

EXXON RESEARCH AND ENGINEERING COMPANY

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GOVERNMENT RESEARCH LABORATORIES
W. M. COOPER, JR.
Director

December 7, 1978

Dr. Edward E. David, Jr.
General Administration
FP #101/Room G-119

Dear Ed:

A set of highly visible programs has been developed to help clarify the mechanisms associated with storage of carbon dioxide, and thus help predict the likelihood of a greenhouse effect. The programs will make use of Exxon facilities such as tankers and drilling ships to measure the rate of CO₂ uptake by the various layers of the ocean. Sophisticated techniques involving measurements of changes in isotopic ratios of carbon and the distribution of radon in the ocean will be used in conjunction with state-of-the-art techniques to measure CO₂ concentration in the atmosphere and in the oceans.

In addition to the ocean related work, a program is proposed to determine the source of the annual atmospheric CO₂ increment that has been increasing since the Industrial Revolution (1860). Researchers have attributed the CO₂ increment to varying combinations of fossil fuel burning and forest clearing. The program would measure the concentration of C-13 (stable) and C-14 (radioactive) in wines from sources that have well documented histories of temperature, weather, and location as a function of the time the wines were produced. By taking into account the relative absence of C-14 in wines, we will be able to estimate the contribution of fossil fuels (in which C-14 has decayed over the thousands of years of storage), and thus determine the relative concentration of fossil fuel derived CO₂ that was present in the atmosphere at the time the grapes were grown. Similarly, by analyzing the wine for the relative depletion of C-13 (this isotope is less reactive in photosynthesis than the predominant C-12), we will be able to estimate the contribution of forest clearing to the growth of CO₂ in the atmosphere. The wine measurement program would provide a unique and novel method to unravel the historical source of the incremental growth of CO₂ in the atmosphere.

We propose to implement our programs by May 1, 1979 in order to begin to assess the real meaning of the greenhouse effect to Exxon. We would start by equipping a tanker on the Persian Gulf to Aruba and Houston run with continuous instrumentation to measure CO₂ in the atmosphere and



in the ocean. A number of batch ocean samples will be taken and stored for measurement of C-14. This measurement will be used to estimate the penetration of CO₂ into the ocean. The equipment will be manned by two ER&E technicians. We expect to conduct measurements for at least a year, and this will involve 5 round trips. Preliminary discussions with Esso International tanker personnel on the feasibility of using Exxon tankers have been favorable.

The drilling ship program which is designed to measure the mass transfer coefficient for CO₂ between the atmosphere and the ocean as a function of weather conditions would probably be started in Exxon drilling operations off the coast of Australia. The program would involve a month or two of Rn-222 on-board measurement using conventional equipment for α -counting. The program would get underway towards the end of the Summer of 1979. The wine measurement program would procure some 100 bottles of wine that have well documented histories, probably from a single chateau in France. These wines would be analyzed for C-13 using the highly sophisticated facilities at EPRCo., and for C-14 using the unique equipment at the University of Miami (School of Marine and Atmospheric Science). The program would start in May 1979.

We expect to conduct these programs in two phases over the period 1979-1984 (inclusive). Phase I would start May 1, 1979 and be conducted entirely with Exxon funding over the first year. Phase II would start as soon as Government (DOE) funding can be obtained. We visualize the drilling ship operations and the wine measurements programs to be entirely funded by Exxon and the tanker measurements program funded by the DOE. Our screening-type estimates in 1979 \$ indicate the Phase I programs will cost 0.5 M\$ and the total programs (Phase I and Phase II) 8 M\$. Personnel costs account for over 70% of the cost, so methods of automating the tanker sampling program will be sought during Phase I.

In view of the highly complex nature of the programs, and the need to integrate the Exxon results into the global weather modeling programs, we intend to work closely with a university and the Government. We are currently considering a cooperative program with Columbia University's Lamont-Doherty Geological Observatory because two of the outstanding oceanographers and experts on the CO₂ problem, W. S. Broecker and T. Takahashi are associated with that institution.

The rationale for Exxon's involvement and commitment of funds and personnel is based on our need to assess the possible impact of the greenhouse effect on Exxon business. Exxon must develop a credible scientific team that can critically evaluate the information generated on the subject and be able to carry bad news, if any, to the corporation. This team must be recognized for its excellence in the scientific community, the government, and internally by Exxon management. We see no better method to acquire the necessary reputation than by attacking one of the major uncertainties in the global CO₂ balance, i.e., flux to the oceans and providing the necessary data. In addition, the international significance of the proposed programs will enhance the Exxon image in the public domain and provide great public relations value. As a consequence of the above, these programs are prime candidates for early implementation under the National Impact Program charter.

The first part of the report is devoted to a description of the experimental apparatus and the method of measurement. The results of the measurements are given in the following tables.

The second part of the report is devoted to a discussion of the results of the measurements. It is shown that the results are in good agreement with the theoretical predictions. The third part of the report is devoted to a discussion of the errors in the measurements.

The fourth part of the report is devoted to a discussion of the conclusions of the experiment. It is concluded that the results of the experiment are in good agreement with the theoretical predictions. The fifth part of the report is devoted to a discussion of the future work.

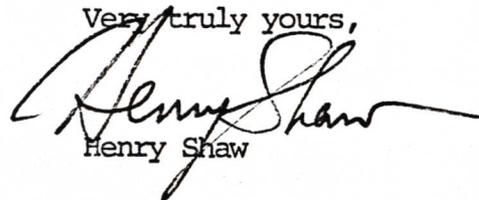
The sixth part of the report is devoted to a discussion of the references. The seventh part of the report is devoted to a discussion of the acknowledgments. The eighth part of the report is devoted to a discussion of the appendix.

The ninth part of the report is devoted to a discussion of the bibliography. The tenth part of the report is devoted to a discussion of the index. The eleventh part of the report is devoted to a discussion of the summary.

December 7, 1978

We have attached to this letter two appendices which assess the state-of-the-art on the greenhouse effect and provide details of the proposed programs. We are looking to you and the management council for guidance.

Very truly yours,



Henry Shaw

HS/jep

Attachments

cc: J. F. Black
W. M. Cooper, Jr.
R. T. Craig
F. J. Feely
W. Glass
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