MARCH 1981

A REPORT TO THE

U.S. DEPARTMENT OF ENERGY

THE MANAGEMENT AND USE OF

DOE-PROVIDED DISCRETIONARY FUNDS

JANUARY 1980 - DECEMBER 1980

THE UNIVERSITY OF ILLINOIS

AT URBANA-CHAMPAIGN

OFFICE OF ENERGY RESEARCH

DOE/ER/10004-3

DISCLAIMER

DE-AC02-78ER10004

THE MANAGEMENT AND USE OF DOE-PROVIDED DISCRETIONARY FUNDS

Progress Report
for the Period January 1980 to December 1980

University of Illinois at
Urbana-Champaign
Office of Energy Research

March 1981

Prepared For

THE U.S. DEPARTMENT OF ENERGY
UNDER CONTRACT NO. DE-AC02-78ER10004

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Abstract and Progress Report Overview

The following progress report has two distinctly different components. The first section deals with a summary of the final project reports for each of the projects supported during 1980. That is, the second year of discretionary funding. The second component deals primarily with the beginning of the third year effort. As our second progress report indicated, we had been reasonably successful in initiating, during the first two years, a wide range of exploratory research and course development projects. We selected the initiatives from those proposals submitted on a campus-wide solicitation. We attempted to emphasize that exploratory research which tended to be an interdisciplinary thrust. In the final analysis, the program for the first two years resulted in an even balance between projects of a single disciplinary nature and those which called for a collaboration among two or more disciplines.

However, as we indicated in our second year progress report, the faculty at the University of Illinois at Urbana-Champaign was far more responsive in proposing highly focused disciplinary projects. The first two year's experience suggested to us that perhaps a different mode of research support might be pursued. In fact, the proposal we submitted for the third year articulated that we specifically utilize the discretionary funds to encourage a distinguished multi-disciplinary group in Engineering Materials to direct their attention to the materials problems that are associated with advanced techniques of coal utilization. Thus, the second part of this progress report will deal with the beginnings of this new thrust.

Summary of Final Progress Reports from Projects Supported During 1980

Included in the Appendix A of this report are contained the complete program reports as submitted by the investigators. Those reports are herein summarized.

1. An Assessment of the Impact of Commission Regulation on Prices, Expenses, Rates of Return and Financial Strategies of Electric Utility Firms - Walter J. Primeaux, Jr. ($10,591).

This was a two phase study which has now been completed. The efficacy of electric utility regulation has not been finally determined. The purpose of this study is to assess the impact of commission regulation on the level of earnings realized by electric power utility firms. Previous studies have relied upon price data which were generated during the very early days of utility regulation; moreover, cross section analyses, aggregating firms controlled by diverse regulatory regimes, were employed for assessing the effects of regulation.

Time series data for the individual electric firms operating in Florida, Iowa, and Mississippi were used in the analysis. These are the only three states regulated since World War II and it was possible to compare profit rates for the individual firms before and after Commission regulation was instituted and to make an assessment of the effect of the charge in each case -- the data for each firm are for the period 1948 through 1976.

The results show that firms in the sample were earnings economic profits prior to regulation and that regulation is responsible for substantial reductions or total elimination of those profits.

It should be also noted that this work resulted in a working paper and two papers to be published in scholarly journals. Public policy recommendations and the significance of the results for the various theories of regulation are presented. This work has also extended the investigators inquiry into additional questions suggested by the initial effort.

2. Radiative Collision Lasers - M. H. Nayfeh ($11,207).

Combined with other funds, this DOE grant is permitting the development of a new class of lasers. Radiative collision lasers are promising because of their energy storage capabilities and the variation in the gain which can be achieved. The experimental apparatus has been constructed, and emission studies have been made. The two photon laser-induced collision has been studied. It was found that a new intensity induced collisional shift makes the two photon line-shape sensitive to the intensity. A paper entitled, "Two Photon Laser-Induced Radiative Collision" will be submitted shortly.

3. NO_x Decomposition in a Catalytic Muffler - R. I. Masel ($14,500).

The thrust of this work was to determine the mechanism whereby NO_x decomposes in a catalytic environment. Experiments were attempted on tungsten in which the decomposition mechanism became better understood. NO decomposition and co-oxidation on platinum were investigated. This work resulted in one master's thesis and two papers presented at meetings of the American Institute of the Chemical Engineers.

4. Fuel/Air Control System for Catalytic Combustion Driven Stirling Engines--A Feasibility Study - Michael J. Binder ($15,000).

This work was undertaken to demonstrate adequate transient response of engine speed to a change in fuel/air ratio. The results of the experiments are that a qualitative demonstration can be formed, but the results are not satisfactorily predictable or repeatable. Catalytic combustion for energy conservation in a stirling engine has been demonstrated. A sufficient amount of evidence to write a proposal to continue our experiments on a larger scale engine has been completed. Two publications are under preparation.

5. Regional Environmental-Economic Optimization Models for Evaluating Policies Which Affect the Development of the Electric Power Industry in the Midwest - George Provenzano, D. F. Hang, and H. F. Williamson, Jr. ($23,070).

One of the major accomplishments of this study has involved the development of a computerized data management and model construction system. This system (1) inputs costs and technical data on power plant and transmission line operations; (2) computes from these data the cost and technical coefficients for the model and (3) assembles these coefficients into an appropriate input format for a mathematical programming package. This procedure was necessary because the kinds of models being developed in this study tend to be very large and require a substantial amount of data management. The data management system has been developed in a manner that is suitable for constructing both the linear and quadratic programming models discussed above and it is completely flexible in its ability to construct models for regions of different size.

6. Analysis of Public Attitudes on Nuclear Power - Martin Fishbein and Arthur Chilton ($15,752).

This past years work has been devoted primarily to the third of three studies dealing with respondents' attitudes toward a hypothetical nuclear powered plant under consideration for construction in the respondents' local community versus respondents' attitude toward a nuclear power plant under consideration in another state. There were seven other factors included in the study ranging from questions of accident probabilities, plant size, type of construction, radioactive waste procedures, and so forth. Preliminary analysis on study 3 has been completed. A final analysis will be completed this summer.

7. Impacts of Energy Shortages Upon East Urbana, 1980: A Re-Study and Analysis--Demitri B. Shimkin ($20,743).

This support permitted the revisiting of two previous surveys on changes in energy use in a middle class population. The first survey was undertaken prior to the oil embargo in 1972. The second, shortly after the oil embargo in 1974, followed by the present study, which took place during 1980. The general findings show a remarkable continuity of values and behaviors between 1974 and 1980. Household autonomy, mobility, and material possessions continue to be important. Adaptations to economic stresses have been extensive, including an intensified work effort, behavioral economizing in the home, and a marked shift in vehicle composition toward small cars. Individual savings have provided the resources for these adaptations and other property purchases. Public resources have played no visible role; government in general is regarded with suspicion.

A report has been issued entitled, "How Midwesterners Cope: Report of the East Urbana Energy Study," and a paper will be presented to the Society for Applied Anthropolgy in April.

8. Alcohol Energy Systems for Corn Farms--Errol D. Rodda and colleagues from Agricultural Engineering, Animal Science, and Food Science ($29,677).

This project has been directed toward the development of technology appropriate to the production of fuel grade ethanol on a small scale (1000 gallons per day or less). A laboratory fuel alcohol production system using five 200 liter drums with 25 kg batches of corn has been built and operated. Work is underway to ascertain the minimum convergence to permit the use of farm produced ethanol (180-190 proof). The acceptable combustion efficiency,

a mixture of four parts unleaded gasoline, one part ethanol, and one part N-butanol showed promise and will be tested. The initiation of this work percipitated the granting of equipment funds by the Illinois Institute of Natural Resources. Two publications have been prepared.

9. Feasibility of Greenhouses Heated with Surface Application of Power Plant Cooling Water--P. N. Walker and colleagues from Agricultural Economics, Agricultural Engineering, and Horticulture ($21,012).

This project has addressed several questions in parallel. An assessment is made of the commercial viability of surface heated greenhouses in the midwest with an estimate of energy savings. Changes in plant growth characteristics; a projection of energy savings in the event of wide spread adoption; and the legal and institutional issues related to this technology are also addressed.

A mathematical heating model has been developed which predicts hourly weather conditions and resulting energy usage with and without surface heating. In turn, the model has predicted the annual heating energy consumption for a 4,000 square meter greenhouse with a conventional heating system versus one utilizing surface heat from waste heat water. The range of energy savings has been calculated and presented in publications under review.

10. Replacement of Petroleum Fuels with Alcohol--Spencer C. Sorenson, Ronald D. Matthews, and Carroll E. Goering ($25,562).

Two experiments have been conducted, one dealing with the development of an appropriate mix of diesel fuels with ethanol for possible field use in agriculture, and the other the testing of the effects of various levels of ethanol added to gasoline. In the first experiment, a mixture was calculated

as a function of a number of appropriate functions. Comparisons were made between the blended fuel and number two diesel fuels over a range of equivilent ratios and several speeds. In the ethanol gasoline blend tests, it was found that, with a baseline fuel of 85% octane, a 20% ethanol blend created a modest increase in the octane level with the conclusion that 20% ethanol would result in approximately 22% reduction in petroleum use. Two master's theses have been prepared as a result of this work, and a paper is being prepared for presentation to the Society of Automotive Engineers on the diesel fuel work.

In addition to the research initiatives supported and described above, discretionary funds were also used to support a post-doctoral fellowship for a period of one year in the laboratories of Professors Tony Crofts and Charles Arntzen. This collaboration was directed toward a biophysical analysis of photosynthetic processed in intact plants. This work was motivated by an increasing interest in biomass production and the need for nondestructive means for rapidly assaying photosynthetic activity IN VIVO. The funding level was $12,500.

Program Proposed for 1980-81

In April of 1980, the University of Illinois submitted a proposal to the Department of Energy for a distinctly different program to be undertaken in the third year of the Disciplinary Funds Program. That proposal called for the engaging of faculty members in our distinguished Engineering Materials Group in the conduct of research that was more specifically applicable to the materials problems encountered in modern coal conversion system. The effort has been entitled, the Coal-Utilization Materials Engineering Research (CUMER) program. In July of 1980, the CUMER Advisory Committee, composed of Professors F. V. Lawrence (Chairman of the Engineering Materials Group), H. K. Birnbaum, F. A. Leckie, and J. J. Stukel, was appointed. On July 24th a solicitation for proposals from relevant faculty was announced. A copy of that solicitation is enclosed in the Appendix B. A deadline of October 1, 1980 was placed on the solicitation.

In a February 9th meeting between the Advisory Committee and the investigators given awards, the following summary of the interrelated projects was presented.

This report summarizes work to be performed under funding from the Coal Utilization Materials Engineering Research program, starting January 20th, 1981. Seventy-five thousand dollars ($75,000) of the total grant awarded to the university has been allocated to 5 individuals (at $15,000 each) to initiate relevant materials research. These are:

D. L. Marriott
J. Mazumder
B. Muddle
M. Rigsbee
J. Stubbins

Although funding is, normally, on an individual basis, there is a degree of co-ordination in the choice of topics. The special problems of coal gasification and liquification are related firstly to the highly aggressive environments, secondly to wear and abrasion, and thirdly to the interaction between these phenomena. With this emphasis in mind the proposed work addressed three related topics.

1. Fundamental studies of material deterioration due to environmental attack, wear and high temperature damage.

2. Formation of resistant surface treatment using laser technology.

3. Design of surface treated components as composite structures to resist cyclic service loadings.

There is no rigid demarcation between individual projects as far as the above topics are concerned. As will be seen from their description in the following section, there is a reasonable amount of overlap of interests. This is in line with the interdisciplinary nature of the work involved, ranging as it does from fundamental materials studies, through engineering design studies to production processes, and ensures a high element of co-operation between the investigators.

Description of Individual Projects

1. Creep-Fatigue Interactions in Pressure Vessel Steels -

B. C. Muddle

This project is a fundamental study of basic failure mechanisms in low alloy and stainless steels commonly used in petro-chemical applications for pressure vessel construction. It is proposed

to perform creep/fatigue testing initially in air and later in H_2 and H_2S atmospheres on 2 1/4 Cr-1 Mo steel and type 347 stainless steel in order to correlate changes in microstructure with observed mechanical behavior using scanning and transmission electron microscopy.

The aim of the work is to gain insight into the part played by H_2 environment in acceleration of creep rate and fatigue damage accumulation.

Initial environmental testing will be carried out on a modest scale at atmospheric pressures, and at temperatures up to 500°C. The program will be expanded to include high pressure testing once the environmental rig being designed by J. F. Stubbins and D. Socie is completed (see project No. 4 below)

2. Corrosion Resistant Coating by Laser Alloying - J. Mazumder

The major causes of failure in coal conversion systems is erosion-corrosion. The most common material used for the coal conversion system is low alloy steel (2.25 Cr, 1 Mo steel) of pressure vessel quality. Sometimes a protective coating is required to prolong the life. The objective of the proposed program is to develop a laser surface alloyed coating to improve the corrosion-erosion property of 2.25 Cr, 1 Mo steel used for coal conversion systems.

Laser surface alloying offers the possibility of generating materials and metastable phases at the surface which are either new or have unusual properties. Using the laser surface alloying technique working surface may be modified to provide characteristics necessary for the end use application.

The proposed research program will investigate the relationship between the processing parameters and resulting microstructure and alloy composition. Correlation between the microstructure and corrosion-errosion properties will also be studied. The problem of reproducibility will also be addressed.

A three-dimensional heat transfer model developed by the author will be used to determine the thermal history of the processed zone. This will also be verified experimentally. An attempt will be made to generate dimesionless plots for prediction purposes.

3. High Temperature Materials Testing - D. I. Marriott

Theoretical and experimental studies are to be made of the behavior of low alloy steels, with and without cladding, at temperatures where creep is not normally considered a problem but where the influence of the environmental, in particular hydrogen attack, may increase the creep rate.

The object is to develop design procedures to govern allowable stress levels for component design under environmental conditions encountered in coal liquefaction plants.

So far, a review of materials problems encountered in coal plant design has been carried out.

Work planned for the immediate future includes the setting up of creep testing, adapting the Bree Diagram design chart for composite pipes, and developing a continuum model for the interaction between creep damage by void initiation and growth, and hydrogen attack.

This is essentially component oriented, relying heavily on basic materials studies performed by other investigators. In particular, collaboration with B. Muddle on damage mechanisms and J. Mazumder on surface coating production is planned.

4. Carburization and Internal Oxidation Studies on Materials for Use in High Temperature Coal Gasification and Liquefaction Processes - J. F. Stubbins

This project will address carburization, and external and internal oxidation effects in high temperature alloys for use primarily in coal gasification environments. The physical and chemical make-up of oxides and carbides will be studied in detail as a function of alloy composition. In addition, changes in alloy mechanical properties with carburization and oxidation will be determined. All testing will be carried out in gaseous atmospheres where the oxidation potential and carbon activity are controlled by the ratios of hydrogen, water, carbon monoxide, carbon dioxide and methane in the test gases.

A major component of the CUMER program is the development of an environmental testing rig. This rig which is also required for the other projects, is being developed largely as a responsibility of J. F. Stubbins, since this project contains the greatest complexity of environmental conditions.

5. Improved Corrosion Resistance through Microstructural Surface Modification - M. Risgbee and C. Altstetter

This research project is directed toward the development of surfaces resistant to erosion in environments encountered in coal gasification/liquefaction processes. The initial portion of this research will involve development of laser

surface modification techniques and characterization of the produced microstructures for selected cast irons. Next, hard-particle abrasion and wet-slurry erosion tests will be devised (and equipment built) to evaluate the processed material under conditions which simulate the environments found in advanced coal utilization equipment. It is expected that close interaction between the various phases of this project, i.e., laser surface modification/microstructural characterization and erosion/wear testing, will allow the development of a more fundamental understanding of how surfaces can be optimized with respect to their erosion/wear resistance.

In addition, the design phase of an environmental facility was approved. A draft of the initial design is in the Appendix B. As originally proposed, the Engineering Materials phase of the DOE discretionary funds program was likely to last two or perhaps three years. We have just received a no-cost extension of this program which would carry the effort through May 20th, 1983. As requested, progress reports will be submitted for the years 1982 and 1983.

FINANCIAL REPORT FOR YEAR 3 OF THE
DISCRETIONARY FUNDS PROGRAM
FEBRUARY 1981

Balance carried forward from prior years (For details see report of March 1980)	$ 1,959
Committed to Professor Marilyn Brown for a consumer study*	1,959
	0
Funds provided 1980-81**	225,000
Funds committed to 5 approved projects under the CUMER program	75,000
Balance carried forward	$150,000

*The results of this study will be carried in the next year's report.

**No cost extension to 1983 approved.

APPENDIX A

INDIVIDUAL PROJECT REPORTS
SUPPORTED DURING 1980

TITLE: Radiative Collision Lasers

PRINCIPAL INVESTIGATOR: Munir H. Nayfeh, Assistant Professor
Physics

STUDENTS: David B. Geohegan and G. B. Hillard

PROJECT PERIOD: May 25, 1979 - May 25, 1980

FUNDING LEVEL: This project is funded by DOE at $11,207 level. This fund covers the salary of half time graduate research assistant, D. B. Geohegan. The project is also supported by a department and Engineering College Fund of $23,000 for the period (January 1 - December 1, 1980).

Moreover, some theoretical aspect and the study of the nature of radiative collisions was supported by the principal investigator NSF grant PHY 78-25247. The grant is $164,000 for two years for the period July 1979 - July 1981.

BACKGROUND: We use a new light controlled collisional transfer process to develop a new class of lasers: radiative collision lasers. The process involves the collision of two atoms with an energy defect ΔE much larger than KT; and thus the cross section for chemical reactions or collisional transfers is very small. The collisional transfer or the chemical reaction however, can be induced in the new process by irradiating the system with carefully tuned light; absorption of one or more photons is utilized to conserve energy between the initial and final state of the colliding system, i.e. $nh\omega=\Delta E$.

A laser system based on this process is of practical interest because of two important reasons. Firstly, a great amount of energy can be stored in the system by using a metastable or a radiatively trapped resonance state as the initial state. Secondly, the gain of the system can be varied by varying the number density of the acceptor species.

The research involves the study of discrete-descrete, and discrete-continuum transfers in the collisions of various atoms. We will also study the atom-molecular radiative collision; specifically the case of a predissociating molecular acceptor state promises inversion and perhaps gain. Moreover, the multiphon aspect of the process will be studied.

PROJECT DESCRIPTION AND RESULTS: The experimental setup is described as follows. A pulsed electron source is used to prepare a population of metastable atoms. After a certain time delay with respect to the pulses, the laser is fired into the cell. The spontaneous emission or the ionization from the acceptor species is monitored. Time resolved measurements will be taken by delaying the laser pulses with respect to the electron pulses, which yield spectroscopic data that help optimize the system

We have already converted an old electron microscope to a pulsed electron source. The CW mode was changed to pulsed operation by harmonically deflecting the beam across an aperature. We achieved 10-15 ns pulses with up to 10 KHz repetition rate. The electrons have a range of energies 25, 50, 75, 100, and 125 KV, from a stabilized power supply. Coupling of the electrons to high pressure chambers is achieved. We have built an interaction chamber with ports for detection of fluorescent light and with electrodes for detection of ionization. A pulsed laser system tunable over the visible and UV spectrum

is available in our laboratory. A proportional counter filled with NO and aVUV monochromator for the detection of short wavelength photons (10 eV photons) are in operation. A system for detection of time intervals ranging from a few ns to a few μs and an LSI/23 microprocessor are already built.

We made some emission studies. More emission studies will be taken. We studied the two photon laser induced radiative collision. We treated the two photon-one collision and two photon-two collision cases. We found a new intensity induced collisional shift which makes the two photon lineshape highly sensitive to the intensity, and may make the lineshape symmetric. We are presently studying the effect of continuum states on this process. The study "Two Photon Laser Induced Radiative Collision" by M. H. Nayfeh and G. B. Hillard will be submitted shortly.

TITLE: An Assessment of the Impact of Commission Regulation on Prices, Expenses, Rates of Return and Financial Strategies of Electric Utility Firms

PRINCIPAL INVESTIGATOR: Walter J. Primeaux, Jr. Professor
Business Administration

STUDENTS: Edward Bubnys
Andrew Jaski
Han Bin Kang

PROJECT PERIOD: May 21, 1979 - May 21, 1980

FUNDING LEVEL: $10,590

BACKGROUND: Although the conventional view is that business regulation provides positive benefits to society, it has not been actually established that those beneficial effects do occur. Indeed, previous research by the author raises serious questions about the whole notion of the natural monopoly concept.

Economists, in general, have begun to question whether regulation provides positive benefits to society. This is particularly true about public utility type businesses.

Since the energy crisis there has been even increased concern about the impact of regulation on utility company profits and prices. It is assumed that regulation causes lower prices and lower profits, but the actual effects are unknown.

Another area of concern is the impact of regulation on the capital structure of utility firms. That is, how do regulatory constraints cause utility firms to modify their capital structures. If, indeed, there are such effects (as indicated in previous aggregate research by the author) it would be useful to examine these effects on individual firms through time series analyses.

PROJECT DESCRIPTION: This research is divided into two parts. The first part is designed to examine the individual firms in states where electric utility regulation was established since WW II. This kind of sample would allow a comparison, before and after regulation, of the effect of commission regulation on prices charged, on expense levels, and on rates of return earned.

Time series equations will be developed for each firm for each of the variables mentioned above. The statistical technique will be multiple regression analysis. The equations will permit a rigorous assessment of the effects of utility regulation on the performance of firms in the industry.

The second part of the study examines the same sample of firms, examining financial behavior before and after regulation. It will be possible to examine capital structure changes taking place because of regulation by a state commission.

By the use of multiple regression analysis of time series data, an examination will be made of each firm's adjustments to financial capitalization and financial strategy.

RESULTS: On July 29, 1980, working paper No. 692 was issued by the College of Commerce and Business Administration at the University of Illinois, reporting the results of the first phase of this study. From preliminary results of this research, a paper was presented to the Southern Economic Association meeting in Atlanta Georgia in November, 1979. This first phase of the study is complete and is a success.

While developing the data and analyses used in the first phase of this study, several new ideas and perspectives have been developed which have caused me to undertake an additional project which was originally unintended. This project involves an even more sophisticated econometric model of public utility regulation. The econometric work has all been developed and the final paper is in the process of being written and will be completed in a matter of days. As mentioned earlier, this really constitutes an important expansion of the work made possible by the grant.

The second phase of the study is also being written at this time and will be completed in a matter of days. The computer work has all been finished, the library work is all done, and the only thing remaining to be completed is the writing up of the research results. Hopefully, I will present these results to an academic conference during the next academic year. The second phase of the study is virtually completed and is also a success.

Overall, this project has produced fruitful results. In addition to the proposed research which generated very significant results, additional projects will continue to be developed from these beginnings. New ideas for several additional projects have occured to me while completing the proposed research. These are all important matters which should be examined to help formulate public policy in the energy industry. Consequently, it is fair to say that the investment in the grant was money well spent. When the results appear in the academic economic journals, which will probably be quite soon, they will also awaken interest in additional research by other professors.

In summary, then, my work on the basic proposal is virtually complete and the results are very exciting. The project is a success. I am grateful for the support because the grant has made it possible for me to explore areas of interest faster than would have been the case without this assistance.

TITLE: Catalytic Decomposition of NO_x

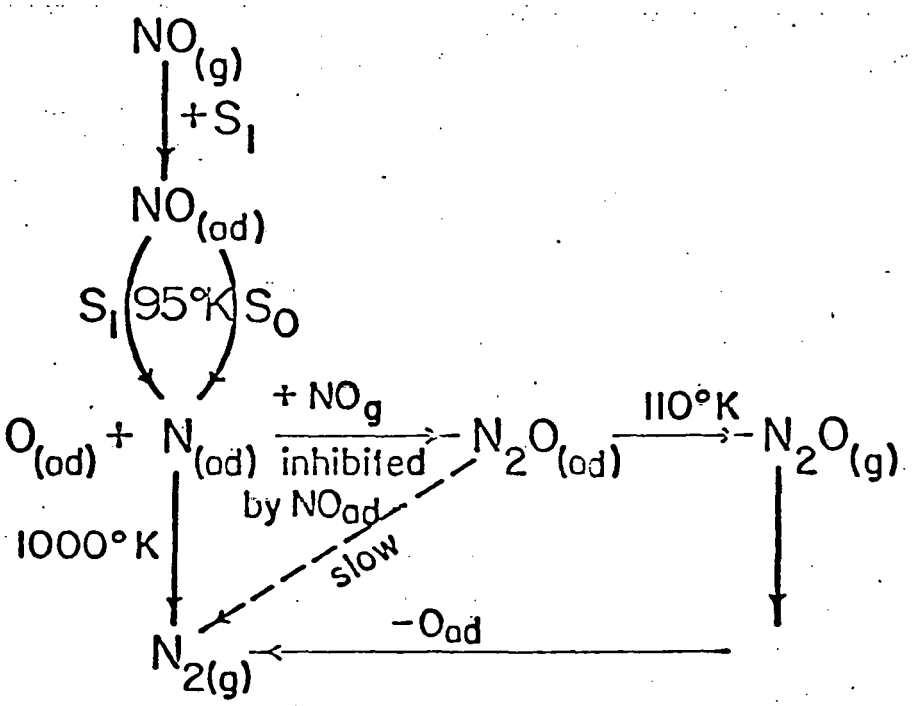
PRINCIPAL INVESTIGATOR: R. I. Masel, Assistant Professor
Chemical Engineering

PROJECT PERIOD: May 21, 1979 - May 20, 1980

FUNDING LEVEL: $14,500

BACKGROUND: An improved NO_x removal catalyst would result in sizeable fuel savings in an automobile. The progress toward the production of improved catalysts has been limited because of a lack of understanding of the basic chemistry involved in the catalytic reaction. It is not clear how the rates of the individual steps in the reaction are affected by the local catalytic environment. Here it was proposed that a novel combination of transient response methods and surface spectroscopy be used to measure the rates of the elementary steps involved in NO_x decomposition in an attempt to see how these rates are affected by the local catalytic environment.

ACCOMPLISHMENTS: Our first studies were directed toward determining the mechanism of NO decompoition on tungsten. We have found that, on tungsten, NO decomposes via the mechanism:



With two different states for oxygen. One of these, an oxide like state, has unusual properties. It is possible these properties could be exploited to yield better catalysts.

We have also explored the mechanism of NO decomposition on platinum. Essentially we see the same mechanism as with tungsten except that there is no oxide formation. The NO decomposition step is much slower without an oxide, and hence the pure platinum catalyst is much less selective than the pure tungsten one.

We also looked briefly at the mechanism of CO oxidation on platinum. We have observed a very simple reaction. We were not able to observe the oscillations, and other unusual phenomenon reported by previous investigators. Other workers have since looked for the oscillations in this system and have not been able to find them either when the experiments were done carefully. It has been found that oscillations arise because of poor experimental technique, i.e., impurities in the system, or variations in the feed temperature. We have lost interest.

STUDENTS: This work is part of the Master's Thesis of D. Horton, I. Ang, and W. Banholzer.

PAPERS: Two papers were presented on this work:

"Catalytic NO Decomposition an Elementary Step at a Time," presented AIChE Meeting, San Francisco, November, 1979.

"The Mechanism of NO Decomposition on Tungsten and Platinum," presented AIChE Meeting, Chicago, November, 1980.

TITLE: Fuel/Air Control System For Catalytic Combustion Driven Stirling Engines - A Feasibility Study

PRINCIPAL INVESTIGATOR: Michael J. Binder, Assistant Professor
Mechanical and Industrial Engineering

STUDENT: Randall L. Davis, Graduate Student

PROJECT PERIOD: May 21, 1979 - May 20, 1980

FUNDING LEVEL: $15,000

BACKGROUND: Faced with today's stringent environmental and energy requirements, the Stirling engine is emerging as a viable commercial proposition. One relatively new heat source currently being investigated for use with Stirling engines is catalytic combustion. This technique utilizes a solid-phase catalyst supported on a ceramic monolith to stabilize hydrcarbonoxidation oxidation reactions which are too fuel-lean to proceed in the gas phase. Because the advantages of the Stirling engine and catalytic combustion complement each other, the concept of a catalytic combustion driven Stirling engine for automotive application or for stationary power generation would appear to have great potential for maintaining a health environment while conserving our dwindling petroleum supplies.

The incorporation of a catalytic combustion system as the energy source for a Stirling engine gives rise to the possibility of controlling engine speed by variation of the fuel/air ratio due to the wide range of equivalence ratios over which reactions may be stabilized by catalytic combustion. This means of engine speed control would be preferable to any of the current means.

PROJECT DESCRIPTION: The objective of this research is to investigate the feasibility of controlling engine speed through variation of the fuel/air ratio in a catalytic combustion driven Stirling engine. Primary concern is centered on the engine speed response to a change in the fuel/air ratio. A small commercially available demostration Stirling engine is used in this study. Heat is supplied by the catalytic combustion of a methane/air mixture and cooling is provided by circulation of water through a cooling jacket. Simultaneous monitoring of fuel flow rate (with constant air flow rate) and engine speed will allow determination of the engine tranfer function as a function of the pertinent engine parameters.

A secondary objective of this project is to introduce extremely capable junior and senior mechanical engineering students to state-of-the-art research by involving them as part of the research team through an ME 293 Independent Projects Course. It is felt that this type of involvement is an extremely valuable contribution to their overall educational objectives, as this project introduces the students to a wide variety of practical, academic, and research topics including temperature, pressure, flow, torque, and power measurement techniques, engineering design, heat transfer, thermodynamics, and combustion sciences; and areas of active research such as catalytic combustion and Stirling engine technology.

RESULTS: The ultimate objective of this research project - the demonstration of an adequate transient response to engine speed to a change in fuel/air ratio - has been demonstrated qualitatively although the results are not satisfactorily repeatable or predictable. The problem seems to lie in instabilities in the catalytic combustor resulting in non-uniform temperature changed both across any cross-section of the combustion and along the length of the combustor. Efforts are continuing to be made to improve the combustor performance, although it is felt that the small size of our test model may be contributing to the problem. We have been able to demonstrate the ability to use catalytic combustion as an energy source for a Stirling engine. Our engine has run successfully throughout an equivalence ratio range of 0.15 to 0.50, with the respective engine speed range being 180 to 1900 rpm. The upper value of equivalence ratio is limited to avoid thermal destruction of the ceramic monolith. We feel that the lower value of equivalence ratio could probably be extended if provisions were made to preheat the incoming air for combustion. Given the small scale of our model, we do not feel this is to be a feasible approach for our present project. We feel that even if we are not able to quantitatively demonstrate adequate transient response of engine speed to fuel/air ratio change, we have compiled sufficient evidence to write a proposal to continue this study on a larger scale engine.

PUBLICATIONS: Two publications are presently in the preparation stage. One involves the educational benefits of incorporating undergraduate students into state-of-the-art faculty/graduate student research projects, and the other involves the demonstration of successful steady-state operation of a Stirling engine at different equivalence ratios by use of catalytic combustion. We are also examining the literature to determine whether a simple optical tachometer system which we developed might merit a technical note. At present, we are awaiting arrival of a new heater head before we begin a final attempt to demonstrate transient behavior. If we are successful in that attempt, we will publish these results as well.

TITLE: Regional Environment-Economic Optimization Models for Evaluating Policies Which Affect the Development of the Electric Power Industry in the Midwest

PRINCIPAL INVESTIGATOR: George Provenzano, Assistant Professor
Environmental Economics

Daniel F. Hang, Professor
Nuclear Engineering & Electrical Engineering

Harold F. Williamson, Jr., Associate Professor
Economics

STUDENTS: Parveen Jain
Chun-Chi Wu
Richard A. Walasek

PROJECT PERIOD: May 21, 1979 - May 20, 1980

FUNDING LEVEL: $23,070

BACKGROUND: The problems of determining optimum investment strategies for the electric power industry have motivated the formulation and application of optimization models of integrated power generation and transmission system. Engineers, economists, planners and policy analysis in industry and government use these models to identify and evaluate the economic and environmental tradeoffs associated with alternative utility expansion plans. Integrated mathematical models of this kind are interdisciplinary in nature and provide a means of systematically dealing with complex economic, technological and environmental relationships which must be considered in utility planning.

The particular models that will be formulated in this study will be designed to address the problem of determining optimum strategies for guiding utility industry investment planning in the face of (1) anticipated changes in electricity rate structures; (2) the large number and high costs of various power generation activities; and (3) the corresponding large number, high costs, and complexities of different technical alternatives for controlling the environmental consequences associated with power generation activities. Inputs into the models will include information on unit costs and resource requirements; current and potential locations; and pollutant emission rates and emission controls for existing and potential power general activities. For a given electric energy growth scenario, the models will determine the optimal sizes, types, locations, and pollution control alternatives for power generation activities needed to meet future demands for electricity. Although the model implementation phase of this study will be oriented toward an electric utility expansion in the Midwest, the proposed models would be applicable to similar problems in any region of the country.

PROJECT DESCIPRTION: The objectives of this research are to formulate and implement innovative environmental-economic optimization models for evaluating policies which affect decisions by the electric power industry to invest in new generation and transmission facilities. Specifically, multiperiod, multi-plant, multimarket regional models of power plant and transmission line construction and power generation and transmission activities will be constructed. To demonstrate their capabilities, these models will be used to examine

the responses of these activities to (1) alternative proposals for time-of-use pricing of electric power; (2) rapidly escalating power plant construction costs; and (3) alternative mechanisms for preventing significant air quality deterioration. Although the proposed research will in part be greatly facilitated by the modelling and data transformation procedures that are being developed with an existing UIUC Institutional Energy Program grant, the proposed modelling analyses represent entirely new departures from the current effort.

RESULTS: One of the major accomplishments of this study has involved the development of a computerized data management and model construction system. This system (1) inputs costs and technical data on power plant and transmission line operations; (2) computes from these data the cost and technical coefficients for the model and (3) assembles these coefficients into an appropriate input format for a mathematical programming package. This procedure was necessary because the kinds of models being developed in this study tend to be very large and require a substantial amount of data management. The data management system has been developed in a manner that is suitable for constructing both the linear and quadratic programming models discussed above and it is completely flexible in its ability to construct models for regions of different size.

TITLE: Nuclear Power and Public Attitudes

PRINCIPAL INVESTIGATORS: Arthur B. Chilton, Professor
Nuclear Engineering

Martin Fishbein, Professor
Psychology

STUDENTS: Ron Hinkle
Edward Kelenyi

Although not supported by the project, the following are also participating:

Barbara Anderson
Susan Middlestadt
Rense Lange
Jean Chung

PROJECT PERIOD: September 20, 1978 - June 20, 1979, Renewed through May 20, 1980.

FUNDING LEVEL: $14,297 + $15,752 + $3,000 additional support from the Illinois Power Company.

BACKGROUND: Our ongoing research is concerned with understanding the public attitudes toward various energy alternatives, with particular emphasis upon attitudes toward the use of nuclear power. The social conflict surrounding technological development in this area necessitates through consideration of public values and beliefs.

PROJECT DESCRIPTION: Two studies have been conducted to date. Study I, conducted during spring 1979, surveyed 224 respondents living near various power plants (i.e., Three Mile Island and selected conventional and nuclear plants in Illinois). Questionnaire based interviews assessed respondent attitudes toward the use of five energy sources (nuclear, solar, coal, oil and hydroelectric) as well as beliefs regarding the consequences of the use of each energy source.

Study II was conducted during fall 1979. One hundred college students rated the acceptability of a number of (hypothetical) proposed power plants. These plants varied systematically in terms of fuel source (nuclear, coal, or unspecified), aspects of possible accidents (probability, severity, potential for radioactive leakage, scope of effects), level of pollution, location (in terms of local population density), economic impact, energy shortage, plant supervision/regulation and a number of other attributes. The design of this study differed from Study I and previous questionnaire research in that the impact a change in a given plant attribute might be expected to have on public opinion was assessed. (For example, how much change in acceptability would occur if the probability of radioactive leakage was reduced by a factor of 10?) Further, the magnitude of impact from alternative changes is readily compared.

Since our previous report we have completed analyses of study II and conducted a third study similar in design to study II but focusing entirely on hypothetical nuclear powered plants. Half the respondents rated plants "under consideration for construction in your local community" while the other half rated plants "under consideration for construction in another state". Other

variations included: (1) Type of supervision (normal vs community), (2) Magnitude of energy shortage faced by the surrounding area (severe vs. moderate), (3) Type of construction (above or below ground), (4) Plant size (small vs. large), (5) Radioactive waste (stored on site or transported our of state), (6) Accident probability (low, average or high relative to other nuclear plants) and (7) Accident scope.

Unfortunately, we were only able to complete preliminary analyses on study III prior to the termination of the grant and, although I still intend to complete the analyses on this study and to write up all three studies for publication, it now looks like these tasks will not be accomplished before this summer.

TITLE: East Urbana Energy Project: 1980 Report

PRINCIPAL INVESTIGATOR: Demitri B. Shimkin,Professor
Anthropology and Geography

STUDENTS: Carolyn A. Sprague
Romy Borooah, Dorothea Milton,
Srila Sen, Mark Woodard,
Kevin Doolen, David Karlquist,
all graduate students.
Sara Gold, undergraduate.

PROJECT PERIOD: January, 1980 - January 1981

FUNDING LEVEL: Funding received from the Office of Energy Research was $20,743.00. Of this amount, about $1,400 in discretionary funds remain to pay costs of final manuscript preparation, and to cover further analysis and preparation of an additional paper to be given by Ms. Sprague at the Society for Applied Anthropology Conferences in Edinburgh, April, 1981.

BACKGROUND: Between 1972-74, the College of Engineering undertook a study to investigate the effects of energy shortages upon social structure, generic activities and value schemata. The object of study was East Urbana, a homogeneous urban-fringe settlement area with a younger, white, middle-income blue collar population. Among the findings were: (1) high value placed upon household autonomy, maximum dependence upon "things" and an aspiration for continued physical and social mobility; and (2) a basic stability in values seen in limited response to the 1974 energy crisis. More recently, the continuation and intensification of energy shortages and inflation made desirable a re-study of East Urbana.

PROJECT DESCRIPTION: The 1980 Energy Study interviewed 155 households and a total of 220 individuals in East Urbana. Methodology consisted of stratified sampling of residents living in conventional single-family dwellings, apartments and mobile homes. All interviewing was done face-to-face in respondents' homes. The instruments were designed to gather information on (1) the technical knowledge of householders in regard to energy saving in housing and transportation; (2) the key economic choices, including qualitative changes in products purchased in 1979 and anticipated in 1980; (3) the rationales of choices, with reference to individual goals vs. emulations vs. felt obligations; and (4) the significance of public resources in adapting to economic pressures.

ACCOMPLISHMENTS: The basic aims of the project have been met. All data collection has been completed and a report on findings is in final preparation. The general findings showed a remarkable continuity of values and behaviors between 1974 and 1980. Household autonomy, mobility, and material possessions continue to be important. Adaptations to economic stresses have been extensive, including an intensified work effort, behavioral economizing in the home, and a marked shift in vehicle composition toward small cars. Individual savings have provided the resources for these adaptations and other property purchases. Public resources have played no visible role; government in general is regarded with suspicion.

The 1972-74 and 1980 data have been integrated into a comprehensive report of 210 manuscript pages and 49 tables, entitled How Midwesterners Cope: Report of the Eart Urbana Energy Study, by Sprague and Shimkin. The table of contents is as follows:

This report is essentially aggregate in nature. The analysis of internal variations in coping levels and their socio-economic and psychological determinants is presently being carried out by Ms. Sprague. These results will be included in a paper entitled, "Values, Socio-Economic Stresses and Consumption Behavior in a Middle-Class Population", to be given at the Society for Applied Anthropology Conference in April, 1981, at Edinburgh, Scotland.

References: Hyland, Stanley E., et al.

1975 The East Urbana Energy Study, 1972-1974: Instrument Development, Methodological Assessment, and Base Data. College of Engineering, University of Illinois, Urbana-Champaign.

TITLE: Alcohol Energy Systems for Corn Farms

PRINCIPAL INVESTIGATORS: E. D. Rodda, Professor, Electric and Power Processing
Agricultural Engineering

D. L. Day, Professor, Structures and Environment
Agricultural Engineering

D. R. Hunt, Professor, Farm Power and Machinery
Agricultural Engineering

A. H. Jensen, Professor, Animal Science
Agricultural Engineering

M. P. Steinberg, Professor, Food Engineering
Agricultural Engineering

GRADUATE STUDENTS: Yun-Long Ling
Marvin Pitts
S. Purkyastha
Curtis Weller

Another graduate student, William Hudson, was employed for two months during the summer. Three undergraduate students are employed up to ten hours per week.

PROJECT PERIOD: December 1, 1979 - May 20, 1981

FUNDING LEVEL: $29,677

BACKGROUND: The future liquid fuel needs for mechanized corn production suggest the use of farm biomass to produce alcohol to extend or replace petroleum fuels. Integrating a livestock enterprise with alcohol production would permit major cost and energy savings through direct feeding of the residual grain without drying. Biogas produced through anaerobic digestion of animal manures can provide the heat for cooking, conversion, and distillation. The digester sludge will provide 10% of the nitrogen fertilizer for corn production in a completely integrated system. The energy output to input ratio is 2.5 without taking credit for either the sludge as fertilizer or the possible feed value of the spent beer. Though industrial economics of scale can significantly reduce the processing costs, the costs of collecting, transporting, and storing raw materials may make smaller plants more economical. Opportunities appear to exist for alcohol fuel production on a comparatively small scale by individual farmers and local groups.

PROJECT DESCRIPTION: A critical need exists for the development of technology appropriate to fuel-grade ethanol production on a small scale (1000 gallons/day or less). Small scale system design must consider the limited time that farmers have available for management.

The research objectives are (1) to design and build a small scale alcohol system based on corn, (2) to study the alcohol system management requirements in a farm operation, (3) to develop the basis for integrating a livestock operation to utilize the residue materials and produce biogas for the process energy, and (4) to study tractor engine cold starting problems, evaluate field performance, and demonstrate the feasibility of alcohol as a tractor fuel.

ACCOMPLISHMENTS: A laboratory fuel alcohol production system using five 200-liter drums with 25 kg batches of corn has been built and operated. Temperature control and agitation are automatic; start-up and transfer operations are manual. Use of the system is planned for a research project involving substantial quantities of corn so heavily infected with aflatoxin that it cannot be marketed. Use of this corn for alcohol production, accompanied by a simultaneous detoxification treatment to permit feeding of the spent mash, would permit almost complete salvage of corn that would otherwise be condemned and buried.

Work is underway to ascertain the minimun conversion to permit the use of farm produced ethanol (180-190 proof) with acceptable efficiency. Conversion of a diesel tractor engine into an alcohol-burning, spark-ignition engine was completed, but more development remains to regain the performance of the original engine. The vaporization characteristics were determined for mixtures of unleaded gasoline, 190 proof ethanol, and additives developed by the USDA Northern Regional Research Center to eliminate separation problems in engine fuels. A mixture of 4 parts unleaded gasoline, 1 part ethanol, and 1 part N-butanol showed promise and will be tested.

An experimental machine to harvest sweet sorghum juice as feedstock for ethanol production was built and tested. Further development is required to extract an acceptable percentage of the available juice.

The funds granted under this project were a major factor in the development of a proposal for an integrated farm energy system. A research contract with funds for equipment only has been funded by the Illinois Institute of Natural Resources under the Energy Bond Fund Program. Specifications are being prepared for a biogas system to be built on the University Swine Farm, a microprocessor control system is on order, and bids are being solicited for an extrusion cooker.

A critical need still exists for funds to support three graduate students at a minimum of $6,000 per student per year plus overhead.

Publications:

Hunt, D. R., "Converting a Diesel Engine to Alcohol", Agricultural Engineering, 61:12 (1980), 12-13.

E. D. Rodda and M. P. Steinberg, "Energy Analysis of an Agricultural Alcohol Fuel System," Invited Paper presented at 73rd Annual Meeting of the American Institute of Chemical Engineers, Chicago, IL. Nov. 20, 1980. 9 pages.

TITLE: Feasibility of Greenhouses Heated With Surface Application of Power Plant Cooling Water

PRINCIPAL INVESTIGATORS: J. B. Braden, Assistant Professor
Department of Agricultural Engineering

L. A. Spomer, Assoticate Professor
Department of Horticulture

P. N. Walker, Associate Professor
Department of Agricultural Engineering

OTHER PROFESSIONAL PERSONNEL: S. S. Lazarus, Agricultural Economist
Department of Agricultural Economics

PROJECT PERIOD: February 1, 1980 - May 20, 1981

FUNDING LEVEL: $21,012

BACKGROUND: Heating energy is a major and rapidly increasing cost of operating a greenhouse. For many operators in cooler climates this cost is $90,000 per hectare per yearand is their single most important operating cost. Surface-heating greenhouses with waste heated water promises to reduce heating costs. Using this system, greenhouses are heated with waste heated from electric generating plants or other industries by applying this water to the ridge of the greenhouse and allowing it to run over the outside surface.

Previous research on this project by University of Illinois personnel includes the construction and monitoring of a 4m x 8m temporary-type greenhouse surface-heated with water form Illinois Power Company's Vermilion Power Plant. This work conclusively demonstrated that the heating system functions. Typically, a flow rate of 0.094 L/s per m^2 of greenhouse area was sufficient to heat the greenhouse to 15^{o}C when the outside temperature is -6^{o}C using 30^{o}C water. Only one water flow rate was tested.

In 1977, a laboratory sized greenhouse model was also constructed at the University of Illinois to test different water flow rates, and different water application systems. It was found that low pressure application systems and smooth greenhouse surfaces such as glass or plastic film, rather than corrugated fiberglass, work best because the entire surface can be covered with a thin film of water. It was also found that the conduction-convection heat transfer coefficients between the water and the outside air and between the water and the greenhouse interior were not a function of water flow rate.

Further research is underway at the IP's Baldwin Power Plant to study hear transfer aspects of this heating system.

This research has demonstrated that the surface-heating concept is technically promising and has pointed the way to the system configuration which works best. However, the above-mentioned projects have been limited to technical features of the system. The economics of this technology remain to be clarified before serious steps are taken toward moving this technology from the experimental phase to use by private entrepreneurs.

PROJECT DESCRIPTION: Two questions are central to the usefulness of surface heating technology: (1) Under what conditions is it likely to be attractive commercially? and (2) How widely might it be adopted and what energy savings might be expected as a result?

This project addresses the preceding questions with the following objectives: (1) to assess the commercial viability of surface heated greenhouses in the midwest and estimate energy savings at typical installations; (2) to develop estimates of the sensitivity of commercial prospects and energy savings to heat requirements (climate), marketing costs, charges for heated water, and changes in plant growth characteristics; (3) to project regional and national applicability of this technology and resulting energy savings in the event of its adoption; and (4) to report legal or institutional issues surrounding implementation of this technology.

ACCOMPLISHMENTS: A mathematical greenhouse heating model is being used to evaluate surface heating. The first stage of the model predicts typical hourly weather conditions for the geographic area being studied. This information is then used to predict greenhouse energy usage with and without surface heating. Finally the energy usages and other costs and benefits are converted to economic measures of system viability.

This model was used to predict the annual heating energy consumption of a 4000 m^2 glass greenhouse both with a conventional heating system and with a surface heating system for a range of water, air, and greenhouse temperatures similar to conditions at the Baldwin Power Plant experimental greenhouse. A double-layer, polyethylene-covered greenhouse was also studied. The net annual energy savings ranged from 22.5% for water 5°C cooler than Baldwin conditions to 80.4% for water 5° warmer than Baldwin conditions. The highest monthly absolute savings were in November because of relatively high water temperatures and cool air temperatures.

Using 1980-81 prices, annual energy cost savings corresponding to the energy savings cited above are are 18.0% and 76.6%. A present value analysis of savings and added costs over the 20-year life of the system using a 12 percent discount rate and a 15 percent energy cost inflation rate showed that the surface heating system more than paid for itself under each of the conditions studied. Net present values corresponding to the energy savings cited above are $4,000 and $427,000 which are equivalent to net annual returns of $400 and $57,200.

Further economic analyses are underway. The economics part of the model is being improved to allow price variability to reflect uncertainties about future fuel prices. Additionally, the analysis will be extended to regional and national greenhouse production to see what energy savings might be available from this technology.

Publications:

Lazarus, S. S., J. B. Braden, and P. N. Walker. 1981. Economics of surface-heating greenhouses with waste heat. Illinois Research. 23(2). In press.

Walker, P. N., S. S. Lazarus and J. B. Braden. 1981. Surface heating greenhouses: Microeconomics. Under review for publication in Transactions of the ASAE.

TITLE: Replacement of Petroleum Fuels with Alcohol

PRINCIPAL INVESTIGATORS: S. C. Sorenson
Mechanical and Industrial Engineering

C. E. Goering
Agricultural Engineering

STUDENTS: Frank Ferfecki
Hamid Shirvani
Rakesh Sachdev

PROJECT PERIOD: January 21, 1980 - January 20, 1981

FUNDING LEVEL: $25,562

USE OF ETHANOL TO MODIFY PROPERTIES OF DIESEL FUELS

BACKGROUND: The current U.S. Agricultural system is highly dependent on petroleum. Most of the field work on American farms is done with diesel powered tractors and combines. Because a dependable supply of petroleum fuel for agriculture is no longer assured, it is prudent to investigate means for augumenting diesel fuel supplies.

PROJECT DESCRIPTION: Blends of No. 2 diesel and No. 4 were augumented with anhydrous ethanol and n.butanol. Fuel properties of the blends were studied, and primary alkyl nitrate was used to raise the cetane rating of the selected blend. A direct-injected, natually-aspirated diesel engine was used to evaluate the chosen blend comparatively with No. 2 diesel fuel.

ACCOMPLISHMENTS: Equations defining a region of allowable blending-component proportions were developed. The defining equations were based on a water sediment limit, a viscosity limit, low-temperature miscibility, and cost of the blends. The chosen blend contained, by volume, 48.5% No. 2 diesel, 4.85% No. 4 diesel, 2.91% anhydrous ethanol, 14.55% n.butanol and 3% primary alkyl nitrate. The blend had excellent stability at -20 ^{o}C, the viscosity was 2.043 mm^2/s at 38 ^{o}C, and the cetane rating was 40.8. The gross heat content of the blend was 39084 kJ/kg (86.2% of that of No. 2 diesel). Data from engine tests were used to compare the blended fuel to No. 2 diesel over a range of equivalence ratios (Φ) and at several speeds. Use of the blended fuel increased the brake specific fuel consumption (BSFC) as compared to No. 2 diesel. The increase in BSFC at a given Φ ranged from a few percent at full load to approximately 50% with a light engine load. The blended fuel also produced more exhaust smoke at a given Φ. At any given Φ, the blended fuel produced slightly higher engine power at medium or high speeds and slightly less power at the lowest engine speed. Exhaust temperatures were essentially equal for the two fuels at medium or high speed, but the blend produced noticeably lower exhaust temperatures at the lowest engine speed. The ignition delay was essentially the same for the blended fuel as for No. 2 diesel. Although the blended fuel produced satisfactory performance in a deisel engine, the long term effects on the engine were not studies are are unknown.

REPLACEMENT OF PETROLEUM WITH ETHANOL IN GASOLINE ENGINES

BACKGROUND: Various claims have been made concerning the effect of ethanol-gasoline blends on the performance, fuel economy and exhause emissions from gasoline engines. Consequently, this study was undertaken to provide a carefully controlled study of these effects.

PROJECT DESCRIPTION: A single-cylinder research engine was used to study the effects of the percentage ethanol blended into gasoline. A baseline fuel with an octane number of 85 was mixed with ethanol in volumetric ethanol concentrations between 5 and 25%. Tests were made at fixed compression ratio and at the knock limited compression ratio for the various blends. Power, fuel consumption, and exhaust emissions were measured for all tests.

ACCOMPLISHMENTS: The tests indicate that with an unmodified engine, most changes observed with ethanol-gasoline blends were due to the changing stoichiometric air requirements of the blended fuels. When the results were compared at the same relative amount of stoichiometric air, i.e., equivalence ratio, power and exhaust emissions were essentially unchanged and the fuel consumption increased due to the lower energy content of the alcohol. For a given power output of the unmodified engine, the effective petroleum replacement value of the ethanol was approximately 70% of its volumetric percentage in the blend. For example, at stoichimetric conditions, and the same power output, the use of 20% ethanol would reduce the amount of petroleum fuel used by only about 15%.

With the 85 octane base fuel, the ethanol serves as an octane improver. When this effect is taken into consideration, the compression ratio of the engine may be raised to increase the thermal efficiency. This results in an effective petroleum replacement value slightly higher than the volumetric percentage of the ethanol in the blend. Thus, when the engine is modified, to use the increased octane fuel, a smaller engine would deliver the same power with the same nitric oxide and carbon monoxide emissions, but with higher hydrocarbon emissions. In this case, the effective petroleum replacement value of the ethanol was approximately 110% of its volumetric percentage in the blend. For example, the use of 20% ethanol would result in approximately a 22% reduction in petroleum fuels.

Publications: At the date of this report, no publications have been issued concerning the work. Currently, two MS theses are under preparation which describe the work on the diesel and gasoline engines. In addition, a paper on the diesel engine studies is being prepared for presentation at the SAE Earth-moving conference in Peoria in April, and will appear as SAE paper 810681 entitled, "Performance of Alcohol Blends in Diesel Engines", by Hamid Shirvani, C. E. Goering, and S. C. Sorenwon. It is also expected that a paper will be written concerning the gasoline engine studies, although the journal to which it will be submitted has not been decided yet.

APPENDIX B

SOLICITATION LETTER UNDER THE CUMER PROGRAM

INITIAL DESIGN AND SPECIFICATION FOR THE CUMER ENVIRONMENTAL FACILITY

University of Illinois at Urbana-Champaign

College of Engineering
MATERIALS ENGINEERING
100 Talbot Laboratory
(217) 333-3751

Mailing Address:
Materials Engineering
216 Talbot Laboratory
Urbana, Illinois 61801

File Director Jones

July 24, 1980

TO:
R. Alkire
C. J. Altstetter
H. K. Birnbaum
R. W. Bohl
S. D. Brown
H. T. Corten
J. E. Greene
F. A. Leckie
J. Majumdar
D. Marriott
M. Metzger
J. Morrow
B. Muddle
D. S. Philips
J. M. Rigsbee
S. Risbud
D. F. Socie
J. J. Stukel
S. S. Wang

FROM: F. V. Lawrence

RE: Coal-Utilization Materials Engineering Research (CUMER)

This memo will summarize our meeting of July 14, 1980 in which the initial plans of the three-year, Coal Utilization Materials Engineering Research (CUMER) project were discussed.

In June of this year, we received advice that $225,000 had been placed at the disposal of the Materials Engineering Program to initiate coal-use-related materials engineering research. A portion of these funds (~$100,000) are to be used to create unique laboratory facilities in the Materials Engineering Research Laboratory (MERL) useful for coal-use-related research, and the balance (~$125,000) will be awarded in small (one or two year) grants (~$15,000/year) for the initiation of research. Application for either equipment or research initiation funds may be made to the Advisory Committee (Professors Birnbaum, Lawrence, Leckie, and Stukel) by submitting a short letter proposal (2-5 pages) with a budget.

In evaluating proposals received, the Advisory Committee will be guided by the following general principles:

1. The proposals should demonstrate that they are the result of or that the research will involve an effort to uncover the "real" materials problems encountered in the transportation and conversion of coal. Travel funds are available; the CUMER project has funds for bringing appropriate speakers to campus (the latter strategy is encouraged). It is expected that receipt of a research initiation grant will lead to the writing of a further (external) proposal.

2. The formation of research groups (particularly interdepartmental groups) is encouraged. It is hoped, however, that the newer faculty, particularly, will benefit from the CUMER program.

Proposals should be prepared during August and September. The Advisory Committee would like to receive the first proposals on October 1, 1980. If an investigator intends to submit a proposal at a later time, it would be helpful to receive a letter of intent on that date. The initial commitment of funds will be made on October 15, 1980.

FVL:dm
cc: M. K. Blanchard
College of Engineering Dept. Heads
J. J. Desmond
D. C. Drucker

MERL
GASEOUS CORROSION TESTING LABORATORY

A. Room and External Systems Design

1. Room location and size:	South Talbot, basement 26' x 13'
2. Room layout:	see fig. A
3. Gas delivery & storage area:	see fig. A
4. Room venting:	a. continuous positive ventilation b. large volume ventilation during alarm period
5. Safety	
a. Room atmosphere:	a. continuous monitoring, species specific, with IST SS detector
b. Pressure retorts:	b. high pressure confined to retort, retort design provides protection
6. Flexibility	
a. Test gas change:	a. gases and room monitors can be changed at will
b. Lay-out, internal:	b. room internals can be rearranged at will
c. Expansion, external:	c. limited ability to expand the work area

B. Gas Delivery System

1. Types of gases:	H_2, H_2O, CO, CO_2, CH_4, NH_3, H_2S, N_2 & He
2. Delivery system:	see fig. B
3. High pressure operation:	pressure stepped up at retort - no high pressure gas supply lines
4. Gas control and monitoring	
a. Gas chromatography:	a. handles almost all species with proper columns, columns are interchangable
b. H_2O and O_2 cells:	b. precise monitoring of these species
5. Ancillary equipment	
a. Vacuum pumps b. N_2 and He delivery	necessary for system purging and test start-up
6. Flexibility	
a. test gas mixtures	a. completely interchangable, GC columns must be changed
b. test pressure	b. controlled at the experiment

C. Test Equipment

1. Type	
a. Corrosion/exposure	dedicated equipment (?)
b. Creep-rupture	
c. Fatigue	
2. Test retorts	designed for specific experiments

D. Approximate Systems Costs

1. Room and external systems	(K$)
a. room walls	0.9
b. outside pad	1.3
c. outside brick wall	0.7
d. outside fence	0.5
e. outside gate	0.2
f. outside roof	1.0
g. brick-up windows	0.6
h. inside doors	0.8
i. inside removable roof	1.5
j. room wiring	1.0
k. exhaust to roof	1.0
l. emergency exhaust	1.0
(m.) gas detector system	8.0
(n.) detector wiring	0.5
total	19.0
2. Gas delivery system	
a. Gas chromatograph (w/o mass spec.)	30.0 to 40.0
b. Others	not costed
3. Test equipment	
a. Test stands	availability assumed
b. Retorts	not costed

JAS 9.2.81

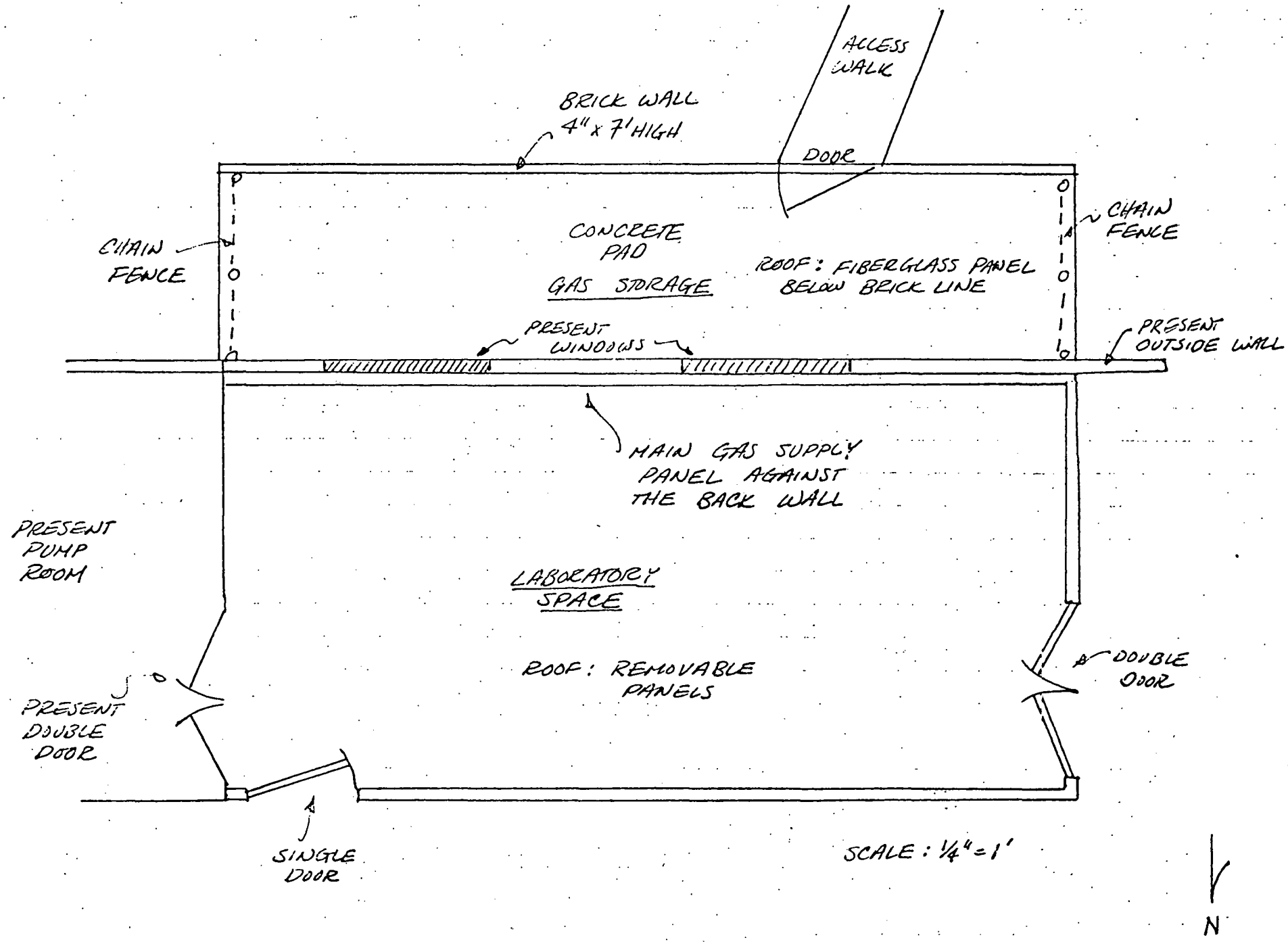


FIGURE A
MERL CORROSION LAB ROOM

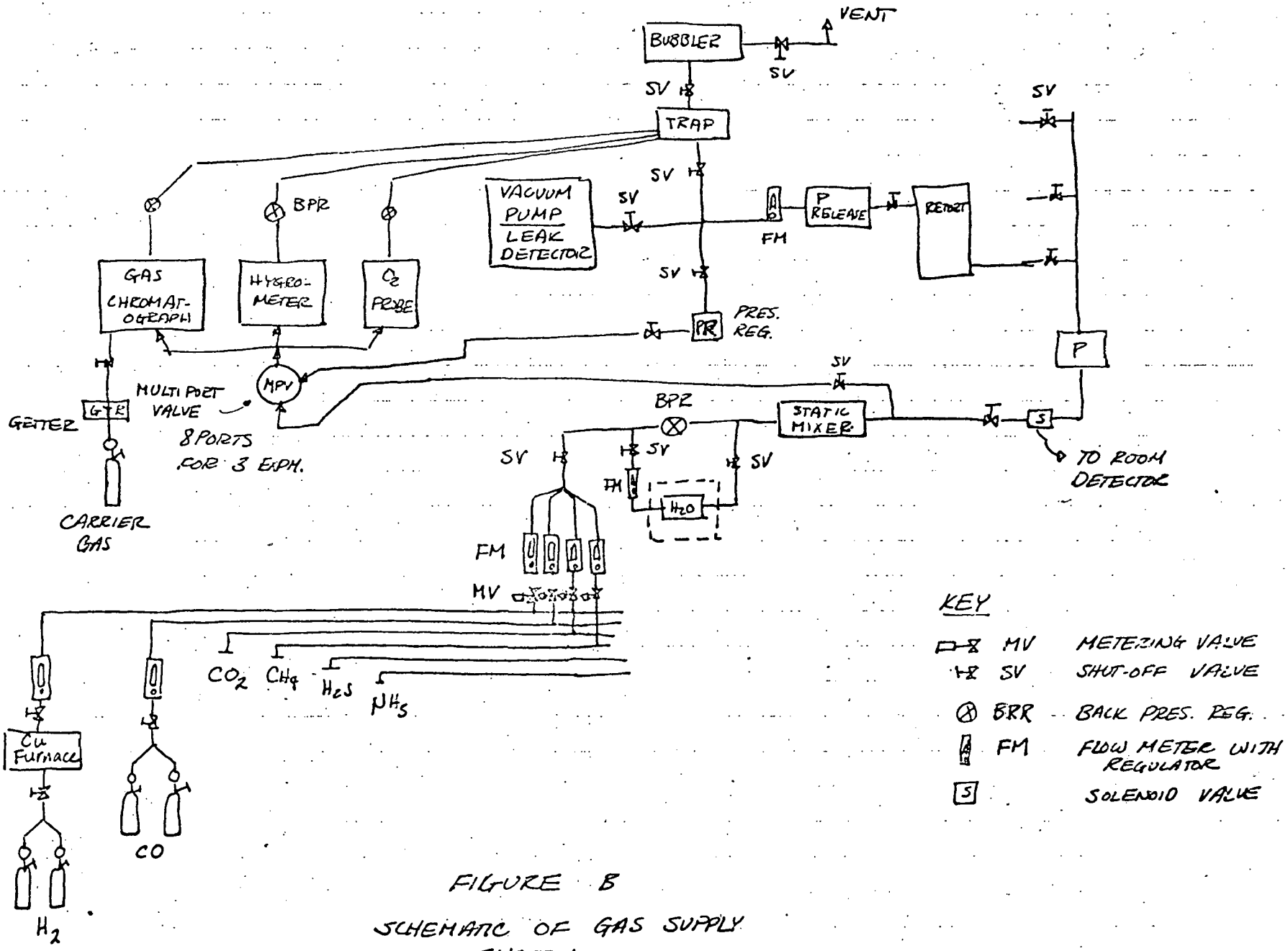


FIGURE 8

SCHEMATIC OF GAS SUPPLY SYSTEM