THE
NUCLEUS

November 1992 | Of the Northeastern Section of the American Chemical Society | Vol. LXXI, No. 3

Monthly Meeting

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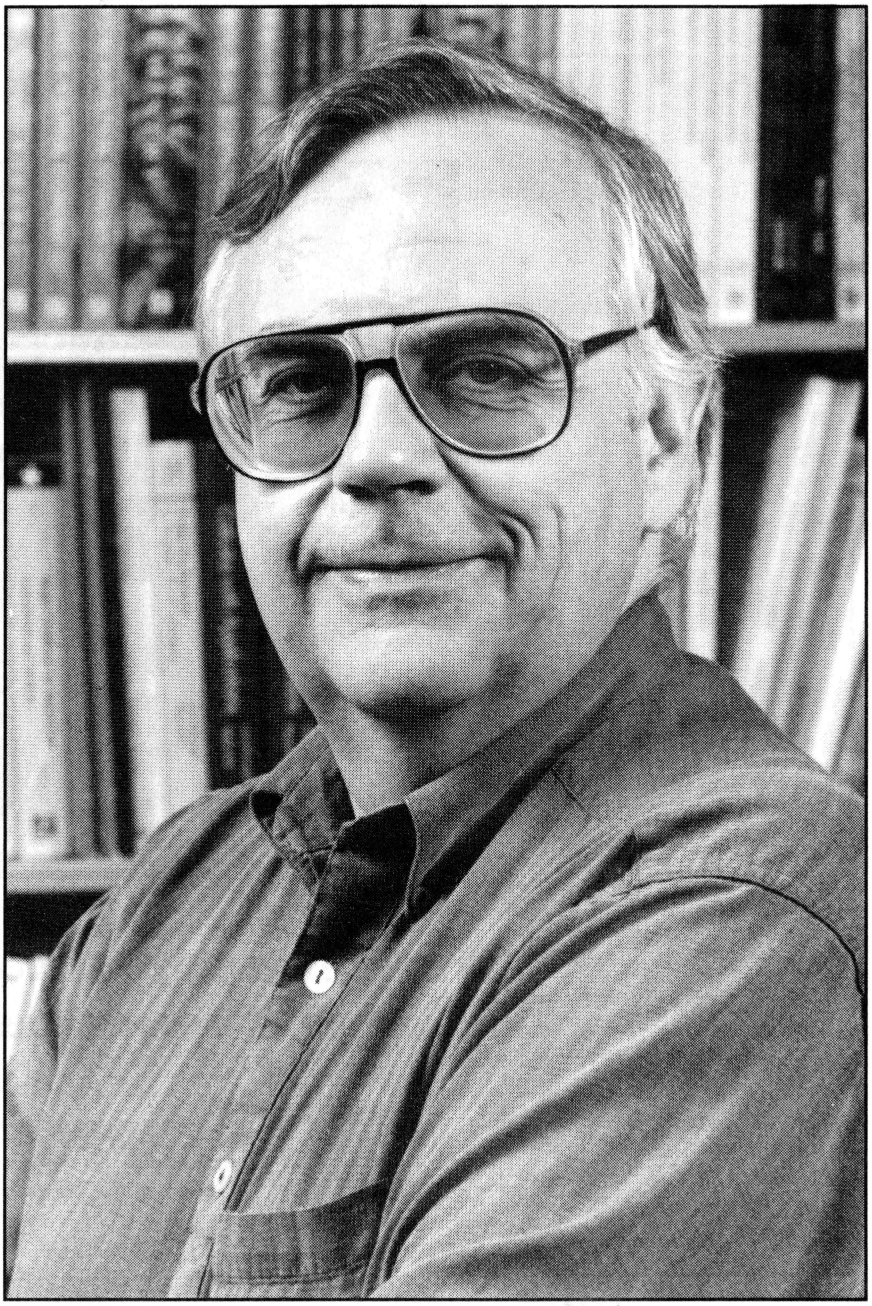

The Northeastern Section of The American Chemical Society, Inc.

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THE
NUCLEUS

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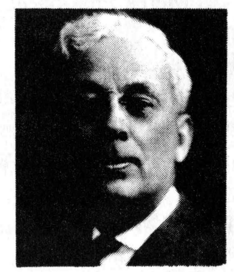
Published monthly from October to May by the Northeastern Section of the American Chemical Society, Inc.



The Nucleus is distributed to the members of the Northeastern Section of the American Chemical Society, to the secretaries of the Local Sections, and to editors of all local publications. Forms close for advertising on the 1st of the month of the preceding issue. Text must be received by the editor six weeks before the date of issue.

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The Corporate Affiliates Program

Following the lead of the National ACS in Washington and its Corporation Associates group, The Northeastern Section in 1990 enlisted the participation of industrial concerns in our area by founding the Corporation Affiliates Program. In the two years that this program has been in effect the number of participating companies has risen significantly and now numbers eighteen. The companies lend financial support and commit to the progress we are making in two key areas: 1) the improvement of the public perception of the chemical industry and profession, and 2) the early education of students in chemistry.

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Designing Experiments for Process Optimization:

Quality the Japanese Way

A One-Day Workshop Presented by the Northeastern Section A.C.S. Committee on Continuing Education
Instructor: Brad Jones, DOE Products Manager, BBN Software Products

Saturday, November 21, 1992, Boston College, O'Neill Library. Rm. 248, Chestnut Hill, Mass.

Learn how to optimize processes quickly and accurately. This workshop introduces beginners to the methods that helped make the Japanese so commercially successful. You will learn how to establish test parameters and measure results, and how to use software to determine optimum conditions. The techniques can be used for widely diverse problems ranging from making pipes to manufacturing pharmaceuticals. Hands-on experience with computers will be included.

Program:

8:30-9:00 AM	Registration and coffee
9:00-10:30	Process Optimization: A case study
10:30-10:45	Coffee break
10:45-11:15	Design Fundamentals I
11:15-12:00	Hands-on workshop
12:00-1:00 PM	Cold buffet lunch provided
1:00-1:30	Design Fundamentals II
1:30-3:30	Hands-on workshop
3:30-4:00	Closing remarks

Advanced registration required by Nov. 9, 1992
Registration is limited to 26 persons.

Registration fee

A.C.S. Members	$75.00	Non-A.C.S. Members	100.00
Retired A. C. S. Members	25.00	Students, High School Teachers	25.00

For Further information contact Prof. E.J. Billo 617-552-3619

Registration form for Workshop
Name ______________________ Tel. ____________
Company ______________________
Address ______________________
____

Mail with remittance to:
(checks made out to NESACS)

Prof. E.J.Billo
NESACS
Department of Chemistry
Boston College
Chestnut Hill, MA 02167

November Meeting

The 747th Meeting of the Northeastern Section of the American Chemical Society: Presentation of the 41st James Flack Norris Award for Outstanding Achievement in the Teaching of Chemistry to Dr. Jerry A. Bell, AAAS (on leave from Simmons College)

Thursday, November 5, 1992; Simmons College, 300 The Fenway, Boston

5:30 Preprandial Hour: Special Functions Room

6:30 Dinner: Fens Dining Room

8:00 The Evening Ceremony will take place in Lecture Hall C 103 *(Black tie optional.)*
Dr. Katie Stygall, Chair, Northeastern Section, presiding
Introduction of the Awardee by Dr. Bassam Shakhashiri, U. Wisconsin-Madison
Presentation of the Award by Dr. David Haines, Chair, Norris Award Committee
The Norris Award Address: *Don't Mellow!* Dr. Jerry A. Bell

Please make dinner reservations no later than October 30 with Dr. Katie Stygall, (508) 372-7161 ext. 311. Reservations not cancelled at least 24 hours in advance must be paid. Members, $21; Non-members, $23; Retirees, $12.50; Students, $8. THE PUBLIC IS INVITED. Call Dr. Stygall a few days in advance for special services or transportation.

The next meeting will be on Thursday, December 10, 1992 at Boston College. The Medicinal Chemistry Group Symposium on Molecular Modelling will feature Martin Karplus, Harvard. For further information call Mark Froimowitz, 855-2406.

Abstract

Science education has (rightfully) come under intense public scrutiny as society has become increasingly dependent on its science and technology while public understanding of science and scientific literacy appear not to have kept pace. Academic scientists have done pretty well at training new scientists who come prepared with the same attributes as successful scientists, but have done very poorly in educating the great majority of society that does not wish to work directly in science. We too often assume that those who choose not to pursue science cannot understand scientific evidence and argument and must simply be told the results. What could be more dull? Insidiously, these same notions also creep into our courses for prospective scientists and they, too, are faced with textbooks, lectures, laboratories, and examinations geared to finding the right algorithm (the one acceptable to the instructor). Real problems are, however, rarely susceptible to solution by application of a single algorithm. My presentation will include demonstrations for increasing the involvement of students in the analysis of actual systems and suggestions about increasing rigor (without terror). –J.A. Bell ◇

Biography

Jerry A. Bell is Professor of Chemistry at Simmons College, where he has taught since 1967. Beginning January 1992, he has also taken a new position as Director of the Science, Mathematics, and Technology Education Programs in the Directorate for Education and Human Resources of the American Association for the Advancement of Science. He moved to Washington, DC during the summer of 1992.

He received his A.B. (1958) and Ph.D. (1962) in physical chemistry from Harvard and, on three separate occasions, has done a year of postdoctoral research in chemistry and biochemistry as a visiting faculty fellow at Brandeis University.

His major professional interests in most of his career have focused on the kinetics of free radical and photochemical reactions and on science (chemical) education at all levels, especially the use of hands-on approaches to teaching. He has developed and published new laboratory materials for almost all the courses he has taught and now is strongly advocating the introduction of small-scale techniques in all instructional chemical laboratories. He is also committed to the use of lecture demonstrations as a most effective classroom teaching technique.

To promote these ideas, he has been on the instructional staff and/or directed workshops and teacher institutes for science teachers at all levels since 1965. He was the first Academic Director (1982, 1983, and 1987) of the Summer Institute for High School Chemistry Teachers at Princeton University. At Simmons, he developed and directed (1984) the first of a series of partnership workshops in science for elementary, middle, and secondary school teachers funded by the N.S.F. For two years, 1984-86, he served at the N.S.F. as Director of the Division of Teacher Preparation and Enhancement. From 1986 to mid 1989, he was the Director of the Institute for Chem-

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Health and Safety On My Mind

by M.A. Solstad

The first week in November is National Chemistry Week again. Many of you may be planning exciting chemical demonstrations for the public. In many cases you have volunteer help from among your more enthusiastic students. That's great, *but* ... Before you embark on this enterprise, THINK!

- Do I know everything about this reaction?
- Has it ever been reported to go awry?
- What would happen if —
  The audience got too close?
  Someone bumped the table?
  That baby in the front row got away from mommy?
  I was distracted for a minute and the reaction got too hot, too cold, or too wet?
  That little Dennis the Menace wants to play with matches and my chemicals?
- If you can give satisfactory answers to all these questions, then go ahead and have fun. But don't neglect protective clothing and goggles for you and your audience.

Don't be lulled by the fact the experiment was written up in an ACS journal or magazine, or by the National Association of Science Teachers. The Committee on Chemical Safety has seen some unsafe experiments slip through. If you're not sure, call James Kaufman, Lab Safety Workshop at Curry College, 617-333-0500. He has the background to advise you. ◇

National Chemistry Week

For information call Katie Stygall at (508) 372-7161 ext. 311

Nov. 2 Evening of Demonstrations at Harvard University, Science Center, Oxford Street, Cambridge.

Nov. 3 Open House at academic and industrial laboratories for students and teachers in grades 4 through 12

Nov. 5 Northeastern Section Norris Award evening at Simmons College *(see p. 5)*

Nov. 7 *Innovations in College Chemistry Teaching*, Bradford College, Bradford, MA

Historical Notes

by Edward R. Atkinson, Amerst, MA

We apologize for the incomplete obituary of Stanley E. Dale in the October issue and present the full text here.

Stanley E. Dale, 67, died on June 19,1992. A native of Evanston, IL, he received the B.S. and M.S. degrees in chemical engineering from the University of Michigan. During the 1950-1960 period he was employed by the Callery Chemical Co. and then joined the professional staff of Arthur D. Little, Inc. for the balance of his career. His specialty was safety work for the petroleum and petrochemical industries, with emphasis on the handling of gases containing hydrogen sulfide. He became director of a section dealing with process technology, safety and risk assessment in the chemical industry including exploration and production on platforms in the North Sea and the Gulf of Mexico. It was my good fortune to be associated with Stan on a few jobs and I admired his complete familiarity with the art and science of chemical engineering. He enjoyed classical music, was a subscriber to the Boston Symphony,and maintained a massive stereo system in his car. ◇

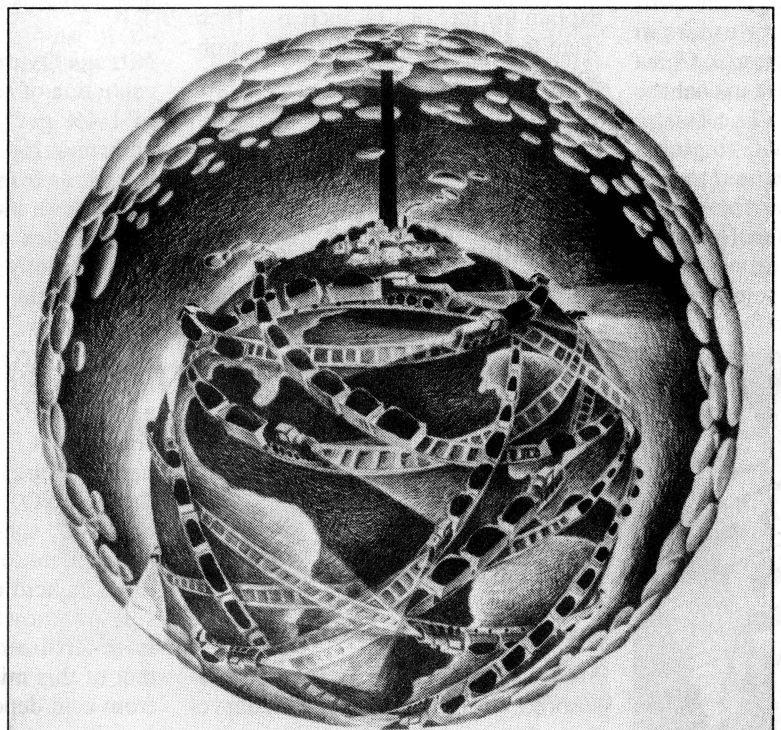
Environmental Chemistry Column

The Return From Rio: How Can We Mitigate The Greenhouse Effect?

by David Ham, President, Envirochem, Inc.

The "Environmental Chemistry Column" has so far covered the atmospheric chemistry of the most prominent air pollution problems; greenhouse effect, stratospheric ozone depletion, urban smog, and acid rain. This article starts an extension of this series to discuss some aspects of approaches for mitigation and control of the pollution that contributes to these problems. The goal is to continue at the level of technical quality that helps those of us in the chemistry community to discuss these topics more knowledgeably.

From April through July we all encountered constant media coverage of the "Rio Conference," a common name used for the United Nations Conference on Environment and Development held in June in Rio de Janeiro, Brazil. The most prominent controversy surrounding this meeting related to the refusal by the U.S. government to agree to *commitments* for reductions in greenhouse gas emissions supported by essentially all other nations. A compromise was reached with a broad agreement to pursue reductions in these gas emissions, but with no commitments.



A View Through the Ozone Hole – © Rob Dunlavey

To provide some background for understanding this issue, we need to consider several questions: sources of these greenhouse gases, approaches to reduce these emissions, at what costs? This article covers some technical responses to these questions without addressing the final policy questions.

The greenhouse effect (GHE) may lead to significant climate change in our lifetimes due to infrared radiation reflected from the earth being trapped by anthropic (human-made) gases. Besides the omnipresent radiation trapper, water, the important greenhouse gases emitted directly to the atmosphere are carbon dioxide, chlorofluorocarbons (CFC's), methane, and nitrous oxide. Ozone in the troposphere is also an important GH gas, but it is produced in the lower atmosphere from precursor nitrogen oxides and hydrocarbons (see *Tropospheric Ozone, Summertime Surprise* in the March 1992 *NUCLEUS*). The global warming potentials (GWP's) of these gases are computed from their absorption coeffi-cients times the integral of their concentrations over their lifetime in the atmosphere divided by the same product for CO_2. Estimated values for the GWP's are CO_2=1, CH_4= 7.6 per molecule (21 per unit mass), N_2O = 290 (molecule or mass basis), and in the thousands for each of the CFC's. About two thirds of the worldwide warming due to human activities of all kinds results from CO_2, with about 20% from CH_4, 10% from CFC's, and 3-4% from N_2O. The warming effects are thought by many to be counteracted at least in part by reflection of incoming sunlight by pollutant aerosols. (For more details on the greenhouse phenomena, see C. Kolb's articles in the April and May, 1991 *NUCLEUS*.)

The U.S. is currently the largest single greenhouse gas emitter, producing about 24% of the total worldwide increase, mostly from our use of fossil fuels. To address possible mitigation efforts, we first need to consider the total anthropic sources of these gases, emphasizing fossil fuel sources. Then we can discuss technologies to reduce these sources and estimates of their costs.

Even though CFC's are important greenhouse contributors, we do not need to consider controlling them now, since they are already being phased out under the Montreal Protocol and the 1990 London Amendments to this protocol. These agreements were forced on the world community by the very pressing problem of the stratospheric ozone hole caused by CFC's. The effects of the CFC substitutes being introduced need to be assessed for both of these atmospheric problems.

Sources And Uncertainties

Predictions of future climate changes depend on estimations of future concentrations of the substances that modify the earth's radiation balance. These concentrations depend on population, economic growth, historic changes (such as dissolution of the USSR), energy prices, technological advances (e.g., in renewable or nuclear power generation), and fossil fuel supplies. These factors indicate that developing countries, with rapidly increasing populations and energy use, will replace the U.S. as future leaders in GH gas emissions. For example, China projects a four fold increase in coal use in the next fifty years. The future trends are necessary inputs to global circulation models that are used to estimate the effects of various future scenarios on our future climate. However, the obvious uncertainties in predicting trends in these variables, emphasized by the fact that we cannot yet quantify the present trends, limit a meaningful discussion to control of present sources of the most important GH gases.

Carbon Dioxide: The atmospheric concentration of CO_2 has increased more than 25% from its preindustrial level. The CO_2 increase accounts for about 66% of the worldwide GHE. The main anthropic source is from fossil fuel combustion for electric power generation, transportation, and heating. About 46% of these CO_2 emissions remains in the atmosphere. Extensive recent efforts by scientists from a variety of disciplines have failed to close the material balance for carbon to explain the rate of CO_2 increase. There seem to be missing carbon sinks, probably mostly biological.

Much attention has been paid to CO_2 produced by land use changes, such as deforestation, which have produced somewhere in the range of 10–40% as much CO_2 as fossil fuel combustion over the last couple of years. In the long run this source cannot continue to contribute at this level. All plants eventually die and decay with the carbon returning to CO_2. Unless we can store the carbon in some form such as wood or solid carbon in a permanent way, changing the vegetation from forests to grasslands, or even deserts, will cause only a one time change in the steady state, increasing CO_2 level. We must control fossil fuel combustion to stop the steady rise of CO_2 concentration.

Methane: Methane is a strong IR absorber with an atmospheric lifetime of about 11 years, causing it to be a worse actor than CO_2 with a GWP of 7.6 on a per molecule basis. Estimates of annual total (anthropic plus natural) methane production worldwide are in the range 250- 500 Tg ($T=10^{12}$). There are many uncertainties in the magnitudes of different sources. The rate of increase of CH_4 in the atmosphere has decreased in the last decade; this trend is not well understood. Recent isotopic studies indicate that about 20% of the worldwide emissions comes from fossil fuels.

Fossil fuel sources of methane emissions result from the production and distribution of gas and oil as well as coal mining. Venting and flaring of methane occur at both natural gas and oil well heads. Methane leaks from many kinds of equipment used for production and processing of oil and gas. Methane also leaks from high pressure natural gas transmission lines and low pressure delivery systems. Estimates of the total of these emissions in the U.S. are 2.6-4 Tg/yr. About 5 Tg/yr of methane are estimated to escape during coal mining operations in the U.S. Different estimates of methane leaks do not agree, especially from the pipeline systems in the former U.S.S.R. The GHE due to methane is thought to be about 20% of the worldwide total.

Nitrous Oxide: The atmospheric concentration of N_2O is increasing at a rate of 1/4% per year. Well established anthropic N_2O sources include direct emissions from adipic acid production (for nylon), nitric acid production, and automobiles with three way catalysts. Until recently, coal fired power plants were thought to produce large amounts of N_2O. This inference has been shown to be incorrect due to unrecognized reactions in the sampling procedures used for GC measurements. Now it seems that fossil fuel power plants mainly contribute to N_2O indirectly through NO_x (NO plus NO_2) production. NO_x species are oxidized in the atmosphere to nitric acid and precipitated as acid deposition. Bacteria in soil are known to reduce the nitrates from fertilizers to form N_2O. The extent of this microbial N_2O production from acid deposition from fossil fuels is unknown, but could easily be large enough to account for a major part of the N_2O sources that balance atmospheric photolysis losses to cause the observed increase.

N_2O is not yet limited by any regulations or agreements. Problems may occur because N_2O is known to be produced directly by fossil fuel technologies under development. Several NO_x abatement processes currently being introduced can produce N_2O as a product. Circulating fluidized bed combustors, being developed for future use, are known to produce large amounts of N_2O.

Mitigation Options and Costs

As the largest contributors to the Green House Effect (GHE), uses of fossil fuels offer the potential for the largest reductions with concomitant cost savings. The fossil fuels that we combust are coal, oil (including that distilled to gasoline), and natural gas (NG, mostly methane). The amounts of CO_2 produced by each fuel, expressed on a basis of grams of carbon per unit energy released are about: coal = 25, oil = 20, and NG = 15 gC/MJ. Based on our relative use of these three fuels in 1989, their contributions to the CO_2 increase are coal = 35%, oil = 45%, and NG = 20%. As pointed out above, each of these fuels also contributes to the methane build-up and indirectly to increased N_2O through NO_x production.

No single solution can reduce a significant fraction of the total emissions that come from so many sources. We need a strategy with a large variety of measures. First steps should rely on currently available technologies that can be implemented within the next decade. For these technologies, the impacts and costs can be estimated most accurately, an important consideration for overcoming institutional barriers.

The build-up of CO_2 and other gases in the atmosphere can be mitigated either by reducing the sources of the emissions or by counteracting their effects. Some serious discussions of counteracting measures center on biomass fixation, possibly by fertilizing the oceans to increase CO_2 uptake. Another possible measure is to inject dust into the atmosphere to reflect incident radiation. In addition to the massive efforts and costs to pursue these approaches, they suffer from the disadvantages of introducing a new set of large uncertainties into the climate change possibilities. By far the safest and most economical approaches in the uncertain near term will rely on direct reduction of GH gases at their sources.

Direct approaches for reduction include efficiency improvements, fuel switching, and flue gas clean-up, the capture of the gases at the plant exhaust.

Improved Efficiencies

The most cost effective measures for GH gas reductions are demand-side energy reductions, decreases in energy use for residential, commercial, industrial and transportation applications. If implemented, a wide variety of these efficiency measures can lead to reductions of more than 20% of the total U.S. CO_2-equivalent emissions at an estimated net cost savings of $82 billion annually! (All cost figures are in constant 1989 dollars based on a 6% real discount rate, the interest rate paid on capital investment.)

Supply-side energy efficiency improvements can be accomplished by equipment modernization and improvements in operation and maintenance at existing coal-fired and hydroelectric power plants. Most coal-fired plants now operate at efficiency percentages in the low 30's range and could be improved to almost 40%. Since power plants are centralized and involve large individual units, efficiency measures can be implemented more easily than demand-side measures. Power plant improvements could yield total U.S. CO_2-equivalent reductions of almost 1% with no net cost. Additional improvements could be achieved by up-grading simple-cycle gas turbines used for power generation to combined-cycle systems (gas turbine followed by a steam turbine for better heat recovery). This improvement can increase efficiencies from 25-30% to greater than 50%.

Fuel Switching

Fuel switching is often mentioned as a promising approach for GH gas reduction. Replacing coal with either oil or NG in manufacturing processes seems like a good approach because of the substantial differences in CO_2 produced, but this would result in significantly higher costs for little reduction in CO_2 emissions. Increased use of NG has the associated problem of increasing emissions of methane, a worse GH gas than CO_2. Improved NG transmission systems could reduce methane leaks considerably, but the net costs

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Proposed Amendments of the Constitution and Bylaws

The following amendments to the constitution and bylaws of the Section have been approved by the Board of Directors. These amendments have been required or recommended by the ACS C&B Committee. The committee accepted some, and rejected one of the amendments which were voted last year by the Section. The rejected amendment was that of Article VIII, Sec. 6 for specific provisions to fill vacancies in the list of Councilors and Alternate Councilors.

Deletions in brackets [ ], additions underlined:

Explanatory text, not part of the Section's documents, is in *italics*.

Inasmuch as the requirement of official headquarters for Local Sections has been removed from ACS documents, references to headquarters are to be deleted from Local Section documents.

Article III - Territory

Section 1. The territory of the Northeastern Section shall comprise that portion of the United States that may from time to time be set apart by the Council of the SOCIETY as the territory of the Northeastern Section. [The headquarters of the Northeastern Section shall be in metropolitan Boston, Massachusetts.]

The ACS C&B Committee has recommended a change in wording of Article V, Sec. 3 to avoid confusion in the succession of Chairman of the Section when that office has become vacant.

Article V - Officers and Duties

Sec. 3. The Chairman-Elect shall perform the usual duties of Vice-Chairman and shall succeed to the Chairmanship [either] at the expiration of the Chairman's term of office. In the case of [or to fill] a vacancy in the office of Chairman, the Chairman-Elect shall assume the added duties of the Chairman for the unexpired term.

After consulting the ACS C&B Committee concerning the rejected amendment of Article VIII, Sec. 6 the following amendments are proposed:

Article VIII - Elections

Sec. 1 ([i]*j*). Except as stated below, [A]all those elected shall take office on January 1 following the date of their election, and shall continue in office until their successors have been duly elected and qualified. Those elected to fill vacancies in the list of Councilors or Alternate Councilors shall take office on notification of their election and serve for the remainder of the term or until their successors have been duly elected and qualified.

The ACS C&B Committee recommends that members be able to vote on amendments even if they have not been acted on or passed by the Board of Directors.

Article XX - Amendments

Sec. 3. If a proposed amendment under Section 1 or 2 above is not approved by a majority of the Board of Directors, it may, nevertheless, be brought to the members for a vote if a petition supporting such amendment has been signed by at least 3% of the members of the Northeastern Section and has been presented to the Board of Directors. The procedure for subsequent publication and voting shall be identical to that in Sections 1 or 2 above, as appropriate.

Sec. [3] 4 *renumbering the present Sec. 3.*

The corresponding amendment to Bylaw X:

Bylaw X - Amendments

Sec. 2. If a proposed amendment under Section 1 is not approved by a majority of the Board of Directors, it may, nevertheless, be brought to the members for a vote if a petition supporting such amendment has been signed by at least 3% of the members of the Northeastern Section and has been presented to the Board of Directors. The procedure for subsequent publication and voting shall be identical to that in Section 1 above.

Sec. [2] 3 *renumbering of the current Sec. 2.*

The amendment of Article XX must undergo a special procedure: Publication in the NUCLEUS at least four weeks prior to the Annual Meeting of the Section preceding the Annual Meeting at which the vote is to be taken. Therefore, Article XX can be voted on at the earliest at the 1993 Annual Meeting, i.e. the December 1993 meeting. For consistency, the amendments to Bylaw X are to be voted at the same time, even though they do not require the year's delay.

All other amendments are to be presented for a vote at the December 1992 Section meeting.

The ACS C&B Committee has made an editorial change to make our Article XX, Sec. 4 and Bylaw X, Sec. 3 (amended numbering) conform with the Society's documents.

Article XX, Sec. 4 and Bylaw X, Sec. 3

For information only, no action required.

Following adoption by the Northeastern Section, amendments shall become effective upon approval by the Committee on Constitution and Bylaws, acting for the Council [of the SOCIETY], unless a later date is specified. ◇

Environmental Chemistry Column

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would probably be significant. Certainly, burning the NG that is currently vented, as opposed to flared, would decrease the impact on the GHE by converting the CH_4 to CO_2. Preferably, the vented and flared gases would all be used to generate power at the oil or NG production sites. Another form of fuel switching, replacing fossil fuel plants with nuclear or renewable fueled power plants, is the most expensive approach for reducing CO_2 emissions.

Transportation systems offer another opportunity for emissions reductions by fuel switching. Even a compact car emits about a half pound of CO_2 into the atmosphere each mile on the highway! Transportation uses about 30% of the total fossil fuels in the U.S. and, in addition to CO_2, produces about 44% of the total NO_x leading to N_2O. The use of alternate fuels (reformulated gasoline, NG, methanol from NG, electric cars) would only lead to GH gas emissions reductions of less than 25% compared to gasoline and would involve an extensive, expensive new infrastructure. Very large emissions reductions can be achieved only by using methanol or ethanol made from newly grown biomass.

Another possibility for improvements in the transportation sector is through improved catalytic converters. Catalytic converters were not designed with N_2O in mind, and, in fact, increase the exhaust levels of N_2O by about 10-fold. Possible benefits from these improvements are uncertain, mostly because of the unknown extent of indirect production of N_2O from NO_x outside of the catalyst.

Flue gas Clean-up

Several processes have been developed for scrubbing CO_2 from exhaust gases. All of them require large energy inputs that reduce plant efficiency, thus requiring the production of more CO_2. The best developed approach uses monoethanolamine (MEA) to absorb CO_2 at a cost of $62 per ton of CO_2 avoided. This cost is high compared with only $30 – $70 per ton of CO_2 removed by replacing existing coal fired plants with lower emitting technologies after the old plants are fully depreciated. Other technologies for capture of CO_2, such as pressure swing absorption processes, membrane separation, cryogenic fractionation, or molecular sieves, are even more expensive.

The large expense of these processes results from separating N_2 from CO_2. A promising process that has been tested at large scale, but not yet developed commercially, involves using an air separation plant prior to combustion to prepare pure O_2. The flue gas, containing mostly CO_2, is recycled to moderate the furnace temperature. Water is easily removed by condensation. Analysis has shown that this process can be less expensive than the MEA process.

All of the flue gas clean-up approaches suffer from the additional drawback and expense that the captured CO_2 must be recycled or sequestered in a long term way to avoid having it return to the atmosphere. Commercial demand for CO_2 is saturated and these uses generally return the CO_2 to the atmosphere, so CO_2 disposal becomes purely an expense. The only cost effective way to return the carbon in the CO_2 to a fuel such as methanol is to obtain the large amount of energy required from the sun through some photosynthetic process. However, photosynthesis is so inefficient (<1%) that unreasonably large areas of land or water would be required. Possibilities for CO_2 disposal include oil reservoirs, gas reservoirs, aquifers, or the deep ocean. The ocean is the most promising; the capacity is enormous, but the storage lifetime is finite. The deeper the injection of the CO_2 into the ocean the longer the lifetime but the greater the cost. From the locations of most power plants, transportation of the CO_2 to the ocean is another large expense. Adding any disposal costs to the expense of the CO_2 capture makes all flue gas clean-up processes non-competitive at present.

Conclusion

We cannot quickly change our economic dependence on combustion of fossil fuels. However, detailed analyses have shown that the U.S. can reduce GH gas emissions by up to 40% of current levels at a net cost savings. These reductions require a variety of measures, mostly involving demand-side efficiency improvements. With growth in the developing countries, our future efforts to deal with this global problem must be more international.

Uncertainties in climate models and their interpretation of the historical climate record, as well as uncertainties in GH gas sources and possible mitigation costs, have led to controversies regarding whether to act to reduce GHE's now or wait for more research. In arguing for delay, the national leadership and media coverage have emphasized uncertainties in available climate models and their different predictions of when the global temperature will change by how much. This unscientific argument clouds the already complex issues and obscures the facts that there is a universally accepted scientific basis for expecting serious climate problems at some time in the future resulting from our use of fossil fuels and well established benefits for starting to deal with these problems now. The issues were raised at Rio; nevertheless, the resulting treaty agreement was weakened to omit any specific commitment for GH gas reductions.

The information in this article is derived largely from the "Pedagogical Symposium on Global Climate Change" presented by the Division of Fuel Chemistry at the August 1992 ACS National Meeting and a "Policy Forum" article in Science, page 148, 10 July 1992. These sources are summaries and up-dates of original sources, especially the 1990 U.N. Intergovernmental Panel on Climate Change Scientific Assessment and its 1992 up-date, and the U. S. National Academy of Sciences 1991 report, "Policy Implications of Greenhouse Warming-Report of the Mitigation Panel." ◇

Biography

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ical Education, headquartered at the University of Wisconsin-Madison, which carries out programs designed to improve chemical education.

Over the years, he has been active in the American Chemical Society, both locally and nationally, serving on the Norris Award Committee and the Norris Summer Scholars Committee of the Northeastern Section, on the Society Committee on Education and the Petroleum Research Fund Advisory Board of the ACS, and several offices in the Division of Chemical Education (including Secretary, 1978-84, and Chair, 1988). ◇

Corporate Affiliates Program

continued from page 4

There are two classes of membership: Sponsor ($250-$999.99) and Patron ($1000 and above). We recognize our Corporate Affiliates by listing them in each issue of the NUCLEUS as well as in literature promoting those of our events funded totally or in part by their contributions.A designated person in each Corporate Affiliate is invited to attend our annual Esselen Award presentation and dinner. This award is given each April in recognition of scientific and technical work that has contributed to the public well-being and has thereby communicated positive values of the chemical profession. The Section pledges to not solicit Corporate Affiliates for any other of our functions or events.

The Corporate Affiliates Program is off to a good start and the hope is that it will grow in the future and enhance the programs of the Northeastern Section. To join or for further information please contact Dr. Michael Strem, Strem Chemicals, Inc. 7 Mulliken Way, Newburyport, MA 01950 ◇

Summerthing at Sandwich

by Michaeline Chen

Rain for the past two weeks and an unencouraging weather report, but we set up the big NESACS sign at Heritage Plantation under gray but dry skies and hoped that the courageous would come. They did!

Highlights of the day included seeing Gary Cooper's 1930 Duesenberg in the antique car collection, seeing how many ACS-ers would fit in a Model T Ford, a lesson in horseback riding given by Dr. Houghton (on the carousel), and seeing the reconstruction of the Revolutionary War at the military museum.

We had a lesson in glassblowing from Mr. Bill Burchfield at the Cape Cod Glassworks and then saw the products of earlier times at the Sandwich Glass Museum. Pressed lacy glass in strikingly vivid colors and popular blue dolphin candlesticks are some of the memories of these collections.

The Doll Museum gave a doll's view of life as it used to be, with yesteryear's houses and furniture, china and tableware. The miniatures were done in extraordinary detail.

Dinner at the Captain's Table (singing "Happy Birthday" to David Williams) celebrated the end of a fabulous Summerthing at Sandwich.

The attendees were Mary and Louis Annese, Cathy and Phyllis Brauner, Henry and Julie Brown, Mary and Dan Burgess, Jean Frank, Barbara and Wally Gleekman, Everett Houghton, Ted and Arlene Light, Emily McHugh, Loretta and Bob O'Malley,Janet Perkins, Dorothy and James Phillips, Rose and Myke Simon, Martha and George Thomas, Virginia and David Williams and myself. ◇

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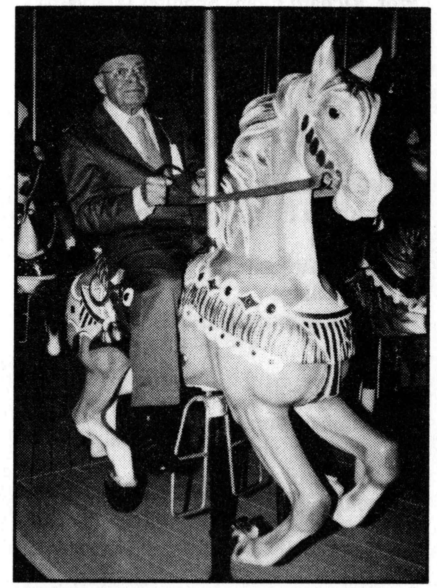
Michaeline Chen bringing ACS'ers to Summerthing??

Photographs by M. Simon



Dr. Everett Houghton gave us a riding lesson

The Welcoming Committee: Emily McHugh, Jean Frank, Michaeline Chen, Mary Annese

Calendar

For additional information, call:
Boston College – (617) 552-3625
Boston University – (617) 353-2537
Brandeis University – (617) 736-2500
Clark University – (508) 793-7116
Dartmouth College – (603) 646-2501
Harvard University – (617) 495-5333
MIT – (617) 253-4080
Northeastern University – (617) 437-2822
Tufts University (Chemistry, Medford Campus) – (617) 381-3441
Tufts University (Chem. Eng., Medford Campus) – (617) 627-3900
Tufts University Health Science Campus – (617) 956-6867
UMass Dartmouth – (508) 999-8232
University of New Hampshire – (603) 862-1550

November 2
Prof. Richard Evans Schultes (Harvard)
"The Possibility of New Chemical Compounds from the Amazon's 80,000 Plant Species"
Brandeis University
Gerstenzang 122 at 4:00 pm

November 5
Prof. Arthur Pardi (University of Colorado at Boulder)
"Solution Structures of RNA"
Boston College
Merkert Chemistry Center, Room 127 at 4:00 pm

November 9
Prof. Richard Johnson (UNH)
"Can 1,2-Cyclobutadiene Exist?"
Brandeis University
Gerstenzang 122 at 4:00 pm

Prof. Y.A. Liu (Virginia Poly. Inst.)
"Artificial Intelligence in Chemical Engineering"
Tufts University, 4 Colby Street, Audio Visual Room 136 at 2:30 pm

November 12
Prof. William N. Lipscomb (Harvard)
To be announced
Boston College
Merkert Chemistry Center, Room 127 at 4:00 pm

November 16
Prof. Kenneth C. Showalter (West Virginia University)
"Propagating Chemical Waves"
Brandeis University
Gerstenzang 122 at 4:00 pm

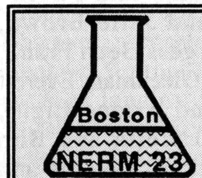
Prof. Sam Gellman (University of Wisconsin, Madison)
"Model Systems for Protein Folding: Conformation-Directory Effects of Polar and Non-Polar Interactions"
Harvard University
MB-23 at 4:15 pm

November 19
Prof. Stephen J. Lippard (MIT)
"Ligand Coupling Reactions Mediated by Early Transition Metals"
Boston College
Mekert Chemistry Center, Room 127 at 4:00 pm

November 23
Dr. Richard D. Siegel and Dr. William Doerr (B&V Waste Science and Technology Corp.)
"Environmental Regulations Present Unique Opportunities for Chemical Processing Industries"
Tufts University
4 Colby Street, Audio Visual Room 136 at 2:30 pm

November 30
Prof. Richard Zare (Stanford University)
"Lasers in Chemical Analysis"
Brandeis University
Gerstenzang 122 at 4:00 pm

Notices for the Nucleus Calendar should be sent to:
Chris Arumainayagam
Department of Chemistry
Wellesley College
Wellesley, MA 02181
Telephone (617) 283-3326
Fax (617) 283-3642
e-mail: CARUMAINAYAG@LUCY.WELLESLEY.EDU



Volunteers Needed for NERM 23

The Northeastern Section will host the Northeast Regional A.C.S. Meeting for the first time in 15 years. The 23rd meeting in this series will be held at Northeastern University in Boston from June 22 – 25, 1993. Volunteers are needed to staff the Hospitality Center and to help with other local arrangements. Please contact either Tom Gilbert at Northeastern (617-437-4505) or Mary Burgess at AMTL/Watertown (617-923-5769).

SERVICES DIRECTORY

Consulting Chemists' Meeting

Building a Company by Exploiting Scientific Ideas

Thursday, November 19, 7 PM

Vista International Hotel, Waltham

Dr. Allan Haberman on "T Cell Adhesion and Homing"

Dinner at 5:30 PM

Reservations required on or before November 17.

Call Debra Saez at (508) 521-1327

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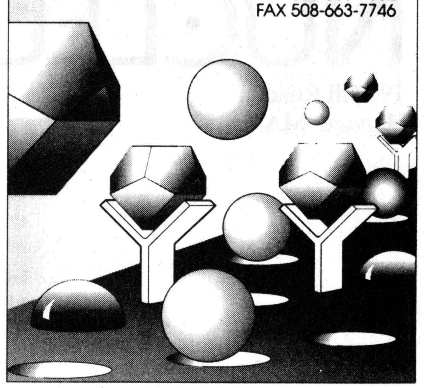

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