

DEPARTMENT OF ENERGY — APPROPRIATE ENERGY TECHNOLOGY

SMALL GRANTS PROGRAM, 1980

1. Project Title: PIEZOELECTRIC POWERED TRANSPORTATION

2. Project Location: Buena Park Orange Calif. 90621
(city) (county) (state/territory) (zip)

3. Total Request: \$ 13,765.00

4. Patent Waiver: I request that the title of any inventions resulting from this project be given to me. In doing so, I agree to the conditions as outlined in the Program Solicitation Booklet.

Yes No Not Applicable

5. Can DOE forward this application to other agencies for funding consideration? Yes No

6a. Principal Applicant (Please print)

Russell D. Francis

(name)

6101 Darlington Ave.

(street)

Buena Park, Calif.

(city)

(state)

90621

(zip)

(714) 522-4187

(phone number)

4-10 p.m.

(hours)

6b. Co-applicant OR Sponsoring Organization, Agency or Business:

(name)

(street)

(city)

(state)

(zip)

(phone number)

(hours)

7a. Russell D. Francis 3-25-80
(Applicant's signature) (date)

(Title, if applicable)

7b. _____
(Co-applicant's signature OR signature of authorized individual within the organization, agency or business)

(Title, if applicable)

PROJECT DATA SHEET

Where did you first hear about the Small Grants Program?

- Direct mail material
- Newspapers or magazines
- Appropriate technology publications
- Meetings, workshops or conferences
- Radio
- Television
- Friends
- Other: _____

9. Check the category that **best** describes your project type.

- Idea Development** (studies, etc.)
- Device Development** (building and testing of new or improved energy-saving devices)
- Demonstration** (demonstrating or promoting existing Appropriate Energy Technologies)

10. Check the **one** category that best describes you, as an applicant:

- Individual
- Local non-profit organization or institution
- State or Inter-state government agency
- Local or county government agency
- College or university
- Small Business
- American Indian tribe
- Other: _____

11. Which of the following category(s) best describes your project?

- BIOCONVERSION**
- Agricultural/Forest waste
- Alcohol production
- Methane production
- Municipal waste use
- Residential waste use
- Other: _____

CONSERVATION

- Building design/retrofits
- Efficiency improvement
- Energy monitoring/management
- Recycling

- Transportation
- Waste heat recovery
- Other: _____

ELECTRIC PRODUCTION

- Co-generation
- Hydroelectric
- Other: Piezoelectric generation

ENERGY STORAGE

- Chemical
- Inert mass
- Fluids
- Other: _____

GEO THERMAL

- Space/Water heating
- Power generation
- Other: _____

INFORMATION DISSEMINATION

- Classroom education
- Library resource
- Training workshops
- Other: _____

COMBINATION SYSTEMS

- Agricultural
- Aquatic
- Residential
- Other: _____

OCEAN

- Biomass
- Thermal
- Wave
- Other: _____

SOLAR

- Active heating/cooling
- Collectors
- Passive (greenhouse)
- Passive (other: _____)
- Photovoltaic
- Other: _____

WIND

- Electric
- Mechanical
- Other: _____

WOOD

- Hot water
- Space heating
- Other: _____

12. What are you going to do with your grant?

- Design and build energy saving devices
- Demonstrate a modified technology to others
- Monitor the performance of a specific energy device or system
- Promote energy awareness through newsletters, libraries, networking, etc.
- Develop training programs or workshops
- Perform community energy surveys and assessments

Study and report on new energy saving concepts

13. What group(s) will directly benefit from your project?

- Homeowners
- Renters
- Low income/minority groups
- Farmers
- Businesses
- Community agencies
- Teachers or other researchers
- Other: _____

14. What is the major energy impact of your project?

- Developing new renewable energy resources
- Encouraging energy conservation practices
- Increasing energy awareness
- Improving the energy efficiency of existing devices
- Substituting renewable energy resources for non-renewable resources (e.g., oil, natural gas, coal)

15. Provide a brief, non-technical, descriptive summary of your project. What are you trying to accomplish with your project?

The purpose of this project is to develop a highly efficient medium of transportation requiring a minimum of raw resources and which is environmentally superior to present day modes of transportation. Through a combination of chemical and electrical technology a system will be designed that will run an automobile thousands of miles without the use of any external fuels. This project will be approached in two parts: A). To determine the optimum conditions for using crystals that show the "piezoelectric effect" under stress conditions. To assemble a device that will generate an electric current upon vibration of this device. B). To design and test an electrical system that can use the electric current produced by the crystal device to run an electric motor. Upon completion of my research I intend to build a working small scale model of the complete system. The current drawback in electric car production today is the short distance that can be travelled before a recharge is needed and the massive number and size of batteries required to do this. I propose my project will drastically reduce these drawbacks.

16. What special energy-saving devices, systems or information will exist when your project ends? How will others use what you have developed or learned?

Futuristic, lightweight electric automobiles can be manufactured with high energy efficiency and minimal environmental impact. A system of harnessing the electric current will be developed consisting of: 1) a filtering network 2) a regulator 3) a battery recharge circuit 4) batteries for starting and backup power. Many potential applications can be developed on the same principle of piezoelectric generation. Wind generators could be developed using this principle. Hydroelectric possibilities also exist. Current day research into piezoelectrics is minimal and development of practical applications has been limited to a small scale. I believe that surfacing and expanding the potential applications of this highly efficient resource could revolutionize the field of energy technology.

17. Detailed project description. Answer **both** parts A and B. Use additional pages, if necessary.

- (A) Provide a complete technical description of your project. Include procedures, drawings and any supporting data that are available. Be sure your answer specifically describes how your project will meet each of the Technical Evaluation Criteria listed in the Program Solicitation Booklet. Clearly indicate any confidential information or data as described in the instructions.
- (B) Fully describe how your project meets the State Review Criteria listed in the Program Solicitation Booklet. Specifically, explain how your project meets community or state energy needs, how you plan to utilize local labor and materials, etc. Describe any special qualities your project has.

(A) TECHNICAL EVALUATION

The object of this project is to develop a highly efficient piezoelectric device and to design a regulatory circuit to harness the energy provided by this device.

A number of crystalline substances have the ability to transform mechanical energy into an electrical charge. This property is known as the "piezoelectric effect". Natural crystals such as quartz, tourmaline and Rochelle salts exhibit the piezoelectric effect. More recently, man-made salts and ceramics are being used because they are chemically inert, hard and immune to atmospheric conditions. Also, ceramics provide for a wide variety of design shapes as well as being capable of exerting and sustaining large stresses. Slight alteration of the chemical composition of the ceramic material causes a modification of the piezoelectric properties, with the advantage of a standard manufacturing process (Williams, 1977). Currently the most widely used ceramic material is lead-zirconate-titanate (PZT-4), manufactured by Clevite Corporation. It has a theoretical electromechanical efficiency of 92% (Minchenko, 1969).

Most of the previous research done in this field has been in the area of electromechanical transducers using the inverse piezoelectric effect. When efficiencies of over 90% are obtained, most of the presently developed methods and design figures can be reversed to develop mechano-electrical transducers with little loss in efficiency. This can be verified by the

experiments of Ohio State University in which they placed a piezoelectric motor end to end with a piezoelectric generator. Here one transducer converts the electrical input energy into vibratory output energy, which is transmitted to the second transducer, the second transducer converts the energy back into electrical energy. The mechanical dimensions and electrical specifications of both transducers were identical. The overall efficiency of the system was determined to be 95%. Fig. 1 is a drawing of O.S.U.'s motor generator set. The design is based around the catenoidal horn but horns of any type and shape can be computed.

O.S.U. has also done some research in generating electricity with ceramic crystals. By hitting a stack of 28 crystal rings (3 1/2 inches in diameter and 1/2 inch thick), with 12,000 p.s.i. they got a burst of about 275,000 volts at 2,000 amps (Armagnac, 1969). 12,000 p.s.i. is not easily obtainable from the weight of an automobile chassis but 550,000,000 watts of electricity is more than enough for the average electric motor!

My 1st objective is to design a small but efficient device to generate this electricity by utilizing the vibrational characteristics of an automobile on the road. Similar to a shock absorber, this device will absorb the shocks of the road bumps and convert them into electric current. Several of the devices could be placed in series and/or in parallel to generate an average voltage of say 115 volts. Hydraulic methods could also be used to amplify the vibrational effects. The voltage outputs of these crystal devices would have to be highly regulated and filtered to harness and stabilize the short bursts of power available,

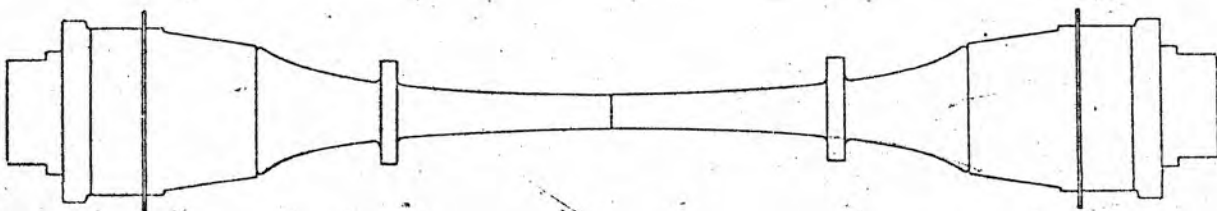


Figure 1

This is my second objective. As a piezoelectric crystal is compressed it generates voltage in one direction, As it expands back to its original shape it generates a voltage equal in amplitude in the other direction. Therefore we have a variable frequency voltage source, varying in amplitude dependent upon the pressure on the crystals.

Fig. 2 shows the theoretical waveforms and a simplified version of a regulator circuit.

After the output is regulated and filtered, it drives the DC motor as long as it is at or beyond a designated threshold level. Below this level the batteries will supply back-up power. The batteries therefore, are primarily used to drive the motor during low crystal output, and during starting after a stopped condition. The batteries could be rechargeable from house current using a built in charge circuit if the system was designed to operate at 115 volts. The crystals would greatly limit the drain on the batteries and extend the distance required before recharging is necessary. A test apparatus will be set-up similar to figure 3. From this test apparatus an analog-digital converter will be designed to retrieve and analyze data on my home computer. This will facilitate in the design of the crystal unit and regulator systems.

Williams, Elaine; "pyroelectric and piezoelectric devices";

Electronic Engineering, June 1977 p. 97

Minchenko, Hildergard; "High Power Piezoelectric Transducer design";

IEEE Transactions on Sonics and Ultrasonics,

July 1969, p.133

Armagnac, Alan P.; "Power from Crystals to Drive Strange New Tools",

Popular Science, Aug. 1969

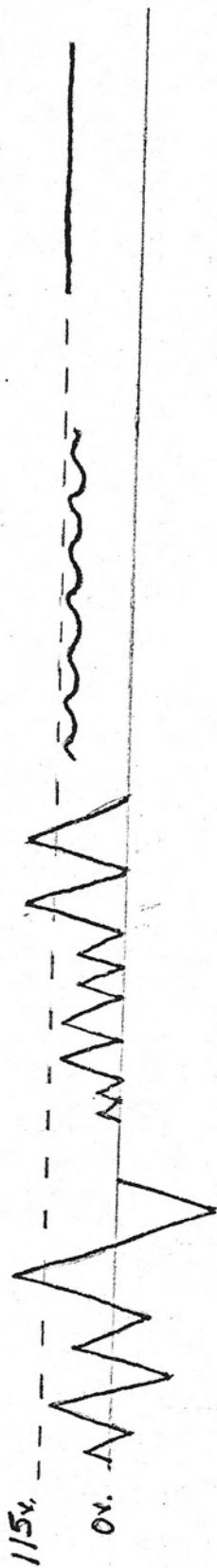
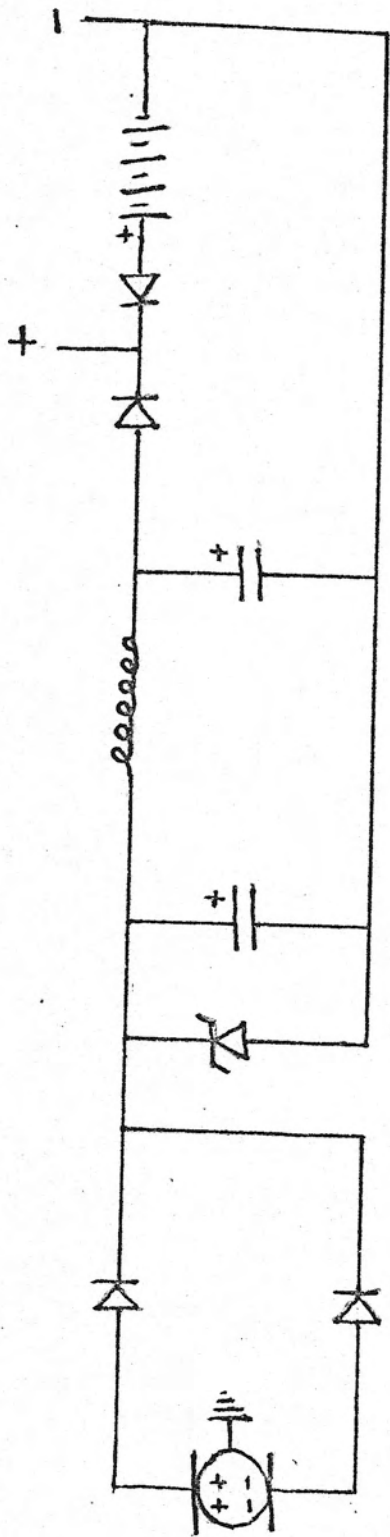


Figure 2.

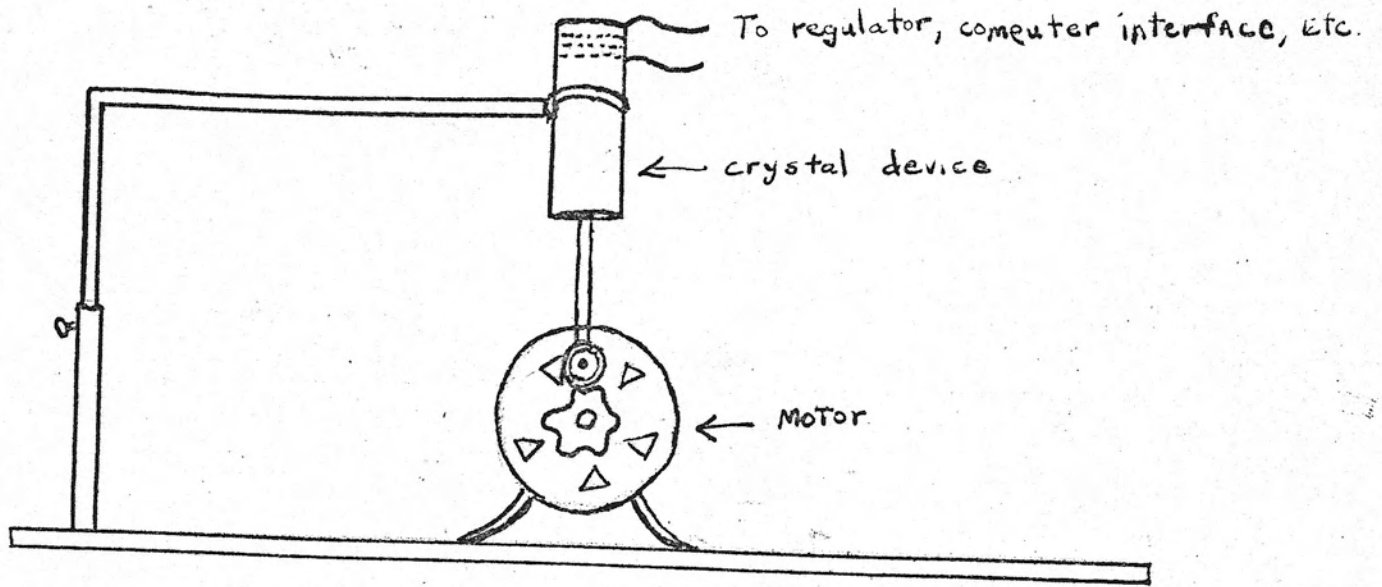


Figure 3

B). STATE REVIEW CRITERIA

Because of the density of California Cities, Californians must tolerate a high degree of noise and air pollution. Skyrocketing gas prices are putting a crimp in the lives of many. Weekend excursions and trips are becoming a burden to families that cannot pay the high cost of fuel. The farmers in the interior valleys of California are merely able to survive due to the high cost of fuel and cultivation of goods.

Development of a project such as this would have a substantial effect on the saving of energy and the cost of transportation fuel and it is 100% pollution free! An inexpensive auto could be developed using a "quiet" electric motor that would never need the expense or time required for a tune-up or carburetor maintenance. Instead only the crystal devices would have to be changed periodically, as the constant stress would deteriorate them. Inexpensive and expensive grades of crystals could be developed and manufactured as drop-in cartridges. The lifetime of these crystals is one area this project will study but the raw materials used to make these crystals are plentiful and inexpensive. It's feasible that cars presently in use could be converted to this as a part or fulltime energy source. Manufacturing of the salts used to make the crystals, crystal cutting plants, and electric motor design and manufacturing would provide many new job opportunities.

Creative people may find new ways to utilize this energy source. As far as I know, knowone has attempted to produce energy for public use by this method. Experiments in the medical field have found the crystals useful in generating large amounts of power for x-ray usage.

The initial research and development should require only 1 year or less based on a 20 hour per week program. Almost all equipment, materials, labor and consultation will be provided locally. Research materials and abstracts are available at Cal State University, Fullerton and other Southern California Universities. Some consultation from Ohio State University will be required as they did a substantial amount of research in the field of piezoelectric crystals in the 1960's. Mechanical and Electrical engineers are available through my present place of employment (General Automation, Inc. - Anaheim CA), for consultation. Chemical and electrical supplies can be obtained through local supply houses.

Upon completion of this project, if the expected results are completed and verified, the idea would most definitely be marketable in all modes of ground transportation. This would inspire the fact that other, safe, forms of energy are available.

Most of the expense and danger of auto pollution regulation could be eliminated. No restrictions would be required other than normal safety regulations.

Because transportation is necessary in today's community, whether it be for work or pleasure, it shouldn't be necessary to pay unreasonably high rates and worry about shortages. The people can turn their thoughts towards the solving of other problems.

18. If you have submitted this proposal to other agencies for funding consideration, list those agencies and indicate the current status of your application with them.

	Agency name	Date submitted	Current status
1.			
2.			
3.			
4.			

19. What are the qualifications of all **key** personnel on the project? Include consultants and subcontractors. Show how much time each participant will devote to the project. Only list qualifications that relate to this project.

RUSSELL D. FRANCIS 1000 Hrs.

B.A. chemistry (1978) Cal. State University, Fullerton

previous research in the field of Crystallography

Electronics & computer technician for 6 years

reliability test engineering of computer products- 1 year

power supply and regulator design and test for General Automation- 2 yrs.

ANDREW D. WOLL 200 Hrs.

Electronics & computer technician - 10 years