



3 4456 0452304 0

**ornl**

**OAK  
RIDGE  
NATIONAL  
LABORATORY**

**UNION  
CARBIDE**

**OPERATED BY  
UNION CARBIDE CORPORATION  
FOR THE UNITED STATES  
DEPARTMENT OF ENERGY**

---

---

# **The Energy-Related Inventions Program**

---

---

## **An Overview of the Evaluation**

E. Jonathan Godarstrom  
Lola M. Brozman  
Marcia L. Florio

OAK RIDGE NATIONAL LABORATORY  
CENTRAL RESEARCH LIBRARY  
CIRCULATION SECTION  
4300A ROOM 173  
**LIBRARY LOAN COPY**  
DO NOT TRANSFER TO ANOTHER PERSON  
If you wish someone else to see this  
report, send in name with report and  
the library will arrange a loan.



**ENERGY DIVISION**

**The Energy-Related Inventions Program: An Overview of the Evaluation**

E. Jonathan Soderstrom  
Lois M. Bronfman  
Oak Ridge National Laboratory

Marcia G. Rorke  
Mohawk Research Corporation  
Highland Park, Illinois 60035

Date Published: September 1983

Prepared by the  
OAK RIDGE NATIONAL LABORATORY  
Oak Ridge, Tennessee 37830  
operated by  
UNION CARBIDE CORPORATION  
for the Small-Scale Technology Branch  
U.S. DEPARTMENT OF ENERGY  
under Contract No. W-7405-eng-26

LOCKHEED MARTIN ENERGY RESEARCH LIBRARIES



3 4456 0452304 0



# **The Energy-Related Inventions Program: An Overview and Assessment**

***The Energy-Related Inventions Program provides support to independent inventors and small businesses with promising energy-related inventions for purposes of moving these inventions closer to the marketplace.***

---

## **Highlights of the Energy-Related Inventions Program**

The Energy-Related Inventions Program (ERIP) is a small program with a budget of about \$5 million per year, jointly administered by the U.S. Departments of Energy and Commerce. Since ERIP's inception in 1975, the Department of Energy has awarded grants totaling \$12.8 million for 165 of 208 inventions recommended by the National Bureau of Standards (NBS).

Of the 165 inventions, 46 have been able to acquire follow-on financing from a variety of sources, accumulating a total of \$48,855,000. Further, 35 of the inventions have reached the marketplace, and their cumulative sales to date total \$178 million. An additional 10 inventions are now starting into production. Jobs that have been created directly by production related to the inventions total 756; additional spin-off jobs attributable to the inventions include component and material suppliers, jobbers, franchisees, and distributors.

The combined investment and sales figures yield a leverage ratio for ERIP funds

of 17.5:1. This leverage ratio compares very favorably with the 10:1 ratio of the National Science Foundation's Small Business Innovation Research program and the Department of Commerce's Technology Commercialization Centers.

The program was recently evaluated at Oak Ridge National Laboratory, with the following conclusions:

1. The evaluation process at NBS has been successful in identifying technically and economically feasible inventions.
  2. The success rate for the program is about equivalent to the reported success rates of private venture capital firms.
  3. The program is supporting inventions at a point in their development where they are supported by neither the venture capital community nor industry.
  4. The one-time DOE grants and the associated ERIP support to inventors have been successful in readying inventors for follow-on financing from the private sector.
-

# The Energy-Related Inventions Program . . .

---

The Energy-Related Inventions Program (ERIP) is a federal program intended to stimulate innovation in the energy field *by individuals and small companies*. The program was established by Section 14 of the Federal Non-nuclear Energy Research and Development Act of 1974 (P.L. 93-577). The goal of the Act is to enlist scientific and technological capabilities so that the nation's future energy needs can be met. To accomplish this goal, Congress directed that the President "establish and vigorously conduct a comprehensive national program of basic and applied research and development..."

The objective of ERIP is defined in the Act as "... the evaluation of all promising energy-related inventions... for the purpose of obtaining direct grants from the Administrator" [the Department of Energy (DOE)]. The program is directed to give "particular attention to the evaluation of all promising energy-related inventions, particularly those submitted by individuals and small companies..." The emphasis that Congress intended individual inventors to be

given is underscored in Section 7 of the Act, which states that the program should provide "incentives, including financial awards, to individual inventors, such incentives to be designed to encourage the participation of a large number of such inventors."

The National Bureau of Standards was directed to evaluate the inventions and advise DOE of all those found to be promising. It was anticipated that support for the inventor could come from any DOE program office, but the primary source of support has been grants administered by DOE's ERIP office.

In practice, NBS evaluates all submitted inventions and recommends to DOE those inventions considered "promising", based on their feasibility and intrinsic technical merit. DOE reviews all recommended inventions to determine if federal assistance can be provided, then negotiates the terms and conditions of each project and administers the support.

In the past, support has been primarily a one-time-only cash grant and technical

assistance. Now support is focused on helping the inventor get private-sector financial support, because of the limited availability of public funds.

The important characteristics of the program are:

- a target audience limited to individual inventors and small companies with energy-related inventions;
- a broad definition of "invention" that permits consideration of innovations as well as inventions;
- acceptance of technologies at any stage in the research and development process except "idea generation" and "full commercialization";
- in-depth evaluation of the intrinsic technical merit of inventions;
- support in the form of an NBS evaluation and financial help either by a small grant used for a task designed to move the invention closer to commercialization or assistance in obtaining private-sector financial support.

## **JAMES A. BAGBY**

Jim Bagby is a coal miner. He has a high school education and has worked most of his life in Kentucky coal mines. His job in the mines involved building brattices—walls by which mine tunnels are sealed against the passage of air or other gases.

Bagby's invention grew out of his work experience: he had an idea for a better

brattice and he built it. He has no other inventive history and has received no other government funds.

## **BAGBY BRATTICE**

The Bagby Brattice is a metal stopping that yields under roof and bottom pressure. The stopping consists of two horizontal,

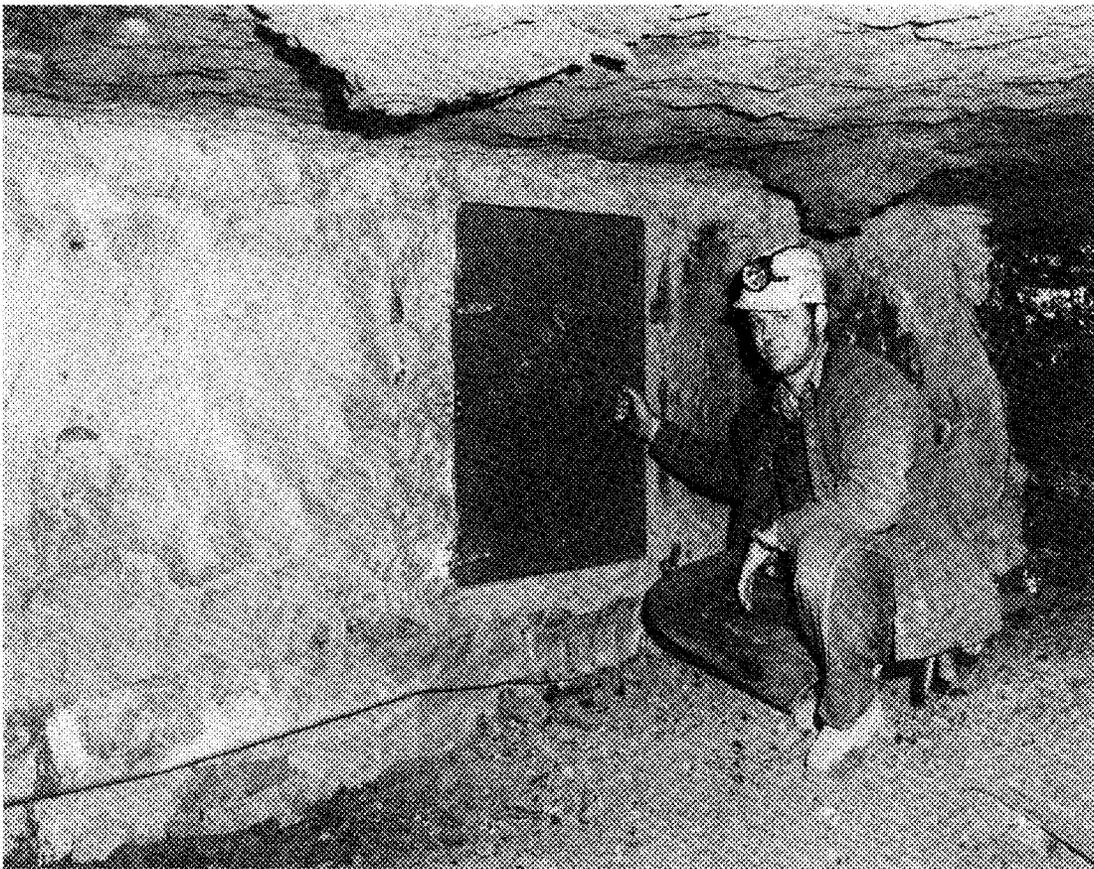
*James A. Bagby with his invention, the Bagby Brattice*

overlapping sheets of annealed aluminum sheeting attached to a metal frame that corresponds roughly to the configuration of the mine entry to be closed. Telescopic posts with shear pins permit the metallic sheets to slide by each other during roof and bottom movements. The metal sheets can be bent to conform with the configuration of the opening. The telescopic posts, supported by anchoring brackets, are inserted directly into the roof, rib, and floor.

While the more commonly used masonry materials provide a fireproof permanent stopping with adequate wall strength to accommodate ventilating air pressure differentials, costs of material, hauling, and installation are substantial. Moreover, because masonry stoppings do not yield, they often collapse because of extreme compressive forces caused by roof sagging and floor heaving. When the masonry stopping collapses, fresh air sometimes is cut off and work halts until the stopping is rebuilt.

Potential applications of the brattice in the mining business are far-reaching, because it can be used in all types of mines to improve ventilation. Other applications involve related uses based on 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 an alarm sensor that indicates roof or floor movement in a given mine location.

The device was conceived and developed during 1974 and 1975, when Bagby worked as a brattice builder. He thought that he had



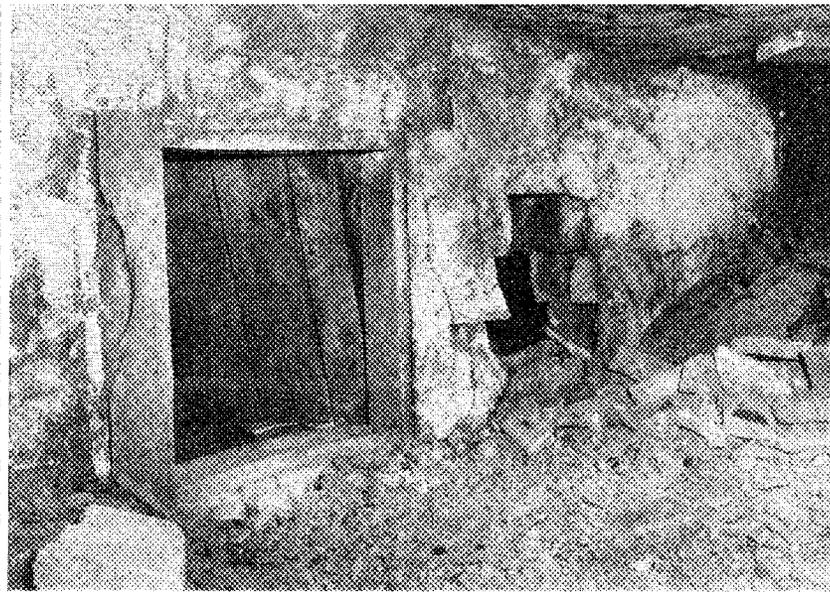
made a novel contribution to the field of mining and mine ventilation but was not certain that the brattice was quite as unusual as he hoped. Therefore, he submitted the invention to ERIP in the hope that NBS would consider and test it; if it was found that the brattice was indeed a revolutionary idea, he would try to market it on a larger scale.

Bagby's invention was in the prototype development stage when it was submitted to ERIP for consideration. He was awarded a grant of \$62,664 to manufacture 25 prototype brattices, install them in a mine, and test their performance over a period of 2 1/2 years. The tests were positive, and the invention has entered a limited production and marketing phase.

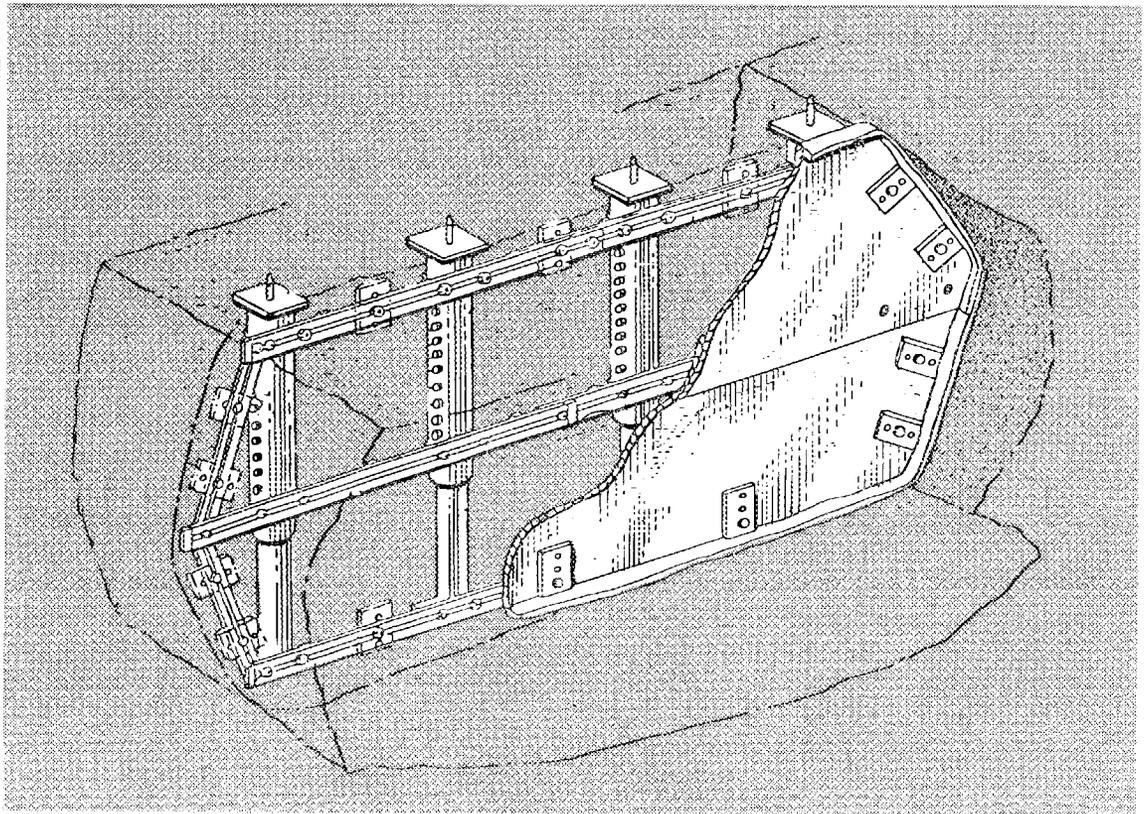
Since the grant, he has:

- acquired business partners and begun to actively market the brattice;
- gained credibility for his invention in the mining industry (an article praising the brattice, written by a ventilation specialist with Peabody Coal Co., was published in *Coal Age*); and
- totalled \$150,000 in sales in 1982.

*The Bagby Brattice is a lightweight, portable, metal stopping used in mines to control ventilation. Made from aluminum with telescopic posts, the brattice is cheaper, easier to install, and not as prone to collapse as the more common masonry stopping.*



*A Bagby Brattice in place in a Peabody Coal Company mine in Kentucky*



## Provides support . . .

---

In response to the Congressional mandate, a program was jointly established in the Energy Research and Development Administration (now DOE) and the National Bureau of Standards (NBS). Each agency provides a unique service to the submitted invention. NBS evaluates all submitted inventions and recommends to DOE those inventions considered relevant, feasible, and having intrinsic technical merit. DOE reviews all recommended inventions to determine if federal assistance can be granted and negotiates the terms and conditions of support for each invention.

### **National Bureau of Standards**

The Office of Energy-Related Inventions (OERI) was established at NBS to conduct the evaluation of submitted inventions. During the eight years of operation the staff size has fluctuated between 15 and 28; as of May 1983, 19 persons are employed. Of these, seven are evaluators, nine are evaluation support personnel, and three are administrative. In addition, NBS maintains an active list of 250-300 consultants, from both government agencies and the private sector. The consultants include university faculty members.

The annual budget for NBS has ranged between \$1.5 million and \$2.5 million.

Approximately 45% of the budget is used for evaluation, 35% for evaluation support operations, and 20% for supplementary activities. These include program development and special efforts to improve the quality of submissions. Improvement efforts currently include sponsorship of the National Innovation Workshop series, inventor information resource centers, and the formation of the National Congress of Inventor Organizations.

The NBS evaluation process begins with the completion and submission of NBS Form 1019, accompanied by an invention disclosure and supporting material. NBS Form 1019 requests data regarding the source of the invention and contains a Memorandum of Understanding that sets forth the conditions under which NBS will accept an invention for evaluation. All technically feasible energy-related inventions, except those which are nuclear-related, are forwarded for first-stage evaluation.

In the next step, OERI either accepts the evaluation request or does not. The decision is based on whether sufficient information is made available for evaluation and a determination that the idea is not obviously fallacious and is within program scope as non-nuclear-energy-related. All acceptable inventions are forwarded for first-stage evaluation.

The first-stage evaluation is a technical screening of the invention's merits based on criteria of technical feasibility, energy conservation, utilization, or production potential and commercialization/utilization potential.

The purpose in first-stage evaluation is to identify promising inventions for thorough analysis in second-stage evaluation. In coming to a decision as to whether an invention is "promising", the OERI evaluator makes use of an extensive consultant network in addition to other information sources. The rule is to obtain brief opinions from at least two consultants; these are obtained sequentially and independently. As each consultant opinion is received and reviewed, the NBS staff evaluator determines whether the invention should be given another first-stage assessment, rejected, or forwarded to an in-depth or second-stage evaluation.

If another assessment is needed, the invention is sent to a different consultant for an independent first-stage review. Only the NBS staff evaluator assigned to the project has access to all review data. Most inventions receive two independent reviews at this stage.

If an invention does not warrant further review, the key reasons for rejection are identified by the NBS staff evaluator and

---

given to the inventor in a letter signed by the NBS program chief. NBS is willing to reconsider its position if the inventor can provide sufficient additional information to justify reconsideration.

If an invention appears to be promising, it proceeds to the fourth process step, second-stage evaluation. In the second-stage evaluation, an invention is analyzed in depth by a consultant with expertise in the appropriate technical field. This individual is asked to assess the technical and/or commercial feasibility of the invention, as well as its potential energy impact, and to report these findings to NBS. Upon receiving this analytic report, an NBS staff evaluator conducts the evaluation and decides whether to recommend it to DOE. If the merit of the invention is still in doubt, NBS may elect to obtain another second-stage consultant review.

If the invention is rejected, the consultant report is sent to the inventor with a letter signed by the program chief, explaining the reasons for the rejection. As in the case of a rejection after a first-stage evaluation, an inventor may request reconsideration if he or she provides additional information upon which to base another evaluation.

When an invention receives a positive second-stage evaluation, a report is

developed which contains the material provided by the inventor, all evaluation results, and a case summary. The case summary particularly addresses what needs to be done next to validate the NBS findings and/or to further develop or commercialize the invention. The report then is forwarded with a letter of recommendation to DOE.

A statistical summary of the NBS evaluation of inventions is given in Table 1.

**Table 1. NBS invention evaluation statistics**

Inventions submitted for disclosure review	19,000
Forwarded for first-stage evaluation	9,000
Forwarded for second-stage evaluation	~ 1,000
Recommended to DOE	225

### **Department of Energy**

NBS forwards recommended inventions to the Energy-Related Inventions Program in DOE's Office of Conservation and Renewable Energy. DOE reviews all recommended inventions to determine if federal assistance can be granted and negotiates the terms and conditions of support for each invention. During the first year, the program operated with only one person on the staff. Over the years, the staff has expanded to the current level of

six persons: four full-time and two part-time. The annual DOE budget has ranged, over the years, from \$1 million to \$3 million.

Once an invention has been received at DOE, it is assigned to an invention coordinator. The coordinator sends a letter to the inventor advising that the invention has been recommended for consideration for federal support and outlines potential forms of support that are available. The letter also requests information from the inventor about:

- the necessary research and development work still to be completed,
- the nature and extent of the principal market(s) for the invention,
- the stage of development of a business plan, and
- the anticipated role the inventor will play in the development and commercialization of the invention.

When the inventor's response is received, a work statement is negotiated that outlines the support to be provided by DOE and the conditions for that support. The form of assistance is determined by information provided by the inventor, the NBS evaluation of the invention, a review by a project manager in an appropriate DOE technical program office, and the availability of funds.

In the past, the primary form of support has been a "one-time-only" grant to the

inventor to perform the "next step" in the research and development process, as agreed upon in the work statement. Typically, funding was for research in one of the following areas:

- feasibility and proof-of-concept studies, laboratory-scale and bench-scale testing and development,
- testing of products or processes at early stages of development,
- testing of products or processes at late stages of development,
- prototype construction, or
- marketing studies, business planning and/or production planning.

To date, ERIP has issued 165 grants for a total of \$12.8 million. Grants have typically ranged between \$50,000 and \$200,000, with an average of \$80,000 per invention.

In addition to the grant, ERIP has provided assistance to the inventor by making contacts with DOE program areas, federal agencies, and other sources of support. Also, publicity has been given to the invention through DOE publications and by sponsorship at technological expositions.

Since FY 1982, grants have no longer been the primary form of support for inventions. Because federal funding is limited to those areas of research and development where private-sector capital is not available,

DOE's primary means of assistance for inventions recommended by NBS is to help the inventor obtain private-sector financial support. This is accomplished by providing:

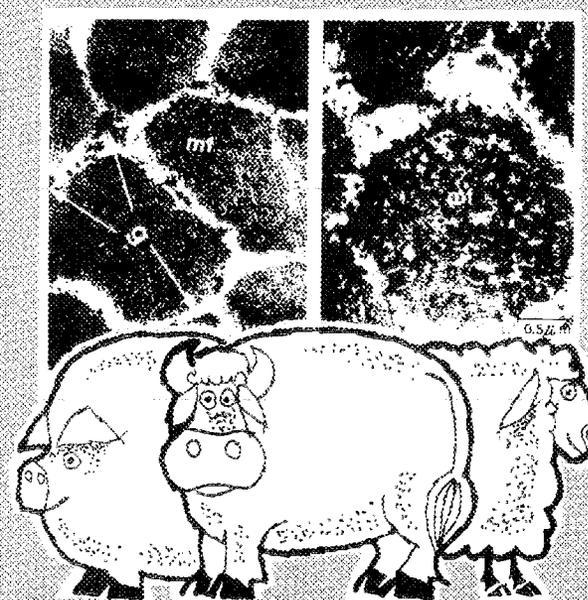
- brokering services designed to obtain financing, licensing, or other types of private sector support; and
- technical and business consultation.

A pilot brokering program was begun in

FY 1982 to identify the most appropriate means of providing these services.

In instances where private-sector support is not available, direct federal support will depend on the availability of federal funds. To supplement limited program funds, DOE provides contacts with other federal programs and seeks to identify potential government markets for the invention.

*Electron micrographs of pre-rigor red meat before (left) and after (right) undergoing the process of hydrostatic pressurization developed by Walt Kennick. The process results in greater tenderness than that produced by the normal aging process. The process also leads to greater efficiencies in production, processing and utilization of meat by-products.*



# ENERGY-RELATED

**The Energy-Related Inventions Program is jointly operated by the National Bureau of Standards (NBS) and the Department of Energy (DOE). Beginning with the submission of the invention disclosure form, the invention passes through a series of increasingly more detailed reviews at NBS. Promising inventions are ultimately recommended to DOE for support in the form of a grant award or brokering assistance.**

Place carbon paper behind this sheet to make Submitter's Copy of page 4.

## MEMORANDUM OF UNDERSTANDING

I have read the Program Description and Statement of Policy on pages 1 and 2 of this form. As the owner, or with the authority from the owner who is listed on Page 3, I have attached (or previously submitted) a disclosure of the identified invention for the purpose of evaluation by the National Bureau of Standards (NBS) pursuant to Section 14 of Public Law 93-577.

I understand that to protect property rights an appropriate legend should be applied to the title page or first page of the disclosure, and that if the disclosure is so marked, the Government will consider all information that is in fact (a) trade secret or (b) commercial or financial information that is privileged or confidential, as coming within the exemption set out in 5 U.S.C. 552(b)(4). Accordingly, I have checked directly below, the box which is applicable to this disclosure.

Yes No

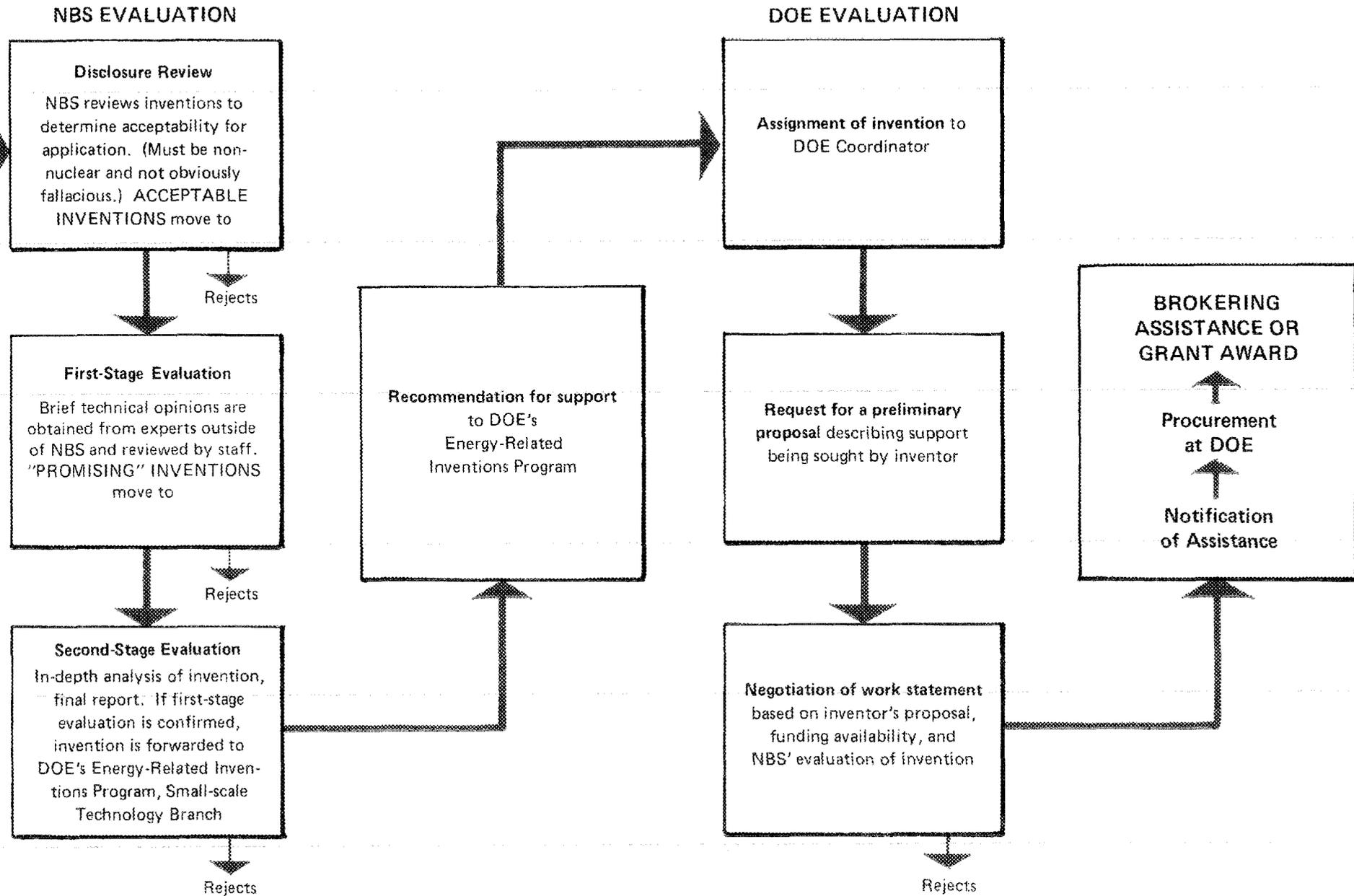
OERI Copy (Place carbon paper behind this sheet to make SUBMITTER'S Copy of page 3)

NBS 1019 (Rev. 2-78)		U.S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS		Follow attached instructions and submit the OERI copy of this form and other descriptive material of invention to: Office of Energy-Related Inventions National Bureau of Standards Washington, D.C. 20234 (Please print or type all information)	
Energy-Related Invention Evaluation Request				This box is for office use only	
Name and address of Inventor		Date		ER No.	
Telephone No. Name and address of Owner, if different from above		Classification		Tech. Category	
Telephone No. Request is being submitted by (check which): <input type="checkbox"/> inventor <input type="checkbox"/> owner <input type="checkbox"/> other		Analyst		Date	
Name and address of Submitter, if not inventor or owner		Other (Identify)			
Size of company involved (write No. of employees 'S gross last year; N if none)				No. of employees 'S gross last year	
The name or title of this invention is					
Stage of invention development (check to indicate steps completed and current status; highest number checked will indicate current status)					
<input type="checkbox"/> 0 Concept Definition		<input type="checkbox"/> 1 Concept Development		<input type="checkbox"/> 2 Lab. Test	
<input type="checkbox"/> 3 Patent applied for		<input type="checkbox"/> 4 Patent granted (Patent Nos.		<input type="checkbox"/> 5 Eng'g Design	
<input type="checkbox"/> 5 Prototype Development		<input type="checkbox"/> 6 Prototype Test		<input type="checkbox"/> 7 Production Eng'g	
<input type="checkbox"/> 8 Limited Prod. Mktg		<input type="checkbox"/> 9 Production and Mktg		<input type="checkbox"/> 0 Not patentable	
<input type="checkbox"/> 1 Not applied for		<input type="checkbox"/> 2 Disclosure Document Program		<input type="checkbox"/> 3 Patent applied for	
<input type="checkbox"/> 4 Patent granted (Patent Nos.		Check the item below that most nearly describes why you are requesting evaluation			
<input type="checkbox"/> 1 I wish the U.S. Government to provide funds to support development of the invention or new concept. Support is first needed for (write in)					
<input type="checkbox"/> 2 Development is complete. I need assistance to bring my invention or product into full utilization. Assistance is needed in (check which ever applies):					
<input type="checkbox"/> General Marketing		<input type="checkbox"/> Selling to the Government		<input type="checkbox"/> Business Management	
<input type="checkbox"/> Other		<input type="checkbox"/> 3 I only desire an opinion that the disclosure describes a technically valid invention. This information is for			
<input type="checkbox"/> use in marketing		<input type="checkbox"/> use in obtaining private development support		<input type="checkbox"/> other (specify in disclosure)	
<input type="checkbox"/> 4 The Small Business Administration suggested I request evaluation from NBS in connection with a loan application					
<input type="checkbox"/> 5 Other (specify)					
<input type="checkbox"/> Yes <input type="checkbox"/> No Has the invention been disclosed to other agencies of the Government? If yes discuss in disclosure					
<input type="checkbox"/> Yes <input type="checkbox"/> No Has the invention been disclosed to any private companies, patent attorneys, etc.? If yes identify in disclosure					

## INVENTIONS

Form 1019 submitted to  
 Office of  
 Energy-Related Inventions,  
 National Bureau of Standards,  
 Washington, D.C. 20234

# INVENTIONS PROGRAM PROCESS



### **ESKIL L. KARLSON**

Eskil Karlson is a professional inventor whose experience crosses several disciplines. He has worked in fields as widely disparate as physics, cancer research, and chemical processes, with recent emphasis on ways to make processes continuous. He has obtained more than 100 patents in several fields. He has submitted applications for patents for two inventions and is preparing five or six additional applications for patents.

Karlson has a master's degree in zoology and a D.Sc. in physics. He also makes a point of going back to school and taking courses whenever he encounters a new field of research and finds that he needs more information.

Karlson worked for several years for the Atomic Energy Commission but has followed an entrepreneurial path for the past several years. He has benefited financially from several companies which he has formed; they are still extant and successful. He is not interested in the continuous operational aspects of business, preferring to spin off his creations. He has had continuing connections with universities, among them Harvard and Yale. At present, he teaches and has a laboratory at Gannon University.

Karlson has extensive experience in obtaining government support for his research.



## **CONTINUOUS, LOW-ENERGY MASS SEPARATION SYSTEM**

The purpose of Karlson's 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.

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 energy-intensive methods of separation. It is anticipated that this invention will make separation far more efficient in terms of time and energy.

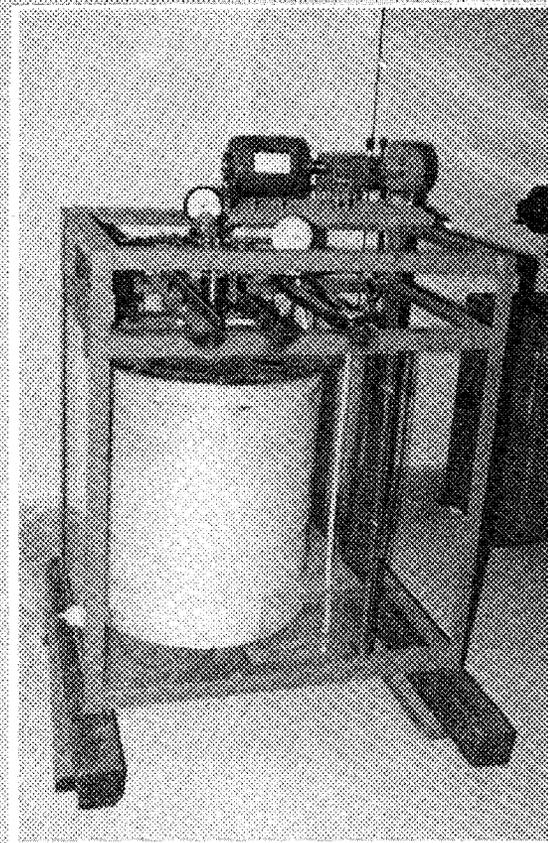
The development of a continuous and rapid process for separation requiring low-energy inputs would have significant applications where separation is used now and would open up many other areas of application in pharmaceutical production and in environmental cleanup (for example,

purification of brackish and salt water and cleaning of effluents). Karlson is also investigating the possibility of extending the technology to such other areas as the separation of blood and the field of genetic manipulation.

As with most of his inventive activity, Karlson's invention was in response to a request to solve a problem. He was asked to develop a system for separation or extraction that was less energy-intensive. Prior to submitting it to ERIP, he worked on the invention for three years, using his own laboratories for development and his own resources for patenting. Just prior to submission he encountered technical problems that required considerable resources for materials testing. He also needed more laboratory space for building a larger prototype than he had made before.

The invention was in the laboratory testing stage when it was submitted to ERIP. Karlson was awarded a grant of \$83,015 to build and test two laboratory models. While the tests demonstrated the feasibility of the process, additional research is necessary before the inventor can reach his goal of bringing the technology to a point where he can license or sell it to one of the several companies already interested in acquiring and commercializing it.

*A laboratory model used to demonstrate the feasibility of a continuous, low-energy mass separation system. A wide range of applications is possible for this system. Any two or all three current separation techniques are combined in a process capable of large throughputs and significant reductions in time and energy.*



## To independent inventors and small businesses . . .

---

ERIP has a distinctive target audience: independent inventors and small businesses.

The definition of an independent inventor is a broad one. The program has supported a Ph.D. physicist at Princeton and a carpenter from Massachusetts with only a high school education; a professional inventor with more than 100 patents and a Kentucky coal miner with only one patent; an academician on the faculty of Oregon State University and an entrepreneur who has started six successful companies.

While seemingly diverse, these inventors usually share important common attributes. Although their formal education is varied, they often have considerable technical experience in the area in which their invention is applicable. With few exceptions, most grantees have some entrepreneurial

experience—an attribute considered essential by ERIP personnel. The majority of the inventors are serious and creative people with a strong interest in ensuring that their inventions are ultimately commercialized.

In some cases, the program directly supports the inventor; in other cases, support is given to a small business formed by the inventor or to a licensee who has acquired the right to commercialize an invention.

The definition of a small business is generally defined by the Small Business Administration as any company with fewer than 500 employees. As with inventors, small businesses funded by ERIP are characteristically diverse. Both moderately large businesses (50 to 100 employees) and very small businesses (1 to 10 employees)

have been supported. The function of the firms also differ: some firms are engaged in research and development, some in manufacturing. Moreover, supported firms span a wide variety of industries: from mining to milling to fabrication. While the ERIP has supported established firms which have been pursuing commercial endeavors for a number of years, support is often given to recently established firms, to take advantage of market opportunities provided by the invention. Experience in receiving government contracts is likely to be the exception rather than the rule.

Sorting Out the Gadgets That Cut Your Heating Bills

# Mechanix ILLUSTRATED

**The Real  
Lowdown  
On Those  
Radar  
Detectors**

**Build Your  
Own Duck Boat**

Complete Plans in This Issue

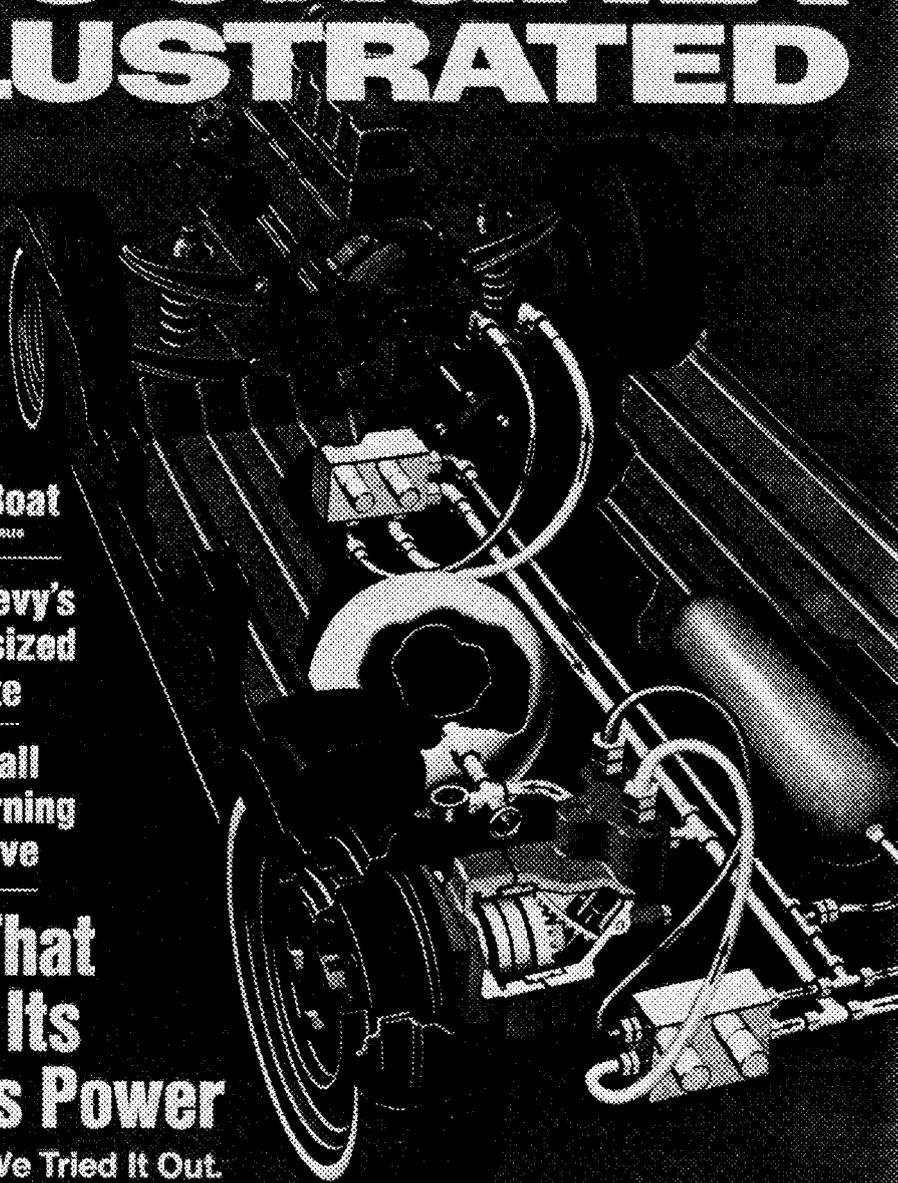
**We Test Chevy's  
New Downsized  
Intermediate**

**How to Install  
A Wood-Burning  
Heating Stove**

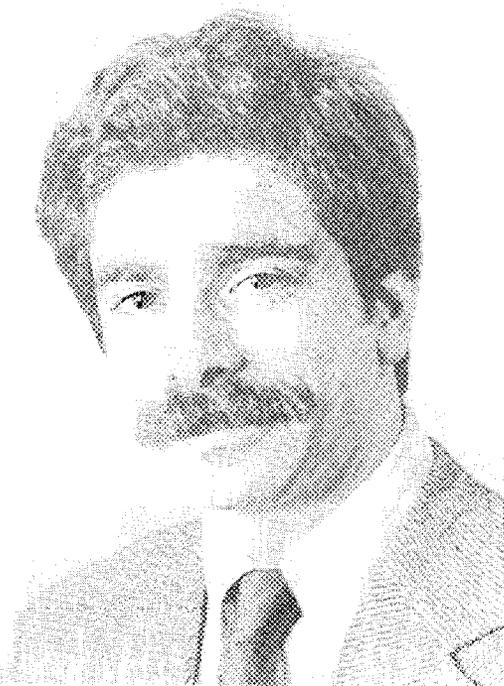
**A Car That  
Stores Its  
Surplus Power**



**We Tried It Out.  
Our Opinion:  
It Works!**



*The Inertial Storage Transmission, invented by Vincent Carman and marketed by Advanced Energy Systems of Portland, Oregon, uses a hydraulic system to store kinetic energy from a vehicle slowing down, for use when it speeds up. The system improves the efficiency and reduces fuel consumption in automobiles.*



## **MICHAEL ZINN**

Michael Zinn is one of a group of individuals who have formed a company, Bio-Energy Systems, to exploit market opportunities for alternative energy products. His company specializes in buckling off-the-shelf components into new combinations to create new products.

Zinn can be more accurately described as an innovator than as an inventor. He does not create new technologies but rather adapts existing technologies to new uses. With considerable entrepreneurial skills, he brings the new products into the marketplace.

Zinn graduated from a technical high school where he learned plumbing, heating, and air conditioning. Following high school, he acquired three years of college training and held a variety of industrial and contractor's jobs, learning systems design along the way. He acquired additional knowledge on various other jobs. While running a DOE-funded project that converted chicken manure to methane, he got the idea for a solar collector, called SolaRoll.

Zinn held no patents prior to his invention, although he made improvements on the equipment used for the methane gas project. He has since acquired or applied for eight patents for various aspects of SolaRoll. Although he previously worked on a DOE-funded project, he did so as an employee and had never before sought funding or assistance from a government agency.

## **SOLAROLL**

SolaRoll uses ethylene propylene diene monomer (EPDM) synthetic rubber as the principal component of a flat-plate solar collector for use in residential and industrial heating, both solar and radiant. SolaRoll's uniqueness stems from the fact that it is effective, cheap, durable, and homeowners can install it 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 expensive plumbing that is subject to leak development due to weather stresses. EPDM had, as Zinn knew, found widespread industrial applications at temperatures through 400°F. Based on experience from previous jobs, he concluded

that EPDM had ideal characteristics for solar collectors.

Zinn assembled the original prototype of his invention in his garage with the help of some friends. In two years Zinn and his friends, using their own resources, progressed to the point where they had manufactured and sold several prototypes. This was before Zinn applied to ERIP.

Zinn had encountered no significant technical problems prior to submitting his invention. His problems were, in his words, "capital and credibility". His capital needs did not relate to technical or manufacturing problems but to the problem of financing scientific testing that would attract attention to the invention and for 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 on the market.

SolaRoll was in the limited production and marketing stage when Zinn submitted it to ERIP. He was awarded a grant of \$110,000 to test the performance of SolaRoll in a variety of applications. Since the ERIP support, Zinn's company, Bio-Energy Systems, has:

- achieved volume manufacturing and sales (over \$4 million in 1981) through 400 distributors and dealers in the U.S. and from licensees in five foreign countries;
- turned a profit for three consecutive years;
- issued a public stock offering of \$2.5 million;
- changed the corporate name to

BESICORP GROUP, INC., employing around 100 people, with separate divisions for sales, installation, and financing of commercial and industrial systems; and

- received a \$350,000 loan from the Small Business Administration.

Although initial sales have consisted primarily of home heating and swimming pool applications, Zinn has concentrated on finding wider market applications for his

product. He and his colleagues have completed the following design and development:

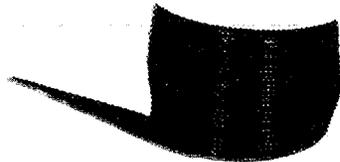
- devised radiant heat distribution systems for greenhouses, homes and factories,
- developed the "Systemizer"—a system for placing a hot-water system into an existing house using its storage tank,
- developed the "Biotrol"—a water-to-water heat pump coupled with SolaRoll,

- designed a large system for commercial applications in which an unglazed collector is hooked to a commercial heat pump controlled and operated by a computer system, and
- designed a program to install solar collectors at no cost to the end user—through a shared savings of energy costs and tax credits with a third-party investor.

*SolaRoll is a continuously extruded, synthetic rubber tubular mat which can be used in a variety of commercial and residential applications. SolaRoll can be used to construct very large solar collector plates without connecting extensive and expensive plumbing. It is effective, cheap, and durable; homeowners can install it themselves.*

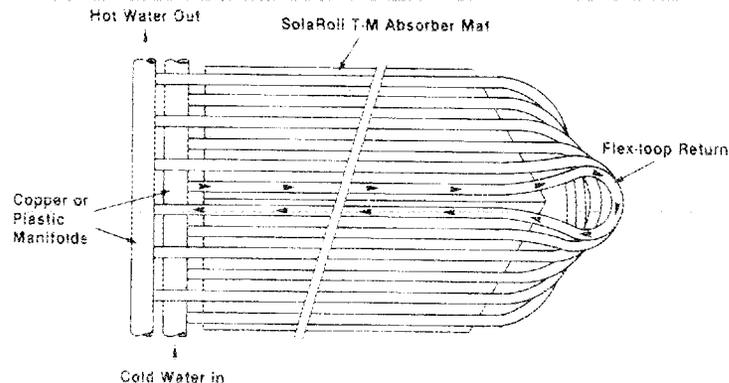


(Dimensions in Inches)

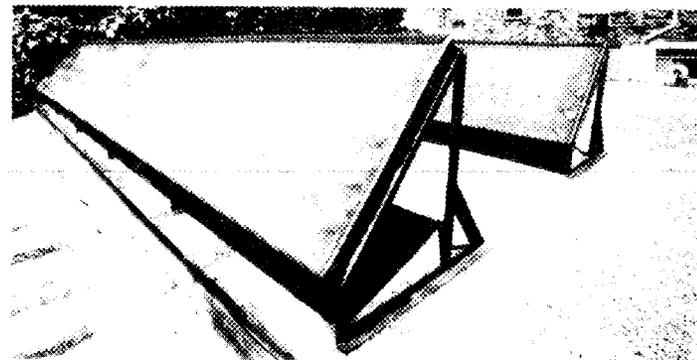


ROLL OF T-M ABSORBER MAT

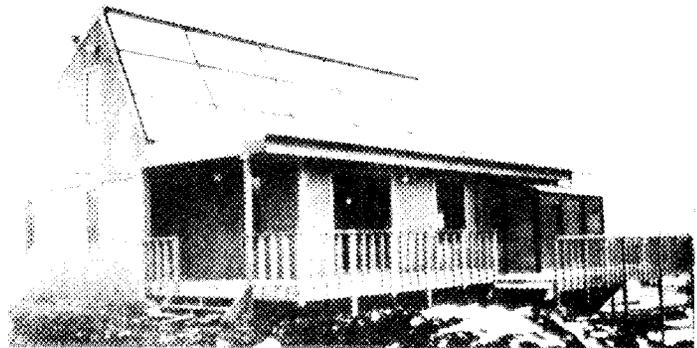
T-M ABSORBER MAT CROSS SECTION



TYPICAL ABSORBER LAYOUT



COMMERCIAL INSTALLATION



RESIDENTIAL SYSTEM

## With promising energy-related inventions . . .

---

Not all inventors and small businesses are eligible for the program. To be eligible, one must have an invention which is both *promising* and *energy-related*. An energy-related invention is defined as any non-nuclear technology which will result in generating or saving energy. Technologies can be at any stage of development between initial conceptualization and full commercialization. Incremental as well as quantum-leap advances in a technical field are considered; newness in a patent sense is not required.

A "promising" invention must have technical soundness or intrinsic technical merit, as well as commercial feasibility and the potential for significant impact in the energy area. The definition of "invention" is broad and is linked to the concepts of energy savings and increasing energy supplies. An idea may be quite familiar and may have originated with others, but if it represents a new potential for saving or producing energy in its present application, it is defined by ERIP as an invention. Also, old ideas which may now be feasible because of changes in market or technological conditions fall under ERIP's definition of invention. As a consequence, the program funds both inventions and innovations.

The original intent of the program was that recommended technologies would receive support from program offices

already established in DOE. For this reason, no direct source of funding for inventions from the program was available to ERIP until several years after the program began.

Further, experience has demonstrated that many of the inventions recommended by NBS do not fit into DOE's defined program areas. Because there is no established program area, the technology does not represent an accepted research direction for the program office, or the technology is not at a stage of readiness to qualify for that program's support. Or a program may not have a source of discretionary funds to support a particular invention, however interesting. For these reasons, DOE program offices have shown active interest in only five of the inventions recommended by NBS. Thus, ERIP is providing support for worthy technologies which might otherwise be overlooked.

To date, a wide variety of technologies have been funded (see box). They are energy-related in diverse ways: some represent new products or processes that are more energy-efficient than those presently available; some are designed to enhance existing conventional supplies; others tap alternative sources. Examples of energy-conserving technologies include high-efficiency products such as hot-water heaters, furnaces, and internal combustion engines; thermally efficient construction

materials; and waste heat utilization techniques for residential, commercial and industrial applications.

Technologies that enhance energy production address problems related to exploration, extraction, and transportation of conventional energy sources, as well as the recovery and utilization of previously uneconomic energy supplies. Inventions designed to develop alternative energy sources have spanned the range of available renewable resources, from solar to geothermal to biomass.

All the technologies supported by the program are expected ultimately to have significant energy impact. "Significance" is a relative term, depending on such factors as size of market, number of alternative applications, and the adoption and use of the technology.

For most of the technologies that have been supported to date, it is still too early to judge individual or cumulative contributions. However, a recent study by MIT investigating the energy savings potentials of five funded inventions supports the contention that these inventions would have a considerable impact on energy use. The study found potential energy savings to range from 0.03% to 0.60% of total U.S. energy consumption. Such figures reflect only the market potential, however, and not actual penetration.

# ERIP-Supported Technologies

---

---

## Conservation

---

---

### Products

- **ELDON DIRECT-FIRED GAS HEATING SYSTEM** (Harry Wood, inventor)—a direct-contact, gas-fired hot-water heater.
- **THERMAL SHADE** (Thomas Hopper, inventor)—a multilayer window shade, with reflective surfaces, which can be fitted to conventional windows to reduce heat loss.
- **SUPER U-SNAP STRAPS** (James Kessler, inventor)—an insulation system for prefabricated industrial and commercial buildings.

- **IONIC FUEL CONTROL SYSTEM** (Enoch Durbin, inventor)—a system for controlling the air-to-fuel ratio of internal combustion engines.
- **HYDROCOIL WASTE HEAT UTILIZATION** (Robert Jones, inventor)—a system for recovering waste heat from the exhaust gases of gas-fired or electric grills used in restaurants.

### Processes

- **CHILLCAST** (James L. Chill, inventor)—a

completely enclosed, continuous casting process for non-ferrous metals that reduces worker exposures to lead fumes.

- **MAHALLA PROCESS** (Shalom Mahalla, inventor)—a hydrometallurgical process for extracting high-purity metallic copper from chloride solutions without direct energy input.
- **FLASH POLYMERIZATION** (Richard Panico, inventor)—a process using pulsed xenon-arc discharge lamps for polymerizing thermosetting resins.

---

---

## Supply Enhancement

---

---

### Conventional Sources

- **MAGNETO-ELECTRIC EXPLORATION METHOD** (Sylvain Pirson, inventor)—a method of exploring for gas and oil deposits by plotting the intensity and polarities of local perturbations in the earth's magnetic field.
- **COKE DESULFURIZATION PROCESS** (Douglas MacGregor, inventor)—a process which removes organic sulfur from high-sulfur coal by introducing sulfur during the coking process.
- **HASPERT MINING SYSTEM** (John

Haspert, inventor)—a piece of mining equipment that can drill a large, rectangular hole on a sloped heading with the lowest specific energy requirement of any similar device.

- **TUBULAR PNEUMATIC CONVEYOR PIPELINE** (Lemuel Ply, inventor)—a pneumatic tubular conveyor pipeline for transporting dry, granular materials, such as coal, over long distances.

### Alternative Sources

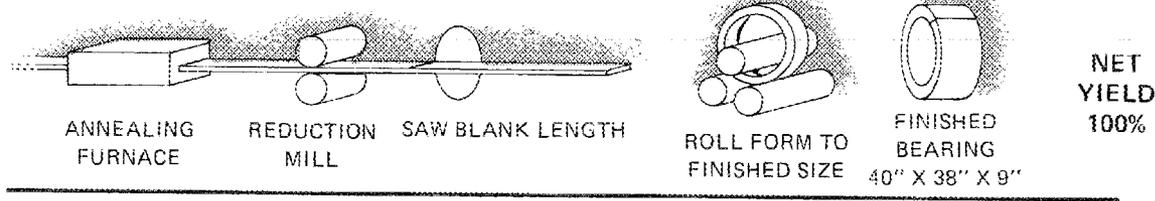
- **WOOD GAS REACTOR** (Robert Caughey,

inventor)—a device to produce fuel gas from wood.

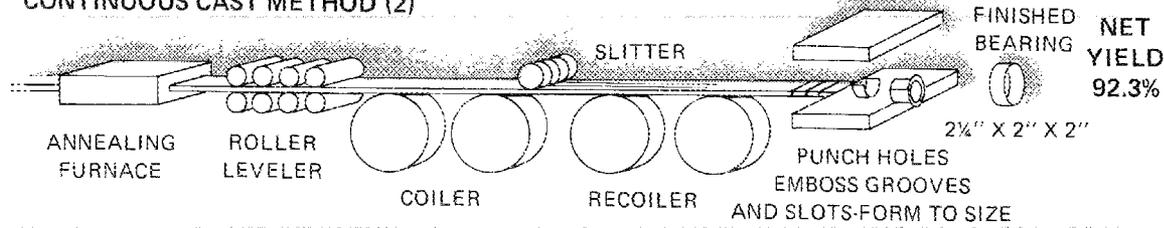
- **AERODYNAMIC LIFT TRANSLATOR** (Dan Schneider, inventor)—a wind-activated power-generating system providing large power outputs in regions where the direction of prevailing winds does not vary appreciably.
- **SOLAR SPAN PRISM TRAP** (John Mattson, inventor)—a lightweight, all plastic, solar collector using "black" liquid both as an absorber and energy transfer fluid.



**CONTINUOUS CAST METHOD (1)**

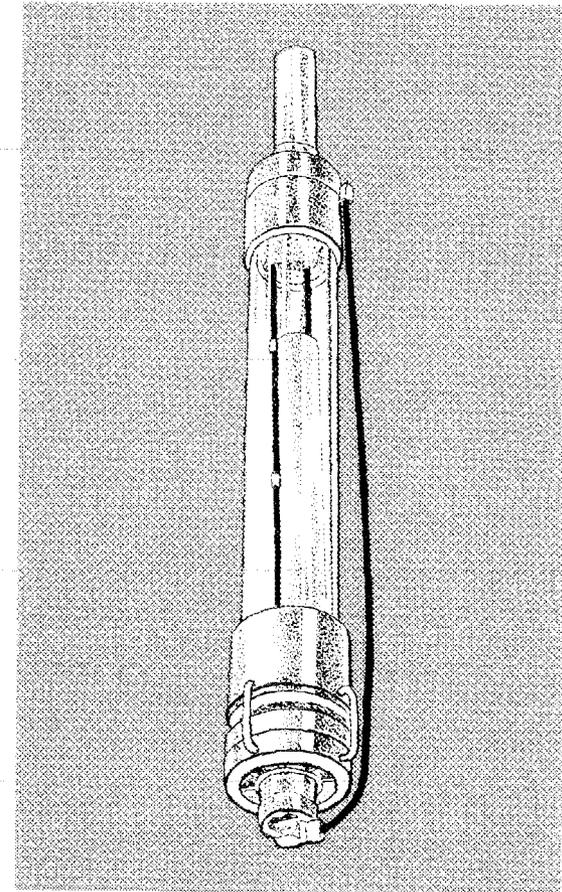
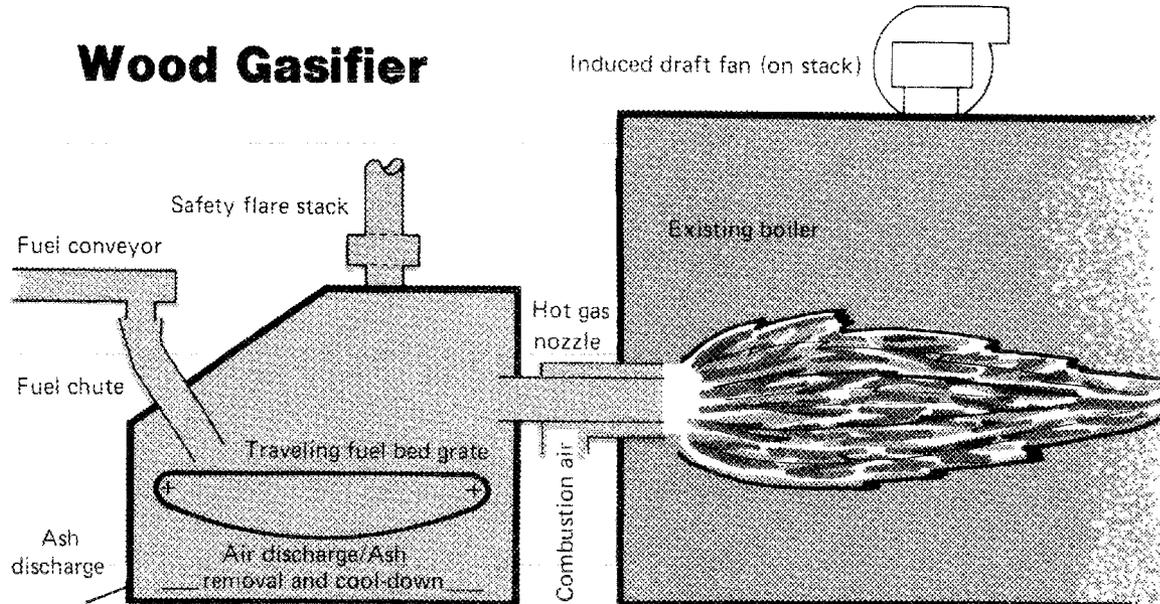


**CONTINUOUS CAST METHOD (2)**



*The Wood Gas Reactor, invented by Robert Caughey and marketed by Forest Fuels, Inc. of Manchester, New Hampshire, is a staged combustion system producing a fuel gas from wood suitable for use in existing gas- or oil-fired combustion equipment. It is a practical and economic system for replacing existing industrial boiler installations.*

**Wood Gasifier**



*The Submersible Wastewater Respirometer invented by Robert Arthur provides a continuous automatic indication of bioactivity and oxygen consumption requirements in a wastewater plant system. The invention controls the electrically powered compressors or aerators to fluctuate with oxygen demand, and energy is saved.*

## DAN BEN-SHMUEL

Dan Ben-Shmuel has been characterized as a latter-day Renaissance man—metal sculptor, poet, inventor, and now entrepreneur. Ben-Shmuel has been self-employed all his life. He worked as a sculptor and managed his own real-estate holdings prior to submitting his heat extractor invention to ERIP.

He has had no formal technical training at all. 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 knowledge necessary for constructing large, heavy metal sculptures and complex equipment.

Ben-Shmuel has a history of successful inventions of both small and large textile machinery and the machine tools required for its manufacture. He holds about 30 patents on these inventions; they constitute a rewarding and lucrative sideline and have familiarized him with the patenting process. Prior to receiving a grant from ERIP, Ben-Shmuel had neither applied for nor received support from the federal government.

## HEAT EXTRACTOR

Dan Ben-Shmuel developed an innovative use of a common technology, a heat exchanger. Because of the increase in energy prices, the device has become economically attractive for a number of new applications in both the residential and industrial sectors.

The device uses water or an alternative fluid in direct contact with stack gases to

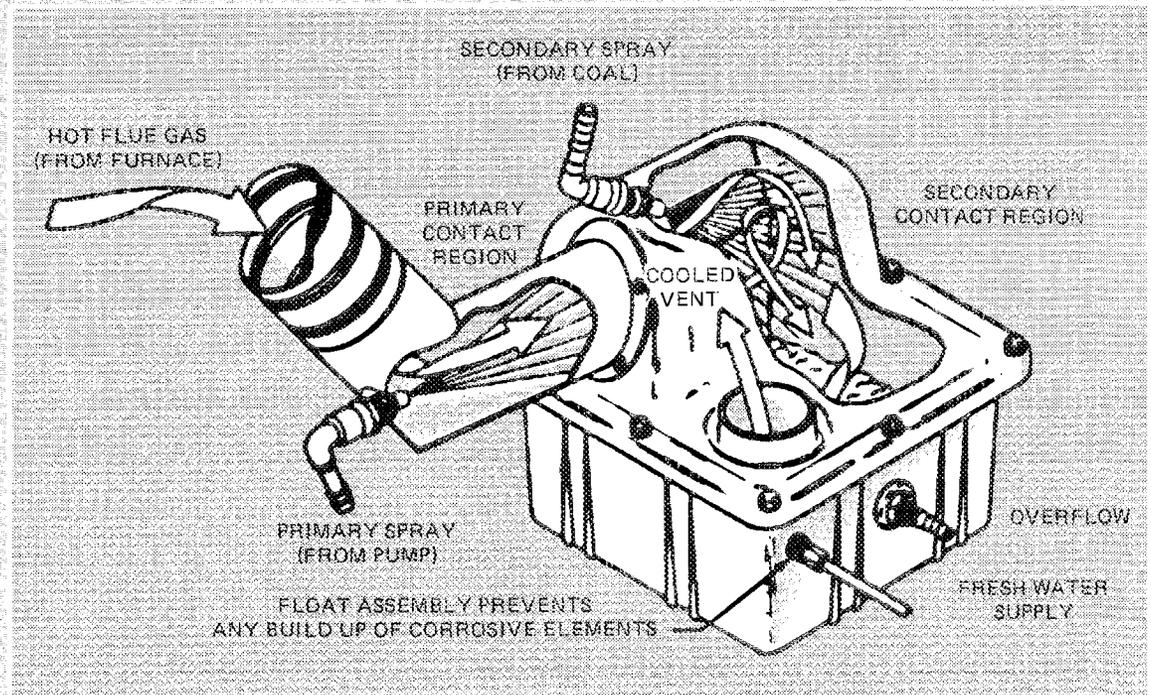
extract heat from the gases. The heat is then removed from the coolant by means of a secondary heat exchanger. The secondary heat exchanger performs the dual function of (1) cooling the working liquid, which then recirculates through the stack gases and (2) transferring the heat into an external system that carries the energy to alternative uses such as the heating of buildings and chemical processes.

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. Its pollutant-removing capacity makes it particularly promising for use in coal-burning power plants.

Both the energy-savings potential and pollution control characteristic of the technology made it attractive to ERIP.

Ben-Shmuel's development of the original crude heat extractor was a reaction to rising heating costs in his own real estate properties. His invention was in the prototype testing stage when he submitted it to ERIP for support. Having solved the major technical problems, Ben-Shmuel encountered the obstacle of lacking capital and credibility. He needed capital to promote and manufacture his innovation and scientific test



results to persuade prospective customers. He was successful in placing ten units, but after five years had invested \$100,000 of his own money and reached the limits of his resources. Because of the initial capital costs and the financial risk of installing a unit, Ben-Shmuel was unable to attract money from the private sector. However, he recognized ERIIP as a potential source of funds for the necessary testing.

A grant for \$125,000 was awarded to Ben-Shmuel for a cooperative demonstration and testing of his heat extractor at the Mohawk Paper Mill in Hudson, N.Y. Since the ERIIP support, the Heat Extractor Corporation has become a going concern. The business has developed in the following ways:

- A \$400,000 loan has been received from the Small Business Administration.
- There are about 250 employees.
- A version of the Heat Extractor has been exclusively licensed for the residential sector to Sears, Roebuck and Co.
- Sales are currently \$25 million a year in the United States and abroad.

The Heat Extractor

Originally developed for commercial and industrial applications, the Heat Extractor has been adapted for residential use and is currently being sold by Sears, Roebuck and Co.

Heat efficiently with . . .

## THE HEAT EXTRACTOR® System

REDUCE YOUR ANNUAL HEATING BILLS BY 30%\* to 34%\*\*  
 BY REDUCING THE AMOUNT OF HEAT WASTED UP YOUR CHIMNEY.  
 THE HEAT EXTRACTOR CAN UPDATE YOUR PRESENT GAS OR OIL FORCED  
 AIR CENTRAL FURNACE INTO A SIZEABLE FUEL SAVER.

WHEN HEATING OR COOLING

SHOP  
SEARS  
FOR  
**HOME  
COMFORT**

See efficiency stories on pages 998 to 1,020

SAVE \$300\*  
OR \$340\*\* ON

YOUR ANNUAL HEATING BILL  
 IF YOUR LAST ANNUAL BILL WAS \$1000

THE HEAT EXTRACTOR® System qualifies you for the  
 15% ENERGY TAX CREDIT, see p. 532 for more information

**HEATING OPERATION:** When a furnace is burning, exhaust gases reach very high temperatures—400° to as much as 700°F. That is, heat being wasted up the chimney along with the dollars it costs to produce the heat. THE HEAT EXTRACTOR® system will capture most of these wasted Btu's of heat so they can be kept in the home to add warmth and comfort. THE HEAT EXTRACTOR® system is so efficient that the temperature of the exhaust will be reduced to 75° to 95°F, which is about the same temperature as your breath. See Saving Story at right for more information on heating operation.

**PARTS INCLUDED:**

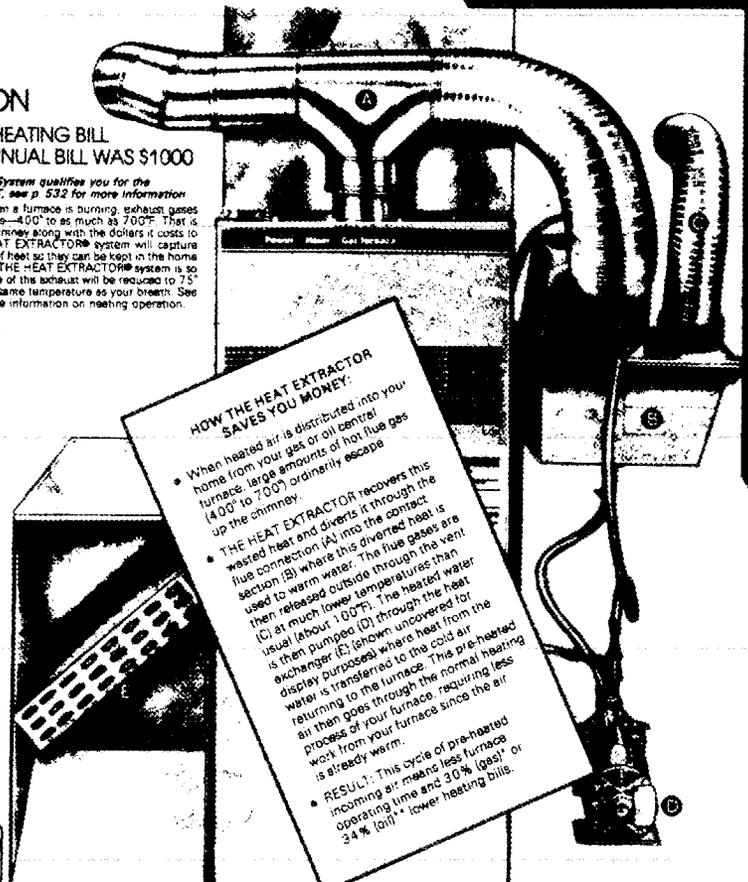
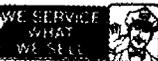
Flue contact section (where water is heated); heat exchanger coil with universal coil box adaptable to any return air duct; fill and drain valves; pump with 1/2-HP motor and electric controls; drain and fill tubing, plastic plumbing and fittings, 4-in. vent pipe and vent cap for outlet. Also includes necessary components to adapt THE HEAT EXTRACTOR® to existing flue pipe.

**INSTALLATION:** Requires at least a 2 ft clearance on 1 side of furnace. Installation is no more complex for a do-it-yourselfer than installing a replacement furnace or adding an air conditioning system or have Sears install it for you. Includes installation and operating manual.

**ELECTRICAL ORDER INFO:**  
 Pump, 1/2-HP, 50-Hz, AC. See warranty (CO), p. 529.

For Gas-burning Furnaces  
 up to 210,000 Btu/h only  
 Shpg. wt. 97 lbs.  
 42 A 75901N . . . \$499.99

For Fuel-oil-burning  
 Furnaces up to  
 210,000 Btu/h only  
 Shpg. wt. 99 lbs.  
 42 A 75902N . . . \$499.99



**HOW THE HEAT EXTRACTOR SAVES YOU MONEY:**

- When heated air is distributed into your home from your gas or oil central furnace, large amounts of hot flue gas (400° to 700°) ordinarily escape up the chimney.
- THE HEAT EXTRACTOR recovers this wasted heat and diverts it through the flue connection (A) into the contact section (B) where this diverted heat is then released outside through the vent (C) at much lower temperatures than usual (about 100°F). The heated water is then pumped (D) through the heat exchanger (E) where heat from the pre-heated water is transferred to the cold air returning to the furnace. The pre-heated air then goes through the normal heating process of your furnace, requiring less work from your furnace since the air is already warm.
- **RESULT:** This cycle of pre-heated incoming air means less furnace operating time and 30% (gas)\* or 34% (oil)\*\* lower heating bills.

\*Based on Sears laboratory testing of a gas furnace with an input of 125,000 Btu/h and a seasonal efficiency of 85.4%. Your actual savings may vary depending on the actual efficiency of your furnace.

\*\*Based on Sears laboratory testing of an oil furnace with an input of 132,000 Btu/h and a seasonal efficiency of 74%. According to Department of Energy information, the average furnace built in 1975 had a 73% seasonal efficiency. Your actual savings may vary depending on the actual efficiency of your furnace.

†This is about 80% of your total annual natural gas bill, excluding fuel costs for such things as cooking, drying clothes, etc.

‡This is 100% of your total annual fuel bill for oil.

§Based on the cost of the system only. Depending on your individual tax circumstances, you can claim up to a 15% Federal Energy Tax Credit for this system. This tax credit can also apply to installation costs you may incur for this system.

Annual heating bill cost	Annual fuel savings when you use THE HEAT EXTRACTOR®	15% Energy Tax Credit
\$800†	HEATING WITH NATURAL GAS is 30% fuel savings††	\$75
\$1,000†		\$75
\$1,200†		\$75
\$1,000‡	HEATING WITH FUEL OIL is 34% fuel savings‡‡	\$75
\$1,500‡		\$75
\$2,000‡		\$75

July 1975



### **HARRY E. WOOD**

Harry Wood is the only person listed in the New Orleans telephone directory as an inventor. As a chemical engineer, he has directed research departments for a number of major U.S. corporations in such diverse fields as food, gypsum, and oil field equipment. For the past ten years he has been self-employed as a designer and consulting engineer.

His diverse experiences have made him familiar with a broad range of technologies. Most of his work has involved designing and developing new devices; one job was to evaluate existing patents and to devise a

slightly different approach to the same technology. Wood considers himself to be a "tinkerer", and when he has an idea for an invention, he is able to do the design work with little or no outside assistance.

Wood has a history of inventions. He estimates that he has designed about 20 products or processes, but the number is likely 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. Wood currently holds only one patented invention, the Direct-Fired Gas Water Heater supported by ERIP. Over the years, he has been issued patents on a number of other inventions, but he has chosen not to maintain them because of the expense and the fact that he perceives "patent pending" status as affording more protection. Prior to receiving a grant from ERIP, Wood had neither applied for nor received support from the federal government.

### **ELDON DIRECT-FIRED GAS HEATING SYSTEM**

Wood's invention is a 100%-energy-efficient, gas-fired water heater for commercial and industrial use. Most conventional water heaters are only 70-80% efficient, with most of the energy loss due to the character of the heat transfer agent. To accomplish his highly efficient heating, Wood developed a method and design which blows a natural gas flame into direct contact with a "rain of water."

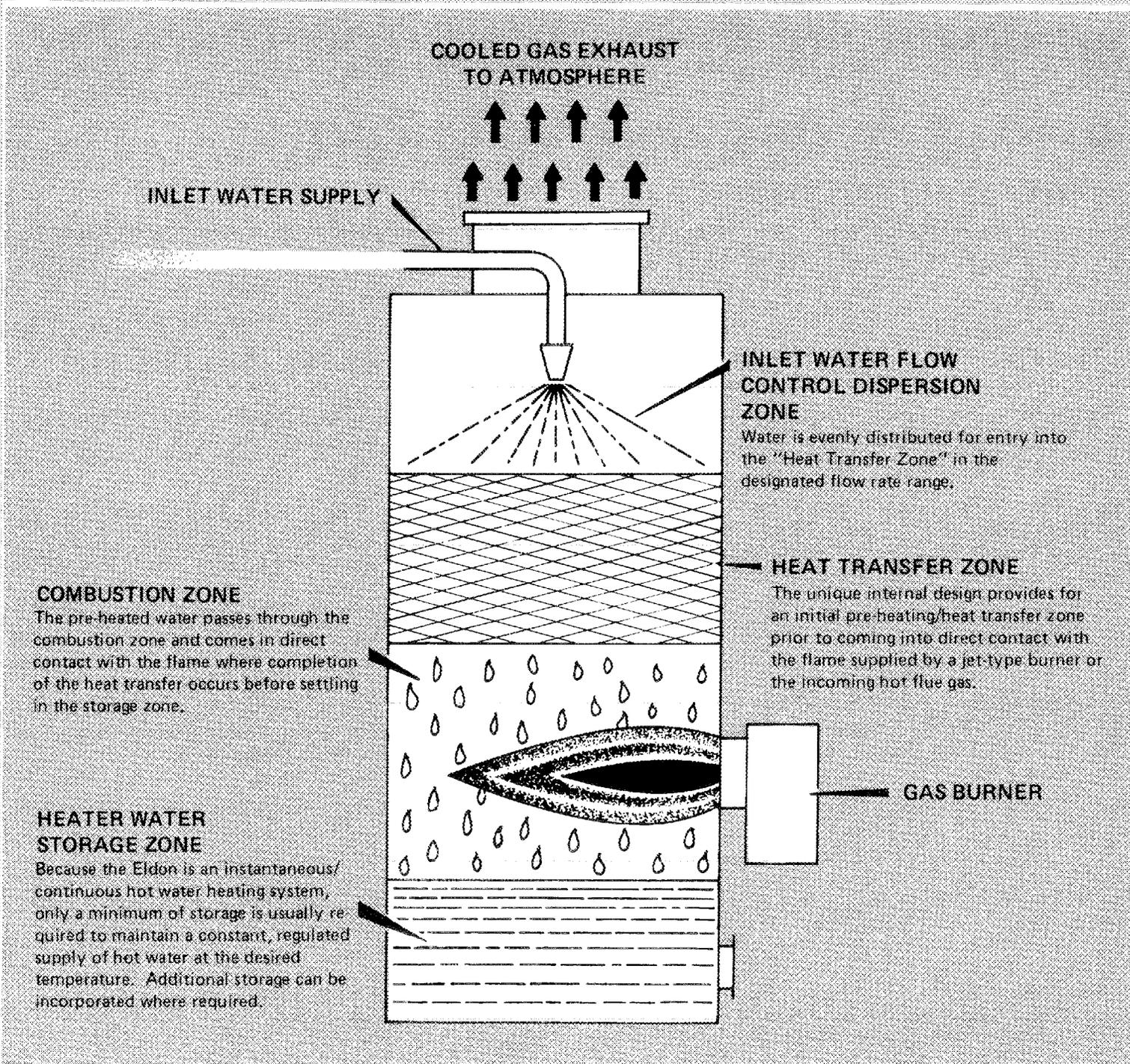
The idea for this invention came to Wood when he observed that when water comes

in direct contact with ice, cooling is extremely efficient. He reasoned that if hot combustion particles come into direct contact with cold water in a sealed tank, the same efficiency would result for heating. The invention was originally conceived for use in the residential and small-business markets, but the application shifted to large industrial and commercial users because of the high cost of control parts and the fact that optimal savings accrue to users of large quantities of hot water.

Wood developed a working model in his garage before he submitted the invention to ERIP for support. A number of technical problems arose while he was developing the model, but he readily resolved them. He then recognized the need to build an operating prototype to demonstrate the benefits of his device to potential customers. He tried a number of different sources but was unable to raise the necessary capital to install a prototype in a 210-unit apartment complex. At this point, he decided to submit his invention to ERIP.

Wood was awarded a grant of \$72,600 to install and test a working prototype in a New Orleans hotel. Since the ERIP support, Wood has:

- sold ten units for about \$30,000 each;
- licensed his invention to the A. O. Smith Company, which sold four more units before the license was revoked;
- licensed his invention to Kemco Corporation, which has sold 67 units and has orders for 30 more; and
- adapted the technology for use in a heat reclamation system which he is presently marketing himself.



Water is evenly distributed for entry into the "Heat Transfer Zone" in the designated flow rate range.

The unique internal design provides for an initial pre-heating/heat transfer zone prior to coming into direct contact with the flame supplied by a jet-type burner or the incoming hot flue gas.

The pre-heated water passes through the combustion zone and comes in direct contact with the flame where completion of the heat transfer occurs before settling in the storage zone.

Because the Eldon is an instantaneous/continuous hot water heating system, only a minimum of storage is usually required to maintain a constant, regulated supply of hot water at the desired temperature. Additional storage can be incorporated where required.

*The Eldon Direct-Fired Gas Water Heater*

# For purposes of moving these inventions closer to the marketplace.

The overall goal of the program is to stimulate innovation in the energy field. The ERIP has established a near-term objective of assisting inventions in moving "one step" closer to the marketplace. The next step in the development of the invention is negotiated between the program and the inventor, described in a mutually agreed upon statement of work. This statement of work then becomes the condition for the ERIP support. The program has been successful in moving many grantees to the next step. In a recent evaluation of ERIP conducted by Oak Ridge National Laboratory, only 2 of the 30 cases studied had been unable to complete the prescribed work statement.

Successful completion of the work statement should enable inventors to do one or more of the following:

- compete effectively in obtaining other grants or contracts that permit further development of the invention;
- assemble, with some confidence of success, a business enterprise in which the inventor is a major participant in producing and marketing the invention; or
- negotiate mutually beneficial arrangements with an existing company to develop the invention for commercialization.

ERIP has awarded grants totalling \$12.8 million for 165 of the 208 recommended by NBS. Forty-six of the inventions have been able to acquire follow-on financing or support. Such support comes from a number of sources in the public and private sectors and includes money raised through public offerings, contracts or grants, bank loans, private sector investors such as venture capitalists, and invention licensees. The 46 inventions supported by the program to date have received the amounts of additional support shown in Table 2.

**Table 2. Additional support received by ERIP-supported inventions**

Financial sources	Number of inventions	Total financing received
Bank loans and venture capital	22	\$26,045,000
Public offerings	3	7,500,000
Government (non-federal)	2	6,200,000
SBA guaranteed and direct loans	9	2,950,000
Self-financed or other	5	1,870,000
DOE programs other than ERIP	4	1,040,000
EPA	1	250,000
<b>TOTAL</b>	<b>46</b>	<b>\$45,855,000</b>

Of the 165 inventions supported by the program, a total of 35 have been able to enter the marketplace, with cumulative sales to date totaling over \$180,000,000. More than half of these sales were generated by only two grantees who received \$235,000 in grants from ERIP.

The combined follow-on investment and sales figures result in a leverage ratio of 17.5:1. This leverage ratio compares very favorably with the 10:1 ratio of the National Science Foundation's Small Business Innovative Research Program and the Department of Commerce's Technology Commercialization Centers.

Commercialization of the 35 inventions has resulted in the creation of 756 direct jobs. Other jobs attributable to the inventions include component and material suppliers, jobbers, franchisees, subcontractors and distributors, although the total number of these additional jobs is unknown. The 756 jobs amount to one job for every \$17,000 of federal funds expended for ERIP grants. The number of jobs resulting from ERIP support can be expected to increase as more inventions reach the marketplace and as individual companies grow.

The degree of market activity for these inventions is surprising because the program is relatively young. The time usually required for most technologies to complete the innovation process may range from 5 to 30 years. The ERIP program has only been in existence since 1975, so it is still too early for many of the supported inventions to have achieved their full potential in terms of impact on business activity and/or the energy field.

All of the inventions are expected to have an impact on the energy field once they reach the marketplace. These impacts will result either from more efficient use of energy or the enhancement of energy supplies. Determining the actual level of impact is difficult. Calculations of energy savings require information on prior energy-use patterns and consumption levels after adoption of the new technique or equipment. A similar approach is necessary for assessing the impact of inventions that enhance energy supply. In the case of an improved mining technique, for example, an estimate of energy benefits requires an understanding of the cost of developing the supply under existing technology and how that cost shifts with the use of the invention. Frequently this information is unavailable or prohibitively expensive to develop.

Of the 35 inventions which have reached the marketplace, 25 provide direct energy savings benefits. Of these inventions, 11 provided reasonable estimates of energy savings benefits. These 11 inventions alone provided about 3.16 trillion Btu per year. This translates into the equivalent of about 545,000 barrels of oil, worth more than \$15 million dollars at current prices.

Energy-saving inventions include:

- The Woolworth Preheater, marketed by International Preheater Company, which utilizes waste heat from hot billets to

preheat scrap metal. Installed at the Knoxville Iron Company, Knoxville, Tennessee, the preheater increased production while reducing electrical requirements for meltdown by 44 kWh per ton. This reduced requirement produced a 12-million-kWh energy savings over a 12-month period, equal to 120 billion Btu or 20,000 barrels of oil.

- Harry Wood invented a high-efficiency industrial and commercial water heater. A direct-contact, gas-fired device, it can extract the latent heat of water vapor during combustion. Licensed to Kemco Corporation of Milwaukee, 67 units have been sold and are currently operating. It is estimated that these water heaters have saved a total of about 430 billion Btu or 74,000 barrels of oil.
- Solaroll, invented by Michael Zinn, uses a synthetic rubber, EPDM, to develop a variety of solar and radiant heating systems for residential and industrial uses. Zinn's corporation, BESICORP, has sold over six million square feet of Solaroll. It is estimated that these installations have saved 1.17 trillion Btu, or over 200,000 barrels of oil.

Enhancement of energy supplies can take a variety of forms:

- The use of alternative fuel sources such as the wood gasifier developed by Forest Fuels, Inc. is one example. The Wood

Gas Reactor is a practical and economic gasification system available to replace high-cost oil and gas in industrial and commercial applications. Forest Fuels has sold 12 systems, each producing between 4 and 17 million Btu per hour.

- Capturing a previously unusable source of energy is another means of enhancing fuel supply. The Schneider Engine, invented by Dan Schneider, is an example. Operating on the principle of aerodynamic lift rather than the more conventional rotary propulsion, this engine is able to generate hydroelectric power under low flow conditions incapable of driving standard turbines. This engine has the added advantages of lower initial cost and lower maintenance cost. The six systems currently in operation are capable of generating an average of 6.5 million kWh per year or 65 billion Btu per year.

The estimates for both energy saving and supply enhancement are likely to grow as more inventions reach the marketplace and as sales grow for those inventions that are already commercialized.

While the primary focus of ERIP support has been toward inventions with potential for an impact on the energy field, in a number of cases the support has contributed to unanticipated developments that have consequences beyond the energy field.

Unanticipated developments include improvements in environmental health and safety and alternative applications or spin-offs of the technology that are also promising.

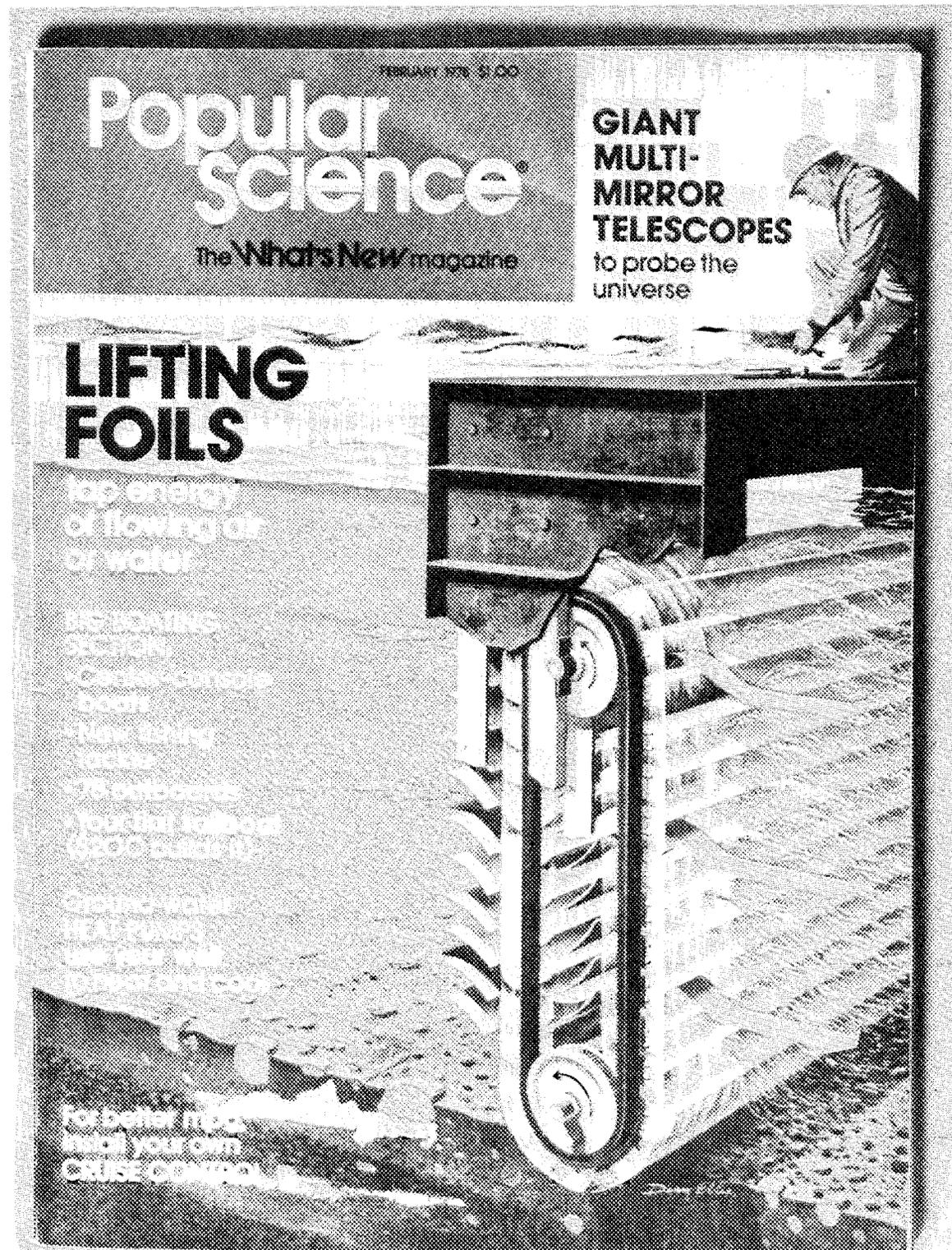
**Improvements to environmental health and safety include:**

- development of a mine brattice that is not only portable but is also capable of improving ventilation and carrying an alarm sensor for roof and floor movement in the mine shaft.
- development of a continuous casting process for non-ferrous metals, the only process available that meets the Occupational Health and Safety Administration's standards for workers' exposure to lead fume emissions.

**Spin-offs include:**

- transfer of technology developed by DMC Technology for oil well drill bits to the production and manufacturing of saw-blade

*The Schneider Engine, invented by Dan Schneider, generates hydroelectric power based on aerodynamic lift rather than conventional rotary propulsion, giving it the ability to operate under low flow conditions incapable of driving standard turbines.*



---

and diamond-core bits, as well as utilization of the technology for basic research in ballistics and high energy lasers (HELs);

- marketing of a fireproof, moldable insulation that is a component of the building technology developed by ISTECH;
- development and pilot plant demonstration of an alternative coke desulfurization process by Diamond West Corp., after the original process was proven infeasible through experimentation using ERIP funds;
- adapting a wind-powered engine developed by the Schneider Engine Company for use in a 0.5-MW, low-head hydro pilot plant in Turlock, California;
- applying the process for continuous-vapor deposition of silicon carbide to the optics field, particularly in the production of laser mirrors; and
- adapting an ion-drift, air-mass flow sensor meter for use by the Department of Defense with the Short Take-off and Landing (STOL) aircraft and M-1 tank.

---

### **Evaluation of the Energy-Related Inventions Program**

*A recent evaluation of ERIP conducted by Oak Ridge National Laboratory reviewed 30 grantees and their technologies in depth and came to the following conclusion:*

*There is sufficient evidence at this early date to state that the program is meeting its goals and objectives. Not only did the projects move one step as defined by the work statement, but nearly 50% of them obtained additional support and a surprising number (five) of the grantees have been commercialized.*

*After reviewing the five cases in which full production was achieved, the evaluation further concluded:*

*ERIP is supporting inventions in the innovation process at a point where they are*

*supported neither by the venture capital community nor by industry. The government provides the bridging capital necessary for the owner of a technology to develop or acquire the expertise and the documentation or other materials for getting the major capital needed to establish a solidly based venture. ERIP is actually functioning as a special investor.*

*The evaluation further notes that by funding technologies close to commercialization as well as long-term, high-risk technologies, the government is not only helping to stimulate innovation in the future, but also, like any good investor, is funding projects that are likely to succeed.*



## **RICHARD ENGDahl**

Richard Engdahl holds a B.S. degree in mechanical engineering and has taken numerous graduate courses, principally in control technology. His whole technical career has involved heat engines and ceramic materials. Engdahl has 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, before

forming his own company to do research and development. He has received extensive support from the government for his research.

Although Engdahl is a highly creative person, he holds no patents. Much of his career has been devoted to materials development, which results in "know-how" rather than patents. In his study of control technology, for example, it was necessary to understand entire systems, so that he could 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.

### **CHEMICAL-VAPOR-DEPOSITED CERAMIC TURBINE ROTOR**

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. Long available in combination with other materials, there has been no way, to date, to form SiC in its pure state, maximizing 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.

Engdahl saw the primary application of his invention as a means of producing one-piece turbine rotors that allow the construction of small, highly efficient turboelectric plants. This, in turn, would permit decentralization of the power generation system and greater flexibility in responding to changes in energy needs for communities or regions.

This invention evolved over a period of ten years and is still in an early stage of research. The process currently will yield blocks of SiC able to withstand pressures of 120,000 psi at 1400-1500°C. His immediate target is to increase the pressure from 120,000 to 200,000 psi at 1400-1500°C. Then he will work at depositing SiC on a one-piece rotor mold.

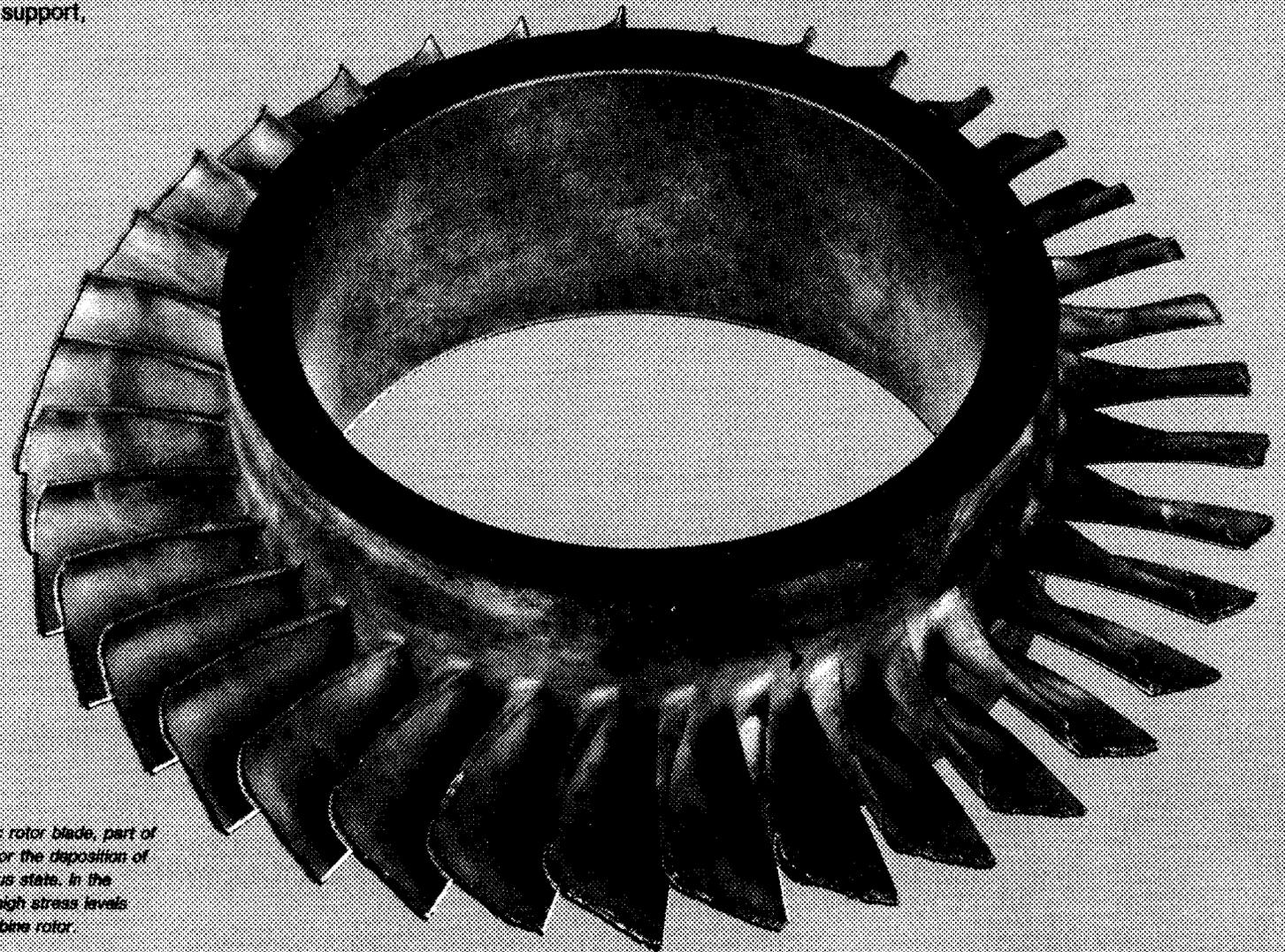
Both private and public funds have contributed to the development of Engdahl's invention. Differences in development goals (possible applications) have resulted in roadblocks in the path of reaching his goal of creating a one-piece rotor. For example, Engdahl applied to the DOE's turbine program, which rejected him because clients of the program were building large turbines and were not interested in a rotor for small turbines.

ERIP represented an alternative source of funding for basic research. Engdahl's invention was in the engineering design stage when he applied for the ERIP grant. He was awarded \$125,000 to conduct a research program designed to improve the material properties of his CVD SiC deposited on metal.

As a consequence of ERIP support, Engdahl has:

- made progress in improving the material properties of CVD SiC deposited on metal, refined the mixture of gases used to carry SiC through the process, and has a product with the strength he wants at the required temperature;
- continued to develop other applications in

a number of other industries, for example, the optics industry. (Because CVD SiC is virtually nonporous, it can be polished to within 4 angstroms, smooth enough for a variety of scientific and high-powered applications such as mirrors.)



*A pattern mold is used to form a ceramic rotor blade, part of a process invented by Richard Engdahl for the deposition of solid silicon carbide (SiC) from its gaseous state. In the resulting pure state, SiC withstands the high stress levels required of a maximum efficiency gas turbine rotor.*

*INTERNAL DISTRIBUTION*

- |   |                                |
|---|--------------------------------|
| 1. R. L. Anderson                                       | 18. D. W. Jared                |
| 2. R. B. Braid  | 19. H. C. Jernigan             |
| 3. R. S. Carlsmith                                      | 20. S. V. Kaye                 |
| 4-5. Center for Energy and<br>Environmental Information | 21. R. J. Kedl                 |
| 6. B. Clark   | 22. D. C. Parzyck              |
| 7. N. E. Collins  | 23. G. T. Privon               |
| 8. E. D. Copenhaver                                     | 24. C. A. Sady                 |
| 9. R. M. Davis  | 25. A. C. Schaffhauser         |
| 10. R. C. DeVault                                       | 26. J. W. Sims                 |
| 11. R. H. Dilworth                                      | 27. E. J. Soderstrom           |
| 12. R. C. Durfee  | 28. P. J. Walsh                |
| 13. P. D. Fairchild                                     | 29. T. J. Wilbanks             |
| 14. W. Fulkerson  | 30. Central Research Library   |
| 15. T. G. Godfrey                                       | 31. Document Reference Section |
| 16. D. M. Hamblin                                       | 32-33. Laboratory Records      |
| 17. E. A. Hirst   | 34. Laboratory Records (RC)    |
|   | 35. ORNL Patent Office         |

*EXTERNAL DISTRIBUTION*

36. Office of Assistant Manager for Energy Research and Development,  
Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN 37830
37. Dr. Fritz R. Kalhammer, Electric Power Research Institute,  
P.O. Box 10412, Palo Alto, CA 94303
38. Dr. Todd R. LaPorte, Institute of Government Studies, University  
of California, 109 Moses Hall, Berkeley, CA 94720
39. Mr. Laurence I. Moss, Energy/Environmental Design and Policy  
Analysis, 5769 Longs Peak Route, Estes Park, CO 80517
40. Dr. Milton Russell, Center for Energy Policy Research,  
Resources for the Future, 1755 Massachusetts Avenue, N.W., Washington,  
DC 20036
41. Dr. William H. Williams, American Bell, Building 83, Room  
1B23, 100 Southgate Parkway, Morristown, NJ 07960
- 42-442. Social Impact Analysis Group Distribution, Energy Division
- 443-469. Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830