people from MIT and published in *Technology Review* was extremely valuable in this effort.

Other than periodic monitoring by DOE, Quality Industries received little technical assistance. In Mr. Dornier's view, they asked for little because they had the expertise to solve the problems or knew where to go to obtain it. Therefore, as a result of contact with DOE, no groups or individuals were contacted to provide assistance.

Overall, the best experience with DOE was receiving the money and the worst experience was the time (6 months) it took to get the funding. If they developed an energy-efficient invention in the future and they needed money, they would be willing to go through the DOE funding process again. Mr. Dornier's overall assessment of DOE was positive.

Participant's Assessment of the ERIP

Mr. Dornier stated that the best part about the program was that, because of the funding, he was able to solve the technical problems (i.e., refine the invention). Without the money he would not have been able to complete the project.

The major impediment was the amount of time it took to secure funding.

The overall assessment of ERIP by the interviewee was very favorable. He likes the concept of the program and feels that it provides the small inventor of energy-related products an opportunity to commercialize his product.

OUTCOMES

Current Status of the Case

Under the ERIP contract, all problems identified in the proposal were resolved. The use of special filters to collect the dust solved the dust problem. All conveyor problems were solved and, too, the problems with motor drive shaft breaking.

The product is fully commercialized; however, as pointed out, the product had been commercialized prior to the submission of their proposal to NBS. At present, Quality's license to market the product has been revoked by Mr. Boulet. Mr. Boulet plans to market the invention himself. Mr. Dornier refers all inquiries about the dryer to Mr. Boulet. At present, no new dryers have been sold because of the slump in the sugarcane industry.

According to Mr. Dornier, Quality Industries would probably produce the product should someone decide to purchase one. In addition, it is possible Mr. Boulet or Mr. Dornier will be talking with other industries in an effort to market this invention. It does not appear that much effort is being expended on the part of Quality Industries or Mr. Boulet to market this invention.

Tangible Outcomes

Two tangible outcomes can be identified. First, all major technical problems were solved, and the technology is known to work. It dries bagasse effectively and is an energy-efficient product. However, because of economic conditions, no new Flexaflo dryers have been sold.

Second, a major professional paper on the technology was written by professors at MIT. This document has been published.

In the view of the manufacturer, the invention is a technical success and may become a success in the marketplace once economic conditions change.

Intangible Outcomes

Several intangible outcomes were identified. First, the knowledge in this field has been increased and expanded. Second, there was a positive working relationship between some members of the DOE staff and the developer. Finally, there has been an increase in the developer's ability to interrelate with federal funding resources.

INTERVIEWER COMMENTS*

The major operational issue is the long time it takes to process the proposal and provide funding to the successful applicant. Clearly, the small inventor with little capital cannot often afford to wait a year or so to receive funding. In order to compete in the market-place, more rapid turnaround would improve the chance of successful commercialization.

It is unclear why funding was awarded for this project. Two NBS evaluations (Stages I and II) recommended against funding. The sugar-cane industry was in a slump and still is. The application of this technology to other industries was a possibility, but no clear plan was presented. The grantee, Quality Industries, was not a small operation, and its financial resources were quite strong. The principals, Mr. Dornier and Mr. Dietrich, had invested about $1,000,000 in the invention; however, they could not raise an additional $100,000 to solve the problems identified. It is curious why this amount could not be raised by these individuals. One conclusion is that they perceived the improbability of marketing the product in a depressed market.

The major policy issue is: Were the criteria used for selecting grantees sufficient to allow for the identification of those inventions which were not only technically feasible but, also, which had a high probability of being commercialized successfully? At present, do criteria exist which facilitate the evaluation not only of the invention <u>but also the inventors</u> and those responsible for its commercialization?

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*Mr. Boulet, the inventor, disagreed substantially with Mr. Dornier on matters related to the stage of development of the technology, when submitted to ERIP, the responsibility of Quality Industries, and Mr. Dornier's ability and qualifications to develop the technology. None of these disagreements relate to the participant's participation in the ERIP program. While the comments are not included in this document, they are available for review upon request.

PARTICIPANT:	Enoch J. Durbin (69) Durbin Associates 246 Western Way Princeton, New Jersey 08540
CASE TITLE:	Ionic Fuel Control System for the Internal Combustion Engine
FUNDING LEVEL:	$87,051
CASE STATUS:	Complete
INTERVIEWER:	Marcia L. Grad M. L. Grad Consultants 3930 North Pine Grove Avenue Chicago, Illinois 60613

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Enoch Durbin, the inventor, earned his doctorate in mathematics and physics. He identifies himself as an applied scientist (in contrast to a theoretical scientist) and as an interdisciplinary engineer (electrical, mechanical, and aeronautical).

Dr. Durbin is a member of the Princeton University faculty — Professor of Aero-Mechanical Sciences — and is part owner of a company that manufactures one of his inventions.

Most of the 12 or so patents granted to Durbin are in the instrumentation and control field. In addition, he has "lots" of other inventions for which he has not patented yet. Although many of Durbin's inventions fall in one general area, it is interesting that his one entrepreneurial adventure involves the manufacture of a tennis racket he invented. He clearly understands that his talents are invention-related and that he is not, and has no desire to be, an entrepreneur. As part of his effort to commercialize the tennis racket, Durbin contacted about fifteen diverse sources of venture capital. Of these only one was a state source of assistance.

Durbin had one interesting discussion with a New England-based company specializing in commercializing technologies. In his opinion, the company overestimated the capital requirements for his startup manufacturing firm to increase its own "up front share." Ultimately, he started the company with far less capital by assembling an harmonious group who thought the product was excellant, and that the project would be fun — and perhaps even rewarding financially.

Description of the Technology

The technology supported by the Energy-Related Inventions Program is classified as "Combustion Engines and Components." It is a system designed to measure the air breathed in by each cylinder of an engine and to determine the appropriate amount of fuel to mix with the existing air. The key to this system is an ion-drift air mass flow sensor meter, Durbin's invention, which is protected by patents. The system, in simplistic terms, regulates instantaneously the air-to-fuel ratio for auto engines in order to optimize engine performance and conserve fuel.

Durbin has been involved in ion mobility research for some time. During the Vietnam War (about 1967), he served on the Army Science Advancement Committee and was asked to find out why army helicopters were crashing as they hovered during rescue operations. The answer to the problem led to the development of an air speed instrument which controlled the ion flow, allowing pilots improved control of air speed and thereby preventing the stalls and crashes. This invention was not adopted by helicopter manufacturers. Durbin then worked on the development of a twin-axis ion air flow meter for a military application. In 1977, Durbin took a sabbatical to work in International Telephone and Telegraph's R&D laboratory in England. Under the arrangement with ITT he could work on any problem he wished for one year; during the year he worked on the development of a control system for internal combustion engines and reached a point where he had a breadboard prototype of his invention together with preliminary test data. After the sabbatical, Mr. Durbin continued the development of his system, including participating in discussions with Bendix Aviation, United Aircraft, and General Motors regarding commercialization of the system.

This system has been evolving since 1967. The first technology developed was licensed to Aerospace Corporation, and Durbin has used the royalties from the license to continue development of this technology (over one million dollars); Durbin estimates he has invested about a quarter of a million dollars of his own; and ITT contributed all costs of work performed in their laboratories in England. Durbin has drawn on the expertise of patent attorneys in the process of obtaining two U.S. patents and five foreign patents.

The greatest problem Durbin encountered in the development of his technology was his inability to explain it to potential users (for example, auto manufacturers) in terms which they would understand (namely, financial) and which would stimulate their investment in or purchase of the technology.

This technology is unique because other carburetors lose fuel down the side of the engine. In other engines the air and fuel travel to cylinders at different rates; thus the ratio of air to fuel is incorrect when they arrive at the cylinders. There have been no other efforts made to keep the air-to-fuel ratio constant at the cylinders. The energy savings characteristics of this invention are that

- It makes auto engines more efficient because the air-to-fuel ratio being correct improves the rate of fuel consumption and

- It cuts hydrocarbon, nitrogen oxide, and carbon monoxide emissions.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mr. Durbin first heard of the program when he was delivering a paper which included a description of his invention at the American Philosophical Society in Washington, D.C. When he completed his presentation, a member of the audience — an NBS evaluator — stood up and told him he should submit his invention to the ERIP for evaluation.

Mr. Durbin reports he decided to submit this invention to ERIP because his wife thought it would be nice if he got some financial help to complete the development work.

Durbin's expectation of the NBS was very high — especially with respect to the length of time it would take for his invention to reach DOE and the DOE support system. The reason for this is that the NBS evaluator mentioned above had told him that he had already passed through the first-stage evaluation and that he should "zip right through the remainder of the evaluation." Both the evaluator and the inventor began the process with unrealistic expectations.

Durbin feels that he had to "educate" the NBS evaluators — both internal and external — and clearly states that he did not receive any technical assistance from them. He had been working on the problem as well as the solution for many years, and he did not need assistance — he did need funding to continue his work. In particular he was discouraged by the lack of expertise in the field exhibited by the external second-stage evaluator. During the evaluation period he did solve some of the problems related to operating the meter in an automotive environment; he does not attribute this to his interaction with the NBS but to the passage of time and his laboratory work.

Durbin did not identify a benefit from participating in the NBS technical evaluation; he felt he knew more about the technology than NBS did, so the technical evaluation was unnecessary. With respect to problems encountered in dealing with the NBS, he responded that the evaluation was a waste of valuable time. He was impatient because he was trying to solve an energy problem. He rated the technical content and quality of the evaluation, personal contact with NBS (Mrs. Nichols), and attention to confidentiality as very satisfactory. He felt that the correspondence was anonymous and that the evaluation was not helpful, since it did not address commercialization issues. And he rated the time required for evaluation as unacceptable. He does not remember the evaluation form and did not, therefore, comment on its clarity.

He has submitted only this invention to NBS for evaluation and would not submit any others if he had them. He would not recommend the program to others because it is too time-consuming and too bureaucratic.

Experience with the DOE

When his invention was recommended for DOE support, Mr. Durbin felt that the process had been completed and that he would receive direct funding. In fact, it took over a year for the project award to be completed.

Durbin specified that program personnel put him in touch with G. Callahan (contract officer) and that the program chief, Pat Donohoe, guided him through the formalities of obtaining a patent waiver. Of course, he did receive money to complete the negotiated work statement tasks:

1. Design and build an experimental test facility.

2. Review alternative operational configurations of the sensor and compare them with respect to their ability to operate in an engine environment and their production costs.

3. Build and test three breadboard prototypes of the three most promising configurations.

4. Assess, with the assistance of an outside firm, the

   - complexity of construction,
   - performance in a variable automotive environment,
   - feasibility of mass construction, and
   - effect on the control system of complexity and cost for each,
   - and select the most promising prototype.

5. Design and build an engineering prototype of the most promising sensor.

6. Adapt the ion fuel system to incorporate the sensor.

7. Solicit manufacturers' evaluation of the system's performance in automotive engine control applications during the federal driving cycle tests.

A 12-month grant was awarded in the amount of $87,051 to complete the above tasks. Durbin completed the work and submitted a final report.

During the grant period, Mr. Durbin stated, he built and debugged the sensor, tested its operation in the system, and contacted Eaton Manufacturing Company (auto supplies) to evaluate the technology and determine if they wanted to license it. Eaton Manufacturing built their own model, and he submitted his final report on time (i.e., he completed the work within the time specified). Thus he feels a good amount of progress was made while working with the DOE.

Participant's Assessment of the ERIP

Durbin reports that the money and Gene Callahan (contracts officer) were the best things that happened to him as a result of his participation in the ERIP. The greatest difficulty he encountered was actually getting the grant issued. He found it difficult to determine if he would go through the DOE funding process again and finally said he would only do so if he were desperate for cash. He would like to have had access to "nurturing" assistance as well as cash.

It appeared that Durbin had given a good deal of consideration to his experience with the program as well as to how it should be run. It is his opinion that the Department of Energy has little sense of mission, so it is doomed to not doing anything positive and to frittering away its resources.

He feels that ERIP should be in the business of "nurturing creativity," just as he is as a professor in a university. He observed that inventors must be tenacious to contribute creatively — having the idea is not enough. Inventors will encounter a great deal of disinterest on the part of others (including government) and they must wait interminably when dealing with the ERIP. He feels that most invention submissions could be evaluated by a group of four or five professionals in the course of one afternoon without making too many errors in judgment. The inventors of inventions evaluated as promising would then be contacted by the group in order to obtain more technical information. The government would not only provide money to those evaluated positively but would also provide "nurturing" activities and access to those in the business of exploiting technology (e.g., manufacturers, testing companies, venture capital sources, and entrepreneurs). In short, the program would emphasize matchmaking as a service for inventors, because typically inventors are not interested in participating in commercialization activities, and they won't give up their invention until someone takes it away from them. The program would help inventors overcome such liabilities.

The ERIP concept has been distorted, according to Durbin. All promising inventions should be funded at a low level (about 10% of the submissions if the current funding level is maintained). The cost of producing one B-1 bomber would pay for this kind of program, or redirecting the cost for bureaucrats to push papers in this program would support it.

OUTCOMES

Current Status of the Case

Since completing the DOE grant, two working models have been tested, one in a Volkswagen and one in a Toyota, in Vancouver, Canada, where Durbin has been teaching, and the engine is being modified to run lean (and thus to conserve fuel). Furthermore, he is now experimenting with the use of methane and other natural gases with a higher octane number in the engine. These are natural outgrowths, in Durbin's opinion, of the DOE work.

In addition, he has established a viable research laboratory in Vancouver with financing from the Province of British Columbia; the Government of Canada has invested $6 million in natural gas research in western Canada.

Tangible Outcomes

Mr. Durbin identified the following as tangible outcomes of his participation in the ERIP:

- $6 million Canadian research program.
- Establishment of a new laboratory to perform research on the use of methane for motor vehicles.
- Policy changes in Canada.
- Development of a world conference on the use of methane in motor vehicles (in order to obtain broad-based input for the field and establish a knowledge base), with a subsequent meeting to consider the establishment of an ongoing international working group.

Intangible Outcomes

The following have been identified by Durbin as intangible outcomes:

- An opportunity to work with auto manufacturers.
- An increased knowledge of the auto industry.

- Increased knowledge of licensing and the need to finalize details prior to actually licensing.
- Acquisition of the knowledge of the "painfully slow rate of innovation within large American automotive companies."
- Acquisition of knowledge of how to "enter" and "deal with" a major manufacturing company.

INTERVIEWER COMMENTS

Mr. Durbin, unlike many inventors, is very much aware of his lack of desire to participate in entrepreneurial activities. He was clear that his talents lay in the technical areas and that he would not venture into the entrepreneurial arena. Indeed, he has hired a president for his manufacturing company, which is evidence of his self-awareness.

Durbin's negative experience with the large auto manufacturing companies exemplifies the conventional wisdom regarding the "not invented here (NIH)" syndrome as well as the inability of large companies to deal with the individual inventor. And it contributes to what we know when he states that "innovation in the auto industry originates with sports car buffs and racers who demand improvements and innovations which may be adopted by the industry at a later time." This confirms that in many large traditional (with respect to innovation) companies, innovation originates outside the companies and is forced on them.

His comments regarding the NBS in-depth evaluation (i.e., second stage) raise questions regarding the appropriateness of using evaluators for inventions that fall into a category of "quantum-leap" inventions by experienced, technically sophisticated inventors.

PARTICIPANT:	Richard Engdahl (31) 318 Victory Drive Hernden, Virginia 22070
CASE TITLE:	Chemical Vapor Deposited (CVD) Ceramics Turbine Rotor
FUNDING LEVEL:	$125,000
CASE STATUS:	In process
INTERVIEWER:	Sumner Myers Institute of Public Administration 1717 Massachusetts Avenue, N.W. Washington, D.C. 20015

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Richard Engdahl, developer of the chemical vapor deposited (CVD) ceramics turbine rotor, holds a B.S. degree in mechanical engineering. While he has not bothered to earn a master's degree, he has taken numerous graduate courses, principally in control technology. In his control work, Engdahl "learned to appreciate and understand entire systems, in order to develop controls for them." He understood that improving the performance of the weakest element of the system could significantly improve the entire operation. This background led him to the concept that a one-piece silicon carbide turbine rotor would enable turbines to operate at higher temperatures and therefore more efficiently which has implications for the whole power generation system.

Engdahl worked with high-temperature ceramics since World War II, when he was employed at Wright Field to analyze captured German aircraft turbines. Since then he has worked for the National Administration for Civil Aviation (NACA) and a variety of private companies. His whole technical career has involved heat engines and ceramic materials.

Even though Engdahl is a highly creative person, he does not hold any patents. Much of his career has been devoted to materials development, which results in "know-how" rather than patents. In addition to Engdahl's technical know-how — which is considerable — he has bureaucratic know-how. Since he has dealt with various government agencies from the very beginning of his career, he knows how to get his projects funded and how to work effectively with such funding, and its restrictions, to get the job done. This talent — in combination with Engdahl's technical creativity — helped him get ERIP funding without agonizing over the delays inherent in such a system.

Description of the Technology

Engdahl invented a process that makes possible the deposition of solid silicon carbide (SiC) from its gaseous state. Silicon carbide is a material whose physical properties allow it to withstand the high stress levels required of a maximum efficiency gas turbine rotor. While SiC has long been available in combination with other materials, there has been no way, to date, to form SiC in its pure state; additives degrade its high-temperature strength.

Engdahl's process, chemical vapor deposition (CVD), allows the formation of pure silicon carbide. SiC is circulated in a gaseous state either into a pattern mold or over a metal part, preformed in the desired final shape. The SiC bonds to the mold or to the substrate at high density and maximum strength.

CVD has the additional advantage of producing SiC pieces in their final shape. Other ceramic processes require extensive cutting and grinding to transform ceramic slabs into usable parts. The use of molds for CVD SiC eliminates that problem altogether. The potential of fabricating a ceramic part in final shape may lead to a one-piece high-temperature turbine rotor. Such a rotor could be the key component of high-efficiency energy generating systems.

This invention evolved from ten years of Engdahl's work on thermionic converters for both military and civilian applications (Office of Coal Research). To protect the thermionic device it was necessary to make envelopes of materials which were able to perform under high temperatures. The suppliers of this material, vapor deposited silicon carbide, weren't particularly interested in improving its performance — which forced Engdahl to work on it.

Engdahl succeeded to such a degree that his employer was encouraged to invest company R&D money in the process. Soon the company felt that, having built up some expertise in CVD, it ought to find some paying applications for it. Its first customer was Ford Motor Company, which was working to develop a rotor with high-temperature ceramic blades attached to a metal hub for use in its experimental gas turbine program. This contract drew Engdahl's attention to the need for more than just a ceramic blade — Engdahl realized that in order for a small turbine to operate at its highest efficiency it should have a one-piece ceramic turbine rotor which could withstand very high temperatures and pressures.

He knew that if a gas turbine rotor could withstand a higher stress level, which he felt CVD silicon carbide could, power could be generated at a significantly higher efficiency. This would mean that smaller, high-efficiency power plants could deliver at least as much power as a big plant with low efficiency. What's more, a turbine rotor that would operate at very high temperature would permit rearranging elements of the power generating system for still greater efficiencies. For example, the steam turbine, whose efficiencies are greater at higher temperatures, could precede the gas turbine, which can operate efficiently at lower temperatures.

Eventually, Ford canceled its turbine program. While the chemical vapor deposit process had been developed well enough to make single blades, much more work would be necessary in order to get to a one-piece turbine rotor. For reasons unrelated to the Ford contract, Engdahl left his employer and set up his own company (with James Withers), to pursue his idea.

Engdahl set up his company with James Withers, who was responsible for marketing and outside contacts. Although Engdahl has done all the technical work, Withers is the "inventor of record" for ERIP because he submitted the application.

Engdahl's new company got some funding from the Army to work on developing CVD high-performance silicon carbide. The Army was not interested in the rotor as such, which gave Engdahl a good deal of freedom to run his R&D. He kept working on the material, aiming for the rotor, which would impact the whole system of power generation.

Engdahl felt that DOE's turbine program should fund his rotor research because of its system implications for power generation, and he proposed that they do so. However, the DOE turbine program rejected Engdahl's proposal on the grounds that DOE clients were building large turbines and weren't interested in a rotor for small turbines. If Engdahl succeeds with his small one-piece turbine rotor, he may be able to sell it to what now appears to be a reluctant market. At this point, however, it's not clear that manufacturers of large turbines will buy Engdahl's small turbine rotor.

CVD silicon carbide has applications in other industries (e.g., optical industry). Because CVD silicon carbide is virtually nonporous, it is ideal for use in developing scientific inventions; it can be polished to within 4 angstroms — that is, smooth enough to be used for a variety of scientific and high-power applications.

Engdahl works on these applications in order to get the money he needs to keep improving the CVD process. He still has his eye fixed on the main objective — developing a one-piece turbine rotor that can operate at high temperatures — which takes money. Funds from various sources, presumably earmarked for particular projects, are commingled to support the development of the CVD process, which leads ultimately to the inventor's primary goal — the turbine rotor.

The most important potential application for the CVD process is the high-temperature, high-stress one-piece turbine rotor needed for increasing turboelectric generating efficiencies. Smaller, more efficient plants could be built and more quickly. This could be very important because large power plants now require over ten years to get into operation. The flexibility inherent in small plants is also important. No one can accurately predict community development patterns or energy needs far enough ahead to construct large power plants, but if smaller plants were available they could respond easily and quickly to emerging patterns, simplifying planning and service for power companies. Because they would be comparatively unobtrusive, such plants are also likely to be more acceptable in communities. In short, Engdahl's rotor innovation, though small in itself, would make a big difference in the systems that used it. In that sense, it is a "linchpin" innovation worth pursuing.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Engdahl's firm is located near Washington in Herndon, Virginia, which means he is close to what happens in federally sponsored R&D. He heard of the inventions program through a number of sources, both written and oral. As noted earlier, he tried to get funding through one of DOE's conventional programs and through that experience was attracted to the ERIP.

The invention was submitted to ERIP with the expectation of getting financial support. That expectation proved to be entirely realistic in that the support was provided.

NBS provided no special services to the inventor because the situation did not require such services. The inventor is a sophisticated technical person who knows his field. He also knows how to do business with the government.

Engdahl, who was generally cool in his ratings of the features of the NBS element of the program, had a very high regard for the entire program. He felt that the program's objectives made good sense and that the government pursued these objectives in a systematic manner — which called for no exceptional appreciation in his ratings.

Experience with the DOE

The inventor expected DOE to fund the project — which is what happened. He was given no special services, nor did he need them. His assessment of DOE was the same as for NBS. He was totally satisfied with it.

Program Participant's Assessment of the ERIP

The best thing about the program was the money it provided to support an idea that didn't quite fit into DOE's conventional approach (which approach was governed by a client industry with self-defined "needs").

The greatest impediment to Engdahl's dealing with the program was inherent in the nature of the program — large numbers of inventors, each of whom must be dealt with, causing delays to all the others.

Engdahl's overall assessment of the program was positive. This was undoubtedly colored by his having received financial support. Even so, his appreciation of the program seemed to go beyond his personal benefit. For example, Engdahl discussed the pros and cons of having the invention program more generously funded. Other parts of DOE, for example, do research on turbines and materials at much higher funding levels. But he balanced his suggestion by observing that, should ERIP give out larger chunks of money, they would be pressured to supervise the inventor's work more closely, and that would be counterproductive to the inventor.

OUTCOMES

Current Status of the Case

Engdahl appears to have made good progress during his contact with ERIP. The grant objective was to improve the material properties of CVD SiC deposited on metal. Engdahl has refined the mixture of gases used to carry SiC through the CVD process. The final product is now clear to the strength he wants at the required temperature. When pressed for dollar specifics, however, none were available. Part of the reason may be that ERIP money has been commingled with funds from other sources to further the development of the CVD process and ceramic material. In the interview, Engdahl could not attribute specific accomplishments to specific funds. He could, of course, do so if this were officially required.

The CVD process currently will yield blocks of silicon carbide able to withstand pressures of 120,000 pounds per square inch (psi) at 1400–1500°C.

The inventor's current plan is to continue working on CVD silicon carbide until he can produce a block of material with the desired resilience. His immediate target is to increase the pressure from 120,000 psi to 200,000 psi at 1400–1500°C (2500–2700°F). Then he will work at depositing silicon carbide on a one-piece rotor mold.

Tangible Outcomes

The tangible outcome of Engdahl's participation in ERIP might be a revolution in the way turbines are designed and integrated into power generator systems. At the very least, the outcome will be a better ceramic material.

Intangible Outcomes

The intangible outcome for the inventor was increased credibility with his bankers. He borrows on an SBA guaranteed loan program. The support of DOE increased his corporate credibility with SBA, making them more willing to guarantee loans.

INTERVIEWER COMMENTS

I have no special comments on operational issues. The program seems to function smoothly, fairly, and, all things considered, expeditiously. Most important, the program has identified a potentially fruitful invention that is particularly appropriate for government funding. My question is, How might government (i.e., ERIP) identify more of the same?

As noted above, this invention seems particularly appropriate for government support. It is, in a sense, "linchpin" technology. If it succeeds — if turbine rotors can be made in one piece of high-performance ceramics — turbines will be built smaller, and power generation systems can be redesigned. But the manufacturers of today's large turbines are interested primarily in improving the marginal efficiency of their current products — large turbines — not small rotors, which will make large turbines obsolete. In short, the turbine manufacturers are unwilling to loose Schumpeter's forces of "creative destruction" on themselves. Nevertheless, it is in the nation's interest for this kind of technology to succeed. It therefore deserves government support — despite the rhetoric which says that if an innovation is a good one, the market will support it.

The invention deserves government support on other grounds as well. It could be important for national defense. Indeed, the Department of Defense is also interested in CVD silicon carbide as a potential substitute for materials used in defense hardware. Some critical materials come from hostile parts of the world, and DOD is therefore willing to fund the development of American-based alternative materials, especially through small businesses.

Engdahl compared DOD's more successful approach to R&D with that of DOE (not the invention program). His perceptions are interesting because the characteristics that he appreciates in DOD seem to exist or be present in ERIP:

1. DOD has a more long-range perspective on R&D than DOE. DOE's short-term strategy means that they fund evolutionary developments in existing technology, not very innovative ideas. ERIP funds innovative ideas.

2. While DOD works under time constraints much like DOE's, "there are people in the group that have longer range points of view." DOD R&D management is a mixture of military and civilian personnel, specifically to overcome the long-term-short-term problems. ERIP is under pressure to get innovations funded, but the innovations are not under time pressure; ERIP's responsibility is just to move them one step forward.

3. DOD also has a mixture of highly competent technical people and administrators, while DOE is primarily administrative. The mix allows DOD a wider scope of effort and a better appreciation of the R&D process than is possible at DOE. ERIP relies on outside technical evaluators who really know their fields.

4. DOE was set up to <u>help</u> industry, not to have any in-house technical capacity of its own. So DOE's work is determined by industry, which calls for incremental advances rather than for innovations that will invade their markets. ERIP funds such "invasionary innovations."

5. Engdahl liked the idea of the inventions program because it is a "competitive funding source." If one agency doesn't appreciate the idea being proposed — not unusual in the case of really innovative ideas — a competitive agency might. Indeed, the fact that there is a competitive funding source for the same idea should induce the agency which doesn't understand the innovation to "listen harder" in order not to pass up a good bet. For example, Chester Carlson's idea for xerography was rejected by 20 companies who couldn't or wouldn't appreciate it. If Xerox Corporation had never happened or failed, that would have ended the matter. But it succeeded, which caused these unappreciative managers a good deal of embarrassment. Now they listen harder.

6. Competitive funding lends itself to the indirect "idea" approach and leads away from the direct "response to need" approach to innovation. Engdahl noticed that the conventional ceramics process actually weakened the final product when it operated at high temperature. Instead of just working on this particular problem, he took the approach of creating a material that would strengthen under stress. He did not answer an articulated need (a nonweakening process). He pursued a technology idea, chemical vapor deposition of silicon carbide, and came up with a product superior to expressed need (a potentially radical new power provision system). In short, it's often important to "outflank" an articulated need with a totally new approach. And because this approach may find no support in the private market and it is in support of the national interest, it should be supported by government.

PARTICIPANT:	Dr. George R. Fitterer (18) P.O. Box 206 Oakmont, Pennsylvania 15139
CASE TITLE:	The Control of the Analysis of Low Carbon Aluminum Steels Using Oxygen Sensors and Iron-Aluminum Alloy
FUNDING LEVEL:	$99,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Albert Shapero Shapero-Huffman Associates 2342 Dorset Road Columbus, Ohio 43221

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

The inventor, Dr. Fitterer, received a B.S. in chemical engineering from Rose Polytechnic Institute in Indiana in 1924. In 1926 he became a Research Fellow in a United States Bureau of Mines project at Carnegie Institute of Technology, from which he earned an M.S. degree in metallurgical engineering in 1927. He obtained his Ph.D. in metallurgical engineering from the University of Pittsburgh in 1930.

Upon receipt of his baccalaureate, Dr. Fitterer worked as a metallurgist and metallographer in industry for three years, then worked as a Research Fellow for the U.S. Bureau of Mines until obtaining his M.S. Continuing to work for the Bureau, he successively served in more responsible positions, and when he left the Bureau in 1933 he was head of the Metallurgy Department. From 1933, Dr. Fitterer's career has been primarily academic, though he has also been continuously associated with industry through consultation and through companies he has formed. Beginning with his Ph.D. studies, Dr. Fitterer has spent his academic career at the University of Pittsburgh. While president of his own company, Fitterer Pyrometer Company, Inc., he served as lecturer at the university. Since 1938 he has successively been Chairman of the University's Metallurgical Engineering Department (14 years), Dean of the School of Engineering and Mines (12 years), and holder of the first Distinguished Professorship of Metallurgical Engineering (9 years), while simultaneously serving as Director of the Center for Study of Thermodynamic Properties of Materials for eight years.

Dr. Fitterer's academic output has included two books and some 100 articles. He has received many honors, including three honorary doctorates, professional society awards, U.S. Navy citations, and election to the position of Fellow by professional societies. The inventor has also served in many capacities for the United States: as a U.S. delegate to various United Nations technical conferences, as Director of U.S. AID programs for the development of universities in Chile, on the National Academy of Science NATO scholarship committee, and on the White House Committee on Engineering Education in Latin America.

Dr. Fitterer is now 80 years old and, as he puts it, has retired three times but is still working. Through Fitterer Engineering Associates he consults to industry and government and continues to do research and development. He identifies himself as an applied scientist.

Dr. Fitterer has about ten patents, but this is only one measure of his invention history. In keeping with his academic career, his "inventiveness" includes such nonpatented research firsts as the determination of the equilibrium constant for the reaction of silicon in liquid steel, the determination of the phase relations in the system $FeO-SiO_2$, and the relation of the atomic structures of metals to their entropies.

Description of the Technology

Dr. Fitterer's invention is classified as an industrial process. The purpose of the invention is to provide better control of the production of low-carbon aluminum-killed (LCAK) steel, which is about 20% of the steel made in the United States. To produce LCAK steel, a considerable amount of the oxygen introduced into the liquid steel by the basic oxygen furnace is removed before the steel solidifies. One way of removing the oxygen is by the use of the aluminum, which bonds with the oxygen in the melt. Dr. Fitterer's invention consists of two parts: (1) the use of iron-aluminum alloys in place of pure aluminum in the deoxidation process and (2) the use of oxygen probes (O probes) invented and manufactured by Dr. Fitterer to monitor and thus provide the basis for better control of the deoxidation process.

Iron-aluminum alloy has a higher density than pure aluminum, which causes it to sink more effectively into the molten steel, resulting in more efficient and rapid deoxidation and avoiding the problems that occur with pure aluminum, which remains on the surface of the melt and combines with oxygen in the air. The use of the O probe permits systematic monitoring of the oxygen content in the melt as compared to the present practice, which depends on the visual observational judgments of the operators. The perceived advantages of the invention are that it would lower the loss of high-quality steel melts because of unacceptable amounts of oxygen or aluminum and would lower the amount of aluminum used. Lower wastage lessens the requirement for additional melts and their associated energy demands. The use of ferrous aluminum alloys decreases the amount of aluminum used and saves energy since producing one pound of aluminum requires 3.5 times the energy required to produce one pound of steel. At the start of the project there were no iron-aluminum alloys being made in the United States. Now three companies are making them from scrap aluminum, as in cans, etc.

The ideas incorporated in the invention submitted for evaluation are the culmination of decades of research by the inventor into the problems of deoxidation of liquid steel and into thermodynamics generally. The inventor has worked on deoxidation problems since the 1920s. The idea of using aluminum alloys instead of aluminum to "kill" steel has been around since the 1930s. The O probe was developed by the inventor in 1966, patented in 1971, and commercially produced and sold since that time. (In fact, the inventor has had to spend a great deal of time and money defending his patent from many infringers, one measure of its utility.) The invented process was a natural culmination of the inventor's work in the field.

Since Dr. Fitterer's invention is really part of an overall progression towards greater systematization and control of the deoxidation process in the making of LCAK steel, he perceives "problems" as a series of developmental questions to be addressed scientifically rather than as imposing barriers. One technical problem he encountered was obtaining a good source of electrolyte with a good particle size. A logistic-technical problem was getting the proposed iron-aluminum alloy and O probe measurement tested sufficiently under operating conditions.

The inventor comments that the ERIP funding came at a good time because his company was experiencing cash flow problems but that was not so much an invention problem as a particular time-bound problem.

The most direct potential application of the invention is the use of iron-aluminum alloys and systematic testing for oxygen content in production of LCAK steel. The invention appears to promise significant improvement in productivity by requiring less time, producing less scrappage, and using less energy per melt. Further, either of the two parts of the invention has the potential for making some improvement in the LCAK steel-making process. Use of iron-aluminum alloy in place of aluminum in the present process can reduce spoiled melts. Better monitoring of oxygen content using the probe can provide useful data to support or replace the observation-based decisions of operators.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

The inventor first heard about ERIP through an announcement of the program received by the University of Pittsburgh. Since Dr. Fitterer has spent a good many of his 57 working years on projects originating in government agencies, responding to the ERIP announcement was not something very different from his past practice. One major factor affecting his response to ERIP was that the inventor was sincerely interested in doing something about the energy problems from a patriotic viewpoint.

Through his application to ERIP, Dr. Fitterer sought financial support to carry out extensive testing of his invention, and he expected nothing else from NBS. His long experience with federal government projects made him thoroughly realistic in his expectations. He did not receive any particular services from NBS.

The inventor's overall assessment of the NBS is quite positive, with highest marks given to personal contacts with NBS and the tone and wording of NBS communications. He felt that the technical content and quality of the evaluation were good but of no particular value to him. His only criticism had to do with the length of time to complete the processing and the lack of feedback on how the evaluation was progressing, which left him with a feeling of great uncertainty. He felt that some of the time problem was due to the fact that his was one of the early inventions to go through the process.

Experience with the DOE

As with NBS, Dr. Fitterer's expectations of DOE were very realistic. He expected direct funding and got it. He was pleasantly surprised by receiving a call from the thermocouple division in DOE with an expression of interest in his work. Though his overall assessment of DOE is positive, he felt that the evaluation time was too long. Also, as he put it, "I was a bit miffed by having my project evaluated again."

Participant's Assessment of the ERIP

The inventor feels that the best thing about ERIP has been the opportunity to do something about the energy problem. "I started out to do something for the conservation of energy and feel good that I've actually done it." The fact is that Dr. Fitterer has received no personal gain from his successful completion of his ERIP project, but as a result of the project there is an increasing use of iron-aluminum alloys in place of aluminum in the LCAK steel production process. He obtains no tangible return from the use of alloys; further, his O probe is tied up in bankruptcy proceedings, and he has actually lost income from his invention.

There were no impediments to participating in ERIP as far as the inventor is concerned. He has since recommended the program to others and has submitted a second energy-related invention to ERIP.

In a rather odd side-effect way, participation in ERIP indirectly led to Dr. Fitterer's loss of control of his company and its subsequent bankruptcy. Once the project began producing useful results, the venture capital people who had invested in the company saw it as an opportunity to capitalize on their investment. They moved in to control of the company and brought in outside management with no experience in the field, who instituted a series of sharp price increases on the O probe. This led to loss of sales and bankruptcy.

The inventor's positive assessment of the program as a whole is most convincingly demonstrated by his recommendation of the program to others and by his own submission of a second invention for evaluation. The program satisfied his main objective of doing something personally about the country's energy problems. In addition, the program provided the inventor with a chance to test his original conceptualization and calculations, something very satisfying to him. "My life in applied science has provided me with some opportunities for small technical and intellectual victories," says Dr. Fitterer from his perspective of 80 years of life and 57 years as a professional.

OUTCOMES

Current Status of the Case

The ERIP-supported project has been completed, and the final report was submitted on September 14, 1978. As proposed, the invention was operationally tested with the cooperation of the McClouth Steel Company.

The advantage of using iron-aluminum alloys in place of aluminum was demonstrated operationally and the possibility of even more effective alloys suggested. The use of the O probe in the McClouth Steel Company tests provided excellent information, but whether it could lead to more timely intervention is still dependent upon further developments. The probe does what it is supposed to do and provides excellent data leading to a clearer understanding of the deoxidation process. Whether the probe could be used as part of a more systematic operational control process was still in question at the end of the project. O probes are being used extensively in the steel industry but only as an addendum to the observational process.

Dr. Fitterer is currently looking into the development of instruments similar to the O probe for use in the copper maunfacturing process.

A nontechnical problem is holding up work in the O probe area. Dr. Fitterer's company, which carried out the project, was taken over by the venture capitalists who had invested in it and has since gone into bankruptcy. Though Dr. Fitterer still holds the patents on the O probe, a great deal of money owed him is tied up in the bankruptcy proceedings, and he must wait for their outcome.

Tangible Outcomes

Iron-aluminum alloys are being used increasingly in the production of LCAK steel. For example, Raritan Steel Company is now using 45,000 pounds of the alloy monthly. Several minimills are using the alloys within and outside the United States, and some of the larger steel producers are now experimenting with the use of the alloys.

INTERVIEWER COMMENTS

When asked to comment in general on inventing, Dr. Fitterer turned to the interviewer with a question, "When you studied engineering, did you have to take a course in 'shop' where you had to make things?" Dr. Fitterer is a particular kind of academic inventor and applied scientist, much more representative of pre-World War II engineering education, that is almost completely gone today — the conscious integration of the abstractions of science and the pragmatics of application. During the interview the inventor described a great many of his personal experiences with both research and applications that constantly led from one to the other. Further, he expressed the strong opinion that his early undergraduate experiences with specifying, designing, making, and assembling mechanisms was essential to his ability to invent.

This particular case also illustrates the powerful appeal of national need — patriotism — to some inventors. It seems almost anachronistic to state what might have been obvious at one time, that there are many talented people who will respond to a direct and credible appeal for help with national problems.

The inventor in this case also represents what might be called a "sophisticated" respondent to government programs. He has had a lifetime of experience in dealing with the government, and while expressing some criticism of the time it took for the evaluation process to be completed, he expressed understanding of the problems of a new program that is just starting up. It might be useful to determine the relative experience with government of an applicant so that a bit more orientation can be provided to the tyro.

This case illustrates one of the problems in getting new technology adopted by industry. The small steel companies, the so-called "minimills," have already adopted the use of ferrous aluminum alloys, but the big companies are only beginning to experiment with them. This has been typical of the steel industry in recent years. Minimills are profitable and innovative and have been all through the past few years. On the other hand, one of the big companies moved in and infringed Dr. Fitterer's patented O probe, and he had to enter into litigation, which he eventually won. But the big company subsequently issued orders not to use his instrument.

PARTICIPANT: Joe Willis Fowler (45)
508 Old Tavern Circle
Knoxville, Tennessee 37922

CASE TITLE: Bulk Cure Tobacco Barn Demonstration Program

FUNDING LEVEL: $54,980

CASE STATUS: Project completed; final report accepted

INTERVIEWER: Gregory Grapsas
Systems and Applied Sciences Corporation
6811 Kenilworth Avenue
Riverdale, Maryland 20840

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Joe Willis Fowler has a B.E. in mechanical engineering from Tulane University.

Mr. Fowler considers himself an entrepreneur. He was founder and owner of a lighting sales agency, director of merchandising for a lighting firm, and founder and owner of a successful marketing organization for a small manufacturing facility. He has directed marketing programs for GTE Sylvania Indoor Lighting. In 1975, he developed, invented, and produced energy-related farming equipment. He currently acts as an agent for companies which produce heat pumps, water heaters, and vent dampers.

This invention is the only invention submitted to NBS by Mr. Fowler. However, he has developed six other inventions, including two ("Flip Flop" and "NR Power System") which were developed in concert with his curing barn as aids to reducing electrical consumption associated with the heating plants in these barns. As in the case of the bulk cure tobacco barn, neither of these inventions ever achieved true market penetration.

Description of the Technology

The invention is a tobacco curing barn. It is a "trailer-like" structure fitted with a rooftop solar collector; there is insulation on all external walls and floor and a recouperator. Air from the solar collector and tobacco chamber is heated and forced under the drying chamber. It then passes up through the tobacco and is discharged or recirculated through the system.

Fowler is familiar with North Carolina and tobacco farming. He realized that the area most in need of improvement in the tobacco industry involves the use of excessive LP or natural gas in heating (drying) the tobacco. He decided to address this need with his bulk cure tobacco barn.

Prior to submitting the invention to the ERIP, Fowler had assembled a staff of 25 persons and had marketed 50 bulk cure tobacco barns. He had developed marketing brochures and was actively marketing his products. The approximate monetary investment by Fowler was in excess of $200,000.

No major technical problems were encountered in development. Placement of controls, safety features, etc., were developed without any real difficulties.

Problems were encountered in market penetration from the beginning. Fowler feels that the tobacco farmer is conservative, not likely to try new products, and not familiar with the technical jargon; furthermore, he feels farmers are unable to evaluate the claims of energy-saving devices.

The tobacco farmer depends on the LP or natural gas suppliers to supply him with fuel in a timely manner. The above suppliers also control a major share of the sale and distribution of cheap barns which are designed to use large amounts of gas fuel. The suppliers possess a strong lobby and have a vested interest in maintaining the status quo.

In fact, Fowler cited several instances of attempts on the part of the LP gas industry to discredit or impede his invention. These included false claims as to energy efficiency of competitive conventional barns, delays caused by licensing his invention to an individual whose son owned an LP gas distributorship (unbeknown to Fowler at the time), and even potential sabotage by one distributor who, Fowler believes, overstated LP consumption to a tobacco farmer in South Carolina who was evaluating Mr. Fowler's barn.

An additional problem, according to Fowler, involves the academic community, specifically the fact that no energy efficiency standards exist to measure tobacco bulk curing structures. While several workshops have been held in recent years (in which Fowler has participated), the American Society of Agricultural Engineers and the Agricultural Engineering Section of the annual Tobacco Workers Conferences have yet to develop a standard. Fowler feels that the absence of this standard has prevented him from achieving full credibility with his invention.

The barn has application in the areas of tobacco curing, peanut drying, and grain drying. It can also be used as a greenhouse or as a building heater.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

In 1975, J. W. Fowler quit his job as marketing manager for a local firm in order to develop, build, and sell his energy-efficient bulk curing barn. By 1976, Fowler had 20 units in operation and was attracting the attention of agricultural engineers in the Ontario Ministry of Agriculture and Food and Ministry of Energy. At its peak, his firm, Carolina Thermal, employed 25 persons. At present, he is the only employee.

Joe Willis Fowler read about the ERIP in a magazine and submitted his invention for evaluation. His submission was made both to obtain extra funds and to attain some credibility among his target audience with his product. Fowler already had over 50 units that had been in operation for one year, but he required the credibility that the ERIP could provide to market his invention further.

His expectations of NBS were realistic, and the evaluation did provide his thermal barn project with the credibility he sought. It also gave him the added incentive to continue marketing the invention.

His experiences with NBS were generally good, although he felt that the time required for evaluation (eight months) was excessive. He did, however, rate the technical content, personal contact, and helpfulness of the evaluation very high. Furthermore, while not requiring technical assistance, Mr. Fowler did feel that the NBS evaluation forewarned him of the LP gas industry's reluctance to accept this invention.

Experience with the DOE

Fowler's expectations of DOE were realistic in the sense that he hoped DOE would provide him with sufficient funds to continue to market his invention. It should be noted that Mr. Fowler had invested $200,000 of his own money and five years of time in the development of his invention. Consequently, Fowler wanted funding to optimize the system design, field-test the system, and educate prospective buyers. Fowler had identified university research stations and university personnel who were willing to assist him in evaluating the project. His total grant request of \$110,000 was submitted to DOE by November 21st — 17 days after he was asked by the Inventions Support staff to outline the assistance he needed.

DOE awarded a grant of \$54,980 in June of the following year to operate a demonstration project with four barns.

The only change in Mr. Fowler's invention occurred as a result of Department of Transportation's (DOT) rescinding a previous order concerning tractor-trailer braking systems. Originally, Mr. Fowler was able to obtain inexpensive mobile trailers which were obsolete due to lack of computerized braking systems. After DOT rescinded their action, Mr. Fowler could no longer purchase trailers as inexpensively as before.

Delays in funding occurred due to the lengthy DOE funding process (over which the Inventions Support staff have no control). Fowler's general assessment of DOE is favorable. He expressed his appreciation for the help and assistance provided by his coordinator (D. Mello).

Participant's Assessment of the ERIP

The best thing about the ERIP was the \$55,000 grant.

The greatest impediment involved delays in receiving the money and the fact that not enough money was given to allow market penetration. Since the project was funded in three steps, Fowler had to wait numerous months for the final report to be accepted and the final payment to be made.

Fowler says that he liked the ERIP since it provided him the necessary money to continue his marketing efforts.

OUTCOMES

Current Status of the Case

During the ERIP contract, the invention moved from limited production and marketing to the discontinuation stage. Fowler had reached full production and marketing by the time he was notified of the favorable NBS evaluation. The DOE grant award kept Carolina Thermal financially solvent, which would not have happened were it not for the grant award.

A senior evaluator called Fowler's submission "one of the best" inventions evaluated as of that time. An independent evaluator (Dr. G. D. Christenbury) evaluated Fowler's barns during the 1977 and 1978 seasons.

DOE awarded Fowler $54,980 in June of 1978 to operate a demonstration project in which he was to manufacture four barns, install them at selected sites, monitor their performance, and assemble operating data. All barns were to be monitored by the U.S. Department of Agriculture and the University of North Carolina. In conjunction with this effort, Mr. Fowler obtained a bank line of credit of $360,000 through SBA. He has been unsuccessful in obtaining funding through DOE's Appropriate Technology program and also through the State of North Carolina's Energy Office.

At present, the inventor has been forced to discontinue all marketing efforts. While he still has an interest in the bulk cure tobacco barn, he feels that he has been forced out of the market due to false claims from competitors, the LP gas lobby, and a trend against conservation of energy.

Currently, Fowler is trying to sell his business, including related land and equipment, to replace the $200,000 depletion to his savings incurred because of the invention.

Fowler has no plans to continue development of the tobacco barn, although he is still interested in the concept. He feels that the LP gas companies have had an adverse impact on his invention in North Carolina. Since they control both the sale of gas and the sale of cheap barns, he views the market as difficult, if not impossible, to penetrate given the status of his finances.

Tangible Outcomes

Fowler succeeded in obtaining test results on the four barns built under the contract. The business did continue during the year in which grant monies were administered. Mr. Fowler readily admits that his business would have failed sooner than it did were it not for the grant award.

Intangible Outcomes

Fowler learned that energy conservation was not as critical a national concern as he previously believed. It should be noted that Mr. Fowler's invention came into being well after the initial 1973 oil embargo and high energy prices but before the next sharp increase in 1979. Consequently, his target audience had become acclimated to reasonably stable prices in the 1975-78 time frame. Mr. Fowler believes that had his invention been introduced a few years earlier or later, its likelihood of success would have been much higher. More important, he discovered that an energy-related invention could not be marketed in an area in which energy distributors had an entrenched, established market with ready access to the potential buyer.

INTERVIEWER COMMENTS

Joe Willis Fowler represents a difficult case study in determining the effect of the ERIP. Fowler was more advanced in terms of product development and marketing strategy than either Bagby or Jablin. He had generated enough academic interest that his barns were receiving independent evaluations at the same time as the NBS evaluation.

Several factors combined to bring the invention marketing effort to a halt, these being the strength of the LP gas business, the traditional attitudes of the potential buyers, the truncation of the original proposal to the $55,000 figure, and lack of endorsement by the agricultural and academic community.

The LP gas business is strongly entrenched in North Carolina (and elsewhere) and cannot be underestimated in terms of protecting its established customers from new ideas which will take away from its profits. Fowler experienced real problems from "disinformation" provided by the LP business and unsupported claims by its sellers.

The lack of an established standard by which to evaluate Fowler's claims also played a role in Fowler's failure to achieve success. Fowler was unable to achieve real credibility or support among academics due to the ongoing standards study.

The farmers who were to buy Fowler's product are noted for their traditional attitudes and beliefs. Fowler knew the market was difficult and had budgeted money to educate this audience. The reduction of the project grant eliminated this funding and correspondingly hurt his chances for success.

In view of the market penetration problems, it seems that the grant should have been larger to cover all the inventor's original aims, since that request was reasonable. The one-time funding aspect of the program did not help Fowler either, since the market he was attempting to enter was established, knew about and even licensed the invention, warned its customers about Fowler, and was in the business of selling energy — not conserving energy. Given the background information on Fowler's invention, the interviewer had expected to find a cynical person, frustrated by the disappointments and anxieties of his efforts. Nothing could have been further from the truth. While Mr. Fowler did make comments highlighting his difficulties with the LP gas distributors and the academic community, the interviewer came away from the visit with the impression that Mr. Fowler is a strong-willed man who strove to bring his invention to fruition but who, ultimately, was forced by financial circumstances to terminate his market penetration efforts. He, in fact, cites his failure or inability to do a complete market study and evaluation as a contributing factor to the invention's marketing woes. In addition, Mr. Fowler became very disillusioned with the patent system as a result of several cases of clear infringement which he intimated to this interviewer. These infringements, according to Mr. Fowler, pertained to this curing barn and other inventions that he had developed previously.

While one also may consider him a cynic in view of his comments concerning the patent system in general and his attitude towards the LP gas industry and the academic community in particular, the evidence he presented and his otherwise positive attitude indicate otherwise. Essentially, Mr. Fowler developed the right idea but at the wrong place and time and under unfavorable circumstances.

Policy and operational issues are difficult to assess in the case of Fowler. Operationally, Fowler experienced no problems in receiving an NBS recommendation. His invention was one of the quickest to be evaluated and recommended. DOE also moved extremely rapidly in seeing to it that Fowler received funding.

The decision to fund four demonstration barns for Fowler might not have been the best way of dispensing the grant, however. In view of the fact that the LP gas industry is such a strong force in North Carolina, it seems that a wiser course of action would have been to hire a consultant from the LP gas industry to evaluate and test the invention (as in the case of Bagby).

Policy recommendations which can be drawn from this case are twofold. First, it appears that, contrary to the program personnel comments that each inventor's case is unique, Fowler's and Bagby's cases are similar.

Both faced a marketing challenge from an established competitor. Bagby involved the competition in the evaluation of his product. Despite an initial antagonism, they found the product was a good one and assisted in marketing by seeing that the favorable results were published. Given the success of this approach with Bagby, Fowler should have been directed along the same path.

A second policy recommendation involves the one-time funding rule. It is the opinion of the interviewer that this attitude hurt Fowler's chances of success. The DOE grant only kept Fowler's hopes going for one more year without achieving any real success in preventing the inevitable. If the grant had been more substantial and had been distributed over a longer period of time, it is conceivable that the product would have eventually obtained a greater acceptance among farmers.

PARTICIPANT:	Dr. Robert Gordon (99) Mr. Oscar Weingart Structural Components Corp. 5344 North Irvingdale Avenue Azusa, California 91102
CASE TITLE:	Light Weight Composite Trailer Tubes
FUNDING LEVEL:	$96,000
CASE STATUS:	Project completed; final report completed
INTERVIEWER:	Herbert E. Kierulff Kierulff Associates 815 West Argand Seattle, Washington 98119

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

In 1978, Mr. Oscar Weingart, of Structural Composite Industries, Inc. (SCI), submitted a proposal entitled "Light Weight Composite Trailer Tubes" at the request of the firm's president, Dr. Robert Gordon. Dr. Gordon told the interviewer that he was the inventor of this product but that he assigned Mr. Weingart the task of proposal preparation and planned to use his services in performing the contract work if it were funded.

Unfortunately, the time delay between the original submission and final funding by DOE necessitated transferring Mr. Weingart to another project. He has since left the company, but the relationship between Mr. Weingart and Structural Composite Industries remains amicable.

Dr. Gordon and his partner purchased the firm from a larger corporation in 1971. They manufacture:

1. a number of commercial pressure vessels (including fireman's self-contained breathing cylinders and commercial aircraft escape slide inflation vessels),

2. energy and transportation structures (including large spars/blades for wind energy systems and specialty large-size structures), and

3. aerospace products (including filament-wound pressure vessels to military specification and cryogenic system thermal isolators and support structures).

The firm is in the size category of "21-100 employees." Since its founding in 1971, the company has had only this government grant.

Dr. Gordon, a Ph.D. in nuclear engineering, classifies himself as a composite structures engineer involved in research and development as well as production and manufacturing engineering. As president of the company, he is also concerned with management. He has obtained five patents, has two patents in preparation, and has applied for one other.

Description of the Technology

The idea for the tubes project came from a brainstorming session led by Dr. Gordon. In answering the question "What business are we in?" the team came to the conclusion that the company had been opportunistic up to that point. They decided that the company should be in the transportation business — transporting gases and other lightweight materials. Previously, SCI had been producing small-sized containers (such as the fireman's breathing cylinder).

Dr. Gordon suggested that they move toward producing a large cylinder. The idea of trailer tubes naturally suggested itself.

Currently, hazardous materials such as compressed gases are transported in large cylinders (22 inches in diameter and 34 feet 4 inches long). As a result, as much as 96 percent or more of the weight being transported may be metal cylinder. According to Dr. Gordon: "You are transporting steel back and forth [across the country]."

SCI decided to develop a filament-overwrapped composite cylinder which would be lighter weight, safer, and cleaner (less subject to corrosion). In other words, they planned to make a larger modified version of their current product available for transporting gases across country.

Company personnel spent six months and approximately $15,000 to $20,000 researching the literature on the technology and doing studies. They concluded that the development cost was too much for the company to bear alone. Further, they could obtain no evidence about the compatibility of aluminum (around which the filament would be wrapped) with compressed natural gas and hydrogen.

Another unanswered question was whether such a huge tube could be physically closed at the end. Could it be spun closed? Finally, the new product would be more expensive than the tubes now in use. It would be made from tubing rather than flat plate. Would enough weight be saved by the SCI filament-overwrapped composite tube to offset the higher cost?

The researchers determined, with the help of their patent attorney, that it was not possible to patent the product. Simply making things larger generally does not qualify for a patent. However, the machine used to make the product can be, and is, patented.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Dr. Gordon believed that the NBS would support his development effort financially. The NBS asked several questions about the marketing potential of the product after reviewing the proposal:

- How did SCI determine the number of tubes that could be sold?
- How did SCI obtain the going price of the steel cylinders currently in use?
- Had the company looked at the foreign market?

NBS personnel offered no advice, nor did the invention change during the evaluation.

The greatest benefit obtained from the NBS technical evaluation process was the authority to proceed with the grant process. The greatest drawback was the time period involved (four to six months).

Dr. Gordon has submitted two other inventions to the NBS since 1975:

1. A project to build windmill blades. When the company received a NASA grant to proceed, the request for DOE funds was withdrawn.
2. Machinery to make large composite structures. The company withdrew this project when the DOE grant for the development of trailer tubes came through.

Dr. Gordon will definitely submit future energy-related inventions to the NBS. In the past, he has gone to NASA, Boeing, and other organizations because their response time has been rapid. Also, prior to the trailer tube proposal, Dr. Gordon was under the impression that the ERIP was for "cutting edge" research for an individual inventor who needed $25,000 or less. Dr. Gordon noted that "we have many ideas that are energy-related and that [the ERIP] would be a good program."

Dr. Gordon has mentioned the program to several others. He will continue to recommend it to those inventors who do not require a quick proposal response.

Dr. Gordon was satisfied with the NBS technical evaluation. His responses to specific questions about the evaluation are displayed in Table 1.

Table 1. Rating of the NBS technical evaluation

Component	Very un-satisfied	Un-satisfied	Average	Satisfied	Very satisfied
Technical content and quality of the evaluation			X		
Personal contact with NBS				X	
Helpfulness of the evaluation		X			
Time required for evaluation		X			
Clarity of evaluation form			X		
Tone and wording of correspondence				X	
NBS attention to confidentiality		No way of evaluating			
General level of satisfaction with NBS				X	

Experience with the DOE

Dr. Gordon expected to obtain direct funding from the DOE within 30 to 45 days after the invention was recommended. Instead, the process took six months. Once the grant came through, however, the DOE was very understanding about reporting. There was no "'typical government' pressure for reports."

Because funding was slow in arriving, Dr. Gordon was forced to put Mr. Weingart on another job. He also lost an opportunity to buy an economical quantity of aluminum tubing 20 inches in diameter. Instead of being able to buy two, the delay necessitated his buying an entire run of 14 tubes. This cost $35,000 in extra inventory at today's high rates of interest.

The tube project has been discussed with other companies, and they may help fund future development. Now, these firms are waiting to see the completed demonstrator tube.

The DOE funding carried SCI through the completion of a detailed design. The company has built the tooling to spin-close the ends of the tubes and bought two large tubes for prototype development (along with the 12 other tubes stored in inventory). They have also made a mockup of a 4-foot-long aluminum liner and are developing the fiber winding technology for wrapping it. What is left is to develop the closing technique for the tubes.

Participant's Assessment of the ERIP

Overall, Dr. Gordon thinks the program is worthwhile and should be continued. He would like to see program personnel stay closer to each project and be concerned with its marketing. It would be very helpful if these personnel would contact venture capitalists and large companies, "adding DOE/NBS clout directly" to the task of further development and commercialization. A follow-on funding capability for projects by DOE is also desirable. Thus DOE should not necessarily drop the project after the next step forward.

In Dr. Gordon's view, DOE project coordinators should have travel budgets which would allow them to visit projects once per quarter. "All inventors tend to lose perspective. DOE could supply this and some words of advice (in face-to-face visits)."

OUTCOMES

Current Status of the Case

The ERIP support permitted Dr. Gordon to bring his idea close to the demonstration stage. He would never have spent the $150,000 required to do this on his own, although he was willing to spend approximately $55,000. The decision to proceed with development was based on receipt of DOE funding.

The development program is currently running on SCI-supplied funds. Dr. Gordon hopes to carry it as far as proof-testing the 4-foot model for materials compatibility and pressure as well as for fatigue capability. If the model passes the tests, the company will look for supplemental grant funds that could take it through a Department of Transportation (DOT) test. Hopefully, this test will lead to a DOT exemption which will qualify the unit to transport gases. Mr. Mello told the interviewer that prior to granting DOE funds an informal understanding was arrived at whereby DOT probably would approve the final product if the tests are passed.

Intangible Outcomes

As a result of the experience, Dr. Gordon has developed a knowledge of ERIP, and this will be helpful. On the other hand, he is "highly annoyed by the time it took [to obtain funding]. If the company was depending on it, they would be bankrupt." But, as he said later, "without it we wouldn't have gotten started."

INTERVIEWER COMMENTS*

All three inventors I interviewed said that it was the ERIP that made the difference between continuing or quitting. The reader should note that this point is not verifiable. We just don't know whether this is true or not, and there is no way of finding out. We do know that inventors are often a tenacious breed and that funding can pop up unexpectedly from many sources. Conventional wisdom and currently available data indicate that inventors, as a rule, make lousy entrepreneurs.

The fact that the two recognized that a large company would have to take over their product and manage it after it got off the ground showed uncommon good sense. I suspect that an inventor who wanted to hang on to his invention would constitute a poor risk for ERIP — especially considering the large-scale nature of many energy-related inventions and the sophisticated management challenges they pose.

The "one-step further" rule invites the "so what" response. If one step further somehow does not ensure "successful" commercialization, why go one step further? Somehow ERIP must assure itself that if DOE funds are forthcoming and the project is moved ahead one step further (successfully), this will have a high probability of inducing successful commercialization. However, this puts ERIP in the business of

- evaluating potential markets,
- evaluating potential financial resources,
- evaluating the probability of successfully producing a product to specifications at a price that will sell.

If this is the case two questions arise:

1. Should ERIP be in this business of complete feasibility analysis?
2. If yes, do they have qualified people to help?

*Dr. Kierulff combined his comments for the three inventors he interviewed — Gordon, Haspert, and Jones.

I have evaluated three cases where money was granted and the inventors performed. I have no way of knowing how they were selected or why (they were not privy to the selection process). They would naturally tend to be happy because they got the money and because, after the government granted the money, they were left pretty much alone.

Not one of these inventors has successfully commercialized a product. Whether he will or not — and the success of the ERIP depends on this — is still a matter of conjecture at this point.

It is probably impossible to measure the effectiveness of the program in any scientific sense because of the difficulty in developing an appropriate control group. Also, much time passes between the submission to ERIP and subsequent "successful" commercialization (whatever that means). So output measurement is difficult, if not impossible, in any cost-benefit sense.

The only other alternative may be input evaluation which would include, but not be limited to

1. Evaluation of the qualifications of the ERIP personnel.

2. Evaluation of the criteria and constraints for acceptance or rejection of a proposal

   a. at NBS level,
   b. at DOE level.

3. Comparison of acceptance and rejection practice with the criteria and constraints.

4. Examination and evaluation of ERIP's marketing effort. Have they identified their target market, and are they reaching the market "effectively" which includes defining what "effectively" means.

5. Determining if and/or how the ERIP process can be speeded up.

Finally, large corporations do a less than adequate job, with notable exceptions, of recommending that major new inventions be accepted. This situation is due primarily to the interest of top management in maintaining high earnings per share of the corporation. Like corporations, Government's effort to stimulate innovation also is less than adequate because of the need to demonstrate success of such an effort before the next election (i.e., in a four-year period). Conventional wisdom as well as existing data hold that the time required to get an invention accepted in the market place often exeeds this four-year period. Given that, it is unreasonable to expect the Government to successfully initiate innovation programs unless they are guaranteed a lifetime of at least 10 years if not 15. Perhaps it makes more sense to establish a venture capital corporation in which the Government defines the areas of investment (e.g., energy savings, energy generation) and the Government provides funds for investment. The corporation may involve both NBS/DOE personnel and have a board of directors comprised of independent businessmen. Furthermore, it would have a charter and shares would be sold to the public. The states of Connecticut and Massachusetts have established precedents for government involvement in such a corporation with the establishment of the Connecticut Product Development Corporation and the Massachusetts Technology Development Corporation.

PARTICIPANT:	John C. Haspert (111) P.O. Box 1252 Arcadia, California 91006
CASE TITLE:	Haspert Mining Systems
FUNDING LEVEL:	$125,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Herbert E. Kierulff Kierulff Associates 815 West Argand Seattle, Washington 98119

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

John Haspert left college after three years to join the Army. However, his academic work in mechanical engineering must have played some role in his life. He went on to work in the mining and construction drilling and tunneling field and obtained 15 patents for inventions in this field. Ten of his patents were obtained while working for other companies such as Hughes Tool and the Calweld Division of Smith International and were assigned to them.

In 1969, he started his own mining and construction R&D company, Underground Systems, and he has obtained the other five patents since that time. His company is small, under ten employees, and it concentrates on research and mechanical development of specialized mining and construction equipment. Prior to receipt of the award of the DOE grant, he had never received assistance from a state or federal agency.

Description of the Technology

About seven years prior to submission of his invention to the Energy-Related Inventions Program (ERIP), Mr. Haspert began thinking seriously about the problem of mining coal, shale, and other minerals from large seams in all types of ground formations. A large seam is defined as one with a high heading of over 20 feet. He noted that existing equipment was inefficient because it drilled a round hole in a seam which was rectangular. As a result, miners cut into the overburden and underburden around the seam and were unnecessarily mining earth along with the mineral.

He decided to develop a piece of equipment which could drill a large rectangular hole on a sloped heading. His equipment would increase the productivity of labor and improve safety. He states that the completed product has the lowest specific energy requirement of any similar device. (Fewer inch-pounds of force are required for the removal of a cubic inch of material.)

The product has a patent but no surrounding patents. His patent attorney filed 16 method claims and 8 mechanical claims.

The technology required to build the product is relatively simple. The inventor's problems were in the area of capital acquisition. Because the technology is so specialized, the market is limited, and it is difficult to generate interest in the project by the larger firms in the industry. Also, Mr. Haspert characterizes himself as a researcher, not a financial specialist. The time and effort spent marketing the idea to financial sources takes time away from research, the main function of Underground Systems.

Nevertheless, he has managed to raise $350,000 by mortgaging his home, borrowing from relatives, and obtaining some financial assistance from the Union Oil Company. That and over 6000 hours of work (unpaid) by Mr. Haspert represent the investment to date in this product.

Originally, Mr. Haspert envisioned a market for his equipment in coal and gilsonite mining. With the energy crisis in the United States we began looking for alternative energy sources, and its use in mining shale became apparent.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

When Mr. Haspert approached ERIP in 1976, he had reached the stage of laboratory testing of his mining technique. He heard about the program through the Bureau of Mines in Washington, D.C., when submitting a proposal to the Bureau. In subsequent discussions with Congressman Rousselot, it was decided to send the proposal to the Department of Energy.

Mr. Haspert submitted his mining system invention to NBS with the objective of obtaining funding for an evaluation by an outside group. He needed an unbiased evaluation to prove to potential customers that his system would do what he said it would.

He "had no idea" what NBS would do for him "other than some kind of evaluation." What resulted from his submission was two conversations with Dr. Chugh, of the University of Southern Illinois at Carbondale. Dr. Chugh contacted the Bureau of Mines and found out that the Bureau was evaluating this same technology within the Bureau, unknown to Underground Systems. The Bureau concluded that this technology would work. Dr. Chugh then submitted his favorable report to the NBS.

Mr. Haspert also spoke twice to Mr. Robb of the NBS. These conversations covered the Haspert mining system and the timing of the project. In the opinion of this inventor, "Mr. Robb is a real gentleman."

Mr. Haspert did not change his invention during the NBS evaluation. He reports no problems at all with the Bureau. The greatest benefit resulting from the process was being recommended to the DOE, from which he eventually received a grant. The company was on the verge of bankruptcy at the time, and funding was essential to survival.

In all, Underground Systems has made two submissions to the NBS. The first was the Shale Mining System which is the subject of this report. A grant was awarded and later a sole source contract for follow-up work to provide shop drawings for a prototype machine to apply the mining system. The sole source contract was awarded on September 1, 1981 (see final report, September 1981).

The second submission was made to DOE in July of 1980. It proposed a remote control mining technique for pitching seams and gaseous deposits of coal not minable with techniques used currently by the industry. The DOE advised him in early September 1981 that NBS recommended funding the project's development. He followed his usual pattern of trying to interest private enterprise in his invention initially and then going to government if his efforts failed. His reasoning for this strategy is that private enterprise must eventually commercialize the product, so it makes sense to start with them first if possible.

Unfortunately, private companies will not take the risk associated with the early stages of the innovation process, according to Mr. Haspert. Thus he is likely to be coming to government again with his other invention.

Mr. Haspert has some reservations about government help, however. He is under the impression that if he does not have a patent when approaching the government, he will lose proprietorship control and will encounter difficulties in remaining eligible for royalties from the invention.

He has recommended the ERIP to one other inventor who did submit his invention for evaluation. He feels that the program gives inventors an opportunity to obtain a fair evaluation of their product and some funding to pursue development. "This is especially true," he says, "of large developments." Venture capital is hard to come by for large projects.

In general, Mr. Haspert is "very satisfied" with the NBS. Table 1 shows his evaluation of specific aspects of the relationship.

Experience with the DOE

When the first invention was recommended to DOE for support, Mr. Haspert expected the following, in order of occurrence:

1. DOE contact by telephone and letter.

2. Request for a statement of work.

Table 1. Rating of the NBS Technical Evaluation

Component	Very unsatisfied	Unsatisfied	Average	Satisfied	Very satisfied
Technical content and quality of the evaluation					X
Personal contact with NBS					X
Helpfulness of the evaluation					X
Time required for evaluation				X	
Clarity of evaluation form					X
Tone and wording of correspondence					X
NBS attention to confidentiality[a]			Not applicable		
General level of satisfaction with NBS					X

[a]Mr. Haspert has patent coverage on both mining systems and did not request confidentiality.

3. Meetings between Underground Systems and DOE personnel.

4. Funding of the proposal.

In fact, this was exactly what happened, and Underground Systems received direct funding of $125,000 for the preliminary design of a prototype mining machine.

In addition, Mr. Haspert received information about other DOE investigations of shale mining and was invited to attend a meeting with other companies doing work on shale. He was introduced to Kittron Corporation, a firm working in this area, and Dr. Kiessling, from the University of Houston (Texas), came to California and tried unsuccessfully to introduce him to executives of a large company.

Unfortunately, Mr. Donohoe, the DOE coordinator, suffered a heart attack during the time the project was active and was unable to continue working on the project. Mr. Mello took his place at a time when the work was nearly complete.

Mr. Haspert had no difficulty working with DOE. To him: "The best part of the entire experience was the recognition of the merit of his first invention and their profound interest in the nation's energy supply. By funding his first request, DOE showed its interest in shale oil." Since DOE has recognized the invention, the Colorado School of Mines is doing some investigation of the technology and wants to help; and oil companies interested in oil shale have expressed interest in providing test sites (mining) for the prototype shale mining machine.

The inventions were not developed while working with DOE. Mr. Haspert had a plan before approaching the Department. "The DOE permitted me to lay the plan out on paper."

The sole source contract received in September 1981 from the DOE will allow him to provide shop drawings for the manufacture of an oil shale mining machine and locate a mine site to field-test the prototype. He is considering the Bureau of Mines Anvil Points Mine in Colorado or an available commercial mine. After this second contract is completed and a prototype developed and tested, the inventor plans to commercialize the system by licensing it to large corporations.

Participant's Assessment of the ERIP

Mr. Haspert is obviously very pleased with his relationship with ERIP. That it is a continuing one assures him of longer control over the invention before he must market it to a larger corporation. The closer the product is to commercialization, the greater the interest will be of larger corporations and the greater the reward will be to the inventor.

He noted that a long time period elapses between the time of project submission and funding. It is difficult for smaller companies to finance themselves during protracted waiting periods. He offers no remedy for the situation, however.

OUTCOMES

Tangible Outcomes

Mr. Haspert credits his participation in ERIP with gaining more recognition for his mining system. He showed the interviewer an impressive article in *World Mining* (June 1981) and stated that without ERIP support he could not have been published in this important journal. The funding allowed him to prepare the preliminary design and hire two people to help him.

Intangible Outcomes

The intangible benefits from the program came in the form of education about the government system. He now knows how to approach government for help and how to present his proposals to the appropriate agencies.

INTERVIEWER COMMENTS

See Robert Gordon case.

PARTICIPANT:	Richard Jablin (75) 2511 Woodrow Street Durham, North Carolina 27705
CASE TITLE:	Coke-Quenching Steam Generator
FUNDING LEVEL:	$119,400
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Gregory Grapsas Systems & Applied Sciences Corporation 6811 Kenilworth Avenue Riverdale, Maryland 20840

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Richard Jablin graduated from Webb Institute in 1940 with a B.S. in mechanical engineering.

Mr. Jablin has approximately 35 years of experience in steel mill engineering, environmental control projects, shipbuilding and heavy industry. Since 1975, he has been self-employed as a consultant to the steel industry. Previous to 1975, he worked as Director of Engineering and Environmental Control for the Alan Wood Steel Company and as a mechanical project engineer for the Bethlehem Steel Company; and he served on engineering assignments in shipbuilding and heavy machinery with other companies. Currently, he is the principal owner of Richard Jablin & Associates, a four-person consulting firm, located in Durham, North Carolina.

In addition to this invention, Mr. Jablin has over ten other patents for inventions related to the steel industry.

He has had prior experience with federal grant programs, having received a $25,000 grant from the National Science Foundation to assess the feasibility of producing low-cost oxygen. However, research in that area was terminated following disappointing results.

Description of the Technology

The Coke-Quenching Steam Generator is a method to recover waste heat from hot coke coming from coke ovens. It has broad applications in steel and allied industries.

The invention is a product of Mr. Jablin's many years in the steel industry and of his familiarity with the environmental problems associated with dropping hot coke into large towers or freight cars open to the atmosphere. Mr. Jablin's process generates steam within the confines of a sealed vessel and can thereby be regulated to recover energy for the purpose of operating a variety of machinery. Jablin has invested six years of his own effort and $15,000 in the development of the steam generator.

Mr. Jablin's primary problem was a lack of sufficient funds to build a pilot plant. The technical feasibility of the coke-quenching process (e.g., quality of steam produced, coke quality, and coke handling) could not be determined until the pilot plant was built.

The invention may be used by the steel industry in solving air pollution problems (e.g., dust and carbon monoxide) caused in current quenching operations and, at the same time, harness usable energy which, heretofore, has escaped.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mr. Jablin learned of the ERIP by reading a magazine article. He submitted the invention to the program in order to obtain funds for his proposed pilot plant.

His expectations of NBS, the services they provided, and his general assessment of the NBS evaluation must all be assessed with the understanding that Jablin, as a sophisticated inventor and a knowledgeable expert and consultant in his field of the steel industry, feels that the NBS evaluation was an unnecessary delaying factor in his obtaining a DOE grant. At the time Mr. Jablin submitted his invention to NBS, it was in the concept development phase, where it remained until the time of the NBS recommendation. Only after this point and following receipt of grant money did Mr. Jablin's invention proceed into the current prototype test phase.

It is Jablin's firm conviction that the NBS evaluation was not helpful, that it took too long, and that it contained comments which addressed only minor points (like installation of a fairly common scrubbing system to ensure high steam quality) to his invention. He feels that, as an inventor with much experience in the steel industry, he should have been allowed to go directly to DOE with his proposal. His antipathy towards the evaluation should not be construed as a condemnation of NBS; to the contrary, he acknowledges that NBS is required by law to examine all inventions as fairly and as quickly as possible, and he considered the NBS evaluation to have been professional at all times. He does feel, however, that his invention should have been evaluated much more quickly than it was.

In fact, Jablin recanted from his prior position slightly by acknowledging that the NBS evaluation did protect him when an official at DOE questioned the process. He feels that this official would not have permitted the invention to be funded if NBS had not clearly stated that the process was workable.

Mr. Jablin has submitted one other invention for evaluation (a process to extract energy from molten slag). This invention was not accepted by NBS. Nevertheless, Mr. Jablin took the idea and sold it to a foundry, and it is presently in operation. He now requires additional funding to produce large-scale units.

Mr. Jablin indicated that he would submit future inventions to the program only if financial requirements necessitated. It should be emphasized that Mr. Jablin is a sophisticated inventor, who states he would not even develop an invention outside of his area of expertise. Hence he was not in need of technical assistance.

Experience with the DOE

Mr. Jablin says that he is pleased with his contact with DOE in view of the fact that he was given funding for his invention. He expected DOE to fund his invention and they did. His expectations were somewhat unrealistic, since he hoped to receive immediate funding to conduct a series of laboratory studies and build his pilot plant. He was forced to modify his work statement, to include an analysis of the steam scrubber to ensure that steam quality was good, and at the same time reduce the amount of funding requested.

Jablin's work statement was divided into two phases. The first phase involved laboratory tests to determine the extent of blue-gas formation and to establish that the steam would be clean and nonexplosive. He was also to make an estimate of the pilot-plant cost and secure an agreement from a coke-producing company that they would cooperate in building the plant. In the second phase, Jablin was to design, fabricate, and test a pilot unit.

Jablin's experience with DOE was not without some difficulties, however. Inventions Division personnel contacted an in-house DOE program office to analyze Jablin's invention and comment on its technical possibilities. According to Jablin, this particular in-house specialist had just awarded a large ($500,000) contract to analyze the dry-quenching process (a process considered uneconomical by Jablin and others). This individual strenuously objected to Jablin's invention, and Jablin feels that this criticism was made simply for the specialist's self-interest. Jablin feels he was perceived as a threat and was nearly denied funding. Jablin has high praise for program personnel, particularly his coordinator, G. Ellis, since Ellis was able to get the invention funded anyway.

Participant's Assessment of the ERIP

To Jablin, the best thing about the program is that he received money to build his pilot plant.

Jablin feels that his problems with the in-house DOE specialist (his delaying tactics and refusal to make a recommendation) almost prevented his project from being funded in spite of the fact that NBS had recommended the invention.

Jablin, a pragmatist, feels that the program helped, since he was funded.

OUTCOMES

Current Status of the Case

Progress was made. At the time of submission, the invention was in the concept development/engineering design phase. It currently is in the prototype testing phase. Delays during the grant period occurred due to Mr. Jablin being severely ill. Nevertheless, he persevered, requested and obtained a no-cost extension to the grant, and has now demonstrated that the production of high quality steam and coke are technically and economically feasible using his process.

The inventor is in Chicago at the time of this writing to make a formal presentation of his pilot plant to prospective buyers.

Once the pilot plant is operational, Jablin intends to sell production units to the steel industry.

Tangible Outcomes

Pilot tests of the steam generator have been successful. A European company has made an offer to buy the process, but the terms were not satisfactory. No other funding sources or referrals have been generated as a result of Jablin's participation in the program.

Intangible Outcome

The only intangible outcome from Jablin's participation in the ERIP is that of lost time.

INTERVIEWER COMMENTS

Mr. Jablin's observations must be considered along with the perceptions of the interviewer and the coordinator in order to gain a true perspective of his experience with the ERIP.

Mr. Jablin was ill for an appreciable length of time during the contract, and this illness did affect work on the pilot plant.

The invention, contrary to Jablin's remarks, did not take an extraordinarily long period of time to be evaluated by NBS when compared to other inventions recommended to DOE. The evaluation began with Jablin's submission on June 3, 1977; it was approved 16 months later. While the time period may seem lengthy, other cases have taken longer.

Mr. Jablin's comments that the evaluation was "not helpful" are supported by the absence of progress while under NBS evaluation and by the fact that the second stage evaluator submitted a 1-1/4 page statement which said that the process would work and was potentially economical. The NBS coordinator concentrated almost exclusively on possible development problems connected to the process of obtaining usable steam.

The inventor is correct in being unhappy about waiting 16 months for a brief statement that the process works. Unlike other inventors, such as Bagby, Jablin did not need to be told that the process could work. He knew that the quencher was feasible. The NBS second stage evaluation did not have a marketing impact in the invention's industry and served only to make Jablin impatient at the long wait.

One of the suggestions made by the ERIP evaluators appears to have been given more importance than necessary by DOE to the exclusion of the other ERIP evaluator comments. The inventor is correct in his statement that the scrubber is but one of the many problems which he had to address. The question of the cleanness of the steam received much importance at DOE and became the first three (laboratory testing) tasks to be performed by Jablin.

Comments in the ERIP evaluation about other important considerations for the pilot-plant phase — notably the handling of hot solids by crane, the fouling of gaskets, and synchronization of multiple furnaces — were not addressed in the DOE-approved statement of work. In the opinion of the interviewer, too much attention was given to the selection of a scrubber, spray nozzles, and steam quality during the pilot-plant stage.

DOE's concentration on the question of steam quality to the exclusion of whether the process would actually work to produce steam in a regular flow seems to the interviewer (and the inventor) to be an unfortunate misdirection of emphasis. Moreover, it forced the inventor to be concerned about an area which had a lower priority than other elements of the process. Jablin felt that once he demonstrated that the process worked, installation of a scrubber, to ensure the steam was of high quality, would be a relatively simple task. The inventor was not grossly affected by DOE's decision, however, although it did cost him time in the development phase.

The interviewer recognizes that DOE personnel were aware that Jablin's process can produce toxic gases and thus be dangerous, since the gases produced might explode. The question of steam quality is also an important issue, since without good-quality steam the process is not beneficial, or certainly not as beneficial as it could be.

Moreover, Jablin was unrealistic in his demand that DOE immediately bankroll his project without any consideration of the invention's merits. His proposal is extremely unusual in that it asked DOE to allow him to build a pilot plant based on a concept he had developed. Instead of moving in the normal path of formulating a concept, building a working model (or models), and perfecting the prototype, Jablin essentially asked DOE to allow him to move from a laboratory-scale phase to pilot-plant testing and thereby bypass the engineering phase.

Despite these points, however, it appears that Jablin did benefit from the program. His objections to the length of the NBS evaluation are mollified by the fact that the evaluation provided support when his invention was being examined at DOE. The attention given the scrubber, while not of primary importance in the development of the pilot plant, was an area which the inventor would have had to address ultimately. By solving the problem, the inventor ensured that at least one objection to the process was eliminated.

The inventor's suggestion that a "fast track" be created for individuals such as himself is a valid recommendation and would save time during the initial evaluation process. Such a "fast track" exists at NBS to avoid first stage and enter second stage evaluation immediately, but it might be of benefit to the program to formalize the process with regard to time spent in second stage evaluation.

In summary, Mr. Jablin represents a sophisticated class of inventor who, in spite of physical and financial difficulty, persevered. The length of time necessary for the NBS evaluation should have been shorter, since Jablin was a professional inventor with a workable device. It is possible that if NBS had a formal "fast track" system, Jablin would have benefited. This statement should be tempered by the fact that Jablin is somewhat unrealistic in his convictions about the worth of and required funding for his invention.

While Jablin feels that time was a factor in the NBS evaluation and that the report was too brief, it should be remembered that NBS sent the invention to several experts. In each case, only original material was used, since copies could be lost or not controlled. Each analyst had a time limit and was monitored (and evaluated) by NBS. The inventor was thus receiving a good evaluation of his proposal.

Policy recommendations are exceedingly difficult to make in Jablin's case. DOE's in-house specialist was acting within his prerogative in questioning the merits of Jablin's process. It would seem that DOE should have set a limit on the time required for the evaluation and then forwarded the invention to another analyst for consideration (just as NBS does). Jablin's knowledge of the in-house politics surrounding DOE's evaluation of his invention indicates that perhaps DOE should restrict information about the day-to-day processing of the grant so that the inventor won't have cause to worry.

DOE appears to have devoted too much time to the laboratory-scale testing and given not enough attention to the problems of the pilot plant. Whereas the bulk of the funds ($100,000) went to the development of the plant, the work statement asked that the inventor examine blue-gas formation and clear steam in the first phase before the plant was even built. It would seem that the principal problems the inventor should have been examining were those noted by NBS, namely, maintenance considerations, proper phasing of generators, etc.

In defense of DOE, the entire Jablin project was somewhat daring in that Jablin, unlike other inventors, was basically asking the government to ignore the normal phased development steps and move from the concept stage to pilot-plant production. DOE, to their credit, did allow Jablin to begin the pilot-plant phase and thus bring the process into industry consideration long before such a stage would have occurred. DOE's concern with environmental matters is reasonable and appears not to have detracted from the development of the plant.

Since Jablin is still pursuing his invention and the process is a success, it would appear that DOE made the correct policy decisions. Recommendations would thus involve adopting the same approach with other inventors.

PARTICIPANT: Robert J. Jones (27)
2722 Salmon Drive
Los Alamitos, California 90720

CASE TITLE: Waste Heat Utilization for Commercial Cooking Equipment

FUNDING LEVEL: $65,000

CASE STATUS: Project completed; final report accepted

INTERVIEWER: Herbert E. Kierulff
Kierulff Associates
815 Argand
Seattle, Washington 98119

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Mr. Robert Jones, inventor and the president of Hydrocoil Corporation, has a bachelor's degree in geology, with an emphasis on petroleum geology. In addition, he has attended a local community college to take business courses (management, sales, business law) and certain technical courses such as welding.

For the last 18 years he has been involved in the sale of construction building products. Fifteen of these years have been spent designing and selling ventilation systems for restaurants. He currently sells boiler equipment for Porter Boiler Company in Long Beach, California, which provides him with an income as he continues to commercialize his invention. Porter Boiler fabricates insulated metal cabinets. The owner of Porter Boiler will assist in financing the project as it grows. Mr. Jones holds only the Hydrocoil patent and has no previous history as an inventor.

The Hydrocoil office is located at Penguin Cabinet, Inc., a fabricator of insulated metal food service cabinets in the city of Commerce, California. The owner of Penguin is a stockholder in Hydrocoil and may finance the project as it grows. In the meantime, use of Penguin office space keeps startup costs down.

Description of the Technology

Hydrocoil Corporation manufactures a heat recovery system which represents an entirely new product in the restaurant field. In this section, the technology related to this system will be discussed.

The invention of the Hydrocoil waste heat recovery system was a direct result of Mr. Jones' work in designing ventilation systems for restaurants. He recognized that heat was being wasted, and he began seeking ways to recover it.

The result of his search was a stainless steel enclosed unit which is attached directly to the type of gas-fired cooking appliances found in hotels, hospitals, schools, commercial kitchens, and restaurants. A separate heat transfer and circulation module is located in a place remote from the kitchen work area. The Hydrocoil recovery unit catches the hot flue gases as they leave the appliance combustion chamber. The heat is extracted, and the cooler gases are exhausted into the hood. The recovered heat can be used to preheat air coming into a building or water going to a water heater or boiler. The design of the Hydrocoil system prevents surface-generated grease from coming into contact with the coil surface.

The technology associated with the Hydrocoil system is not new. What is unique is its application to low-grade heat sources, for example, cooking appliances. The system is patented, but there are no surrounding patents to protect the original one. The name "Hydrocoil" is trademarked.

Before his invention was perfected and submitted to ERIP, Mr. Jones encountered several technical problems. First, he had to work out the hardware system itself. The system was potentially dangerous, because it could block the venting of hot gas in an area where people are working. Attention to safety in design, therefore, was a paramount consideration. Also, the system needed to be relatively simple so nontechnical people could use it. Otherwise, marketing would become next to impossible.

When these problems were solved, the inventor had to find ways to reduce the product cost. Finally, it was necessary to prove out the validity of the system and obtain code approvals. It took him about two years, \$10,000 to \$15,000 of his personal funds, and the help of a consulting engineer to develop the product to the prototype development, testing, and engineering stage. At that point (in 1976) he submitted the idea to ERIP.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Mr. Jones learned about ERIP by reading a flyer in a trade magazine. Although he cannot remember the name of the magazine, it was one specializing in the heating, ventilating, and air conditioning industry.

Experience with the NBS

He submitted his invention for evaluation because he needed funds to test the system. Would it work as envisioned, and was it safe? He expected the National Bureau of Standards (NBS) to review the project and recommend that the funds be granted.

Mr. Jones told the interviewer that the NBS had two of their own people evaluate the system, and they in turn called in two evaluators from outside the Bureau. Each of the two outside evaluators telephoned the inventor and spoke with him for about 30 minutes. All four of the people came to a favorable conclusion, and the invention was passed to the Department of Energy (DOE).

The fact that the invention was passed on to DOE was the greatest benefit derived from the NBS technical evaluation process, according to Mr. Jones. He did not change the Hydrocoil system in any way because of the evaluation by NBS.

The only problem the inventor encountered in dealing with the NBS process was time. It took about eight months to get to DOE.

The Hydrocoil product has been this inventor's only experience with the NBS. He reports that, in general, he is "satisfied" with the experience. Table 1 (on the following page) displays his views of specific aspects of the experience. In answering the questions associated with Table 1, the respondent noted that his answers would be based on an experience that happened in 1977 and that it would be hard for him to respond accurately about feelings that were four years old.

Table 1. Rating of the NBS technical evaluation

Component	Very un-satisfied	Un-satisfied	Average	Satisfied	Very satisfied
Technical content and quality of the evaluation			X		
Personal contact with NBS				X	
Helpfulness of the evaluation			X		
Time required for evaluation		X			
Clarity of evaluation form		Cannot remember			
Tone and wording of correspondence		Cannot remember			
NBS attention to confidentiality					X
General level of satisfaction with NBS				X	

He is not sure whether he would submit a future invention to NBS unless he had no other source of funds. "The problem," he said, "is time." It was frustrating for him to wait eight months for the review. "But concept development is expensive and non-governmental companies are not interested. Government may be the only alternative."

He has recommended the ERIP to three or four people. He will continue to recommend the program, because he knows of no other source of capital for the individual inventor.

Experience with the DOE

After the Hydrocoil project was passed to DOE, Mr. Jones expected DOE to evaluate the proposal promptly and provide $65,000 in direct funding for testing. These funds would permit him to prove that an installed Hydrocoil unit could save energy and operate successfully and safely. Mr. Jones suggested safety testing by the American Gas Association (AGA) Laboratories. The DOE suggested Calspan Advanced Technology Center for efficiency testing. The $65,000 cost was based upon quotes from AGA and Calspan.

The grant was slow in coming through. He received letters from DOE every month or so but no grant. Finally, he began calling every Friday to check on the status of the application. When nothing appeared to happen, he contacted his congressman. That action got attention which led to the granting of the application.

When asked what his greatest difficulty had been in working with DOE, he replied: "Bureaucrating. Paper pushing at the lower levels." He recalled that it took between 8 and 12 months to get the grant through.

On the other hand, he did achieve his objective of obtaining safety testing. The AGA Laboratories and the Calspan Center were the testing agents. Mr. Mello, the DOE coordinator in this project, noted that AGA was not set up to do the kind of testing required by the inventor. Thus it necessitated not only dollars but probably also the prestige of DOE to persuade the Association to test the product.

The grant also provided some administrative and overhead expense money that allowed him to continue in business. Although he received no salary, the opportunity to cover some administrative expenses from the grant was both welcome and necessary.

The safety testing by AGA through DOE bought him credibility in the marketplace that was unavailable otherwise. It permitted code approval by local building and safety officials. He had contacted trade associations, universities, public utilities, and other organizations for assistance. With the exception of Pacific Gas and Electric Company, which is buying a unit for evaluation, he got virtually no assistance.

Participant's Assessment of the ERIP

ERIP was virtually Mr. Jones' last chance to develop his invention himself; no one else was interested. The paperwork and bureaucratic tangle were frustrating to him, but again, he had no other acceptable options. And except for the time problem, the ERIP worked reasonably well. Going through the ERIP experience was worth it, since he had no other alternative but to sell the patent for what he considers a relatively small sum.

OUTCOMES

Current Status of the Case

Mr. Jones is an individual inventor with an idea, who had virtually no seed capital to support him. In 1977, when he contacted ERIP, he needed a (to him) large amount of funds to test the effectiveness and safety of his product. He had invested $15,000 of his work capital, but he needed $65,000 to do the test. Without the test he could not proceed, because it did not meet code specifications.

Because he was able to obtain the testing, he now has orders for his product, has invested another $35,000 of his own money in the business, has an investor/partner, and has reasonable prospects for the future.

Through October 15, 1981, Mr. Jones has:

- fabricated and sold three Hydrocoil units;
- manufactured four units for testing (one for AGA Laboratories, another for Calspan Laboratories, a third for the Southern California Gas Company, and the last for internal use);
- begun the fabrication of one unit for sale;
- two units on order;
- four units specified in architectural plans.

He now has manufacturers' representatives covering the entire western United States. It is probable that he will continue to meet market resistance to his product, because its novelty requires him to educate his customers.

Mr. Jones will obtain some financial support from his current partner. He will continue to sell the product nationwide until he reaches a volume requiring large infusions of venture capital and a professional management structure. When this time comes, he plans to merge with or sell out to a large corporation.

INTERVIEWER COMMENTS

Aside from the time problem, Mr. Jones encountered one other difficulty which ERIP may wish to consider. The Hydrocoil unit could be used in many government organizations. It is applicable in military mess halls, government hospitals and office buildings, schools, and so on. The unit now has been tested and shown to be safe and effective by two laboratories hired by the federal government. But Mr. Jones cannot get any federal agency to test and then buy his unit.

He reports that the people at the Veterans Administration say: "We don't have a way to evaluate the product." HEW representatives told him: "We work on a cost plus basis. Lower costs and you lower the plus. Energy conservation is DOE's problem." He claims that the military "passed the buck" and that a local government representative said that it "takes too much paperwork to justify using this. I don't want to do it."

Part of the problem, according to Mr. Jones, is that "the product is not a GSA type item that one buys by the gross. It must be designed into the building system or as a retrofit, which involves interface with the building mechanical system and installation work."

If an energy-saving device with promise has a government market, perhaps ERIP officials could find some way to follow an invention across the spectrum of government agencies. It would seem that the government would at least benefit from having further tests run in the facilities of appropriate agencies.

See Robert Gordon case for additional comments.

PARTICIPANT: Dr. Eskil L. Karlson (104)
4639 State Street
Erie, Pennsylvania 16508

CASE TITLE: Low Continuous Energy Mass Separation System

FUNDING LEVEL: $83,015

CASE STATUS: Project completed; final report accepted

INTERVIEWER: Albert Shapero
Shapero-Huffman Associates
2342 Dorset Road
Columbus, Ohio 43221

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

The inventor, Dr. Eskil L. Karlson, has a D.Sc. in physics and a master's degree in zoology. He also makes the point that he goes back to school and takes courses whenever he bumps into a new field of research and finds that he needs more knowledge. One example he gives is the field of psychology; he went back and took "every course I could find" when it was needed for his research.

Dr. Karlson worked for several years for the Atomic Energy Commission but in the past several years has followed an entrepreneurial path, forming several companies which, he proudly points out, are still extant and successful. He has benefited financially from his companies. However, he is not interested in the continuous operational aspects of business and prefers to spin off creations from his company. He has had continuing connections with universities, among which are Yale and Harvard. At the present time he teaches and has a laboratory at Gannon University for which he pays rent (as he likes to point out).

Dr. Karlson has obtained over 100 patents spread over several fields. Currently he has applied for patents for two inventions and is preparing five or six applications for patents. For several years he has prepared his own patents rather than employing patent lawyers.

Dr. Karlson is a prolific inventor who crosses several disciplines. He has worked in fields as widely disparate as physics, cancer, and chemical processes, but with a recent emphasis on ways to make processes continuous. He sees himself as an applied scientist and believes in a strong dichotomy between "scientific inventors" and "gadget inventors."

Description of the Technology

Though the DOE officially categorizes Dr. Karlson's invention as "miscellaneous," it is more properly categorized as an industrial and laboratory process. The purpose of the invention is to provide a low-energy continuous process for separation of chemical species or different isotopes, in either the gas or liquid phase. The invention combines any two or all three current separation techniques — chromatography, electrophoresis, and centrifugation, which is included in every combination. It is anticipated that the invention will make separation far more efficient in terms of time and energy.

As with most of his inventive activity, Dr. Karlson's invention came about in response to a request from someone to solve a problem. He was requested to develop a system for separation or extraction that did not use heat, and he went to work on the problem. With a grin, Dr. Karlson says, "The truth is that I get most of my ideas while sitting on the head."

The inventor worked on the invention three years prior to submission, using his own laboratories for development and his own resources for patenting. Just prior to submission he ran into two problems that required considerable resources and a larger laboratory. He needed to determine the fillers required for the invention, and since there are thousands of materials that might qualify, there was a need for extensive and expensive investigation and testing. To prove the invention he needed to build a larger prototype than he had made hitherto, and that required access to a larger laboratory.

Separation of materials is a process that is widely used commercially and scientifically. Some of the current uses of separation are found in uranium isotope separation, nuclear waste disposal, and a large number of oil and chemical industry applications. To date, continuous methods with large throughputs have not been feasible; thus current applications have used one or another of the three high-energy methods of separation. The development of a continuous and rapid process for separation requiring low-energy inputs would have significant applications where separation is used now and would open up many other areas of application in pharmaceutical production and in environmental cleanup (brackish and salt water purification and the cleaning of effluents, for example).

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

The inventor became aware of the program through the university as soon as the law was passed. As soon as the announcement came to the university, Dr. Karlson submitted his invention for evaluation. His primary interest in the program was to obtain funding so that he could perform the required testing of materials and obtain the laboratory space needed to assemble a larger prototype for testing.

Since Dr. Karlson has worked for the federal government (AEC) and has received contracts and grants from a wide spectrum of federal and state agencies, including Atomic Energy Commission, National Institute of Health and the Department of Defense, his expectations of NBS were very realistic. When he submitted his invention his only expectation was to receive funding if approved. As far as he is concerned, he received all that he expected, approval for funding.

Dr. Karlson's overall assessment of the NBS evaluation is that it was good. More specifically, he found NBS's forms, correspondence, and attention to confidentiality excellent but judged the technical content and quality of the evaluation good and the time required for evaluation unacceptable. He is tolerant of the time lag because he considers it part of the problem of being a new program that has to work out its procedures.

Experience with the DOE

Again, because of his long-term experience with government programs, Dr. Karlson's expectations of DOE were very realistic. He expected funding and got what he expected. However, in addition he got more than he expected in terms of being referred to others who might answer questions or exchange ideas. He made several references to the value of the network of references he received from Glenn Ellis. The inventor considers Mr. Ellis and his references the best experience he had with DOE. Dr. Karlson commented that the references received from Mr. Ellis have put him into contact with all kinds of people who have been helpful in generating ideas far beyond the scope of the invention itself.

The inventor found no difficulties in working with DOE and made a point of commenting on their special efforts to walk his papers through the system at one time, which cut down on delays.

Participant's Assessment of the ERIP

The best things about the program to Dr. Karlson were (1) the funding to demonstrate his concept and (2) the outside validation, which helped provide that further credibility which helped enhance the interest of others in the invention. Several companies have expressed an interest in the invention. As far as the inventor is concerned, there were no difficulties encountered in the program.

The most telling demonstration of the inventor's assessment of the program can be found in the fact that he has recommended the program to others. Dr. Karlson feels so strongly about the program, despite several ideas for changing the way it is done, that he volunteered to do anything he could to help defend or support the program's continuation.

OUTCOMES

Current Status of the Case

Though the project final report is still to be written, the project is "just about done." The larger prototype has been completed, and most of the testing has been done. The materials for inclusion have been chosen.

The inventor intends to bring the technology to a point where he can license or sell it to a company interested in producing and selling the technology. He has no interest himself in exploiting the invention commmercially.

He is contemplating and conceptualizing extending the technology to the separation of blood and, even more interestingly, to the field of genetic manipulation.

Tangible Outcomes

The tangible outcomes of the program are the test data, the prototype, and the interest of several companies in possible acquisition and commercialization of the technology. The demonstration of the feasibility of the concept is the primary tangible outcome of the program.

Intangible Outcomes

As far as the inventor is concerned, the intangible outcomes include the many contacts he has made and their contribution to new ideas. The demonstration of the concept has also played a part in unfolding new ideas for application, such as in the field of genetic manipulation, for the inventor.

INTERVIEWER COMMENTS

Dr. Karlson represents a rare and valuable resource in the United States, the prolific inventor. Though he himself makes a judgment-filled separation between "gadgeteers" and "scientific inventors," the fact is that there are prolific inventors of all kinds. The prolific inventor, typically, has many patents (on the order of 100 or more) and for each patent can count another 10 to 20 inventions that he never patented. The prolific inventor is also denoted by crossing many fields and practically responding to any question or demand with another invention. Much could be gained nationally by studying prolific inventors with a view to developing policies that would systematize and increase their response to national needs (e.g., a program for providing grants to prolific inventors who say they can do something about any of a list of stated problems).

Dr. Karlson also is an example of a particular kind of inventor-entrepreneur, who starts a company to exploit his invention but really has no interest in continuing with the commercialization and management of the invention once it has been proved and accepted.

PARTICIPANT: W. H. Kennick (109)
Clark Meat Science Laboratory
Oregon State University
Corvallis, Oregon 97331

CASE TITLE: Hydrostatic Pressurization of Pre-Rigor Red Meat

FUNDING LEVEL: $86,000

CASE STATUS: In progress

INTERVIEWER: Gerald G. Udell
Gerald G. Udell & Associates
2265 Shields Avenue
Eugene, Oregon 97405

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

W. H. "Walt" Kennick is the Director of the Clark Meat Science Laboratory at Oregon State University (OSU) in Corvallis, Oregon. A member of the OSU faculty for 22 years, he holds a Ph.D. in animal science with additional areas of emphasis in food science and statistics. In addition to his teaching responsibilities and by virtue of his directorship of the Laboratory, which is part of the OSU Agricultural Experiment Station, Professor Kennick holds a half-time appointment in the OSU Agricultural Experimental Station. He holds no patents and claims no inventions.

Description of the Technology

Tenderness in meat is a critical factor in consumer acceptance in many markets. Thus a great many meat science and industry practices have focused on producing a tender product. This product involves a process of hydrostatic pressurization of pre-rigor red meat round muscle to induce tenderness.

Under this process the meat is taken from the kill floor while it is still warm, bagged, immersed in 105° Fahrenheit water, and subjected to 15,000 psi (pounds of pressure per square inch). Laboratory shear tests indicate that the process results in greater tenderness than the normal aging process. Initial consumer taste preference tests indicate that pressurized meat is preferred over aged meat.

The technology involved in the hydrostatic pressurization process is relatively straightforward. No new, unusual, or complicated equipment is needed. The invention lies in the application of an established technology in a new area.

Dr. Kennick freely admits that the process he is developing is not his invention. He first learned of it while on sabbatical in Ireland while reading an Australian publication. The Australians had learned that meat could be tenderized under pressure at body temperatures but considered this to be a laboratory anomaly that merited only the briefest mention in their annual report. Dr. Kennick projected the implications of the potential of this laboratory finding and began to pursue its development.

During the early stages of the project Dr. Kennick's problems were basically financial. Relevant technical expertise was readily available on the Oregon State campus. He lacked only the resources needed to acquire the equipment and staff necessary to generate the test data essential to validate the process and promote consumer acceptance of the product.

This process saves energy in that it eliminates the necessity to cool and age meat before processing. Additional energy savings are possible through substantial reductions in shipping volume and weight because the meat is boned at the point of kill, rather than at the time of consumption. Of perhaps even greater socioeconomic importance are the greater efficiencies in production, processing, and more complete utilization of meat by-products. For example, this process permits beef producers to focus on efficiency of production, rather than on tenderness. Fewer cattle will need to be fed grains (that could be used for human consumption), and fast weight-gaining animals (such as uncastrated bulls) can compete with slower weight-gaining but tenderer animals (such as steers). Substantial indirect energy savings are also possible by substituting grass-fed beef for grain-fed beef, thereby saving the energy required to raise the grain. While no cost studies have been completed, the researchers involved in the project are projecting a lower cost to the consumer, as well as an increase in consumer satisfaction.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Dr. Kennick's initial exposure to NBS came in the form of a flier which happened across his desk (source unknown). He decided to contact NBS simply because he needed money to continue his experiments. He hoped that a favorable evaluation would result in DOE funding. Since his efforts were blocked by the lack of funds, he felt that he had nothing to lose but something to gain — financial support and perhaps some notoriety or assistance in reaching industry. Dr. Kennick does not recall having any direct contact with NBS after submittting his process for evaluation. His major criticism of NBS was the length of time it took to get through the process. He was, however, impressed with the quality and thoroughness of the NBS technical evaluation.

Experience with the DOE

Dr. Kennick's only expectation of the Department of Energy was that it would follow the NBS recommendation and fund his project.

Dr. Kennick's assessment of the DOE program was mixed. While he emphatically acknowledges that DOE financial assistance has been critical to his progress, his personal experiences in attempting to contact DOE were less than positive. Delays in response to inquiries and ineffective secretarial personnel were his major complaints. As he put it, "They certainly don't put their best foot forward." On the positive side, DOE funding enabled him to retain a young scientist, E. A. Elgasim, to work on the project, thereby generating the data necessary to "catch industry's attention." The project has had a lot of publicity and, as a result of the DOE grant, has "moved much faster and accomplished much more."

Participant's Assessment of the ERIP

According to Dr. Kennick, "I got the money I needed to finish my research." The grant provided him with "spendable money" and the resultant flexibility necessary to continue his work.

Dr. Kennick's greatest problem was the time involved in getting through the process. Closely related to this impediment was the time between inquiry and response by program officials.

The inventor's assessment of the program was, as noted earlier, mixed. While acknowledging the importance of the program's contribution to his research, his reaction to the time delays was, "If we hadn't been so desperate, we might have forgotten the whole thing." Dr. Kennick gave three suggestions:

- speed up the process,
- provide better feedback, and
- increase frequency of contact.

OUTCOMES

Current Status of the Case

The project has not yet been completed, and the grantee has requested a no-cost time extension, as additional testing is desired. Progress on the seven items contained in the statement of work is as follows:

- Testing of the effect of pre-rigor pressurization on large muscle masses has begun but is not yet completed.
- Comparisons of control and treated samples of multi-muscled wholesale and retail cuts produced no significant difference in purge loss or in yield of wholesale cuts. Some differences in yield of individual cuts were experienced.
- The grantee feels that developing different techniques of packaging before pressurization and changing cutting techniques can reduce these losses.
- As noted above, yield test comparisons between hot-boned-treated and conventionally handled boneless carcasses will be carried out.
- Storage life studies comparing treated and control boneless beef cuts have been carried out. Results are preliminary. However, no major negative effects appear to be evident.
- Data from case life studies are not yet available.
- Initial consumer acceptance studies indicate overall consumer acceptance of treated meat. Eight out of the twelve cuts were found to be significantly ($P < 0.05$) more tender than corresponding controls. No differences were observed in flavor. New York and top round cuts were judged to be less juicy.

A much larger test facility, capable of accommodating 75 pounds of muscle, has been constructed. Funds for this equipment were supplied by a $28,000 Pacific Northwest Regional Commission grant. A manufacturer of food packaging equipment has donated a $30,000-$40,000 meat packing machine to the Laboratory to aid in the experiment. With this equipment the Laboratory could begin limited production to test consumer reaction in the marketplace. The major limiting factor at this point is the lack of available live animals with which to experiment. Post-rigor muscle cannot be used, thereby necessitating onsite (or nearby) slaughtering.

The technology is at the point where it could be easily transferred to commercial meat processors. The barrier is not technological but informational. The equipment and process technology needed for commercial application are basically state-of-the-art and should be readily available. However, additional testing and data are likely to be necessary to satisfy both regulatory and commercial interest.

The grantee's basic goal is to finish his research and to see his work adopted by commercial meat packers. He has little interest in becoming an entrepreneur. He intends to continue with his experiment and to work with industry in encouraging the development of the hydrostatic pressurization process.

Tangible Outcomes

The tangible outcomes of this project are readily observable:

- A project scientist is working on the project.
- Data validating the effectiveness of the process and consumer acceptability are being generated.
- Research findings have been published.

Intangible Outcomes

The intangible outcomes of this project are as follows:

- Industry interest has been heightened.
- The project has received additional publicity as a result of DOE funding.
- As noted above, progress has been much faster as a result of the grant.

INTERVIEWER COMMENTS

This case illustrates the point that satisfaction (in this case with a program) is conditioned by more than financial expectations. The grantee in this case gives the ERIP its due. It has been the critical variable in this progress and has been responsible for much of the publicity that his project has received. Yet his overall evaluation of and support for the program is somewhat lukewarm. There are at least three types of reasons for this phenomenon:

- Basic operational flaws in the program, of which the length of time required for evaluation and processing and lack of adequate feedback are symptomatic.
- Unattended housekeeping details which are not major but affect overall impressions. In this instance, infrequency of communication, response time delays, poor telephone manners by DOE secretarial staff, and the fact that the initial portion of the grant, $51,600, came in the form of a check unaccompanied by a letter of explanation were mentioned.
- Inherent difficulties that, so to speak, come with the territory. For example, some time delays are necessary to ensure that the taxpayer's dollars are well spent. Similarly, some level of dissatisfaction is probably unavoidable. While in this instance the grantee got what he wanted, inventors and innovators normally have a long list of needs and wants that in many instances will exceed the statutory limits of the program.

This case, if supported by the experiences of others, indicates that there may be need to rethink (and streamline) NBS-DOE procedures in the Energy-Related Inventions Program.

In the literature the term "typical inventor" frequently appears. There may well be no such beast. In this case there is an individual who is neither inventor, entrepreneur, nor innovator in the classic sense of any of these terms. He did not originate the invention, nor is he interested in personally launching a new venture based on his work. The policy issue involved here is that the program needs to be sufficiently flexible to meet the needs of a wide variety of participants in the innovation process. In this instance, the program functioned well in that:

- the grantee's needs (at this stage of development) have been met, and, perhaps more important,
- what appears to be a viable process of significance has been moved closer to the marketplace.

A second policy issue is related to the nature of that significance. The energy-related impact of this technology is overshadowed by its impact on (a) the meat industry, particularly in the West, and (b) world hunger in that this process, if widely adopted, could release huge amounts of grain for human consumption, as grass-fed cattle could compete with grain-fed animals. While this project falls within the statutory limitations of Public Law 94-480, it raises a policy issue for Congress to consider, namely, should similar legislation be enacted for other crucial areas of technological innovation?

PARTICIPANT:	Douglas MacGregor (86) Stephen Baum Howard Bovers Diamond West Corporation 530 Fifth Avenue New York, New York 10036
CASE TITLE:	Coke Desulfurization Process
FUNDING LEVEL:	$82,500
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Lois Martin Bronfman Energy Division P.O. Box X Oak Ridge National Laboratory Oak Ridge, Tennessee 37830

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

This project involved three key participants — all of whom were interviewed: Douglas MacGregor, Stephen Baum, and Howard Bovers. MacGregor, the inventor, originally applied to the ERIP program for assistance. After the NBS evaluation, control of the coke desulfurization process was given to Diamond West Corporation, the principals of which are Mr. Howard Bovers and Mr. Stephen Baum. Mr. Baum was primarily responsible for seeing the ERIP application through the DOE funding process, and as the grantee, supervised the work of the grant.

Douglas MacGregor is currently the owner and operator of a small business (14 employees) which tests insulating materials. He has a B.S. in chemical engineering and an M.S. in mechanical engineering with some Ph.D. work in chemistry. His work experience reflects his educational background as well as the wide range of interests which have sparked his imagination over the years. He has worked (to name only a few jobs) as an engineer for the Arabian American Oil Company in Saudia Arabia, as a nuclear engineer in Salt Lake City, and as an R&D consultant for an agricultural processes and equipment firm in California. His current business positions include the director or president of seven small firms (e.g., Intergalactic Corporation, Honeykist Products, and Omega Graphics).

Mr. MacGregor claims to have between 140 and 160 patents for a variety of concepts from mechanical toys, herbal cosmetics, and video tape to coke desulfurization.

Howard Bovers, chairman of Diamond West Corporation, has been in the venture capital business for 21 years. He has a background in accounting and financing. His investment activities have been geographically varied but have concentrated on the development of sophisticated technologies. He has no inventions of his own.

Mr. Stephen Baum, president of Diamond West Corporation, has an M.A. in chemistry from MIT. For a number of years he worked as a consultant in the area of hazardous waste management. He has considerable experience working on government projects. Although he has an ongoing interest in inventors, he has no inventions or patents of his own. As president of Diamond West Corporation, a small business with approximately ten employees, he has had primary responsibility for conducting R&D on the coke desulfurization process.

Description of the Technology

The technology developed by MacGregor is a process whereby organic sulfur (up to 99%) can be removed from coke made from high-sulfur coal. The chemical cleaning process is different from other coke desulfurization processes because it uses a unique chemistry. This process involves the introduction of sulfur during the coking process in order to extract sulfur. Its principal applications are in the manufacture of metallurgical-grade coke for the steel industry and electrode-grade coke for the aluminum industry and in the production of a pollutant-free fuel. Because such a process permits the use of lower-grade (high-sulfur) coals in the coking process, the overall impact of the process, if successful, would be to substantially increase the amount of usable coal reserves in the United States.

Mr. MacGregor developed the technology between 1969 and 1971. He had been working on a process to remove by-products from wood materials. Since he had access to this type of laboratory equipment, he decided to "play a little." He developed the theoretical framework for the coke desulfurization process and using some coke he had on hand ran the process on a bench scale. Over the next two years he refined the process, until he applied for a patent (which was granted). Since he had no particular interest at that time in developing the idea further, he put the idea aside. As he explained, no one at that time was particularly concerned about energy shortages or pollution from coal, and besides, ". . . once I know an idea works, I lose interest."

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Contact with the NBS

In the mid-1970s, Mr. MacGregor was working with the AAA Stove Company. One day during a discussion concerning problems of using coal as a fuel, MacGregor mentioned his coke desulfurization idea and patent. He subsequently entered into a business relationship, the specifics of which are unclear, which included, however, transferring control of the patent.

Then, at the urging of the company, he submitted the coke desulfurization idea to NBS for evaluation. MacGregor's expectations of the NBS program were that it would be a good opportunity to get money for development. Although he felt that NBS took too long for the evaluation (one year), MacGregor's overall experience with the program was positive. In retrospect he thought the evaluation was fair. While he had difficulty keeping track of where his project was in the process, he found the NBS clerk responsive and helpful in tracking down his invention. He received no other services from NBS other than the evaluation.

Baum, who took over the ERIP application after the recommendation for funding, also found the NBS reviewers helpful. During the negotiations to buy the license for the process and during Baum's and Bovers's efforts to verify the patented process, Baum consulted with the reviewers frequently. He found all of them cooperative.

Contact with the DOE

When NBS recommended this invention for DOE funding, MacGregor submitted a proposal for $250 million, to develop a laboratory-scale model, a pilot plant, and then a production plant to fully operationalize the process. DOE found the proposal unacceptable, and Mr. MacGregor was so informed. Subsequently DOE received a letter (April 1979) signed by MacGregor (and W. H. Sayer) advising DOE that an exclusive license for the coke desulfurization patent had been granted Diamond West Corporation.

The corporation's representative, Mr. Stephen Baum, had been designated to pursue the grant.

After consultation with DOE, Mr. Baum rewrote the proposal for $82,500. The proposal included three tasks: (1) conducting process research (verification of the patented process), (2) conducting an application study to investigate the most economical and marketable applications for the products of the process, and (3) developing engineering estimates. A grant was awarded in 1978.

Mr. Baum's experience with DOE was very positive. He found Glenn Ellis at DOE to be helpful, supplying him with information and assistance both before and after the grant was awarded. In addition to assisting him in developing the grant work statement, Ellis gave Baum names of people to contact who were working in the area and volunteered the use of DOE's library to conduct a literature search on coke desulfurization. This latter assistance was, according to Baum, extremely valuable. The DOE view of Baum was positive. Baum was responsive and professional in dealing with the agency.

Mr. Baum had some difficulties with the DOE program. The forms, he thought, were complicated. Likewise, the delays in receiving grant monies raised some major difficulties. The timing of payments was crucial to Baum because he was using some faculty and graduate students at Cooper Union School of Engineering and Science in New York to conduct laboratory experiments on the process. These individuals were available during the summer; therefore the funding was needed during that time. Baum spent a considerable amount of his time tracking down where the money was and who was responsible for getting it sent to him.

Another problem which Baum confronted during the DOE funding process was unrelated to DOE, although he thought it might have jeopardized awarding of the grant. Late in the negotiating phase, MacGregor sent a telegram to President Carter demanding attention. Baum and Bovers felt that DOE might respond very negatively to the effort by MacGregor to bring outside pressure and sent a letter to the White House retracting the letter. According to Ellis, however, such actions were not infrequent and had no real effect on his decision.

Participant's Assessment of the ERIP

From Baum's perspective the best thing about the program was that it gave him an opportunity to work on the project. From MacGregor's perspective the best thing about the program was NBS's positive evaluation of his concept.

For Baum there was no worst thing about the program except the results of the tests, which are not the responsibility of NBS or DOE. For MacGregor the worst thing about the program was trying to find out what was going on, particularly after Baum took over.

As for the participants' overall evaluation of the program, it is positive. They would recommend it to other inventors because they believe it fulfills a need to supply seed money for promising ideas. Even MacGregor, whose general evaluation of the government is negative, had a reasonably good experience with the program. His problems and complaints were directed mainly at Bovers and Baum.

OUTCOMES

Current Status of the Case

When the invention was submitted to DOE for evaluation it was a theoretical concept which had been tested by the inventor on a bench scale. The NBS evaluators considered the chemical process as described in the supporting documents and after review recommended the invention for funding.

During the evaluation process, Bovers and Baum were negotiating to purchase the license for the coke desulfurization process (as well as other assets) from the AAA Stove Company. The positive evaluation by NBS was a major factor contributing to their final decision to purchase the license and to form Diamond West Corporation.

When Baum and Bovers assumed responsibility for the process, the DOE, on the basis of MacGregor's proposal, was prepared to reject the invention for funding. DOE's decision was based on a number of factors. MacGregor's original proposal was very unrealistic in terms of the amount of money requested, and the paperwork was sloppy. Moreover, from conversations with MacGregor, Ellis's general impression was that MacGregor did not exhibit the qualities of an inventor or entrepreneur which reduce the funding risk and increase the probability of the success of the invention. Baum's approach to the funding process was, however, positive. He exhibited the entrepreneurial skills and professionalism which DOE thought would make him a good risk. As a consequence, both DOE and Bovers believed that it was important to verify MacGregor's process. For this reason the parties agreed to Task 1 of the work statement. With the assistance of Dr. Kapner, of the Cooper Union School of Engineering and Science, and several of his graduate students, preparations were made to test the concept. Despite numerous efforts and consultation with the inventor (who does not believe there was enough consultation), the tests failed to replicate the inventor's results. The demands and costs of process testing were beyond the expectations of the ERIP reviewers and Diamond West, and a greater allocation of funds and effort to laboratory work was necessary. Tasks 2 and 3 were completed but not as originally designed. In addition, Baum explored the commercial development prospects for the technology with a number of firms. He also conducted a library search on coke desulfurization. Finally, when MacGregor's process failed, Baum expanded the project to include consideration of other coke desulfurization processes.

While Diamond West is pursuing alternative avenues for coke desulfurization, the technology as defined by MacGregor has been tested and has failed to perform. Diamond West has no plans to continue work on this patent in the future.

Tangible Results

Because of the failure to replicate the inventor's test results, there are only limited tangible results from the program. Diamond West still exists, although its prospects for the future are somewhat bleak. Another tangible result is the financial support given one professor and several graduate students at Cooper Union for a summer.

Intangible Results

One important intangible and unexpected result of the program was that it financed the education of a number of people (Baum and some other scientists) on the problem of taking sulfur out of coke. Recognizing the importance of the problem, these people have not given up the hope that they still may find a process that will work. With Bovers's help, they are seeking private venture capital to support their effort.

INTERVIEWER COMMENTS

From a procedural perspective, the MacGregor Baum Bovers experiences raise several problems: (1) the time required was perceived to be too long and (2) the forms and the procurement process were perceived as roadblocks. On the positive side, the nonfinancial assistance which DOE and the NBS evaluators gave Baum was substantial and appreciated. The NBS and DOE staffs were perceived by all parties as being fair and professional.

This case presents some interesting problems. Given the results of the test to validate the inventor's concept, the case represents one of the failures of the program. DOE would have preferred that the case had been validated by an independent third party prior to funding, but that task is not within the mandate of the program. As a consequence, DOE and NBS had to judge the process only on the basis of what was presented in the documents prepared by MacGregor. As it turned out, the patented process did not stand up to testing. To NBS's and DOE's credit, testing was required in the work statement, as it was the logical next step. I do not know how many of the inventions which go through the evaluation process are like MacGregor's in that they need limited funding for concept validation prior to undertaking any major work on the invention. Special consideration may need to be given to this type of problem.

Another interesting dimension of this case is the decision by DOE not to fund MacGregor but to fund Baum and Bovers. Certainly Baum and Bovers feel this decision was appropriate. Both believe that MacGregor has "flashes of brilliance" but that he is financially irresponsible and unreliable. (MacGregor does not have many kind words for Bovers either, although he likes Baum.) Both believe that if MacGregor had received the money the tests never would have been done. This interviewer's brief telephone conversation did not result in such a negative evaluation, although there is some indication that MacGregor stretched the truth in the interview. To illustrate, MacGregor claims to have 140-160 patents (an impressive and difficult accomplishment). A routine patent search only turned up four patents awarded between 1960 and 1981.

Certainly, in retrospect, DOE's decision seems vindicated. Baum and Bovers spent the money judiciously and were able to accomplish the tasks in the work statement. The major problem was not theirs — the problem was with the process.

PARTICIPANT:	Shalom Mahalla (64) P.O. Box 11183 Phoenix, Arizona 85061
CASE TITLE:	The Mahalla Process: A Hydrometallurgical Method for Extracting Copper
FUNDING LEVEL:	$88,933
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	James Petersen Center for Informative Evaluation P.O. Box 17600 Tucson, Arizona 85731

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Mr. Mahalla, the inventor, received a B.A. degree from the University of California in metallurgical engineering. His post-college training came largely from his on-the-job experiences while working in the copper industry.

After leaving school, Mr. Mahalla took a position with Inspiration Copper. He worked for Inspiration Copper as a metallurgical engineer for the next 20 years. Twelve years ago he left Inspiration to work on his own as a consultant to various copper industries. His entire professional experience as an engineer has been within the copper industry, and aside from Inspiration, he had no other "official" jobs.

In his capacity as a metallurgical engineer, he has devoted a considerable amount of his time to helping people develop processes for recovering precious metals such as gold, silver, and copper using a hydrometallurgical process.

Mr. Mahalla has one other patented invention (process), which is to produce very clean copper chemicals from crude copper. It appears that he has been an innovator for many years in the copper industry; however, these are the only two patented inventions to his credit. At present, Mr. Mahalla and Dr. Lester Hendrickson, of Arizona State University, are developing a hydrometallurgical process for tin and silver.

Description of the Technology

The technology is a hydrometallurgical process for extracting copper and is clearly an alternative to the prevailing smelting processes used by 95% of the copper industries today. The Mahalla process eliminates the electrorefining step currently used in most copper refining processes and requires no external source of energy. To accomplish the refinement of copper, the Mahalla process (Patent 4,096,086) places near the top level of a tank containing cuprous chloride complex ($CuCl_2$) a nonconducting (plastic) perforated plate. On top of this plate, iron blocks are placed so as not to obstruct the plate holes. The iron, which can be scrap iron, is surrounded by the cuprous chloride solution.

The Mahalla process refines copper crystals through a chemical reaction between the copper ions in the solution and a more active metal, iron. The driving force for copper precipitation is the electrochemical potential difference between metallic copper and a second reagent, iron, which is consumed. Gradually, copper crystals "grow" through the perforated holes in the nonconductive plastic plate. When most of the copper in the solution has been displaced to a crystalline form, the process stops and the copper can be collected. The copper produced by this process is as pure as or purer than commercially produced oxygen-free high-conductivity (OFHC) copper.

This invention was the result of a sequence of events. Mr. Mahalla was working on a method to purify copper cement. Copper cement, a crude material associated with copper production, is eventually refined into copper. While working in a laboratory on the purification of this cement, something different from the cement showed up. He asked himself what he did to cause this new product to appear. When he tried to replicate his initial finding, he couldn't. After much trial and error, he discovered that when certain variables were manipulated systematically the product could be produced reliably.

At this point he began working with Dr. Lester Hendrickson at Arizona State University (ASU) for the purpose of assisting him to determine the qualities of the copper produced by his method. Dr. Hendrickson determined that the copper was more pure than copper produced by the electrolytic method used in the industry.

When all aspects of the process were developed and the high quality of the resultant copper was established, Mr. Mahalla was issued a patent. The Mahalla process is a unique procedure for refining copper. Its major advantage is that no external energy source is required (including electrical and thermal). Mahalla processes offer a potential energy saving of 10-30% over existing technologies in the copper industries. Second, in contrast to traditional methods, there is no air pollution.

Mr. Mahalla has been working on this particular process for over eight years. During that time he has been involved in identifying and solving many highly technical problems. In addition to his own expertise, he has relied primarily on the resources of Dr. Hendrickson and Arizona State University. Between the two of them, most of the initial technical problems were resolved.

The primary resources needed by the inventor were those of patent attorneys and investors. Approximately $500,000 was needed to move the process to the point where it was patented. According to Mr. Mahalla, the patent costs were the most expensive of all costs. Most of the money came from the inventor and a few investors.

The primary nontechnical problem which had to be overcome was obtaining the copper industry's acceptance of the process. This industry was, and still is, resistant to change. Very large companies, such as those comprising the copper industry, have built-in biases against anyone from the "outside" having a better method or process than they have. When a person from outside comes to a big company, the company says tell us how it works, and we'll let you know if we're interested. From the inventor's perspective, if he reveals all to the company, he is totally unprotected. In Mr. Mahalla's case, he chose to work with the academic community to prove and verify his invention. His hope was that by going through this process he would eventually establish the viability of the Mahalla process.

In terms of technical problems encountered during the development of the process, several stand out as significant. Prior to submission to NBS, and even to date, the process has been in the research and development stage. One of the key problems was the slow rate at which the macrocrystallization of the copper occurred. In order for this process to compete with other processes, it was determined that the deposition rate needed to be increased. Another problem was that impurities needed to be removed and precious metals such as silver recovered. A third problem was that during research and development only laboratory-quality copper solutions were used. A question was raised as to how efficient the process would be if actual leach liquor from copper refineries were used.

The current primary application of this technology is in the copper industry. However, the Mahalla process can be used, with different chemicals and reactive agents, to refine silver, tin, and, perhaps, other similar metals from solutions. Indeed, Mr. Mahalla and Dr. Hendrickson have already established similar processes for other industries.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

While the inventor is uncertain as to how he heard about ERIP, it is certain the the interviewees submitted the proposal to NBS in order to secure funding necessary to continue the process of research and development. While they did not submit their proposal just to receive the NBS "stamp of approval," they realized that acceptance of their project by NBS would be of value in their efforts to secure additional funding.

Essentially, both Mr. Mahalla's and Dr. Hendrickson's expectations of NBS were minimal; they hoped for a good review and positive recommendation for funding. They did not expect nor did they ask for any services, other than evaluation and recommendation, from NBS. The only person with whom they had any significant relationship was the second stage reviewer, Paul Pemsler. Once his report was submitted, that was the end of their contact with NBS.

In terms of the influence of NBS on the invention, there was no change in the basic nature or function of the invention. According to Mr. Mahalla, it's the same "animal" today as it was before they submitted their proposal to NBS. At no time was their proposal rejected by NBS; however, NBS raised several questions about the process that Mr. Mahalla and Dr. Hendrickson had to answer before funding was awarded. Because the answers which they gave to these questions were satisfactory to NBS and because of the favorable review, NBS recommended the Mahalla process be funded. This technology was not changed as a result of interaction between the inventor and NBS.

Overall the participants were quite satisfied with their relationship with NBS. They felt that once NBS got their proposal, they were quite expedient in their review. In addition, there was frequent contact between NBS and the grantees. Both interviewers could find no problem with the NBS system. They rated their level of satisfaction as being totally satisfied with NBS. In terms of specific area evaluations, the interviewers felt totally satisfied with NBS's evaluation, their personal contact with them, the helpfulness of the evaluation, clarity of the evaluation form, tone and wording of correspondence, and NBS's attention to confidentiality. They were satisfied with the time (ten months) required for the total evaluation.

To date, the inventor has submitted only one proposal to NBS; however, he would have no qualms about submitting a proposal again, if he had a different energy-related invention. In addition, both Mr. Mahalla and Dr. Hendrickson stated that they would recommend the program to others.

Experience with the DOE

Once the proposal was recommended for DOE funding, the participants' expectation was that funding would be forthcoming. They did not expect another review cycle from DOE. They felt that further review was not warranted. According to Dr. Hendrickson the DOE review was a technical review; however, according to an interview with Pat Donohoe the DOE review process is not a technical review.

Dr. Hendrickson expected that DOE would move more rapidly on funding their project; however, they experienced considerable delays. DOE required 15 months before the award was made on September 1, 1979. Overall, it took two years one month in order to award the grant to Mr. Mahalla. How long it took to get the money is uncertain. Both interviewees felt that their expectations for a fairly rapid review were realistic.

While Mahalla and Hendrickson knew that support from the inventions program would be a one-term contract, they also thought that ERIP would assist in obtaining funding from other programs if the work was successfully completed under the contract. According to Dr. Hendrickson, they received one letter from someone at DOE, although it could have been from NBS, that led them to believe that DOE would provide additional financial assistance from other programs after the termination of the contract. This expectation was not fulfilled.

In terms of assistance, both Mr. Mahalla and Dr. Hendrickson expected only financial support, as described above. They did not expect technical, management, information, testing, marketing, or business planning assistance. They did not receive any of these types of assistance, either. Recently DOE provided some marketing assistance by paying for a display booth for them at the World Energy Engineering Conference in Atlanta.

The one best experience that these individuals had while associated with the DOE was being funded by them. The one worst experience was communications — the long periods of time between contacts. When they did talk they were told to just keep waiting.

As a result of contact with DOE, they were contacted by two groups. One was the Swedish Industrial Development Corporation and the other the Drenoe Corporation in Pittsburgh. Some correspondence between Mr. Mahalla and Dr. Hendrickson and these two firms occurred; however, there were no identifiable outcomes.

Participant's Assessment of the ERIP

Clearly, the most significant outcome of the grantee's participation in this program was the further development of the Mahalla process. The money which the inventor and Dr. Hendrickson received enabled them to solve some serious problems in their process of refining copper. It can be concluded that receiving the money was the best thing that occurred for them.

The interviewees could not identify any serious problems or impediments to participation in the program. Once contact with DOE was made, support went well and there were no barriers.

OUTCOMES

Current Status of the Case

The progress made by the inventor and Dr. Hendrickson was that they were able to solve the major problems identified in their work statement. In particular, they were able to speed up the process of growing the copper macrocrystals. First, they identified the variables that influence the growth rate of the crystals. Second, they were able to alter the physical geometry of the cell and, thereby, the configuration of the cell and rate of growth.

At present this technology is well established at the bench-scale prototype level. The process has been proved to work, and they are convinced that a larger-scale prototype will work, too.

The next step foreseen by Mr. Mahalla and Dr. Hendrickson is the development of a scaled-up prototype to more accurately simulate the application in an operating copper refinery. Two steps must be considered. First, between $2.5 and $3.5 million must be raised, and second, mechanical engineers need to be deployed to solve a number of engineering problems which will be encountered when scaling up.

Both interviewees believe the most logical and likely source for this money will be the copper industry itself.

Tangible Outcomes

The primary tangible outcome was the development of a successful bench prototype — a prototype which refines copper in an economical and energy-efficient manner. Another tangible outcome is that Mr. Mahalla and Dr. Hendrickson will be attending a large conference in Atlanta for the purpose of setting up a display booth for the invention. The interviewees are going to Atlanta because of the financial assistance offered to them by the DOE.

In addition to the above outcomes, the participation in the ERIP project has enabled four graduate students, under Dr. Hendrickson, to conduct research that directly related to the Mahalla process. As a result, these four students were able to obtain their M.S. degrees. Finally, the interviewees stated that a major outcome was the production of an 80-page technical report on the nature of the Mahalla process.

Intangible Outcomes

In terms of intangible outcomes, both Mr. Mahalla and Dr. Hendrickson believe that they have gained professionally. Both have met with and discussed their process with a wide spectrum of professionals in and out of their field. Both the grantees and the Mahalla process have been nationally publicized as a result of participation in ERIP.

Second, Arizona State University has gained some increase in stature because they hosted the project on their campus. The ASU administration has positive feelings about this project as a result and uses it in their public relations.

Last, the specific technology is unique, and the interviewees feel that they have added significantly to the knowledge base of the field of hydrometallurgy.

INTERVIEWER COMMENTS

The primary operational change that was recommended by Mr. Mahalla and Dr. Hendrickson was the need for more frequent and clear direction. An individual inventor has little, if any, knowledge of the federal bureaucracy. When the forms came to Mr. Mahalla, he had a lot of difficulty completing them. They feel that the DOE should not take for granted that an individual inventor knows what to do with these forms.

The key policy issue raised by the interviewer is the limitation of "one-step, one-time" funding. They believe that in many cases, such as theirs, additional funding is necessary. While they were able to go one-step further in the R&D process, that one step may not be sufficient to insure commercialization of the technology.

PARTICIPANT: Alvin Marks (9)
153-16 10th Avenue
Whitestone, New York 11357

CASE TITLE: Heat/Electric Power Conversion via Charged Aerosols

FUNDING LEVEL: $50,000

CASE STATUS: Project completed; final report accepted

INTERVIEWER: Lois Martin Bronfman
Energy Division
P.O. Box X
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Alvin Marks is an inventor by profession and an entrepreneur by necessity. Now in his early 70s, he has been inventing for almost 50 years. His inventive talent is broad and basic. It reflects his technical competence, gained through education and experience, in the areas of electrical engineering (B.S., Cooper Union School of Engineering and Science) and basic physics. With over 100 U.S. patents and 250 European patents, his two primary areas of invention activity have been in the fields of polarized optics and electric power conversion. As inventor of polarized sunglasses and three-dimensional movies (as well as numerous other polarized optical applications) Mr. Marks has gained a reputation as a first-class inventor. He has had access to government policy circles, as evidenced by an invitation to testify before Congress in 1967, and he has received national newspaper coverage (e.g., *New York Times*). In addition, Mr. Marks and his brother have built a multimillion-dollar research, development, and production corporation (30-50 employees including auxiliary consultants) which provides the support necessary for him to function more or less as an independent inventor. It gives him the financial means to maintain his family and "a room of his own" in which to pursue ideas which interest him. The corporation makes some of its money from the inventions Marks has been able to develop to the point of commercialization. Currently, for example, the corporation is involved in the reintroduction of three-dimensional movies.

While Marks's business activities were able to sustain him in the development — even commercialization — of some of his ideas, they were not able to finance the bulk of his work without some outside assistance. Marks and Marks Polarized Corporation have received over 40 government grants from a variety of agencies (e.g., NASA, the Navy, National Science Foundation (NSF), and the Air Force) over the last 40 years.

Marks's work in the area of electrothermodynamics is one example of the type of work requiring financial support. The work to be done in this field was so basic (from both a theoretical as well as an engineering perspective) and the funds required for R&D so immense (between $100 million and $150 million) that the only real backing Marks Polarized Corporation could provide was the time and money necessary to seek other funding. Moreover, efforts to obtain private funds were unfruitful, and large corporations such as the Westinghouse Corporation were uninterested. The government was the only potential funding source which could support his work at the level he desired and which could afford to take the risk.

Description of the Technology

The technology — Heat/Electric Power Conversion via Charged Aerosols — funded by DOE is a basic process for converting heat to electricity without the use of a mechanical generator. Its application would permit the development of energy-saving cogeneration facilities in a variety of situations including the home. Marks estimates that with cogeneration the technology could reduce energy consumption on nonrenewable fuels by 40% in the United States.

Mr. Marks first developed an interest in electrothermodynamics (a more general and comprehensive term for the charged-aerosol technology) in the 1930s while a student at Cooper Union in New York City. The dominant technology for producing thermal-to-electric conversion was at that time, and still is, based on the use of a mechanical turbine. Mr. Marks felt that the idea of a heat-to-electric conversion process which bypassed the use of the mechanical turbine would ultimately prove to be more efficient and reliable than those processes dependent on the mechanical turbine.

The idea of electrothermodynamics had been around since 1842 but had not been explored in great depth. Mr. Marks has spent the last 50 years researching and developing this concept. From 1932 to 1959, Mr. Marks studied the problem theoretically utilizing his own private resources. He explored the electrohydrodynamic generator and the ion generator (two methods for power conversion without a mechanical turbine), but both proved disappointing. By 1949, Marks, however, had worked out the theoretical basis for the charged-aerosol generator and applied for a patent on the concept. Over the years approximately ten additional U.S. patents have been issued to Marks on the power conversion via charged-aerosol technology. Two other related concepts, the charged-aerosol wind electric generator (power fence) and Marks's charged-aerosol air purifier, have also been developed.

Marks's ability to conduct R&D on this concept, however, was greatly constrained by a lack of money, personnel, and equipment over the years. In addition, Marks's time was often occupied in the pursuit of other inventive interests which were more immediately lucrative.

According to Marks's own estimates, a basic R&D program on the charged-aerosol power conversion process would require \$100 to \$150 million. Marks has never been able to generate this support from either private venture capital organizations or the government. The amount of capital, level of risk, and length of the pay-back period were too great to interest venture capitalists, and the political support necessary to implement a basic government R&D program to develop the technology was never there.

While Marks's persistent efforts to lobby for program support of his concept have failed (in 1967, for example, he asked Congress for a \$60 million crash program, and more recently he outlined a \$150 million crash program), he has been able to generate some government funds over the years. Between 1959 and 1968, five contracts were awarded to Marks for a total of \$750,000 by the Department of the Navy to work on the charged-aerosol power conversion concept. The work funded by the Department of the Navy permitted Marks to concentrate his efforts on developing this concept. As one evaluator of the Navy project noted, Mr. Marks did a "good innovative job of advancing the state-of-the-art considering the funding available under the Navy contracts."

Following completion and termination of the Navy contracts, Marks began looking for money from other government sources. During this period, Marks also developed and became increasingly interested in his aerosol-aerosol wind electric generator (power fence), a spin-off technology of the charged-aerosol power conversion concept, and the aerosol pollution control device. In 1975 Marks was successful in obtaining \$67,000 in NSF funds to work on this concept.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

When Marks came to the ERIP it looked like all private and public avenues for funds to support R&D on the heat-to-electric power generator were closed. Marks had been unsuccessful in persuading the people in coal research at Energy Research and Development Administration to support him and in persuading Congress to support a massive R&D program. Marks first heard of the ERIP through his patent attorney.

In August 1975, Mr. Marks submitted evaluation forms to NBS for the heat-to-electric power conversion via charged aerosols technology. In September 1976, after two years in the review process, the NBS forwarded Mr. Marks's technology to DOE with a recommendation for funding.

When Marks came to the program he was looking for massive funding support for his R&D. Aside from an evaluation, Marks only expected NBS to lend credibility to his concept. Marks did not expect or receive any services other than the evaluation, and he was delighted with the way he was treated. He thought the individuals involved did a fair and professional job. His one complaint was the time required for processing the evaluation.

Experience with the DOE

DOE requested further evaluation of the technology before the office would fund the technology. Specifically, DOE wanted NBS to evaluate Marks's previous work for the Department of the Navy (1959-1963) on electric power conversion. The evaluation, performed by Aerospace Corporation, was favorable, and DOE accepted the recommendation for funding. The original proposal submitted by Marks requested $6 million to underwrite a major R&D program. DOE notified Mr. Marks that the office did not give grants for such large amounts and asked Mr. Marks to rewrite his proposal. This he did, requesting $50,000 to construct and test a bench scale experimental apparatus; specifically, the model would be used to investigate the condensation charging of a steam jet in the range of 1 to 50 atmospheres of pressure.

Marks's impressions of his dealings with the DOE side of the program were similar. The people who administered the program were sympathetic, fair, professional, and, most important, helpful in getting additional funding. His major problem with the program was that the ERIP funds were not enough.

Participant's Assessment of the ERIP

In summary, Marks was quite satisfied with the operation of the ERIP program, and has no regrets about participating. The NBS and DOE were sympathetic and interested in what Marks was doing. Most important, they were helpful in getting additional funding. He feels, however, that the grants awarded are too small, particularly for work on a technology like his own, which he believes needed to be elevated to a program level.

OUTCOMES

Current Status of the Case

As a result of numerous technical and engineering problems, Mr. Marks completed only 25% of the construction of the device during the contract period with the funds allocated. However, he made substantial theoretical advances (new methods for improving deficiencies of the generator), and developed several new related inventions (e.g., the sapphire-stainless-steel joint) for which patents are pending. According to Mr. Marks, these developments have advanced the state-of-the-art for the Electro gas dynamics Generator. Further, Mr. Marks subsequently received funding from the Division of Advanced Energy Projects (DOE) after referral by ERIP. This funding was for $600,000 to be allocated over a three-year period. At the same time, additional funding was awarded to the Naval Postgraduate School at Monterey, California, to conduct parallel work on the concept and to provide Mr. Marks with technical support.

After 1-1/2 years of work on the new DOE contract, it was canceled. The cancellation was a result of an unfavorable evaluation by the project's review team. The review team raised a problem which, according to Marks, was based on a "faulty scientific concept." To respond, Marks felt it necessary to write a scientific paper (at Marks Polarized Corporation's expense) refuting the argument of the review team. It took Marks one year to write the paper, and he presented it in the fall of 1981 at the IECEC Conference in Atlanta. Development of the technology by Mr. Marks is currently at a standstill. He has no additional government funding and no hope for obtaining any in the near future. While he is looking for private investors, he believes his prospects are not very good, since his concept is still in its infancy and requires enormous capital investment before profits are to be made (if any).

Tangible Outcomes

While Mr. Marks completed only 25% of the construction of the Heat/Electric Power Conversion Generator, he would measure the outcomes of his participation in this program in terms of the theoretical (new methods for improving conversion efficiencies) and design (the sapphire-stainless-steel joint) advances accomplished with the funding provided. In his mind there is no doubt that progress was made.

In addition the program did lead to additional funding for both the charged-aerosol heat/electric and wind/electric generators. Specifically, there was funding of the heat/electric charged-aerosol generator for $600,000 from the Division of Advanced Energy Projects (only half of which actually came to Mr. Marks); there was support funding to the Naval Postgraduate School; and there was additional funding for the wind/electric power charged-aerosol generator totaling $333,000, of which $64,000 in funding was received from the Solar Energy Research Institute.

Intangible Outcome

The intangible outcome in Marks's view is the additional exposure of his ideas to the technical community.

INTERVIEWER COMMENTS

From a procedural point of view, Marks's experience with the program has been quite satisfactory, although the issue of the time required for the review was raised.

Mr. Marks is another outstanding example of the independent inventor which the program wishes to support. However, his technology raised several policy issues. First there is the question of whether this is the scale and type of invention which DOE wishes to fund. Clearly, it will take millions of dollars to prove this technology which is far beyond the resources of the program. The technology Marks is promoting is controversial because it is an alternative to conventional methods of electric power generation. Moreover, there are many people in the scientific community who believe it is a waste of valuable resources to continue work on electrothermodynamics. The concept, they argue, has been reviewed, and it comes up short when compared with the working mechanical generators which are in use today. Evidence of this controversy was uncovered by Glenn Ellis of ERIP when he consulted with the coal research people at DOE. Coal research did not fund Marks earlier, even though he received a favorable evaluation by Dynatech Corporation under Contract No. 14-01-0001-1191, relating to Marks's OCR File 411. Ellis's evaluation of their criticisms was, however, that they were based on emotional rather than technical judgments, and his decision was to fund the proposal. In short, the program chose to back this high risk technology when others would not.

A second difficulty with this technology is the stage at which it was funded. Marks came to the ERIP at a very early stage in the R&D process. Although he had been working on the technology for over 40 years, commercialization was only a "gleam in his eye," and the amount of funds as well as the time required for development was and is enormous. The strategy of ERIP given this stage of development was to fund the project for a bit of work in the hope of gaining some visibility for the technology which might lead to future funding. ERIP was successful in this effort; Mr. Marks was funded elsewhere. The fact that these funds were cut off after 1-1/2 years is, I suspect, <u>not</u> an indicator of bad judgment on the part of the ERIP managers. Only time (a very long time) will tell whether Mr. Marks's commitment (and ERIP's) to this technology was well placed.

PARTICIPANT:	John Mattson (117) 361 Moraine Street Brockton, Massachusetts 02401
CASE TITLE:	Solar Span Prism Trap
FUNDING LEVEL:	$98,700
CASE STATUS:	Project completed; final report accepted

INTERVIEWER:	Sumner Myers Institute of Public Administration 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

John Mattson, the inventor of the Solar Span Prism Trap, is a high school-educated carpenter who also graduated from a building trade school in upstate New York.

For the most part, Mattson's carpentry and building skills have been developed on the job over a period of some 15 years. From personal observation, these skills seem to be of a high order. They are based on what is obviously considerable innate talent plus a certain "Yankee mechanic" attitude that results in good work done for the sake of good work.

Mattson seems to have come up with a number of creative ideas before this invention, but none of these have been patented. Interestingly, having applied for some 26 patents on this invention, Mattson is now considering patenting some of his other ideas, both energy- and non-energy-related.

In short, John Mattson reminded me of the kind of creative "Yankee mechanic" that once made New England a great industrial center. Apart from his technical skills and creative abilities he also possesses the personal characteristics often associated with inventors. By any academic standard he is undereducated, yet he is extremely well read in all matters related to his invention (indeed, it was his invention that sent him to the library). He is open, even ingenious, yet he evidences a certain business shrewdness which is obviously growing. And most important, he is personally easygoing but extremely persistent about his invention. As we shall see, this persistence was an important factor in getting his invention funded.

Description of the Technology

The invention is a solar collector plate which has been well described in the final NBS technical review:

> The invention is a "black liquid" solar collector. It is a lightweight, all plastic collector using "black" liquid both as an absorber and energy transfer fluid. It is designed to be used in a draindown mode for both freezing and potential overheating protection. The cover and bottom plates are made of 0.060" UVEX (an Eastman Kodak Butyrate plastic) vacuum formed with prism configurations to allow structural rigidity and allegedly improved solar collection. These plates fit over a flow manifold section for the energy collecting fluid. The manifold consists of three separate plastic plates molded and bonded together. The inlet and outlet manifold connections are on the low side of the collector. After leaving the inlet manifold, the black liquid flows up the manifold lateral passages in the upper plate, through holes at the top, down the manifold passages in the bottom plate, and out the exit manifold.

The importance of this approach lies in the potential for developing a low-cost collector using plastic. That potential was noted in the evaluation but, given the existing need in the industry, was understated.

Mattson became interested in solar collector technology ten years ago when he decided to build one for his own cottage. He answered an advertisement promising building plans for $10. He got the plans, but they were insufficient to build the collector. However, he also got an offer — for $300 he could get a full set of plans plus permission to install the resulting collector on his own home.

Mattson was furious. He decided to design and build his own collector using plastic, the only material he could afford. He resolved that his collector would be so good that "this crook would have to buy it." That proved to be a key decision.

Mattson's first design involved a galvanized corrugated-metal absorber plate with top and bottom sheets of plastic. Water was pumped up to the top and trickled down the back side through the corrugated grooves. Two major problems forced him to make design changes:

1. The plastic sagged from the heat. So Mattson developed a prism structure along the face of the plastic which gave the collector the needed strength. As a fortunate by-product, the prisms added a good deal to the collector's efficiency.

2. Algae grew between the metal absorber and the plastic face. To eliminate this problem, Mattson closed the system to air and changed his clear fluid to a black fluid, which does not support algae growth. The black fluid also added a good deal to the efficiency of the collector. In fact, it was so important that Mattson spent much time searching for the "right" kind of non-toxic, nonstaining dye. The dye he settled on is a secret.

After constructing a few hand-built panels of Lucite to demonstrate the collector's principle, Mattson was stymied. He needed to build actual full-scale working models using the right kind of plastic, which meant that they could not be built by hand. Searching for a strong plastic to take the heat and radiation stresses of solar collection led him first to General Electric Company, then to Eastman Chemical Products Company. Bob Seamans, in Eastman's advertising department, apparently saw in the Mattson collector a potential market for the company's UVEX plastic — a material long used for outdoor signs — and got Eastman to build a set of molds for fabricating the collector. Seamans also publicized Eastman's participation. The important point here is that Eastman's support made it possible for Mattson to demonstrate a full-scale working model of what, until then, had existed as an idea. This was the first huge step forward. It enabled the inventor to show less imaginative people what he had in mind. It also enabled him to see what had to be improved.

The functioning collector panel enabled Mattson to get a $9,000 grant from the state of Massachusetts to have the collector tested by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). However, he learned that ASHRAE had no test appropriate for his collector because it was designed as a skylight which would transmit daylight and solar radiation directly into the room, and at the same time heat water. The ASHRAE test measures efficiency by comparing the water temperature in and the temperature out of the collector and would not measure the heat radiating into the room. In order to conform to the ASHRAE test methods, Mattson modified the design of his skylight collector to heat water only. He now makes both types of collectors.

The ASHRAE test results showed that it was necessary to improve the collector's design configuration, which meant building another working model. This time Mattson was really stymied. Eastman couldn't help, and he simply couldn't find the money to build another model. While he tried to round up funds, he reworked his designs, but the redesigns were largely confined to paper and hand-built mockups.

As it turned out, the time was hardly wasted. During these years of frustration, Mattson came up with a number of ideas that proved to be useful. He has a unique vacuum-breaking system, which doesn't depend on mechanical devices, and a simple flow metering device which keeps the flow even over the whole absorber plate at a flow rate of one gallon per minute. He holds patents on those devices, as well as on the prism structure, the absorber design, the tank design, and the total package.

Mattson continued to work as a carpenter in order to support himself and his invention. He and his brother, George, with whom he was associated in this venture, were constantly looking for funding sources which would allow further development of the collector. They regularly went to energy shows, where they displayed their Eastman collector. Apparently, it was not attractive enough to generate sponsorship. Whatever the case, the Mattsons didn't have any other product to show. They packed up their models and traveled to Washington, D.C., literally walking the pavement and pounding on doors, trying to get a chance to show someone the invention. Neither had any idea who in government might be interested, and they accomplished nothing.

During this period, the Mattsons also tried to interest venture capitalists but to no avail. Some financial people apparently liked what they saw, but in return for bits of money they demanded 90% of the company. Mattson, compulsive as he is, was totally unwilling to make that kind of deal.

Mattson also talked to other collector manufacturers trying to interest them in plastic collectors. For example, he explained his whole principle to Exxon Corporation and Reynolds Metals Company and couldn't understand why they insisted on building fancy, inherently expensive metal collectors — why they couldn't see that only plastic would result in cost-effective collectors. This experience was important because through it the Mattsons learned that their idea was not state-of-the-art.

The plastic black-fluid collector invented by John Mattson has one application that sets it apart from other metal and glass collectors: because it is transparent, it can be used as a skylight. This is an interesting and perhaps important application since it permits the direct use of radiant heat during cold-weather months. During hot-weather months, it may permit daylighting spaces without overheating them.

The real importance of this invention, however, is not so much in its unique application, but in its potential to be cost effective. The evaluation mentioned this in passing:

> The attractive feature of the design is its simplicity and expected low cost....the low cost claims may be somewhat exaggerated, but this collector can be expected to be somewhat less expensive than conventional collectors. There are also advantages in shipping, handling, and installation.

While this assessment is essentially correct, it may well prove to be something of an understatement.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mattson heard about the inventions program through a radio advertisement. He immediately sent the information package he and his brother had put together on the collector and waited impatiently for a response. They had gone about as far as they could without money. Their improvements were confined to paper; without funds, these could not be transformed into working models.

Mattson expected NBS to show some interest, maybe evaluate the product first hand, and eventually provide some money for further development. This was certainly realistic, especially in view of what finally happened. At first, however, he was sharply disappointed. He got a form letter saying the invention was state-of-the-art technology and one that the government could not encourage them to pursue.

Initially, Mattson was very discouraged and accepted what he took to be a qualified judgment of his work. Then, recalling how he had tried to interest other firms in plastics, he just couldn't believe that plastics were, in fact, state-of-the-art. So he telephoned the man whose signature appeared on the form letter and learned that the letter was sent pro forma because there were so many applicants. At Mattson's insistence, NBS then sent out a set of application forms for him to complete in order to reenter the inventions program process.

That application was also rejected, but Mattson persisted and called NBS again, this time in anger. He threatened to contact the President, Senator Kennedy, and anyone else who would see that his work got a fair evaluation. According to Mattson, NBS responded by sending a consultant from the University of Massachusetts to Duxbury for the first stage evaluation. The consultant saw the idea in the Eastman model, though Mattson had not been able to express it on paper. After the consultant's report, NBS sent a second stage evaluation group from MIT. Neither of these evaluations contributed to Mattson's work as such, but they gave enthusiastic approval of his product and boosted his morale.

Experience with the DOE

After the evaluations there was a waiting period. Then came a letter indicating that NBS has recommended the invention to DOE for "possible funding." Mattson expected to have more pushing and filing of forms to do. He emphasized that he got through the program by pushing very hard for a long time. This waiting period was shorter, however, and the whole process sped up significantly after he received his first letter from DOE.

Then a third visitor — presumably sent by DOE helped Mattson tremendously by reorganizing, restructuring, and rewriting the original proposal. Mattson had submitted a long letter outlining everything he wanted to do with the invention. With the DOE consultant's help, he was able to break this down into logically ordered tasks and present his ideas in a way government officials could understand and use. Not only did this result in a better proposal and a better chance of government acceptance, but it clarified the tasks for Mattson himself.

Participant's Assessment of the ERIP

Mattson was absolutely clear on one key point: but for the government's money his invention would be nowhere; at the moment it is on the threshold of success. Mattson, having been propelled forward with government funding, thought the program was "terrific."

The greatest impediment to participation in the program was all the other applicants whose needs also had to be met. Mattson recognized the problem and could offer no solution. I think he overcame that impediment with (1) a good idea and (2) persistence.

OUTCOMES

Current Status of the Case

The grant came through for $98,000, and Mattson stopped work as a carpenter to give his full time and energy to the collector. He built the first full-scale model of the much-improved collector, the design of which he had worked out on paper. Taking that model around to energy innovation shows, he made contact with a marketing firm. This firm, Solar Associates, Inc., in Vernon, Connecticut, represented by Bill Marconi, was selling a brand-name metal collector in Connecticut. Marconi decided to give up that franchise and sell Mattson's system, using Connecticut as a test market. He prepaid for materials and Mattson built some systems which apparently sold like the proverbial hotcakes. Marconi reported that in one evening's marketing effort, he sold more Mattson systems than one month's work selling the metal-and-glass system he previously handled.

From those initial installations, Mattson and Marconi collected performance data, and Mattson made some minor improvements in the design, both for better functioning and better aesthetics. Marconi then took his Connecticut marketing plan and expanded it, aiming for nationwide sales. Within two months, he had customers in 17 states.

At the moment, Mattson can only produce 15 completed systems a week. Mattson is now pursuing a number of alternatives to raise enough capital to equip a factory so his output can match the demand.

Another alternative under exploration is to go public, and Mattson is gathering information on that process. He sees that further down the road.

Through various energy and invention shows, Mattson has developed contacts with both domestic and foreign-based firms interested in his collector. It should be noted that the government invited him to several of these shows. In any event, the Mattson brothers are currently negotiating with firms in the Phillipines, Italy, Ireland, and the United States to produce and sell the plastic black-fluid collector. They are also trying to get financing through a state of Massachusetts bond program.

Tangible Outcome

The tangible outcome of this invention is, in the short run, a small factory producing collectors. In the long run I predict it will save the solar program by showing all concerned that low costs can be achieved.

Intangible Outcome

The intangible outcome will be tangible. Mattson has learned how to patent inventions and make money. He will undoubtedly do more of both.

INTERVIEWER COMMENTS

As noted earlier, but for the ERIP, Mattson's solar panel might never have become a reality. That would have been a great loss; in terms of the nation's solar objective, Mattson's invention could be one of the most important technologies funded by the government. I say this from the perspective of one who was project director of a recently completed assessment of the status of the active solar industry. The team of experts who conducted the assessment strongly urged that the cost of solar systems be reduced by 40% in order to make up for the prospective loss of federal tax credits. The industry had wrongly locked itself into inherently expensive metal collectors which had little potential for cost reduction, even through automation. Coincidentally, the team had seen an early model of Mattson's collector and immediately agreed "that is the way to go." Indeed, Mattson's collector triggered the team's recommendation for more work on plastic collectors because of their cost-reduction possibilities.

The reader should note that:

- Key turning points in the development of this technology all happened when someone actually saw a "product," (e.g., Eastman's Seamans, NBS evaluators, and Marconi, the salesperson). This seems consistent with the traditional government role of sponsoring demonstrations.

- The letter from NBS was unnecessarily discouraging. While it probably screened out the faint-hearted, there ought to be a way to screen effectively without crushing their spirits entirely.

- Mattson spent a lot of time and energy in Washington, yet no one seemed to direct him to either the solar office of DOE or the inventions program. Might things have worked out better if he knew his way around? Could government have set up a point of contact in Washington that inventors would know about?

- Mattson feels that the long time gaps in development kept his ideas from effectively influencing developing collector technology. He is, of course, right, and that is a loss to the nation as a whole. But it has worked to Mattson's advantage. He will have a virtual monopoly on plastic collectors until at least 1985, when FAFCO, a California-based collector manufacturer, will bring a development in plastic "on stream."

- Mattson is afraid now that he will run out of money and have to stop again and that other people will get into the plastic collector business ahead of him. I frankly doubt this. The Mattson collector — thanks to ERIP — is well enough developed to attract private money.

- The need for an ASHRAE test both contributed to and subtracted from his invention by forcing him into the retrofit box business. The skylight had many aesthetic, technical, and cost advantages the box lacks, but the box is suitable for retrofit, which represents a much larger market, where the need is great.

- The importance of energy shows is evident, but going to shows depends on having a product to demonstrate — again emphasizing the importance of sponsoring demonstration models.

- A total lack of interest on the part of metal collector manufacturers indicates that this product is likely to represent an innovation by invasion. The solar industry will be forced to switch from expensive metal collectors to less costly plastic ones as soon as tax credits are removed. Right now they aren't interested, in part because the tax credits offset the high cost of metal collectors.

Should government favor innovations that will succeed by invading an established industry with a completely new technology? In his book Schumpeter argues in favor of the "creative destruction" that results from such innovation. I would agree.

Private firms should be expected to support only innovations that appear to make economic sense _to them_. In point of fact, the idea of a plastic collector couldn't make economic sense to a firm like Exxon, which had already committed its manufacturing process and _thinking_ to metal collectors. The Institute of Public Administration (IPA) team believes that once developed, however, the plastic collector will make obvious sense to both consumers and producers. This can be clear only by hindsight. It was anything but clear until Mattson built his working model. The question to be asked is: What would have happened if the invention program had not sponsored Mattson to build his working collector? Probably no one would have, certainly no one in the solar industry. And so, according to the DOE-sponsored IPA project that assessed the solar industry, the solar industry will pay for this oversight with economic failure when the tax credits are removed. So much for the currently popular idea that if a technology is good enough the private market will develop and use it.

PARTICIPANT:	Robert S. Norris (21) Deposits and Composites, Inc. 318 Victory Drive Herndon, Virginia 22070
CASE TITLE:	Waste Oil Utilization System
FUNDING LEVEL:	$50,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Sumner Myers Institute of Public Administration 1717 Massachusetts Avenue, N.W. Washington, D.C. 20036

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Robert S. Norris, the inventor of the Waste Oil Utilization System, has a B.S. in industrial engineering from Ohio State University. He has not pursued graduate work in his field but rather has trained himself on the job to become an expert in boiler fuels and additives.

Norris spent most of his career working for the Shell Oil Company, primarily in their additives group. After leaving Shell, he set up a one-man business which (1) developed and sold Norris's own boiler fuel additive (patented in 1961) to reduce scale and corrosion and (2) purchased boiler scale from electric utilities and resold it to companies who extracted vanadium from the scale.

Description of the Technology

The invention is a system which utilizes a blend of waste crankcase oil and an emulsifying agent as an additive in large oil-fired furnaces to prevent scaling and corrosion due to vanadium.

As mentioned above, Norris developed a boiler fuel additive that reduced corrosion and scaling. He understood that crude oil, especially from certain areas of the world, contains vanadium in small amounts. When the oil is burned, the vanadium melts and resolidifies on the inside of the boiler, causing corrosion and scaling. Periodically, utilities and other boiler fuel users (like ships) have to scrape the scale off.

The additives which Norris developed worked principally by introducing magnesium (Mg) into the fuel system. The vanadium combined with the magnesium and passed through the boiler system without solidifying. Another important ingredient in Norris's additive was petroleum sulfonate, an emulsifier which keeps soot in emulsion in the oil, thereby preventing the soot from running through the engine and clogging it.

Norris knew that petroleum sulfonate was also used as an emulsifier in automotive crankcase oil. He reasoned that by adding magnesium, waste oil which already contained petroleum sulfonate, could be used as a boiler fuel additive to eliminate scaling. At the same time the waste oil would increase the BTU yield of the boiler fuel.

Finding an economic use for waste oil might ameliorate a serious environmental problem. Since waste oil has no value, it is often just dumped into the sewer system, from whence it leaks into the groundwater system. If the waste oil proved useful as a boiler fuel additive, it would no longer be thrown away. In short, the waste oil utilization system looked promising enough for Norris to develop on his own.

Norris had no trouble developing his waste oil product as such. The introduction of magnesium was accomplished simply by mixing the waste oil with a concentrated solution of water and epsom salts, a magnesium compound. Norris spent seven years getting his waste oil system patented and meanwhile tried to market it. He would approach the utilities whom he had been doing business with and who presumably knew him. Nevertheless, he had no luck in persuading utilities to buy his waste oil additive product.

It is not clear why the utilities refused to buy the product. The principal competitive product is a magnesium oxide powder which utilities usually buy in tank-truck loads, premixed with fresh No. 2 fuel oil. This may well be cheaper.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Norris learned about the inventors program from his Congressman, Rep. Ottinger, from New York. Norris had written to Ottinger during his effort to patent his formula.

At Ottinger's suggestion, Norris wrote to George Lewett, Chief of the Office of Energy-Related Inventions at NBS, and was sent an application. In due course, the product was evaluated first by George Washington University and Spectro Systems. A second-stage evaluation was conducted by the Army Mobility Equipment R&D Command at Ft. Belvoir. Norris hoped that a favorable evaluation and financial support would give the product enough credibility and prestige to persuade utilities to buy it. He also expected the government to actively promote the invention, which, of course, they did not do. Norris's expectations in this regard were totally unrealistic.

The process of getting the grant took two years, which irritated Norris. He was only the 13th grantee and couldn't imagine why, so early in the program, he had to wait so long. He kept after NBS, Ft. Belvoir, and Ottinger to make sure the application got all the way through. The delay frustrated him, and it soured him on the whole inventions program, even though he was pleased by the outcomes of the evaluations.

Experience with the DOE

Norris was awarded a grant of $50,000 for the purpose of undertaking a market study. Even so, his feeling about DOE was similar to NBS — sour. He was upset because he had to wait and because the government gave him no help. He noted that the government did offer him some leads in his marketing effort, but they were largely wild goose chases. Once he went to talk to TVA about using additives for oil burners; when he got there, he found their plants were 99% coal-fired.

In spite of his frustration with the slow pace of government action and the lack of promotional support, Norris would use the DOE program again and has, in fact, recommended it to others.

Participant's Assessment of the ERIP

Despite all of the above and a naturally sour personality, Norris appreciates the fact that he got money to market an invention that is really tough to market.

The best thing to come out of the program as far as Norris was concerned was the marketing money.

Norris claimed that waiting was the only impediment. There was no other block to his participation. Because he was one of the earliest applicants, he had a relatively clear field, even though he didn't appreciate it.

OUTCOMES

Current Status of the Case

Norris has actually made no progress in marketing his invention. Almost all of the government's money has been used, some of it to hire a salesman. But all is not lost, at least not yet. Norris has discovered that the residual sludge from re-refining waste oil works as well for his additive as the complete waste oil product. This would ease the collection problem considerably and might make it possible to produce the additive in large enough quantities and at low enough cost to attract utilities. So, currently Norris is negotiating with a plant in San Diego to use their sludge.

Tangible Outcomes

There are as yet no tangible outcomes — unless we count his hiring of one sales engineer, now gone.

Intangible Outcome

The intangible outcome seems negative. Norris has written several letters to Congressman Ottinger to complain about the ERIP.

INTERVIEWER COMMENTS

I have no comments that bear on the operation of the program beyond saying that, even at an early stage, the government tried to deal expeditiously and sensitively with this inventor. Nothing could succeed in pleasing a person of this sour disposition. The inventor, incidentally, demonstrated enough persistence to get his invention pushed through — but not enough to get it marketed. Until I interviewed Norris I would have argued that the inventor's persistence is a signal of future success.

I am tempted to agree with Glenn Ellis that this sort of idea would never be funded now.

In any event, Norris's invention and conditions of getting funded are anomalies. There is nothing inherently wrong with giving inventors money for marketing. Ordinarily the market effort does feed back on the development effort. As we see in the Norris case, the first invention, waste oil as an additive, wouldn't sell. That information fed back to generate another related "invention" — waste oil sludge as an additive. If that does sell, the nation will gain because it would ease an environmental problem — sludge disposal — through the market system rather than through regulation.

PARTICIPANT:	Sidney A. Parker (43) 5820 Diamond Oaks Drive South Fort Worth, Texas 76117
CASE TITLE:	Thermal Gradient Utilization Cycle
FUNDING LEVEL:	$40,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Arthur Ramseur Arthur Ramseur Consultants 12615 La Bahia San Antonio, Texas 78233

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Mr. Sidney A. Parker is a graduate of Texas A&M University with a B.S. in electrical engineering. He has done graduate work toward a master's degree, also at Texas A&M, and is a Registered Professional Engineer in Texas in mechanical engineering.

He worked for Texas A&M Research Foundation and Carrier Corporation and was employed as manager of compressor research and development as well as advanced research and development with Lennox Industries. With Lennox he established the present Compressor Research Laboratory in Fort Worth, Texas.

Mr. Parker is a prolific inventor. He holds 38 U.S. patents, primarily in the fields of refrigeration, refrigerant compressor design, power generation, self-power large heat conveying means, and low-temperature desalinization (distillation) devices. He has over 150 patents worldwide. He reports having received no state or federal assistance for any other project or invention other than the Thermal Gradient Utilization Cycle (TGUC).

Description of the Technology

The Thermal Gradient Utilization Cycle (TGUC) is essentially a closed looped cycle consisting of four distinct cycle functions as follows:

1. Heat is thermally pumped (vapor pressure pumped) to a higher cooler elevation where it is cooled and condensed giving up its heat and increasing its potential energy thus providing heating to the higher elevation.

2. The condensed cooled fluid from the higher elevation has potential energy which does work at the lower elevation.

3. The condensed cooled fluid from the higher cooler elevation when expanded removes heat from the lower elevation, thus providing cooling.

4. An independent optional Rankine work engine can be regeneratively coupled to the TGUC system. The Rankine engine can have the same or separate heat source but uses TGUC as a heat sink.

Mr. Parker envisioned the process (cycle) being used on a large scale to produce electrical power since TGUC is a land-based cycle and has about the same investment cost and bus-bar cost as the much talked of and funded ocean thermal energy conversion (OTEC) power generation system without the tremendous maintenance and life cost problems of OTEC.

He reports first thinking of the concept while recovering from back surgery and reading technical journals. He had two patents issued on the TGUC prior to submitting it for NBS evaluation and had invested five years of his time and $10,000 to $15,000 in personal capital.

He does not recall any technical or nontechnical problems with the process. He describes the process as being in an engineering design stage of development at the time he submitted it to the ERIP. He believed the primary potential application of the process was in large-scale power production.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mr. Parker recalls reading about the program in a technical journal, perhaps IEEE. He contacted his local U.S. Representative, Olin Teague, who then put Mr. Parker in touch with the appropriate people at the NBS. He recalls periodically hearing about the need for energy independence. He felt it a patriotic duty to submit his process for evaluation if it could help alleviate the energy crisis.

He expected that "by 1981 the U.S. would have a few large TGUC power plants to show to the Saudis." He expected the NBS to approve the process quickly, since it was covered by two existing patents. He first submitted the process to NBS for evaluation in May 1976. He recalls receiving an acknowledgment letter within two months. In November 1976 he and his wife flew to Washington to discuss the project. He talked with someone (he doesn't recall who) on the NBS staff, who said that his process wouldn't work. He persuaded the staff person to submit the process for evaluation. Parker said that during this time he had a WATS line available and he would call NBS, sometimes daily, to check the progress. He also reports having U.S. Representative Olin Teague call NBS several times.

In the spring of 1977, Tom Coultas took over monitoring his project. Mr. Parker reports an admiration for Mr. Coultas but states it was hard selling him on the process. (Mr. Coultas also reports an admiration for Mr. Parker's ability, but he felt the process might have significant technical problems.) Mr. Parker expected the NBS to recommend building a working model of the process. Instead, on September 30, 1977, the NBS recommended that the DOE fund a parametric computer testing of the process. The testing was also to include an evaluation of the economic feasibility of the process compared to other power generation means.

Mr. Parker sees no real benefit from the NBS evaluation, since he already had two U.S. patents covering his process. His worst experience with NBS was getting the evaluators to believe the process would work.

Experience with the DOE

Mr. Parker reports that he expected the DOE to override the NBS evaluation and to have the Corps of Engineers (or someone similar) build a working model of his technology. Instead, the DOE provided a $40,000 grant for further parametric and economic analyses of the TGUC.

The statement of work in the DOE grant includes the following:

> The detailed description of the work to be accomplished under the grant is contained in the attached proposal from Mr. Parker and the accompanying outline of the approach to be used at Texas A&M.
>
> The specific objectives of the study are:
>
> 1. To determine if it is technically feasible to use the TGUC for power production or replacement of an energy system in any of its proposed alternative applications.
>
> 2. To assess the economic feasibility of employing such a system for power production or replacement of an energy system by estimating the ultimate cost of the output.
>
> 3. To identify significant design parameters and define a technically and economically feasible design concept.
>
> 4. To recommend a demonstration facility configuration.
>
> The period of the grant is one year. Quarterly letter progress reports are required in addition to a final report.

The grant period was from September 16, 1978, to September 16, 1979. The study was completed by three professors in the Mechanical Engineering Department of Texas A&M University.

A scholarly final report detailing the analysis is available, which, Mr. Parker states, fully supports the technical and economic feasibility of his process. (Note: Mr. Aellen, DOE monitor, feels that the initial capital cost of a TGUC power plant is so high that no commercial user will be willing to venture these kinds of funds when other options — coal, oil, uranium — are still available.)

Participant's Assessment of the ERIP

Mr. Parker believes that DOE should provide a means for wide distribution of the final reports on approved grants. He also feels that the final reports should be evaluated by an independent group of scientists and experts to determine what future aid should be offered the inventor. He would like more marketing (commercialization) expertise, and he feels that it is DOE's responsibility to help get a proven technology into the marketplace.

Mr. Parker feels that the best thing about the DOE program is that someone had the foresight to set up this kind of program. In his words: "Someone at least understood the need." His greatest difficulty was the paperwork. As an example, he described his attempts to get a grant payment -- finding out where a check was in the system. (Note: Jack Aellen, DOE monitor for this project, reports that in the last year a special contracting office has been established to handle grants.)

OUTCOMES

Current Status of the Case

Essentially, the technology has been documented in the scientific literature, both by Mr. Parker and now by the final report from the DOE grant.

Mr. Parker plans on sending copies of the final report to any interested person, agency, organization, or government.

The final report to DOE includes discussions of

- the operating principle of an atmospheric thermal gradient system,
- a computer model of a TGUC system,
- a parametric study of TGUC,
- a low quality energy conversion unit (LQEC) using low-temperature heat other than atmospheric heat,
- economic analyses — cost input, life cost analysis, second law analysis,
- energy analyses — net energy analysis, second law analysis,
- conclusion,
- references,
- momentum and energy equations and their solutions,
- a computer program of the TGUC system,
- power generation cost estimations — customary method and life cycle cost analyses.

Tangible Outcomes

The grant resulted in computer software programs to simulate the process, an economic feasibility analysis, and a final report documenting the results of the study. In addition, Mr. Parker feels that more people know about the process. It has received the scientific blessing of the Texas A&M researchers who performed the technical and economic analyses.

Intangible Outcomes

Mr. Parker reports increased knowledge of how to obtain assistance from the government. He says that he also found that it is not easy to get a product or process into commercialization as he originally imagined.

INTERVIEWER COMMENTS

The NBS monitor, Tom Coultas, had not received or read a copy of the final report on this project. It would be beneficial to "close the loop" so that the NBS evaluator could see the final result of any grant made on the basis of his recommendation.

PARTICIPANT:	Donald R. Ross (76) 3344 South Grove Forth Worth, Texas 76110
CASE TITLE:	The Ross Furnace
FUNDING LEVEL:	$82,150
CASE STATUS:	Project Completed: Final Report Accepted
INTERVIEWER:	Arthur Ramseur Arthur Ramseur Consultants 12615 La Bahia San Antonio, Texas 78233

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Mr. Ross completed two years of college, majoring in geological engineering. He has worked 28 years for various companies in the private sector, primarily in the diatomaceous earth and perlite industries. He categorizes his jobs as research and development and sales. He is currently employed part-time as a consultant with Sil-Flo, a company with approximately 30 employees, which produces perlite. Since receiving the grant from DOE on April 1, 1979, Mr. Ross has spent the majority of his time developing his invention. This is the only invention Mr. Ross has developed. He has not received any other state or federal assistance on any other project.

Description of the Technology

Many minerals used in industry need to be heated to create or change their chemical or physical properties. Mr. Ross invented a process for heating, but not melting, mineral products. The types of heating are expanding, exfoliating, calcining, sintering, roasting, and drying. He has two types of furnaces as follows:

- Rotary calcining type (for large particles),
- Tilt flash calcining type (for smaller particles).

The idea for his invention evolved over the years as he worked in the perlite and diatomaceous earth industries. He estimates that before he submitted the invention to the Energy-Related Inventions Program, he had invested two years of his time and $30,000 of his personal capital. He had a working model of the invention at the time of submission.

Obtaining financing was his primary nontechnical problem (he applied for commercial as well as SBA grantee loans and was turned down). His technical problems included finding a method of sealing the firebrick into the plenum chamber and finding an abrasion-resistant surface for the burners.

He envisioned his invention being used to expand perlite, with the possibility of producing a hard, lightweight, structural concrete product which would have good energy insulating properties.

His furnace saves energy because the product actually sits on the burner, producing more efficient heat transfer and better use of radiant energy. He applied for a patent on this invention on April 14, 1977, and was granted U.S. Patent 4,263,163 on April 21, 1981.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mr. Ross recalls reading about the program in a commercial or technical magazine. He doesn't remember which one. He submitted his invention to the program in order to obtain money. He had tried unsuccessfully to raise venture capital and had been rejected for commercial and SBA loans. His expectations of the NBS program were to get a positive technical evaluation and hopefully a recommendation for funding to the DOE.

He remembers submitting the invention in April 1977 and not hearing anything from the NBS for 12-14 months. (Note here that documents in his file indicated he first submitted the request for evaluation to NBS in April 1977 and received his first correspondence in January 1978, approximately 9 months later.) His first letter indicated that he had passed the first stage review and would go to a second stage for evaluation.

During the remainder of the NBS evaluation, Mr. Ross recalls receiving periodic notification of his status in the evaluation process. He called his NBS contact (Mr. Howard Robb) several times and was called by the NBS monitor several times. He received notification that his invention was being recommended to DOE for funding on September 18, 1979, approximately 17 months after submission.

He feels he received no technical assistance during the evaluation process. He was not encouraged to talk to the second stage evaluator. It was his perception that NBS did not want a lot of communication between the inventor and the evaluator. In his words, "to keep me from selling my invention to the evaluator." (Note: Mr. Robb, NBS monitor, explained that NBS does not release the names of their evaluators to the inventor to keep inventors from harrassing evaluators. The evaluator, however, is free to contact the inventor directly or through NBS for any further information needed for a complete evaluation.)

Mr. Ross reports the greatest benefit he received from the NBS evaluation was confirmation from an expert source that he had a technically feasible idea. He sees his worst experience with NBS as the length of time required for the evaluation and the long time (nine months) before he received correspondence from NBS. (Note: According to Mr. Robb, NBS instituted a program in 1978 to notify inventors within three weeks that their inventions had been received, with an explanation of what to expect in the evaluation process.)

With the exception of the time required, Mr. Ross rates the NBS evaluation phase as satisfactory.

Experience with the DOE

Mr. Ross understood that the NBS report was a recommendation and that DOE would have to approve it. He expected both direct funding and technical assistance from DOE.

He received a direct funding grant of $82,200 for the period April 1, 1979, to April 1, 1980. The DOE also furnished a management consultant, Dr. Kiessling, from the University of Houston. He met with Mr. Ross twice. Ross reports that Dr. Kiessling was more familiar with high finance and didn't seem to know much about the special problems of inventors or innovators. Mr. Ross expected the consultant to have more technical knowledge as well as management and financial knowledge. He did not recall asking DOE directly for specific technical, management, or financial expertise.

He felt that his relationship with Patrick Donohoe, Chief of the Invention Branch in DOE, was the best experience with the DOE portion of the program. Ross describes Donohoe as "the most honest, straightforward person you could meet." He reports his greatest difficulty in working with DOE as not being able to talk frequently, in the field, to a person who was both technically and managerially knowledgeable about inventors and the innovation process.

The statement of work in the DOE grant to Mr. Ross includes the following requirement:

The grantee will build and assemble two systems: one for the tilt and one for the rotary furnace. Systems will be operated and tested for reliability and accuracy of control. Attention will be given to the permeability and resistance to wear of the porous ceramic brick used in the rotary furnace. Data to be collected during the tests include:

1. Temperatures in the furnance and air system.
2. Gas flow rate.
3. Material feed rate.
4. Weight of collected product.

Analysis of data will include estimated production scale BTU/time, production rates, fuel efficiency, energy balance, and material balance. The economics of production scale use of the Ross furnace will also be estimated. The grantee will submit quarterly letter progress reports and a final report on work accomplished under the grant. Grant period is for twelve months.

Inventor Assessment of the ERIP

Mr. Ross believes that communication with the inventor should be clear, especially at the beginning of the NBS process of evaluation. (Note: NBS now notifies an inventor within three weeks that the application for evaluation of his or her invention has been received and is being processed.) Mr. Ross believes that DOE should have field representatives who are technically or managerially capable who can establish rapport with the inventor and who can lead the inventor through the invention and innovation process.

He believes that DOE should use its influence to help inventors get to top echelons of business to assist in marketing the invention and to get help with specific technical problems using top industrial experts. He feels that the one-time-funding idea is not sufficient. He would like to see a reevaluation at the end of each grant period to see if further funding or technical assistance should be offered.

OUTCOMES

Current Status of the Case

Ross reports good progress in cementing materials (firebrick, etc.) together to withstand high heat. He also discovered a relationship between emissivity of product and heating efficiency and is satisfied that his process works. He has completed the test data required in the statement of work.

He has not yet solved the problem of product abrasion on the burner surface. He has tested several materials without success. He currently has working models of both the tilt and rotary furnaces and is working to find an abrasion-resistant surface for the burners.

He has plans to build a production-sized furnace for use in either the lime or perlite industry. He reports an expression of interest from a company in the field but no offer of funds for the furnace.

Tangible Outcomes

Ross reports having completed the testing required by the statement of work. He has two working models. He has solved his bonding (cementing) problem. While the project kept Ross "alive for one more year" during the grant period, now he is "broke" and working by himself.

Intangible Outcomes

He has further defined his abrasion problem and knows which materials won't work. He has gained a knowledge of surface emissivity, which, he states, is a key to efficiency of the furnace. He has found definite interest in his process in industry if the technical problem of abrasion can be solved.

INTERVIEWER COMMENTS

Mr. Robb, the NBS monitor, had heard nothing of the outcome of Mr. Ross's invention, nor did he appear to be involved with Mr. Ross after the invention was taken over by DOE. Mr. Robb appears to have some technical expertise in the area of Mr. Ross's invention. In fact, Mr. Robb asked this author to pass along some recommendations he had to Mr. Ross about using his furnace as a space heater for factories or to heat hot water in boilers.

It might be of benefit to the inventor and to the NBS for the NBS monitor to continue to act as a technical consultant during the DOE phase. In addition, the NBS could profit from seeing the final results of the DOE grant. This would close the information loop and allow the NBS evaluators to see which inventions and inventors were successful.

PARTICIPANT: Melvin Sachs (73)
Istech, Inc.
29200 Vassar Avenue, Suite 700
Livonia, Michigan 48152

CASE TITLE: Originally funded under name of U-Form Systems and Tech., Inc., now known as Integrated Concrete Technologies

FUNDING LEVEL: $87,230

CASE STATUS: Project completed; final report not yet submitted

INTERVIEWER: Lois Martin Bronfman
Energy Division
P.O. Box X
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Melvin H. Sachs is a 49-year-old registered architect, inventor, and entrepreneur. After graduating from the University of Michigan's architectural school with honors 27 years ago, his occupations have included registered architect; comanaging partner of Livonia Pavilion East (a major building designed by Sachs using integrated concrete technology); managing director of Caribbean Resorts, N.V.; President and Director of Sachs Associates, Inc., U-Form Systems & Technologies, Inc., and Istech, Inc.; real estate developer; inventor/codeveloper (with Calvin Shubow) of Integrated Concrete Technology; and inventor/developer of Integrated Construction Technologies.

In the development of his energy technologies, Mr. Sachs has been associated with a number of small corporations which he headed and which employed less than ten people.

Mr. Sachs has put most of his inventive energies into the development of Integrated Concrete and related technologies. He has four patents and six in preparation related to these technologies. In addition, he has a patent on a wraparound scuba diving goggle, which just expired. He was never able to commercialize this patent, but its principles are now widely used.

Description of the Technology

Integrated Concrete Technology is a building fabrication methodology utilizing permanent forms for the construction of reinforced-concrete buildings. The panels, which compose the form work for the reinforced-concrete structural members of the building, come complete with thermal and sound insulation, vapor barrier, fireproofing, and interior and exterior veneers. Other architectural components, such as windows, spandrels, caulking, and electrical wiring, can be included in the panels. Once concrete is poured into the form work provided by panels, a major part of the construction of the wall for a reinforced-concrete building is simultaneously complete. The panels remain in place, providing the exterior and interior veneers of the building, the insulating forms function to insulate the building, and the cured concrete within the panels provides support for the structure. Construction time to erect the walls of one story of a multistory building is approximately two days. Flooring for the next story can be installed within 24 hours after the wall panels are in place. There are two manifestations of Integrated Concrete Technology: U-Form, the fabricated system, employing light-gauge steel framing members, sheet goods-type veneers, and blanket (nonstructural) insulation; and Incotech, the molded system, which uses no framing members and employs a family of inorganic nontoxic, fireproof lightweight moldable rigid insulations. Because the form work for the concrete is permanent and the panels come complete with interior and exterior veneer plus insulation and other components, many steps in the construction process are simultaneously accomplished, eliminating the need for separate time-consuming, expensive construction activities. An important component of Mr. Sachs's invention concept is that Integrated Concrete Technology will substantially reduce the time for construction of a building as well as the cost. Energy conservation appears to be a by-product of the invention. It was not a deliberately sought-after goal from the start. Through demonstrations, however, the considerable energy-conserving qualities of the invention have received even more attention and continue to gain in importance after the energy crisis of 1973. It has been proved that new buildings constructed with this technology will use 40-50% less energy in operation. Documentation on the operation of the one eight-story 120,000-square-foot general office building constructed with Integrated Concrete Technology is being continuously compiled. The results indicate that the building regularly and consistently consumes only half the energy required by other comparable buildings not utilizing the technology.

While the grant was awarded to conduct tests on the Integrated Concrete Technology, there are two related technologies which were developing simultaneously during the funding process: Intech insulations and the Integrated Construction Technology. These additional technologies, while not specifically addressed on the original application and the work statement, have been beneficially affected by Mr. Sachs's involvement with the ERIP. Intech insulation is the family of inorganic, nontoxic, fireproof, lightweight, moldable, rigid insulations which is used in the molded panel manifestations of Integrated Concrete Technology but which also has a variety of other potential applications (e.g., pipe insulation, board stock, and fireproofing). Integrated Construction Technology is the application of the Integrated Concrete Technology with a specific architectural, engineering, and economic approach to maximize the benefits which are intrinsic to Integrated Concrete Technology.

Early research and development on the invention occurred while Sachs was president and director of Sachs Associates, Inc., a professional architectural-engineering-planning firm formed in 1958; and it continued as a direct consequence of Mr. Sachs's involvement in the design and construction of many subsidized housing projects in and around the city of Detroit. Constantly fighting the budget, Mr. Sachs found the process of constructing buildings frustrating, inefficient, costly, and time-consuming. In doing so he continuously sought out new methods to help reduce costs and overcome many of the traditional problems in the construction industry — specifically, fragmentation, indifference, and specialization — which, he believes, have always led to unnecessarily long construction periods and cost overruns.

> ...All we were looking for was a more efficient way to build buildings to assist us in our architectural practice which concentrated on low cost housing. You know we were continually fighting the budget and the systems available at that time were simply too expensive for these socially desirable, necessary programs.

Mr. Sachs explored the potential of masonry construction (in fact, he says, he literally wrote the first book on high-rise masonry construction in Detroit) but ultimately found that process unsatisfactory. Further research led him to a technology in Canada, Durisol, which utilized rudimentary permanent forms to make reinforced-concrete structures. Although the concept appeared to have the germ of the idea he was looking for, the specific technology had a number of drawbacks (including the fact that the forms were poor insulators), which led Mr. Sachs to design his own permanent forming system after a patent search in the United States. Over the next two decades the concept of Integrated Concrete Technology continued to evolve.

In 1972, in order to further the research and development of his invention, Sachs and his then copartner, Shubow, formed U-Forms International, Inc., which was superseded in 1976 by U-Forms Systems and Technology, Inc. This company continues today but only as the administrative entity for the license granted by it in 1980 on one of the inventions (the fabricated technology) to Universal Component Systems, Inc. In 1980, Sachs then formed Istech, Inc., to continue research and development on the other dimensions of his inventions. This firm presently employs Sachs, his wife, and several consultants. Sachs Associates, Inc., while still a legal entity, employs no people at the present time and does no work.

The research and development of today's technology did not occur without many problems and the investment of considerable time, manpower, and money. According to Sachs, there was virtually nothing in the research and development of his technologies that was <u>not</u> a problem. To illustrate, a major technical difficulty occurred when controversy developed over the use of foamed plastics as insulation materials in buildings. Sachs's original technology utilized urethane. When a previously granted approval for the use of urethane in his panels was revoked as a result of this controversy just days before scheduled construction of a major building project in Detroit, Sachs and Shubow were forced to redesign their panels. This they did, and from this effort came the fabricated panel construction technology. Subsequent efforts to find a fireproof moldable insulation led to the development of a new invention, Intech insulations, and the more advanced version of the moldable panel systems of Integrated Concrete Technology.

The investment of money has also been considerable. To quote Mr. Sachs, in the quest for funds:

> ...individual inventors...at one point or another...have had to resort to business associates, families, and friends. In my own case, at various times, the savings of my wife and children, even my mother, have helped support the effort.

Perhaps most difficult for Sachs was the problem of getting approval of his technology by the regulators of the construction industry. While several buildings have been built with the technology, each early instance involved a courageous act of the director of a local building authority. The institutional barriers to adoption were substantial, and Sachs needed a way to legitimize his technology in the eyes of the construction industry's gatekeepers.

The Integrated Concrete Technology is applicable to all kinds of buildings, even though original designs were for high-rise structures. The fabricated system is applicable in areas in which there exists an industrial infrastructure. The molded version, which utilizes inorganic nontoxic, lightweight, moldable, rigid insulation, is adaptable to areas all over the world because it can use indigenous abundant materials with insulating properties. As a consequence the technology has the potential of providing inexpensive housing quickly to areas of the world where there are major housing shortages. Moreover its energy-saving potential is substantial: existing integrated concrete buildings already meet the proposed U.S. Building Energy Performance Standards.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

In approaching the government for assistance in marketing his invention, Sachs utilized the professional talents of Rowan A. Wakefield, president of Wakefield Washington Associates. Mr. Wakefield is a management consultant who specializes in helping organizations (e.g., the State University of New York and many others) keep track of government grants and relevant legislation. Mr. Wakefield spent a number of months in 1975 looking for ways to help get assistance for Sachs. Initially, contacts were made with agencies that might utilize the Integrated Concrete Technology in construction projects. These avenues were unfruitful. A major problem was the government's rejection of "sole source" provisions: Sachs's invention had no competition to bid against it. Moreover, Sachs's invention did not fall within the areas of interest of any DOE program office. The ERIP, however, did offer an opportunity to get funding and, more important, validation of the concept, as well as potential publicity. In retrospect, validation of the concept and publicity were probably more important to Sachs than the funding, although both forms of assistance were hoped for from the beginning.

When Sachs applied for the grant, many of the major technical problems of the Integrated Concrete Technology had been solved. Mr. Sachs was at a point of limited production and marketing, and seven buildings had already been constructed utilizing the technology. Over the 3-1/2 years of the ERIP review, the technology continued to evolve. Intech insulating materials were refined, and the new versions of moldable panels using the lightweight aggregate insulations were introduced. In addition, a license for the fabricated panels was sold and Sachs went on to develop his Integrated Construction Technology. These developments were unrelated, however, to the activities required for participation in the ERIP.

While there were developments in the technology, these developments did not change Sachs's expectations of the program. His goal was to use the program to expedite the diffusion of his technologies through the validation of his basic concepts and publicity.

Sachs was very clear as to the function of NBS. He felt that if his invention got a fair shake, it would not be turned down and his technology would be validated. Even if the evaluation were negative, Sachs felt that the analysis and report would provide additional valuable information on which he could continue to build.

Although the three first-stage NBS reviewers initially rejected Sachs's application, an NBS review of the disclosure documents found that Sachs's technology was in a state of evolution and required a more comprehensive, in-depth analysis to provide an adequate evaluation of the technology. This in-depth review led to an eventual recommendation for funding. Although Sachs was not aware, until the process was complete, of these negative reviews, he now views the situation as evidence of the superior quality of the program managers at NBS. Sachs also found the NBS review staff responsive and courteous.

A major aspect of the NBS review process which Sachs did not expect was the time required to complete the process. Sachs's invention took 2-1/2 years to get through the NBS process. Because Sachs was dealing wth the government he expected some delays. However, the actual length of time was unexpected since NBS gave him the impression the time required would be short. The reasons for the long delay were unclear. Sachs responded quickly to all requests, and Wakefield maintained regular contact with the agency. In Sachs's perspective, the size of the staff, its work load, and illnesses were the most likely explanations for the delay. As for the service provided by NBS, the most important was the ultimate evaluation and recommendation. While Sachs did not learn anything new from the evaluation, the fact that the government reviewed and approved of his technology for funding was very important.

The NBS evaluation did, however, stress the need to "gain acceptance through the normal building procedures." To do this, the evaluation recommended that testing be done in the areas of fire performance, properties of materials, and durability of performance.

All in all, Mr. Sachs favorably evaluated the NBS side of the ERIP. He would not hesitate to recommend the evaluation process to other inventors. While he has an energy-related invention that he has not submitted for evaluation (Intech insulations), it is only because he feels that there already exists substantial private-sector interest in the technology.

Experience with the DOE

Mr. Sachs's expectation was that DOE would give him a grant, although he did know that there was a possibility he would not be a recipient. The typical grant amount was not known to him, and when he first submitted his work statement it called for approximately $300,000. In addition, the statement requested publicity and marketing expertise as well as fire and structural testing by nationally recognized laboratories. Glenn Ellis indicated that ERIP did not award grants that large and would not provide support for a marketing/advertising campaign. He suggested that Sachs focus on developing a structural design manual and in getting the fire and structural tests in order to "gain acceptance through the normal building code procedures." Sachs responded with a revised request for money ($87,230) and a work statement which concentrated on performing the fire and structural tests. From the time of the recommendation from NBS until Sachs received funding the process took one year. Altogether it took Sachs 3-1/2 years to get through the entire program.

Participant's Assessment of the ERIP

Sachs's overall view of the program is extremely positive. While he does not believe that his participation in the program was crucial to the development of his technologies, he does believe that government support has substantially sped up the process of commercialization for his technologies despite the time required for his project to get through the program. If there is one major fault with the program it is that, in Sachs's opinion, it did not go far enough in publicizing his invention. Sachs cannot understand why, for instance, after six years (3-1/2 years in the review process and 2-1/2 years to complete the contract under the grant) in the program, other offices in DOE did (and still do) not know of his inventions. Likewise, he perceives that greater effort should be made by DOE to transmit information on inventions to other agencies in the federal government or to the state governments. Such an effort, he thinks, would substantially improve the quality of the program and benefit the inventions that go through it.

Finally, for Sachs there is no one best thing about the program, because for him they were all related. The evaluation led to the money which led to tests and to invitations to the Dvorkovitz World Fair for Technology Exchange in 1980 and 1981. When pressed to compare the different benefits, Sachs concluded that while the money and tests were important, the "fact of the grant" and the opportunities which DOE gave him to publicize his invention proved even more important.

OUTCOMES

Current Status of the Case

In 1979 DOE awarded Mr. Sachs a grant of $87,230 for the purpose of contracting with Underwriters Laboratories, Inc., to perform fire tests and with Lev Zetlin Consultants for structural evaluation of testing of his invention, the Integrated Concrete Technology. The goal of these tests was to establish credibility for the technology which would allow it to be accepted through normal building code procedures.

While the final report on these tests is still not finished due to delays at Underwriters Laboratories, neither the DOE coordinator nor Sachs is concerned. The results of the tests are known to be positive. More important, as will be seen in the discussion of outcomes, Sachs made some important steps toward establishing the credibility of his inventions and publicizing them as a result of his participation in the DOE program. Mr. Sachs's future plans for developing the technologies are to concentrate on marketing and commercializing. He has never sought private venture capital for these technologies before but now has prepared a portfolio (or private placement memorandum) for seeking major investors to fund such expansion activities. He is currently seeking $2 million from the private sector to accomplish, among other things, the designing of the machinery necessary for the mass production of his panels and fabrication and delivery systems for his insulation. He is also engaged in developing a bid with Morrison-Knudsen Company, Inc., for a major construction project in Singapore which would utilize his Integrated Construction Technology on a massive scale.

Tangible Outcomes

In addition to having the structural and fire tests successfully completed with favorable results, Sachs received two invitations to participate, with DOE sponsorship, at the Dvorkovitz World Fair for Technology Exchange in 1980 and 1981. At the 1980 Fair, Integrated Concrete Technology received the Best of Tech Ex Award, and in 1981, Integrated Construction Technology received a Fusion Energy Foundation Award. While at the convention, Sachs made business contacts; subsequently, articles were written and new awards followed (e.g., the Inventors Club of America Hall of Fame Award). This exposure led to some important additional outcomes. To illustrate, at the 1980 fair Sachs made contact with the Spiroll Corporation of Winnipeg, Manitoba, which subsequently became the Canadian sublicensee to his licensee for the fabricated-panel system. This new business arrangement opened the way for marketing in Canada and other areas of the world.

In 1981, Sachs was again invited to "Tech Ex" after one of DOE's 1981 awardees dropped out. Outcomes of his participation included a number of business deals. First, a formal agreement for a sales and marketing agent of the Integrated Construction Technology throughout the world was made. Second, participation in "Tech Ex" and the awards reconfirmed and reinforced a previously arranged relationship with Morrison-Knudsen Company, Inc., and Banco Morgage Company, partners with Sachs in the development of Integrated Construction Technology projects. This new confidence has encouraged Morrison-Knudsen to bid on a contract for the construction of 20,000 dwelling units per year for five years in Singapore. These units, if the proposal is accepted, would be built using the Integrated Construction Technology approach.

Intangible Outcomes

As a result of his awards at the "Tech Ex" fairs, Sachs's technologies have received considerable publicity on television, in newspapers and magazines, and in energy newsletters. The effects of this publicity are important to Sachs.

INTERVIEWER COMMENTS

Sachs's experience with the ERIP represents a success story. While he is still at the limited production and marketing stage, he is much closer to his goal of full-scale commercialization of Integrated Concrete Technology and the implementation of Integrated Construction methodology. The program has contributed to his progress. It has supported the technologies by funding tests and reports by nationally known experts needed to establish credibility. By providing opportunities to display his technologies and by disseminating information, the program has helped place Sachs in a better position for seeking venture capital, to make new business contacts, and to publicize his technologies in appropriate construction industry networks.

Sachs did experience some difficulties with program operations which deserve attention:

- The time required for evaluation and funding, given his expectations, was too long. Sachs felt that NBS contributed to the problem by creating the expectation that the process would not take a long time. Information could be provided to inventors about the potential for delays in order to dispel future criticism.

- Sachs also lacked information about the size of the potential grant. Given his familiarity with the other parts of the program, this ignorance suggests a failure on the part of program managers to clarify, from the beginning, its possible size. This situation may be justifiable given the unpredictability of funding available from year to year; however, some effort could be made to describe the basis on which the grant size is determined.

- The cost of participating in the program was not cheap, given the size of the grant awarded.

- Sachs was very concerned that he might lose control over his invention if he received government support; at one point he thought of turning down the grant. The rights of the inventor were not made clear to him from the beginning.

Aside from these difficulties, Sachs found the program procedures to be reasonable and not particularly difficult. One must remember, however, that Sachs had a professional grantsman assisting him. In addition, his own experience working with municipal governments and FHA programs gave him considerable sophistication in dealing with government projects.

From a policy perspective, funding Sachs's invention was appropriate to the mandate of the program. Sachs was an individual inventor in a small firm with a basic potentially viable idea which, if implemented, could fundamentally change the construction industry and produce substantial reductions in energy use in all kinds of buildings.

When Sachs came to the program, his needs were mostly related to marketing. The program as administered, however, addressed only his R & D needs. Through assistance in the form of information dissemination and related activities, the program was flexible enough to also address his marketing needs.

PARTICIPANT:	David J. Secunda (46) 90 Prospect Hill Avenue Summit, New Jersey 07901
CASE TITLE:	Thexon Dehydration Process
FUNDING LEVEL:	$48,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Harold C. Livesay Virginia Polytechnic Institute and State University Blacksburg, Virginia 24060

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

David Secunda is a hybrid type. He holds a full-time job as corporate vice-president of the American Management Association in New York City, which has no direct relationship to his part-time activity as inventor and entrepreneur. Ironically, the Secunda case presents a clear-cut example of the ERIP not only achieving "one more step" but in the process also providing the inventor with a solution to a technical problem that baffled him, with the end result that the inventor has an invention that works but thus far has achieved no commercial success whatsoever. Secunda holds undergraduate degrees in chemical and petroleum engineering. The coinventor of his invention, Prof. Lloy Motz, of Columbia University (who played a major role in the invention's early stages), has a Ph.D. in chemistry.

Secunda worked 13 years as a petroleum engineer for major oil companies, shifted to management, then joined the American Management Association, a management educational nonprofit association. His position at American Management kept him abreast of the market for innovations. He knew, for example, that managers had been told in the early 1970s to be on the lookout for energy-saving technologies.

Prior to his involvement in the Thexon process, as Secunda calls his invention, he had no invention history, except for the development of innovative classroom techniques for management education.

Description of the Technology

The Thexon process removes solutes such as coffee from solution by spraying the solution and minute particles at high speeds through a special nozzle, resulting in dried coffee crystals. Unlike spray drying, which requires massive induced energy and a large working area, the Thexon process works at room temperature within a distance of 30 centimeters.

Prof. Motz "stumbled" on the Thexon phenomenon in his laboratory at Columbia. He could not explain it nor could distinguished colleagues he consulted. He took his idea to Secunda, whom he knew in another context. Secunda thus became involved because "the man walked through the door with an idea." Secunda, perceiving the potential marketability of Thexon as an energy-saver in the food processing industry, formed a group that set up a laboratory to experiment with Thexon. The other associates and Secunda have hung in there for 12 years and over $100,000 and no charges for time.

Secunda had an unusual problem. He had a process that worked and knew how to build the machine required, but he could not explain what happened in scientific terms. You sprayed the stuff, the solvent vanished, the solute emerged, but no one could say why, nor could anyone suggest a way to find out. All laboratory tests that Secunda could conduct provided no answer. He couldn't get potential customers to take him seriously because he couldn't tell them why the thing worked. He had no technical problem with the process itself but rather needed to find a test that would define the process. His nontechnical problems boiled down to a need for capital to find the right tests and run them.

Theoretically, the Thexon process could be applied to any operation requiring the removal of a solute from a solvent. To Secunda, the most promising application seemed to be in the food industry — coffee, sugar, potatoes — because Thexon's room-temperature operation avoided the application of heat that damaged flavor and nutritional values in evaporation and spray-drying methods. The other promising area was in the field of pollution control.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

One of Secunda's clients, a manager at Gulf and Western, told Secunda about the ERIP. Secunda applied because he desperately needed help in analyzing and articulating his process and hadn't been able to find it anywhere. Unlike my other interviewees, Secunda needed and wanted technical as well as financial assistance. He hoped someone in the ERIP would know a suitable laboratory that would explore the Thexon phenomenon.

NBS evaluators couldn't explain the phenomenon either, nor could they suggest who might; therefore, ultimately, NBS did nothing but recommend the project to DOE. Secunda, nevertheless, thinks highly of Sidney Weiser, who shepherded the project through NBS and ultimately wrote the final evaluation report. It was Weiser who called Secunda, told him NBS planned to reject the project at stage one, and arranged for Secunda to come to Washington to put on a demonstration.

With the exception of Weiser, Secunda thought NBS as a whole gave him the runaround. He grew impatient waiting for the evaluation process to go through and called Senator Harrison Williams of New Jersey. "Williams got it from the bottom of the pile to the top of the pile," says Secunda. "Without his help, I doubt if it ever would have come out." Secunda apparently spent a lot of time in Washington, on the phone, and corresponding with NBS (and later DOE), an expenditure of time he considers unreasonable.

Experience with the DOE

Secunda hoped DOE would find and fund a test process. Glenn Ellis found a laboratory (TRW) with a method (laser photography in picoseconds) that explained the phenomenon (it's evaporation), and the DOE grant paid for the tests.

Secunda finds DOE itself, as he finds NBS, bogged down by "bureau minds" more concerned with "pleasing the system than with delivering the goods." He thinks Glenn Ellis, however, a marvel — patient, concerned, knowledgeable, a sure guide through the bureaucratic jungle.

Inventor Assessment of the ERIP

Secunda tends to see his experience with the program — like his total experience of trying to cash in on Thexon — frustrating, time-consuming, vitiating to the spirit, and damned near enough to make a cynic of a saint. "If I'd had any idea what all this would involve," he says, "I wouldn't have let Motz through the door." When I asked if he'd made any other energy-related inventions, he replied, "You couldn't do more than one in a lifetime." As to ERIP, he admits that they took him "one more step" and that he couldn't have taken it without ERIP. But he also wonders what use a one-shot program is and thinks DOE would do well to carry through with some meaningful assistance in commercialization: publicity ("Get it on 'Sixty Minutes'"), subsidies to prospective buyers, or subventions to inventors to assist in manufacturing a prototype. ERIP's internal process could be immensely improved by accelerating the evaluation process at NBS. Secunda suggests that outside evaluations be abolished. "Just convene three Weisers," he suggests, "and let them decide. Take a chance. Hell, in the long run it would cost less, even if nine out of ten projects failed, than it now costs to pay for external evaluations....The bureau minds don't want to move things along. They want to cover their asses." (I didn't ask him for an anatomical explanation of the location of the ass on a bureau mind.)

Glenn Ellis, on the other hand, says that Secunda himself may have been to blame because he spreads himself too thin and "isn't much of an entrepreneur." Pat Donohoe and I agree that Secunda shies away from risk taking, but then, as Donohoe says, Secunda is a guy "with a lot to lose," or, to put it another way, Secunda may need success less as he's already achieved an unusual degree of it in his full-time job.

When asked to state the best thing about the program, Secunda cited Sidney Weiser, Glenn Ellis, and that ERIP produced the desired result.

The greatest impediments to participating in the program were the "bureau minds" and the bureaucratic maze. Secunda doesn't think the process could be gotten through without spending a lot of time in Washington and doesn't think anything would have happened without Senator Williams's help.

OUTCOMES

Current Status of the Case

During the contract period Secunda obtained a documented scientific explanation of the Thexon phenomenon.

Secunda now has a working prototype which is ready for production, but finds himself caught in the "prototype trap." No manufacturer capable of building an industrial-size Thexon apparatus will do so at a cost Secunda can afford, nor will they do it on credit unless Secunda has orders on hand, but he can't get orders because (1) he has no adequate-size machine that he can deliver and (2) major potential customers won't agree to sign secrecy agreements, which Secunda insists on as a condition for letting would-be users build and test the machine themselves. "I can get most of the *Fortune* 500 CEOs on the telephone in 5 minutes," Secunda claims, "But I'm beaten; I can't crack the system."

Secunda himself has no plans. He has turned the Thexon process over to A. D. Little for evaluation and possible development, in return for a 50% interest in the patent and the process.

Tangible Outcomes

No tangible outcomes have been identified.

Intangible Outcomes

One intangible outcome is that Secunda can now explain scientifically how the process works, information without which A. D. Little couldn't have been interested. He also thinks he has learned a good bit about politics, government bureaucracy, and corporate managerial conservatism, the last bit of knowledge he can put to use in his work at American Management Association.

INTERVIEWER COMMENTS

Secunda presents an intriguing case. Here's a guy for whom the system worked, although perhaps only with an assist from Senator Williams — but then that's what senators are for, among other things. Within the framework of the current ERIP policy and procedures, the program would seem to have functioned precisely as intended. Secunda's predicament raises once again the question of whether the strategy makes sense or should be extended to provide tangible assistance in commercialization, once the invention proves practical as an energy saver.

Finally, I can't help but wonder whether Secunda's not partly right about NBS. Maybe they aren't as good as they (and apparently most other people) think. Maybe they do in fact overcomplicate matters to preserve their own importance. (Smile, Max Weber.) Certainly Secunda's case shows the indispensable value of the Sidney Weisers and Glenn Ellises if anything is to get done within the bureaucracy.

PARTICIPANT:	Leonard G. Spelber, President (7) Wastemate Corporation 4830 View Ridge Avenue San Diego, California 72111
CASE TITLE:	Hydraulically Powered Food Waste Disposal Device
FUNDING LEVEL:	$28,000
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	Gerald G. Udell Gerald G. Udell & Associates 2265 Shields Avenue Eugene, Oregon 97405

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Leonard Spelber is president of Wastemate Corporation. Formerly known as Piranha Products, Wastemate is a small research and development and marketing firm. Its only product is a water-powered home food disposal unit.

Mr. Spelber, as is discussed below, is not the inventor of the device. He holds a bachelor of science degree in aeronautical engineering and has held a variety of engineering and managerial positions in both large and small firms. He has served as a consultant to a number of firms, including the initial owner of the water-powered food disposer. Since his involvement with this project, he has obtained an additional patent on the device and has applied for two other patents related to this technology.

Description of the Technology

The invention in this case is a hydraulically powered waste-disposal device. It utilizes rotary driven cutters which move in an oscillary cutting motion and operate in conjunction with fixed cutters. This is in contrast to the conventional pulverization method of food waste disposal. The energy-related feature of this invention is that it uses no electricity. It is powered by water at 30 pounds of pressure per square inch. In addition to projected energy savings of up to one per cent of home energy consumption, it is claimed the device is safer, eliminates electrical problems, provides more efficient disposal, reduces jamming, offers quieter operation, and is cost-competitive.

The device was invented in 1964 by Donald Verley of International Precision, Inc. (IPI). In 1972, an initial patent was issued. However, Verley and IPI decided to abandon the project because of financial limitations. They contacted Leonard Spelber, a part-time consultant, about acquiring the rights to the device. Late in 1974, Mr. Spelber established a California limited partnership, Piranha Products Company, to develop the device.

Mr. Spelber describes his initial problems as "money...money...money." In this instance the technology involved is state-of-the-art. His problem, prior to contacting NBS, was attracting sufficient capital to complete research and development, to purchase the necessary long-life molds and to launch his new product into the marketplace. A joint venture with Rheem Water Heater Division of City Investing Company (NYSE) in mid-1976 provided about $300,000 before it was terminated in mid-1978 with Rheem's decision not to expand their product line.

He knew what he needed and where to get it. His basic need was for money to move the new venture along.

In its current configuration the technology is limited to home and commercial disposal of food and other waste products. Other applications exist for the switching device (which is covered by the firm's second patent). However, the firm has no immediate plans to pursue their development.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

In mid-1975, Mr. Spelber was given a *Los Angeles Times* article about the Energy-Related Inventions Program by a friend. He contacted NBS, and in October he filed a submission. NBS recommended the device to DOE in August 1976. His reason for submitting is best summed up in his words, "Why not? It was just another way to go. I needed the money." His only expectation of NBS was a grant. As he put it, "I didn't expect the complicated process that was to follow." His only reported contact with NBS was receiving copies of the NBS letter of recommendation and the NBS final report. His experience with NBS was not negative. However, it wasn't strongly positive either. This seems to be based on a lack of contact with NBS, rather than on negative experiences. His major criticism of NBS was the ten months it took to complete the evaluation.

Experience with the DOE

Mr. Spelber's only expectation of the Department of Energy was a grant. In May of 1978, he received a $28,000 grant to pay for the preparation of a business and financial plan, the work to be completed within the next four months by a qualified management consulting firm. The purpose of the grant was to help the technology into full production. Fifty copies of the consulting firm's report were mailed to various venture capital firms.

Mr. Spelber's greatest difficulties with DOE were the 21 months it took to complete the process and the insufficient size of the grant. As he put it, "It was too much for too little." From the 50 copies of the business and financial report mailed out, not one inquiry was received. Mr. Spelber feels that the funding was insufficient to generate a business plan.

Participant's Assessment of the ERIP

The innovator's overall assessment of the Energy-Related Inventions Program is that it should continue. He made several specific suggestions for its improvement. The first was to shorten the time span at both the NBS evaluation and the DOE grant stages and he felt that much could be done to streamline the process. One of the worst impediments to the program for Spelber was the 31 months involved in getting through the evaluation and grant processes relative to the level of funding ($28,000 in this case). He also recommended that local (onsite) consulting should be made available by DOE after NBS approval. The function of the consultant would be to help the potential grantee define his or her true need and help frame the request (i.e., proposed work statement) to DOE.

In addition, he felt it would be helpful if NBS and DOE were to play a more active role in promoting approved devices. To Spelber, the best that could have come out of his involvement with the ERIP didn't. More important than the grant to Spelber was the publicity of being a successful DOE grantee. However, Mr. Spelber feels that much of this impact was lost because the initial DOE publicity failed to mention the name of the firm and its location. Finally, in the sense that no investors were attracted to the venture by the DOE funded business and financial plans the funds were wasted. He indicated that some form of an energy-related "seal of approval" would be particularly useful in getting tax credit status for this device. In addition, it would be of significant value in legitimizing his device with consumers.

OUTCOMES

Current Status of the Case

This project has been completed. The business plan called for in the statement of work was finished in 1978. The firm has generated about $2 million in venture capital through stock sale. The extent to which the DOE grant has played a direct role in raising the capital is uncertain. That is, the business plan failed to generate any interest from the venture capital market. Its impact on the SEC and/or the firm's new stockholders is difficult to determine. In any event the firm is poised, ready to move into full-scale production which is scheduled for the second quarter of 1982. In about four years, the firm plans to introduce a larger institutional-sized unit. During the review and contract phases with ERIP, the device moved from the working model stage, when NBS was first contacted, to the point of production and marketing.

Tangible Outcomes

The tangible effects of the grant were, according to Mr. Spelber, limited to the preparation of the business plan. No other tangible effects are traceable to the grant. The most important outcome for Spelber (publicity) was not achieved, and moreover, the financial plan failed to attract investors.

Intangible Outcomes

The intangible effects of the grant are a different matter. Mr. Spelber feels that the credibility generated by the grant and the NBS evaluation had a positive impact on his ability to raise additional capital through stock sales. This impact, he feels, made the grant worth while from both his and the government's points of view.

INTERVIEWER COMMENTS

Operational issues evident in this case are fairly obvious. The NBS and DOE procedures and policies should be reviewed with the objective of streamlining the process. The use of outside consultants should be considered if this task is undertaken. Mr. Spelber's recommendation that consultants be utilized to provide pregrant, onsite advice and direction should be given serious consideration. These consultants could be used to provide better definition to the statement of work to be accomplished under the grant and to provide DOE with a closer relationship with its grantees.

Policy issues are similarly fairly obvious. Mr. Spelber's assessment was that the grant provided him was inadequate to prepare an adequate business and financial plan. In this instance a strong case can be made for the position that a higher level of funding would have been a wiser (more effective and efficient) use of public funds.

Another policy issue is the extent to which both NBS and DOE should play a stronger advocacy role in promoting and otherwise assisting its clients. Mr. Spelber's recommendation for a "seal of approval" for approved devices is worthy of consideration. He is probably correct in his assumption that such a seal would help gain tax-credit status for his device and would be very helpful in assisting new energy-related products to gain acceptance in the marketplace.

PARTICIPANT:	Marvin L. Wahrman, President (79) DMC Technology 3015 S. Orange Avenue Santa Ana, California 92707
CASE TITLE:	Ablative Oil Well Bit Insert
FUNDING LEVEL:	$57,150
CASE STATUS:	Project completed; final report
INTERVIEWER:	Gerald G. Udell Gerald G. Udell & Associates 2265 Shields Avenue Eugene, Oregon 97405

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Marvin L. Wahrman, inventor of the ablative oil well bit insert and president of DMC Technology, is both inventor and entrepreneur. Eighty per cent of his college work (in mechanical engineering, finance, metallurgy, and material science) is at the graduate level, yet he holds no degrees, preferring to select courses to meet his needs as opposed to those prescribed in an academic program. His firm is small (he is the only full-time employee) and highly technical with research, development, and production of diamond cutting elements for the drilling industry.

In addition to and as a result of his current venture, Mr. Wahrman serves on the President's Energy Council, having been appointed by President Reagan in 1981. He also holds an equity position in another technological venture. Mr. Wahrman is no stranger to government grants and contracts, having been Chief of Contract Administration with a large aerospace firm.

Description of the Technology

The invention is a new composite rock bit insert made up of layers of complex microstructures, including tungsten and other carbides as well as cobalt, nickel, cubic boron nitride, diamond powder, and carbon reinforcements. As the softer base metals wear away, the harder abrasives are exposed. The new inserts are a replacement for tungsten carbide inserts used in rotary cone cutter bits for oil and gas well drilling. The new inserts are stronger, have sharper edges, and last longer than conventional types. As a result, down-hole life is extended, and drilling time is reduced by a factor of 3.

Mr. Wahrman's approach to invention has been highly focused. He reasoned that if down-hole drilling time could be reduced, costs would be lowered, and as a result, oil and gas exploration could be expanded. He decided to concentrate in that area and devoted 18 months to the study of drilling methodology and the needs of that industry. The result of his efforts was the ablative oil well bit insert.

Mr. Wahrman faced three basic barriers early in his venture. By the time he had finished his marketing research of the industry, he had a pretty good idea as to how to reduce drilling time. As he puts it, "I didn't try to reinvent the wheel, just redefine it." By borrowing technical know-how from other fields he invented his first diamond cutting element for the drilling industry. He now needed to produce and test his bit inserts. He lacked the financial resources to test his invention (the first barrier), and he needed to develop a manufacturing process. This second barrier is closely related to the first in that his basic need was for money to acquire the equipment needed for manufacturing and to buy the time needed to conduct the necessary basic and applied research. The third barrier was the attitude of industry. A prime example was when Mr. Wahrman was asked to testify before a Senate Sub-Committee against the sale of oil well drilling technology to the Soviet Union.

> Four Ph.D's from the industry testified against me in a closed hearing, trying to discredit my expertise. They actually laughed at me — said it couldn't be done...and what I had done to date was described in a four-letter word.
>
> The first stage evaluation by NBS was offered as partial evidence to Senator Jackson and Senator Percy for their evaluation. Specific questions were asked by the Senators of the four Ph.D's based upon data contained in the report by NBS. Within 10 minutes, the "so-called experts" were too embarassed to continue and asked to be excused. From that point on, the next three hours were devoted exclusively to my testimony against the sale and what damage it could cause the United States.

This technology has a wide variety of applications in the drilling and mining industries. The technology (i.e., the manufacturing process) also has other applications in ballistics and for materials processing in space. Other domestic uses exist as well, such as machine tool cutters.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mr. Wahrman does not remember how he first heard of the Energy-Related Inventions Program. He does recall, however, that he "was flat broke and needed money. I knew I had something. I needed a grant — seed money to kick it over...to get a needed facility." He is very supportive of the NBS: "They gave me encouragement by their very expert analysis in the latter-stage evaluation. It was very much appreciated." (This is particularly true when, as noted earlier, industry experts called his technology "a four-letter word.") He is totally satisfied with NBS. In his words, "On a five-point scale I given NBS a ten!" He has no reservations about recommending it to others and has done so "40 to 50 times." As he put it, "I'll shout it to the world."

Experience with the DOE

Mr. Wahrman says he didn't know what to expect at DOE. "Procedures were muddled. They got bogged down. They lost my package. I flew to Washington and found it on a secretary's desk while she was telling me that it was lost." His evaluation of the DOE process is that "it breaks down at the clerical level. Once it got to Glenn Ellis, no problem." He expected only a grant but says he has received much more: "Glenn is advising me of changes, new areas. They give me a lot of excellent interface with excellent people." He cites a display in the DOE lobby and his inclusion in the 1980 Dr. Dvorkovitz Technology Expo in Atlanta, Georgia, as examples of the technical exposure that he has received from DOE. In addition, he has received a lot of notoriety from having received the grant, and his work has led to his inclusion on the President's Energy Council. Also, DOE provided him with a contact at Sandia Laboratories. Sandia later supplied him with some valuable test data, which he estimates would have cost him $150,000 and considerable time to generate. His only complaint was the minimal level of funding. As he put it, "SRI (Stanford Research Institute) estimated it would cost $5 million for my project. I didn't get enough money ($59,000)."

Participant's Assessment of the ERIP

Mr. Wahrman believes that participation in the program has been critical to his continued existence. As he put it, "This is going to make me a very rich man someday. The potential is mind-boggling."

A strong supporter of ERIP, Mr. Wahrman sees no barriers to participating in the program. He did comment, however, that in the areas of contracts and patent rights, "DOE didn't know what they were doing."

Mr. Wahrman made a number of suggestions to improve the Energy-Related Inventions Program. He said that he "would increase funding 100-fold" and would "expand into all areas of need" and not limit the program to energy-related technology. He also suggested streamlining the process and reducing the amount of time from application to approval and to grant. He commented that he would put more into the first stage evaluation and would increase the budget to allow for closer (and better) attention to administrative details. All of this was mentioned to President Reagan during a telephone conversation.

OUTCOMES

Current Status of the Case

Project status has changed considerably since Mr. Wahrman first contacted NBS in January of 1977. As he put it, "The baseline has expanded tenfold. We are now in limited production. We can custom-build inserts with tailored properties for special applications." As noted earlier, DMC Technology has expanded its target markets and research into a number of new areas. In accordance with the terms of the work plan, DMC Technology is now engaging in limited production in its new rented facility. Laboratory and simulated field testing have been completed. Several oil wells have been drilled using DMC diamond cutters. Penetration rates were 300 per cent faster than with conventional bits. In addition, Mr. Wahrman claims that the bits gave longer life and higher reliability. As noted earlier, DMC Technology has expanded its research and manufacturing horizons considerably since its first contact with the Energy-Related Inventions Program.

In addition to limited manufacturing of bit inserts for oil and gas drilling, coal mining, and mineral and geothermal exploration, DMC Technology has expanded its high-technology R&D efforts in hybrid metal composites, diamond technology, advanced powder metallurgy, polycrystalline diamond particles, and high-strength reinforcements.

The firm intends to pursue basic and applied research, development, and manufacturing in the above areas. In addition, Mr. Wahrman recently received a small contract from the U.S. Army for ballistics research, and he has begun work on robotics for a new generation of coal mining machines. Mr. Wahrman now has the capability to tailor engineer his products in different configurations for the specific needs of his customers.

Tangible Outcomes

As a result of participating in the program, Mr. Wahrman has been able to continue and expand his efforts. As he put it, "The business survived." Important as the DOE grant has been into his project, Mr. Wahrman also considers the NBS encouragement and contacts as well as publicity generated by the program to be highly significant and tangible results of his participation in the program.

Intangible Outcomes

Perhaps the most significant results of the program were the encouragement and legitimization provided by NBS and publicity and contacts furnished by DOE. As noted elsewhere, these results have had some very tangible and significant effects. He has received a letter and congratulatory telephone call from President Reagan on his accomplishments.

INTERVIEWER COMMENTS

Several operational issues are suggested by this case. Although Mr. Wahrman is a strong supporter of the program, he expressed strong dissatisfaction with clerical procedures and what should be routine administrative procedures in contract administration and patent policy matters. His experiences illustrate the need for competent clerical and secretarial support — an age-old problem not easily solved in any organization. While time was mentioned as a negative factor, he did not object to the eight months it took to evaluate and fund his project. The problems Mr. Wahrman experienced at DOE may be symptomatic of inadequate administrative support for the program.

Several policy issues are raised by this case. Within the purview of NBS and DOE administration are the recommendations to increase stage one evaluation funds and streamline the process. Similarly, DOE must walk the fine line of meeting grantee needs but not necessarily their wants. Efficient stewardship of the taxpayer's dollar requires that DOE demonstrate both frugality and generosity at the same time. Funds should be sufficient to get the job done but should not satisfy non-essential wants and whims. Perhaps the policy should be to provide the level of funding that maximizes the return to the federal government. Determining this point is likely to be difficult, at best, and may prove to be beyond the state-of-the-art in many instances. However, this does not negate the appropriateness of a policy designed to strike a proper balance.

Two policy issues that can only be addressed by Congress are the level of funding provided to the program and Mr. Wahrman's recommendation that the program be expanded into nonenergy areas of need. The latter probably goes beyond the statutory limitations of Public Law 96-480, the Stevenson-Wydler Technology Innovation Act. There is much that could be done within the statutory limitations of Public Law 96-480; however, this legislation is currently languishing on the books for the lack of appropriations. Should Public Law 96-480 be funded, a strong tie should be developed between this legislation and the Energy-Related Inventions Program. To a limited extent, such a relationship has existed between the NBS Office of Energy-Related Inventions and several of the National Science Foundation's Innovation Centers. Greater utilization of these centers, particularly by DOE, is worthy of consideration.

PARTICIPANT:	Harry E. Wood (53) 6465 Oakland Drive New Orleans, Louisiana 70118
CASE TITLE:	Eldon Direct-Fired Gas Heating Systems
FUNDING LEVEL:	$72,600
CASE STATUS:	Project completed; final report accepted
INTERVIEWER:	James Petersen Center for Informative Evaluation P.O. Box 17600 Tucson, Arizona 85731

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

Harry E. Wood, inventor of the Eldon Direct-Fired Gas Heating System, received a B.A. in chemical engineering from Tulane in 1958. His training came largely from on-the-job experiences with numerous companies over the years.

His employment experience is varied. In addition to being a chemical engineer and quality control superintendent for such companies as Standard Brands, Hunt Foods, and U.S. Gypsum, he once owned his own machine shop. For the past ten years, Mr. Wood has been self-employed as an inventor, designer, and consulting engineer. He was the only person listed in the New Orleans telephone directory as an inventor; his job might be classified broadly as production and manufacturing engineering. He considers himself a "tinkerer."

As can be seen, Mr. Wood's employment experiences are varied and include working in several totally different industries (e.g., food, gypsum, oil field equipment, and energy). Within each of those industries his experiences also have been varied. Therefore, because of these diverse experiences, his familiarity with different technologies is quite broad. When the idea for an invention occurs, he is quite capable of designing it quickly with little, if any, outside assistance. One of Mr. Wood's jobs was to evaluate existing patents and to invent or discover other ways to do a job with a slightly different approach.

Mr. Wood has an extensive invention history. Most of his jobs involved designing and developing new devices. At present, he has only one patented invention, the Gas-Fired Water Heater. Over the years he was issued a patent on a chemical injector, a device used in the petroleum industry, and on a sand-wash device. In addition, he applied for a patent on a wrench; however, except for the Water Heater, he has not maintained any patents. He did this for two reasons. First, it is very expensive to get a patent. Second, "patent pending" protects the inventor to a great degree because until a patent is issued all information about the invention is kept confidential.

Overall, Mr. Wood estimates that he has designed about 20 products or processes — in all likelihood this number is greater. Most of these are being used in the industrial settings where he once worked. In some cases the companies patented the invention; in others they simply used it. None have been commercialized except for the Eldon water heater.

Description of the Technology

The invention, the Eldon Direct-Fired Gas Heating System, is a highly efficient gas-fired water heater for commercial and industrial use. The idea for this invention came to Mr. Wood when he observed that when water comes in direct contact with ice the energy cooling is extremely efficient. He thought that if hot combustion parts are contacted directly with cold water in a sealed water tank, the opposite would be true.

In order to accomplish this highly efficient heating, the inventor developed a method and design which blows a natural gas flame directly into a "rain of water."

Since he began developing his prototype, the principle behind this hot water heater has remained the same. Only various technical aspects of the invention have changed because he is a "tinkerer."

The principle of this invention is unique; the invention is 100% energy-efficient. Most hot water heaters are about 70% efficient (plus or minus 10%). In addition, the way in which the water is heated is unique. According to the inventor, it is the only water heater in existence that heats by this method.

Prior to submission to NBS, Mr. Wood states that he did not use external assistance to develop his invention. He built it by himself in his own back yard and put his own money into developing a breadboard model. He had the expertise to build the invention. And, while he did try to raise capital to build a prototype for installation in an apartment complex, he couldn't find investors.

Mr. Wood states that a few specific technical problems arose while he was developing a working model; however, these problems were readily resolved by himself. The main nontechnical problem was that he couldn't raise the capital necessary to develop and install the prototype in a 210-unit apartment complex.

The original application of the invention was intended to be in the home and small business market. However, because of the high cost of control parts and the fact that optimal savings are achieved by users who require large quantities of hot water, the application shifted to large industrial and commercial users who need large volumes of hot water. In its present state, it is strictly a large industrial and commercial product. In addition to the application of this technology to heating water, another application is in the heat reclamation industry. At present, Mr. Wood is marketing the Eldon heat reclamation system.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Mr. Wood attended a meeting of inventors and innovators which he and his attorney tried to get together — the American Society of Innovators of Technology. At that meeting someone informed him of the ERIP, and because he needed money to develop a production prototype and could not find financial backers for this project, Mr. Wood decided to approach NBS. The inventor did not approach NBS for technical assistance, since he believed that he already had the technical skills to develop the product.

In terms of Mr. Wood's expectations of NBS, he expected them to recommend that his proposal be funded. All he wanted was "to be able to build a unit, in practice, in operation and in an actual location, so that you can use that as a sales tool." He had no other expectations. He felt that his expectation was realistic, since he knew his invention worked and would save energy.

In terms of services provided to Mr. Wood by NBS, the money was the most important service. Although not exactly a service, the fact that Dr. Pershing's (second stage evaluator) report was favorable and he had the NBS "stamp of approval" proved very valuable in his later efforts to raise support. As he put it, when you are trying to get something off the ground, everything becomes important. He could not recall any other services provided to him by NBS.

During the evaluation process, Wood's invention was rejected only once; however, shortly before receiving the rejection letter, he had solved most of the problems on which the rejection was based. When he was told by phone that he was to be rejected because it wouldn't work, he said: "You're going to have a hard time believing this, but I've got it working on my carport. Do you want me to bring it to you, or do you want to come down here?" He was asked to resubmit his application and was subsequently funded. During the course of contact with NBS, the inventor states that his invention remained the same. It has not changed appreciably.

According to the inventor, the greatest benefit of completing the NBS technical evaluation process was being recommended for funding; the greatest problem was that it took too long.

In terms of his overall level of satisfaction with the NBS, he states that he is neither satisfied nor unsatisfied. With some aspects of NBS he is totally satisfied — namely, personal contact with NBS, clarity of the evaluation form, tone and wording of correspondence, and NBS attention to confidentiality. He is totally dissatisfied with the helpfulness of the evaluation (not because it wasn't good, but because he didn't need it to solve the problem) and the time required for the evaluation. In the latter case, it took NBS nine months to recommend funding of the project.

Since 1977, Mr. Wood has invented two energy-related products. Both of the products were submitted to NBS for funding. One, the hot water heater, was funded; the other was rejected. In the latter case, he will not resubmit it to NBS because he agrees that it is not a unique concept. Mr. Wood states that he would seek funding from the program in the future if he exhausts all other financial possibilities first; however, he also states that it wouldn't hurt to have many irons in the fire. He points out that the 14 months it took him to get funding would be a major deterrent and he would have to think carefully about waiting that long. In terms of recommending the program to others, he said he would, but he would have to point out two problems: the length of time and the small percentage of all applicants who receive funding.

Experience with the DOE

When the invention was recommended to DOE by NBS for support, Mr. Wood had one expectation: that it would receive an expedient positive evaluation and that he would receive the money. As with NBS, he had <u>no</u> expectations regarding technical or management assistance, information, testing, marketing, etc.

While it took a long time, he did receive the grant award, and in this respect his expectation was fulfilled. Also, as with NBS, the DOE "stamp of approval" and the fact that DOE thought enough of the invention to fund it were valuable marketing tools.

Mr. Wood describes his best experience with DOE as actually receiving the money. The worst experience was the length of time between receiving the notice of grant award and actually receiving the money. After waiting several months, Mr. Wood flew to Washington and proceeded to collect all the necessary signatures on the paperwork himself. He received his money shortly thereafter.

Mr. Wood states that he has not contacted groups, organizations, or individuals to obtain assistance in developing his invention.

In terms of his level of satisfaction with DOE, Mr. Wood states that he had nothing but good experiences with DOE. He has developed a positive friendship with some of the current and former staff of DOE, and for that he is grateful. If things could only be speeded up, it would be an even better experience.

Participant's Assessment of the ERIP

The inventor assessed the program quite favorably. The best part about the program was that he was able to take a small, basically fully developed, prototype and to build and debug a large working model. His main difficulty with the program was the time delay. His objection to the time delay is based less on impatience than on pragmatics. If it takes 14 to 18 months to fund an individual inventor or small business, then he believes that there is a good possibility that someone will beat him to the punch. Besides, an individual inventor can seldom afford financially to sit around and wait for funding. In some cases, the inventor may be off doing something else and may not have the time or commitment to the program.

In Mr. Wood's view, ERIP should do two things: First, don't over-evaluate. He does not understand why it takes so many evaluations by internal and external evaluators to decide what to fund. In his view, the evaluations should be very quick, "first cut" evaulations during which each proposal is given a rating of 1 to 10. Then those receiving higher ratings should be looked at more carefully than those with lower ratings.

Second, the inventor should be looked at not only in terms of his invention but in terms of his ability to get it into the marketplace. If the inventor doesn't have the ability to get it into the marketplace, then he doesn't feel it should be funded. From Mr. Wood's perspective, only inventions and inventors which have a high probability of achieving commercialization should be funded. In order to do this, one must look beyond the technical qualities of the invention.

OUTCOMES

Current Status of the Case

Mr. Wood was not funded to develop his invention, which was already developed, but to test a working prototype. The progress made during the ERIP program included building and installing an Eldon water heater in a 210-unit hotel located in New Orleans. He was able to debug his design and begin to market his invention to other people.

The current status of the technology is that it is fully commercialized.

A. O. Smith, one of the world's largest manufacturers of boilers and hot water heaters, has purchased the rights to manufacture and sell his invention worldwide. A. O. Smith estimates that within a short time period, the sales of the Eldon Direct-Fired Hot Water Heater will be in the multimillions of dollars.

He has no plans to develop the technology further at this time.

Tangible Outcomes

Mr. Wood was able to build and sell eight of his inventions. In addition, he has been successful in selling the design rights to a major manufacturing and distribution company which has sold five huge units for commercial plants.

Intangible Outcomes

The inventor developed a good friendship with the people at DOE and NBS. These friendships have been retained and, in some cases, will continue in the future. In general, the invention has made a difference in the knowledge base of the industry. Prior to funding, for example, many "experts" were saying that it couldn't be done. This increase in the knowledge base may have spin-off benefits for other areas and industries. In his view, the development of a totally new technology will have a number of spin-offs, and these are hard, if not impossible, to predict. For example, one spin-off is the application of this technology to the heat reclamation industry. At present, Mr. Wood is marketing the Eldon heat reclamation system.

INTERVIEWER COMMENTS

The key operational issues in this case study are the process whereby inventors are selected and the length of time required for the evaluation process. In this instance it took nine months from receipt of proposal to the point at which DOE received a positive recommendation from NBS. It then took four months to process the recommendation, to make a decision as to whether to fund the project, and to get the money to the inventor.

These are very real problems for an inventor when it takes a year and two months to make an award. The biggest problem for some may be staying alive. In the case of Mr. Wood, he wasn't working; he was devoting his full time to the invention. He had it fully developed, and all he needed was to build a real-life working prototype. Fortunately, he was able to hang on; however, others may be less fortunate.

The value of speeding up the ERIP evaluation process is that it may increase the rate at which products are successfully commercialized. As previously pointed out, time delays may mean (a) inventor loss of interest, (b) inventor loss of ability to partake fully in the commercialization of the product, (c) change in economic considerations which would be a barrier to commercialization, and (d) that an invention be usurped by another inventor.

The key policy issue is who and what should be supported. In the case of Mr. Wood, he already had a fully developed product. Funding was provided to install a working prototype in a real situation. This type of funding clearly worked. As a result, the inventor could more easily sell his invention because customers could see one in operation.

Is the above type of funding the most prudent use of federal money? In Mr. Wood's view it is.

PARTICIPANT: Michael Zinn (106)
Bio-Energy Systems, Inc.
221 Canal Street
Ellenville, New York 12428

CASE TITLE: SolaRoll

FUNDING LEVEL: $110,000

CASE STATUS: Project completed; final report accepted

INTERVIEWER: Harold C. Livesay
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061

THE ENERGY-RELATED INVENTIONS PROGRAM CASE

Program Participant's Background

The term "Schumpeterian entrepreneur" — implying someone who innovates — identifies Michael Zinn more appropriately than the term "inventor." Zinn creates no new technology; he specializes in buckling "off-the-shelf" components into new combinations to grasp market opportunities. Zinn describes himself — and Jack Aellen at DOE concurs — as a "marketing entrepreneur."

Zinn has three years of college training. He graduated from a technical high school where he learned plumbing, heating, and air conditioning. He acquired the rest of his knowledge on various jobs.

Following high school, Zinn held a variety of industrial and contractor's jobs, learning systems design along the way. While running a DOE-funded project that converted chicken manure to methane, he got the idea for SolaRoll, as he later called his invention.

Zinn held no patents prior to his SolaRoll project, although he said he made improvements on the methane gas equipment used in the project mentioned above. Although he previously worked on a DOE-funded project, he did so as an employee and had never before sought funding or assistance from any government agency.

Description of the Technology

SolaRoll uses EPDM (ethylene propylene diene monomer) synthetic rubber as the principal component of a flat-plate solar collector for use in home and industrial solar and radiant heating. SolaRoll's uniqueness stems from the fact that it's effective, cheap, and durable and can be installed by homeowners themselves. The EPDM rubber can be extruded into lengths as long as 50 feet, making it possible to construct very large collector plates without connecting plumbing that is expensive and subject to develop leaks due to weather stresses.

Zinn's interest in solar technology arose from his political opposition to nuclear energy. Based on experience gained on previous jobs, he concluded that EPDM had ideal characteristics for solar collectors. Cheap, readily available, extrudable, capable of withstanding extreme temperature ranges, EPDM had, as Zinn knew, found widespread industrial applications at temperatures through 400°F.

Zinn assembled the original prototype of SolaRoll in his garage with the help of some friends. In two years, prior to applying to ERIP, Zinn and his friends, using their own resources, had progressed to the point where they had manufactured and sold several prototypes.

According to Zinn, he encountered no significant technical problems prior to submission. His problems consisted, in his words, of "capital and credibility." His capital needs, however, did not relate to technical or manufacturing problems but rather to the problems of financing scientific testing that would attract attention to the invention and to the difficulties associated with promoting the product and building a marketing network. SolaRoll worked, but Zinn had no way to differentiate it convincingly from the flood of similar solar inventions appearing in the market.

Theoretically, at least, SolaRoll has unlimited potential in home and industry, with massive savings compared to conventional heating methods. SolaRoll comes in "do-it-yourself" kits that homeowners can install. Its low cost and high efficiency could make it equally attractive to businesses, but thus far sales have consisted primarily of home heating and swimming pool applications.

CONTACT WITH THE ENERGY-RELATED INVENTIONS PROGRAM

Experience with the NBS

Zinn thinks he read about the ERIP "in a journal." He applied hoping to get the funds necessary to finance tests to demonstrate SolaRoll's effectiveness. He too thought an NBS endorsement would enhance his credibility, specifically with the SBA, from whom he wanted (and ultimately got) a loan. Zinn wanted "quick action and an endorsement"; he didn't want or need technical help. Certainly his expectations of overnight results proved unrealistic.

Zinn found his NBS experience "a loser." As far as he's concerned, NBS provided no services except the ultimate endorsement, and that took an "unbelievable" length of time (13 months) to obtain. He says he not only received no technical help from the stage two evaluator but in fact never talked to him. The record, however, suggests that SolaRoll benefited from its passage through NBS, because NBS rejected it twice at stage one and once at stage two. Zinn counterattacked aggressively, demanding to see his entire file under the Freedom of Information Act, and the NBS correspondence hints that he had a word or two with his senators and congressman as well.

Zinn formally appealed all these negative decisions, and the NBS personnel, who apparently wanted SolaRoll to succeed for reasons of their own, helped Zinn marshall his arguments, rewrite his proposals, and assemble the demonstrations that eventually reversed the rejections. In this way, the people at NBS (Howard Robb particularly) probably contributed to the organized presentations needed to bring SolaRoll into the market. They may also have persuaded him to cool his jets a bit and learn some diplomacy.

Unsurprisingly, Zinn doesn't think much of the stage one or stage two evaluations. He admits his own presentations contributed to the failures at stage one but blames this primarily on the opacity of the bureaucracy and its regulations. The stage two evaluation he calls "an uninformed hatchet job." He regards stage three, done by Howard Robb, as a vindication of his original claim.

Experience with the DOE

Zinn didn't expect much from DOE, "just the check." As to what help he actually received, some discrepancy exists between Zinn's account and DOE's. Jack Aellen says that NBS recommended only that DOE furnish money for testing but that Zinn "wanted marketing help and that's what he got." Zinn doesn't see the distinction, since he thought the test results would serve only to support the marketing process, not to improve SolaRoll's technical content. Zinn ran the tests as the work statement prescribed, and, in addition, DOE arranged for his participation at trade and inventor shows, experiences he describes as "helpful at the time, but in the great cosmic mass of things, irrelevant." It's worth noting, particularly in view of Zinn's general assessment of DOE (below), that he subsequently received a $350,000 SBA loan at 7% with DOE assistance.

Zinn doesn't think much of DOE. He says it was impossible to find anyone at DOE except for Pat Donohoe who gave a damn about him or his project and that the process took far too long (one year from NBS approval to DOE funding). He wouldn't advise anyone else to apply to DOE and wouldn't go through the process again himself except as a last resort. He has, he says, no staff to spare for deciphering agency requirements and finding a path through the bureaucratic maze. DOE, he thinks, finances the research of his "multinational competitors" who have whole departments that specialize in dealing with the government.*

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*Having reviewed the above text, Zinn made the following comments in a letter to Jon Soderstrom, 1981.

> Although I expressed certain dissatisfactions, they were more of a constructive nature than the impression creates. I believe that the NBS report certainly helped us get the SBA loan and possibly was instrumental in that. I also believe that the NBS brought us a lot of credibility that we would have had to work very hard to create independently. I do believe delays that we experienced forced us to be so resourceful that our survival was virtually assured in any event in one form or the other. Nevertheless, we did get certain shots in the arm from the report itself, the SBA loan and the $110,000 contract. The marketing consisted of sponsorship at certain technology exhibitions which we certainly appreciated but cannot attribute any sales to.

Inventor Assessment of the ERIP

Zinn thinks that the best thing about the program aside from the money, was that it taught him his company "had to stay lean," depend on its own resources, and not rely on outside help. I suspect the demands for better presentations, particularly at NBS, helped him get his overall act together.

The bureaucracy, with its indifference and bewildering maze of indecipherable regulations, the incompetence of the second-stage evaluator (Zinn's opinion does seem confirmed, if genteelly, by Howard Robb's stage two statement), and the time required combined, in Zinn's mind, to make the program one massive impediment.

Even with this negative view, Zinn thinks the original concept of the program is excellent. He feels, however, that the time required from submission to approval is so long that it negates the benefits. A cost-benefit analysis applied to the current program as opposed to using the same time and energy to pursue alternative sources of aid comes out negative for the ERIP. The program could serve an enormously valuable function, in Zinn's opinion, if it would finance continuing research by proven small producers like him, even if it did so in the form of loans.

OUTCOMES

Current Status of the Case

Zinn's company, Bio-Energy Systems, made considerable progress during the period of ERIP contact. It achieved volume manufacturing and sales (over $4 million) in the United States and abroad, went public with a $2.5 million stock issue, and turned a profit three consecutive years. The problem is to know how much of this to ascribe to the ERIP. Zinn admits that the NBS endorsement, the test results, and the SBA loan helped some, but he claims the process took so long that success had been assured before the grant came through. The DOE coordinator thinks the program played a more significant role. Involvement with ERIP caused no significant technical changes in SolaRoll.

Zinn has acquired or applied for eight more patents for various aspects of his process, but he plays his cards close and will say only that SolaRoll has to be and is continually improved to stay abreast of its competitors.

Zinn's plans have less to do with making technological improvements and more with finding wider market applications — in particular devising radiant heating systems to install in new home and factory construction.

Tangible Outcomes

Tangible outcomes include: tests completed, SBA loan, appearances at inventor and trade shows. All other outcomes, Zinn thinks, resulted from "my own resources."

Intangible Outcome

The intangible outcome in this case is Zinn's negative view of the functioning of government bureaucracy.

INTERVIEWER COMMENTS

Zinn's hostility toward the federal government — it's the old-fashioned liberal Democratic brand, not newfangled conservatism — certainly colors his view toward ERIP. Some of his criticisms, however, have merit. Eighteen months does seem a long time for the NBS evaluation process, even given the rejection and delays at stages one and two. Technological innovations are innately perishable, particularly in the hands of independent inventors, a fact that ought to be translated into a more celeritous handling at NBS.

Zinn's experience with the stage two evaluation suggests that the roseate description of NBS evaluators shepherding their inventors toward success may in fact be punctuated by the occasional incompetent or misanthrope among the contract evaluators. Certainly Zinn's eagerness for and use of the NBS endorsement shows that the agency's reputation carries great weight in the inventing community, but Zinn's opinion of NBS as a whole (as opposed to his view of Howard Robb in particular) deteriorated as a result of his experience. If that reaction turns up in a significant proportion of the sample population, it may be that NBS has a problem: alienating one of its constituencies.

Although Zinn might not agree, Jack Aellen thinks, and I concur, that ERIP did in fact move SolaRoll "one step closer," although it seems that Zinn might have succeeded (as he claims) without ERIP's help. In terms of the "one step closer" policy, the Zinn case counts as at least a partial success. Zinn himself, like my other two inventors, questions the wisdom of that policy, arguing that if the government wants genuinely to aid individual inventors, "one step" simply isn't enough.

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