Canadian Nuclear Society Société Nucléaire Canadienne

CNS BULLETIN SNC

Vol. 9, No. 1 January / February / janvier / février 1988

Editorial

The demise of the *Nuclear Journal of Canada* has given rise to a lot of introspection and some doubt. Comments are heard on what, if anything, will replace the *Journal*, on the inferences that may be drawn internationally concerning the health and viability of the Canadian nuclear industry as a result of this action, and on the status and continued existence of the Canadian Nuclear Society itself.

While the whole episode is saddening, it is now in the past. There are certainly things that can be learned from it, for future guidance, but it is a mistake to try to read too much into or out of this one event.

Consider the comment, voiced more than once, that the demise of the *Journal* would signal the end of the CNS. For seven or eight years the CNS existed without the *Journal* and it seems reasonable to suppose that it would be able to continue existing without the *Journal*, although there may be a period of low spirits and despondency. Fears of the imminent end of the CNS once it is cut off from the *Journal* suggest that those harbouring such fears have a peculiar notion of what the CNS actually is.

The CNS is, or at least should be, more than just a publishing house. It has, or should have, more reason for existing than just to publish a technical journal. It is above all a learned society devoted to excellence and quality in all aspects of nuclear science and engineering. In filling this role, it should serve to provide a forum, outside corporate and commercial boundaries, for the free exchange of technical information among its members. It should also provide points of contact for discussion and peer review with the wider international scientific community. Publishing a technical journal helps to fulfill both of these functions, but a journal such as the *Nuclear Journal of Canada* is academic and international. This refers to both its standards and its readership. Publications other than the *Journal* can be used to serve a readership more limited in scope and interests. But publications are only one channel of communication and interaction.

Conferences, meetings, committees, and other activities fall appropriately within the realm of tasks carried out by a learned society. The fostering of education and technical advancement are also within such a society's purview, as are the provision of guidance to governments or other organizations on any questions within its area of competence and involvement in questions of the day, particularly where such questions affect or are affected by the work of its members. The vital element in all these activities is that they draw on the abilities, interests and academic status of individuals. Even though those same individuals work for corporations and make their views known there, the responsibilities and interests of those corporations are, broadly speaking, a matter of legislative mandate or commercial necessity. The corporations have to discharge those responsibilities but it is the individuals who are ultimately responsible for the excellence of their fields. The overlap in these interests is by no means always complete.

The entire capability of the Canadian nuclear industry resides in the knowledge and the experience of individuals. No amount of reports, procedures, manuals, journals or other documentation could ever replace that intangible expertise. Furthermore, those same individuals are the ones who help set the course for corporations, since corporations can decide nothing for themselves and exist only in law, a fact all too often forgotten. This imposes not a small personal responsibility on those individuals, and the availability of a forum where one can associate with others who have a common interest, seek advice or criticism and generally render unto one's peers, is both wise and healthy.

Such a society in Canada certainly faces problems, not the least of which are a small membership widely scattered, the dominance of a few organizations, a technology and a way of funding, regulating and operating it which is in many ways unique, and proximity to a much larger country with a very much larger sister society. Yet these problems and differences are in themselves arguments for forming and maintaining just such a society and making it as strong and useful as one can. It's all a question of individuals.

What do the individuals think?

On Knowing Things

Late last year, part 1* of the 15 part "science guideline" was published by the Ontario Ministry of Education. (The science guideline, when it is completed, will constitute a description for teachers of the complete science education program for secondary schools in Ontario.) Perusal of part 1 prompted a certain amount of reflection and disquiet. One of the trains of thought arising out of this reflection relates to events that occurred over twenty years ago.

In the 1960s, the New Math swept through Ontario's schools. It was more logical, more complete, more easily understood, and it was also more fundamental than traditional arithmetic and mathematics. At least, that's what we were told.

In fact, it had its roots in developments which took place between late last century and the beginning of the present century and which culminated in the *Principia Mathematica* by Russell and Whitehead. This was an attempt to reduce mathematics to logic and thereby put the foundations of mathematics on a firmer footing. As things turned out, Russell renounced the whole exercise some years later; the foundations of mathematics may not be firm, but is there any reason to assume that the foundations of logic are any firmer? By what

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Guest Editorial

Maintaining Maintenance

Conferences are superb vehicles for getting people who are involved in a particular technology communicating together across all jurisdictional and corporate boundaries. Such was the case at the CNS CANDU Maintenance Conference held recently in Toronto. It was at this event, while partaking of liquid refreshment, that I found myself extolling the virtues of CANDU reactors to an offshore visitor. All of a sudden he asked "If CANDU units are so good why can't you achieve close to 100% availability year after year? With the advantages of on-power fuelling and on-power safety system testing, which many other reactor types do not possess, it should be possible to at least get close."

I reminded our visitor that CANDU performance is still excellent by world standards, our capacity factors are regularly well over 80% compared to about 70% for the rest of the world. I had to admit, however, that the performance gap was narrowing. The rest of the world is improving and the reliability of some of the older CANDUs appears to be declining.

There are obvious contributors (excuses?) for our shortfall in performance: equipment breakdowns, inadvertent trips and major retrofit work, etc. By far the largest contributor, however, can be described by one all encompassing word: MAINTENANCE.

The future economic survival of our industry depends on our ability to keep nuclear plants well maintained and running safely and reliably. The future survival of CANDU technology depends on our ability to demonstrate to the rest of the world that with all its superior attributes, the CANDU can maintain higher than average performance over the long term. This noble objective is also complementary to the philosophy adopted by many electric utilities these days, of making the best of what you've got and holding off on new capital commitments.

So it was no surprise that the message coming from the many speakers at the maintenance conference was indeed that in order to make the best of our nuclear facilities, proper maintenance is essential and with it a high level of commitment and resources.

Maintenance does not go away as a result of design excellence. Designers and the tools and materials they employ are not superhuman or perfect. With the ultra sensitivity of nuclear installations to even the smallest defect in performance, the need for extremely rigorous monitoring and planning is paramount and indeed increases with the age of the plant as the equipment degrades with time. This aspect is particularly pronounced in the nuclear production of electricity since for instance, even very minor defects in equipment, such as heat exchangers, can have a substantial effect on environmental releases. However, when the nuclear facility is viewed as just another electricity factory at the utility corporate level this characteristic can get overlooked, with disastrous results.

It was, therefore, heartening to hear presenters from operations talk on issues related to future maintenance plans and predictive maintenance techniques which they are hoping to employ sometime in the future. There were also talks by designers on items such as the easier replacement of pressure tubes for new reactors. Our designers who gave us the superior CANDU are obviously still designing new plants to be built in a shorter time and for less money and which in theory can be more easily maintained. I would love to see these designers turn their efforts to finding innovative practical ways of maintaining our present facilities, then applying these techniques to new designs.

Our operators should also perhaps listen more attentively to these designers. A designer who wants to test a piece of equipment to predict when it will need changing before it fails should be listened to. Maybe an earlier removal of a pressure tube from Pickering Units 1 and 2 for examination would have revealed the problem that caused the P2 failure. Had we known of the problem before hand, I am not sure what we would have done with the information but at least the incident would not have been a surprise. Surprises cost money in the nuclear business. If you can preplan, you can save extensive plant downtime. If our plant designers employed their talent designing a long life fuel channel that could replace existing ones in a shorter time and for less money and our operators offered unit downtime for the necessary experimentation to develop such a product, I think we would be well on the way to assuring a very solid future for CANDU.

I have used the pressure tube just as an example. There are many other pieces of equipment that are critical to the operation of reactors which do have a finite life and which, with the combined efforts of Operations and Design, could be assured a high reliability and replaced before costly failure. This kind of dialogue between Operations and Design was abundant at the conference and I am sure given the right direction, could be fostered into a fruitful coalition.

There was a dissenting voice however, which although not represented directly at the event, was noticeable by its absent influence. It was obvious that there are presently severe fiscal restraints on our industry particularly on Operation and Maintenance budgets. These tend to force Operations into a firefighting mode because of scarce resources and because firefighting is easy to justify. Designers are forced into the "support by request" mode, because they don't have the proactive support from Operations for predictive work. If there was one message I got out of the conference, it was that we must get out of that mode. Even one notable lunch-time speaker who, being a regulator, usually applies constraints other than fiscal, found it disheartening that at this time in the development of nuclear energy, obvious advances were being compromised by operating budget cuts.

If the industry can combine designers' and operators' efforts with the appropriate commitment of resources, CANDU technology can take full advantage of its inherent superiority. The performance gap can once again be opened between us and other reactor types and we could lead the way to a secure nuclear future. I am not going to predict what will happen if we don't put substantial resources on developing our maintenance technology. Nuclear plant maintenance demands that resources be available to enable it to develop as the process matures. It's a penalty one has to pay for all the advantages of this relatively new industry and believe me, maintaining maintenance in this way is cheap at the price.

Ken Talbot

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means was the solidity of logic to be demonstrated?

The New Math involved set theory, which was said to be both more general and more precise than the then current notions of arithmetic. The problems that set theory gave rise to were demonstrated long ago by Russell himself.

In a certain town there is a barber. This barber shaves the set of men defined as being all those and only those who do not shave themselves. Who shaves the barber? The paradox that results is impossible to resolve and stems from the approach itself. This is not an isolated glitsch as was illustrated by another problem, also pointed out by Russell. In general, sets are not members of themselves. The specific example Russell used was teacups. The set of all teacups is not itself a teacup. There are exceptions, however, and some extraordinary sets are members of themselves. The set of all those things that are not teacups is also not a teacup, so presumably it qualifies to be a member of itself. If we imagine a set constructed of all those sets which are not members of themselves, we can then pose the question: Is this set a member of itself? If it is, it cannot be. If it isn't, then it must be. The problem has no resolution.

Even more spectacular results were achieved in logic, partly in response to the Hilbert program. David Hilbert had concluded that many problems arose from the fact that the axioms underlying mathematical systems were in general not consistent or complete and he set out to correct this situation. The Hilbert program would have had the effect of making all mathematical conclusions mere implications of the axioms used. All the ramifications of a mathematical system would be completely implicit in the assumptions, and would be nothing more than a grand, even if not always obvious, tautology. Just set the knobs, press the button, and Bob's your uncle. Out pops the answer.

Fortunately, it was too good to last. By the time Gödel, Church, Turing, Tarski, Post and Skolem had finished, the Hilbert program was rubble and the face of logic had been altered. It was shown that the only way to arrive at an answer (of which there may be none, one or many) is to move forward a step at a time, using the best judgment that one can bring to bear at each step.

This may seem far removed from science education, but keeping it in mind we can turn to the Ministry document.

The first item listed under the heading "The Aims of the Science Curriculum" indicates that students should acquire "an understanding of the processes of science," which include "identifying a problem, hypothesizing, observing, classifying, measuring, communicating, inferring, formulating theories and models, gathering data, experimenting, analysing, concluding, explaining and generalizing." From this point onwards, however, the "processes of science," and "science" itself, seem to become increasingly generalized terms. We find statements like the following:

"Science is a process experienced by human beings."

"Theories are useful but the investigative process for generating new knowledge is the characteristic that gives science its unique nature."

"... science is a human endeavour involving both process and product."

Eventually, we come to the heading of "Teaching Policy", and the first subheading we encounter there is "Content and Process". "Process" has now become something of a counterweight to "Content", and together they form a slogan which characterizes the current campaign in the war to teach science. Sadly, it may be that this is just the way it is being understood by teachers. One hears comments to indicate that teachers feel we are moving away at last from "content" and toward "process". "Process" does not complement "content"; it is opposed to it. Mastering "content" presumably implies nothing more than a horrible job of memorizing, acquiring information, coming to know "things", facts. What are the implications of mastering "process" as well?

Perhaps the answer to this question is embedded in those items listed under the heading "The Value and Purpose of Science" which appears on page 6 of the Ministry document. Oddly, no "values" are enumerated but science education is said to offer the following "characteristics and benefits": an empirical quality, an analytical quality, a linguistic individuality (?), a dimensional quality, a physiological aspect, a technological aspect and a sociological aspect. The comments elucidating the meaning intended for the last three of these are interesting and are reproduced here complete.

"... a physiological aspect, which provides [students] with an understanding of human biology and the interrelationships between humans and the environment that affects and sustains them;

a technological aspect, which allows them to appreciate the impact of technological innovations on society and to share intelligently in decision making about their use;

a sociological aspect. Many of the present and future needs of students and society relate directly or indirectly to science. Education in science will help students meet such needs as:

a) coping well in the areas of life management and raising children;
b) maintaining healthy bodies;
c) earning a living;
d) evaluating and respecting views different from their own;
e) anticipating far-reaching changes in human behaviour;
f) surviving on this planet;
g) utilizing natural resources wisely and efficiently;
h) making ethical decisions about such issues as genetic engineering, robotization, population control, world hunger, chemical and biological warfare, and nuclear disarmament;
i) solving interrelated environmental, political, social, economic, scientific and technological problems;
j) handing on to the next generation the best and most practical perspectives on science education;
k) maintaining a positive outlook on life and recognizing the benefits that science can bring to enhance life on earth."

To characterize this as a tall order would be to engage in understatement which can only be described as breath-taking. "Science" is apparently a saviour, a panacea. There is little that it cannot do. One can only speculate on the reasons for our notable lack of success in the past in dealing with problems confronting us in most of the areas quoted above. Is it because not enough science has been taught in the past? Or was past science teaching not adequate? Was there too much "content" and not enough emphasis on "process"? Were science teachers not adequately armed for the task in the old days?

These questions are actually disingenuous because it is clear that the benefits which a science education can help to provide, as they are listed in the Ministry document, border on the preposterous. There is no doubt that science has a goodly hand in all the areas listed there. But to imply that a few years spent studying science in school leaves one armed to tackle any and all problems is pernicious and dangerous poppycock. Each of the areas listed is excessively general and skips over questions of how enormously complicated some of these problem areas actually are. It is probably true that some knowledge of how scientists work is of use, but there are as many detailed methods of working as there are scientists. Surely the most daunting task in some of the areas cited is the mastery of such great amounts of knowledge just in coming to an understanding of the prob-

CNS BULLETIN SNC

ISSN 0714-7074

The CNS Bulletin is the membership publication of the Canadian Nuclear Society; 111 Elizabeth St., 11th Floor; Toronto, Ontario; Canada; M5G 1P7. (Telephone (416) 977-7620; Telex 06-23741; Fax 979-8356). Published every two months; deadline for contributions 1st of every odd-numbered month.

Le Bulletin SNC est l'organe d'information de la Société Nucléaire Canadienne.

CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee is $50.00 annually, $25.00 to retirees, $15.00 to students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. La cotisation annuelle est de $50.00, $25.00 pour les retraités, et $15.00 pour les étudiants.

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lem. Does this not equate to "content" and isn't the relevant "process" in most cases that of sifting through the mass, forming judgments on the relevant bits and assimilating them?

The rather arbitrarily defined "process" and "content" are really faces of the same coin and cannot be separated easily. Turning them into a sort of rallying cry or slogan, as the Ministry has done either wittingly or otherwise, seems to have put them in an adversarial context. As soon as this happens, the words start getting in the way of understanding and things move off downhill at a smart clip.

Is there anything else buried in the Ministry's approach?

Science education is said to be important. A listing of all the areas of importance seems to give credence to this view and to efforts to improve the teaching of science. But then we start encountering "Process", "Content", the matching of "Aims" with "Content", and declamations on what the fruits of all this effort will be. Apparently finding just the right mix will open the door to universal understanding of almost any problem you care to mention, and will amount to the democratization of science.

Are there elements of a latter day Hilbert program to be found here? Are we twiddling the science education knobs to find just that setting which will clear the path toward complete understanding and mastery? How can teachers be expected to extract from all the general language, the oversimplifications and truisms and the not terribly clear terminology the directive that the Ministry wants to put across? Are teachers on their own in ferreting out all the buried assumptions, re-interpreting the policy in the light of these exposed assumptions, and then putting it into effect?

What directive *is* the Ministry in fact trying to put across and how is it likely to affect the quality of science education? If innovations such as the new math and the tailspin which the system experienced following the Hall-Dennis report are any indication, then we can only hope that a pedagogical Kurt Gödel happens along fairly soon.

* Curriculum Guideline, Science: Intermediate and Senior Divisions, 1987, Part 1: Program Outline and Policy.

I Thought I Saw a Pussy Cat

One of the challenges of life in the Editorial Office of the *Bulletin* is keeping pace with the onward march of science and technology. It is a major challenge, for when the routine work has been done – the last typographical error checked, the last flong inspected and the mighty presses have begun their thunder – we must sit down and peruse the plethora of literature that crosses our desks for developments of significance, issues of moment and the solution to last week's ENIGMA puzzle in *New Scientist*.

It was during study of this English periodical that we came across an item that drove all thoughts of oversize poultry in the Ukraine from our minds. It appears that Euan Squires, a gentleman from the University of Durham, has come up with a variation of an interpretation of the quantum theory equations by which he suggests that the link between consciousness and physical reality may extend to the possibility of influencing the decay rates of atomic nuclei by thought. Our initial reaction was that since thought power, in a negative sense at least, demonstrably influences molecular movement (as in "a watched pot never boils") there seemed to be no good reason why it should not have impact upon atomic and sub-atomic phenomena as well.

Further examination of the *New Scientist* report reveals that according to Squires, all the quantum possibilities do exist (the "many worlds" interpretation), rather than collapsing into a single reality under the influence of observation (the "Copenhagen interpretation") but are not segregated into other worlds; they are combined into one reality which we are not capable of seeing in its totality. Got that?

This does raise the possibility that a person who complained that this indeed is not the best of all possible worlds might be encouraged to think again and, by doing so, select a more congenial version – an approach that is not only cheaper, but eliminates the unpleasant after effects inherent to the chemical approach to (temporary) world changing which we have heretofore been constrained to follow.

We decided to pursue the matter further by consulting some physicists of our acquaintance. However with one exception, all of them were either working on their MBA theses or out selling real estate. The one exception said he'd think about it. We haven't heard from him since.

Our office cat has clearly sensed our interest in this topic and, no doubt fearing that we may undertake some investigations of our own related to the Copenhagen interpretation and, remembering the feline implications of this with respect to Mr. Schrödinger's conundrum, has made himself scarce.

Of course the implications raised by Mr. Squires are profound, especially in such areas as nuclear reactor control and radioactive waste management. As well, special attention may have to be paid to the psychological profiles of those who work in close proximity to any caesium-based timepiece – indeed, the possibility of a return to the sundial, the sandglass or the water clock for timekeeping must be faced.

While it may be scant comfort, we can at least note that literature has (again) pre-empted science in this regard since Shakespeare observed that there was nothing good or bad, but thinking made it so. And while we trust that many of our devoted readers will worthily devote much of their spare time to crouching in their basements with background meters and frowns of concentration we, for the interim, will stick with that tested and reliable (if temporary) method of influencing reality involving the ingestion of liquids. Then we'll give the matter some thought.

FYI

Milestone: Canada-US Fusion Collaboration Agreement

In today's energy picture, fusion energy is one of the sweeter prospects to contemplate. It seems technically feasible and environmentally benign, and the fusion fuels – deuterium and tritium – are in practically unlimited supply as far as our present civilization is concerned. Deuterium makes up 0.015 per cent of all hydrogen on the planet, and tritium will be bred from lithium by the fusion reactors themselves.

The first commercial fusion energy plant is, however, more than twenty years forward at present rates of progress. Fusion energy development has few rivals, past or present, in scientific and technological difficulty. When fusion energy is a commercial commonplace, after the turn of the century, its development will have spanned the better part of a century. The first fusion energy experiments are now forty years in the past; Europe, the USA and the USSR have been investigating fusion since the second world war. Japan began serious fusion work about twenty years ago. Today these four parties spend an estimated two billion dollars annually in advancing the physics of fusion energy and developing fusion technologies.

Canada's fusion development program began in earnest in 1977, with the start of design work on the Tokamak de Varennes, a research tokamak fusion test reactor now operating at Hydro-Québec's IREQ research site. From this beginning, Canadian fusion work has advanced well enough to achieve significant international recognition among countries with far longer histories of serious fusion work.

Canada's fusion program strategy was simple and effective. The Government of Canada acted on the findings of the 1974 'Fusion Canada' study, which recommended that a national fusion program should capitalize on established technological strengths such as CANDU nuclear technology, the handling of deuterium and tritium, and remote handling expertise, and also recommended that the funded program be limited to a few specialized technical areas, rather than try to duplicate the vastly expensive full scale programs undertaken by Europe, the USA, USSR and Japan. Federal funding, supplemented with provincial and utility funding has been used largely to construct the Tokamak de Varennes (designed for research into plasma physics and fusion reactor materials and technologies) and to fund the Canadian Fusion Fuels Technology Project (CFFTP). CFFTP develops fusion fuels systems and related fusion technologies applicable to a wide range of fusion reactor systems and experimental laboratories.

It is no small measure of the success of Canada's program that the United States and Canada recently entered into an agreement to collaborate in magnetic fusion development. Atomic Energy of Canada Ltd. and the United States Department of Energy signed a Memorandum of Understanding on November 19 last year agreeing to collaborate in this branch of fusion for the next five years. The umbrella agreement allows the two countries to arrange specific topical agreements in a wide range of technical areas, with means of collaboration including the sharing of research facilities and research results. While the two national programs will remain totally independent, the MOU opens the way for collaborative projects with the potential to eliminate costly and time consuming duplication of effort. Previously, there had been much collaboration between individual Canadian and US scientists and research centres on an informal basis.

The National Fusion Program is managed by Atomic Energy of Canada Ltd. The NFP has a mandate to support and coordinate fusion development in Canada. Federal funding is supplied by the Department of Energy, Mines and Resources, through the Panel on Energy Research and Development. The bulk of its funding is disbursed for research and development to Canadian fusion centres. The two main Centres are Tokamak de Varennes (TdV) and CFFTP. TdV is managed and partly funded by Hydro-Québec; CFFTP is managed and partly funded by Ontario Hydro.

The importance attached universally to fusion energy should be clear from the intensive work being funded by the four major developers. Global cooperation has begun on ITER, the International Thermonuclear Experimental Reactor, for which a conceptual design centre has already been designated by international consent in Garching, West Germany. Since the benefits of fusion will accrue to future generations, fusion development is not without an aspect of altruistic concern for the future of society. At this stage, if one could liken the character of the international fusion community to that of a particular person, one might single out the Clerk of Oxenford, from Chaucer's Canterbury Tales. In the Prologue to the Tales, Chaucer writes of the Clerk of Oxenford,

"Inclined to moral virtue was his speech,
And gladly would he learn, and gladly teach".

Fusion energy is a fascinating subject in its own right. It stands a significant chance of becoming an important global energy source, less bound than oil and other fuels by the international politics of fuel deposit location. The US-Canada fusion collaboration agreement is one more indication of its potential importance, both to society as a whole and to Canadian industry in particular. The present pace of development indicates that industry and the nuclear professional alike might usefully look at it with interest.

Robert Macphee,
Consultant to the National Fusion Program

Fusion Basics

The first fusion energy plants will most likely use deuterium and tritium as fuels, confined and consumed in devices which heat them to about 100 million degrees or beyond. At those temperatures the deuterium and tritium nuclei are stripped of electrons and have enough kinetic energy to overcome the mutual repulsion of the coulomb force and fuse into heavier nuclei. Fusion energy comes from the release of some spare binding energy during the fusion process. The basic reaction is D + T = He-4 + n + 14.7 MeV. The lower limit 'ignition' temperature for a D-T fuel mix is about 80 million degrees.

A density × confinement time criterion must be met for fusion to succeed. The minimum ('Lawson Criterion') required for self sustaining fusion is a density × confinement time product of 10^{20} $m^{-3}s$.

The high energy neutrons emitted from a fusion plasma will create tritium in the fusion reactor 'blanket,' by the reaction Li-6 + n = He-4 + T. Tritium generated in the blanket becomes fuel for the reaction chamber. The neutrons will activate the reactor structure.

The two most heavily investigated fusion reactor types are magnetic confinement devices and inertial confinement devices.

Magnetic Fusion devices generate the plasma by ionization and initial ohmic heating of fuel gases. The resulting plasma is confined by strong magnetic fields of several tesla. The best known magnetic fusion device, the tokamak, confines plasma in a toroidal, or doughnut-shaped region. Currents in the megampere range circulate in plasmas of some tokamaks. Plasma pressures are in one atmosphere range. Tokamaks are low plasma density, long confinement time devices. Plasma instability and leakage from the magnetic confinement are important technical difficulties.

Inertial Confinement Fusion devices are high density, short confinement time devices. A high power multi-beam laser heats and compresses small ($\sim$ 1 mm diameter) D-T fuel pellets to supermetallic densities and to fusion ignition temperatures in a few nanoseconds. During the very short laser pulses, instantaneous irradiation power levels in the region of several hundred terrawatts are focussed on the target pellets. Even pellet irradiation and sufficient fuel density are difficult to achieve.

Risk Assessment Compendium (Staff)

"Risk assessment data can be like a captured spy: If you torture it long enough, it will tell you anything you want to know."

This quip from the former administrator of the U.S. Environmental Protection Agency appears as a clarifying statement in the final part of a five part series on cancer risk assessment. Intended to "explore the various scientific topics of public concern to regulate chemicals in the environment", the series appears in nos. 9, 10, 11 and 12 of volume 21 and no. 1 of volume 22 of *Environmental Science and Technology*.

The articles are entitled (in the order of their appearence) "Being more realistic about chemical carcinogenesis", "Physiological pharmacokinetic modeling", "Cancer dose-response extrapolations", "Exposure assessment" and "The risk management – risk assessment interface." Even though the articles stick to chemical carcinogens and do not discuss radiation, aside from the odd mention, they summarize much information. The first article is of particular interest to the general reader since it provides digested data on cancer incidence rates from various causes, natural and man-made, showing the predominance of the former and the relatively minor role played by environmental pollutants.

Special Issue on Acid Rain (Staff)

The August 1987 issue of *CEGB Research* (Number 20), is a special issue on acid rain. Articles include "The transport, transformation and deposition of airborne emissions from power stations", "Soil and its response to acid deposition", "Freshwater acidification and fisheries decline", "Effects of air pollutants on agriculture and forestry", "Effects on structural materials", and "Acid rain – a prognosis".

Communicating About Risk (Staff)

"Explaining risk to non-experts: A communications challenge" is the title of an article by Peter M. Sandman which appears in the Oct.-Dec. 1987 issue of "Emergency Preparedness Digest". The article presents the author's suggestions for simplifying and explaining the concept of risk, risk data and the use of risk comparisons both to the general public and to reporters.

Small Numbers (Staff)

(Based on item in *Science News*, Jan. 9, 1988). If you never read FYI then you may be doomed to go through life in ignorance of the Strong Law of Small Numbers, which states that there aren't enough small numbers to meet the many demands made of them.

Small numbers misbehave, or so says Richard K. Guy, a mathematician at the University of Calgary. An example: the first hundred natural numbers contain ten perfect squares. Are 10% of the first 1000 natural numbers also perfect squares? A little thought shows that it's quite impossible. Then there is the sequence 31, 331, 3331, 33331, 333331, 3333331, 33333331. They are all prime numbers. What about the next one, 333333331? Alas and alack! It's the product of 17 and 19,607,843. (Yes, I checked it on my calculator too.)

Two is the "oddest" prime number.

Eventually we come to Pierre de Fermat, who proposed that all numbers of the form $2^{2^n} + 1$ are prime. It works well for values of n up to four but comes unstuck when n = 5, as you are all no doubt aware.

Finally, a problem for those devilishly clever chaps (and wenches) who design fuel bundles. Using pennies, one can build hexagons (close packed) with 1 (trivial case), 2, 3, 4 and 5 pennies on each of the hexagon's sides. The numbers of pennies involved are 1, 7, 19, 37 and 61. Summing two, three, four and five numbers in this sequence gives 8, 27, 64 and 125 respectively, all perfect cubes. How many pennies per side in the hexagons can one go to and still maintain the pattern?

CNS Division Update

Nuclear Science and Engineering (NSE) Division Election

Four members are to be elected to the 1988 Nuclear Science and Engineering Division (NSED) Executive to fill vacant positions.

Enclosed with this edition of the **Bulletin** are a ballot and an addressed envelope. Each CNS member who belongs to NSED is invited to vote for up to four of the eight candidates, and to place the completed ballot in the addressed envelope. The member's name and signature are to be written in the indicated place on the envelope to allow the Returning Officer to verify that the ballot comes from a CNS member. The ballot should be mailed to reach the CNS office by 1988 March 11.

It is expected that this election will be of interest primarily to NSED members. Because of the self-selecting feature of NSED membership, the Returning Officer will not reject ballots received from a CNS member who is shown on the membership list as not belonging to NSED. Rather, it will be assumed that the member is now interested in belonging to NSED and will advise the CNS office of this in due course.

Short biographical sketches of the candidates are printed below.

Ben Rouben, Returning Officer, NSED

M.B. Carver

Mike Carver has been with Atomic Energy of Canada Limited, Chalk River Nuclear Laboratories, since 1965, He was Junior Research Engineer in the Department of Advance Engineering from 1965 to 1969, and a Simulation Analyst in the Department of Mathematics and Computation from 1970 to 1978. In 1979 and 1980, he was Section Leader in Thermohydraulics Modelling in the Department of Engineering Research, and from 1980 to 1983, Head of the Fluid Dynamics Section in the Department of Advance Engineering. From 1983 to 1986 he served as Head of the Department of Applied Mathematics. Since 1986 Mike has been the Head of the Department of Thermohydraulics Development.

Mike holds an M.Sc. (1965) in Thermodynamics from the University of Birmingham (UK), and a Ph.D. (1987) in Computational Thermohydraulics from the University of Ottawa. Mike is a member of CNS, of the Association of Professional Engineers of Ontario (APEO), and a member of the Board of Directors of the International Society for Mathematics and Computers (IMACS). He is also on the editorial board of the International Journal of Modelling and Simulation.

E.C. Davey

Eric Davey holds a B.A.Sc. (Electrical) from the University of Toronto (1972), and an M.Sc.E. (Electrical) from the University of New Brunswick (1974).

Eric has been employed with Atomic Energy of Canada Limited, Chalk River Nuclear Laboratories, since 1974. For most of his career, he has been involved with the development, evaluation, and qualification of several instruments in support of AECL research activities and the CANDU power-reactor program.

From 1974 to 1978, Eric pioneered the application of micro-processor technology to several instruments and systems at CRNL. From 1978 to 1982, he was Project Leader for the development of a transportable instrument to assay the contents of reactor moderator samples for Boron-10 content via neutron activation. From 1982 to 1986, Eric was primarily involved with development, performance assessment, and trouble shooting of several power-reactor radiation monitoring systems. In addition, Eric led the electronic engineering development and performance assessment for a low-level-waste characterization monitor. Throughout his career, Eric has acted as consultant on radiation effects on electronics to various projects.

Since 1987 January, Eric has been Acting Branch Manager of the Instrumentation and Control Branch at CRNL. He is a member of the Association of Professional Engineers of Ontario (APEO).

T.J. Jamieson

Terry Jamieson holds a B.A.Sc. in Engineering Science (1979) and a M.A.Sc. in Chemical Engineering (1981) from the University of Toronto. From 1981 to 1984 he was employed as a Nuclear Design Engineer in the Nuclear Studies and Safety Department of Ontario Hydro, specializing in post-accident long-term containment response calculations for licensing of CANDU reactors. From 1984 to 1985 he served as a Scientific Research Officer with the Federal Library of Parliament, providing technical expertise to members of both Houses of Parliament. At present, he holds the position of Senior Nuclear Engineer with the Reactor Development Group of ECS Power Systems Inc., in Ottawa, where he is currently in charge of radiation protection for the SAGA-N sea-shuttle project. Terry is a charter member of CNS, a member of the Canadian Radiation Protection Association, and a Professional Engineer (APEO).

P.S. Kundurpi

Prabhu Kundurpi holds an M.Eng. (1968) in Aeronautical Engineering from the Indian Institute of Science, Bangalore, and a Ph.D. (1975) in Structural Mechanics from Loughborough University of Technology, UK. Prabhu was an Engineer in fuel-element design at the Nuclear Power Company, Whetstone, England, from 1976 to 1978. In 1978 he joined the South of Scotland Electricity Board in Glasgow, serving as Engineer in the Reactor Safety Assessment Group until early 1982. Since February 1982, Prabhu has been with Ontario Hydro, where he holds the position of Nuclear Design Engineer.

J.V. Marczak

John Marczak has served on the Executive of the Toronto Branch of CNS for the past four years. He is currently Past Chairman of the Branch.

John received a B.Sc. in Honours Physics from the University of Waterloo in 1981. He holds an M.Eng. in Engineering Physics from McMaster University (1982), and is also pursuing a Ph.D. in Nuclear Engineering from McMaster, now on a part-time basis.

John has been actively involved in the nuclear industry since 1978. As a student, he was employed in the Safety Engineering Group at Atomic Energy of Canada Limited, CANDU Operations, for six co-op undergraduate and graduate work terms. In 1985 he joined Ontario Hydro, where he is currently employed in the Reactor Safety Operations Analysis Section of the Radioactivity Management and Environmental Protection Department.

John has been on the organizing committees of two nuclear symposia. Recognizing the importance of conveying a positive and truthful image of the nuclear industry, he has initiated a CNS Toronto Branch Scientific Excellence Award for outstanding graduating High School students, and has assisted in coordinating a popular local CNS Toronto Branch program.

M. Shoukri

Mamdouh Shoukri is an Associate Professor in the Mechanical Engineering Department of McMaster University, where he is involved in activities related to nuclear engineering. He obtained his Ph.D. degree from McMaster in 1977. Mamdouh joined Ontario Hydro as a research engineer, working on different nuclear reactor thermalhydraulic projects. In 1980 he was appointed Head of the then newly formed thermo-fluids unit at Ontario Hydro Research Division. Mamdouh joined McMaster University in 1984, where he is continuing his research activities in reactor thermalhydraulics and safety.

Mamdouh Shoukri is a registered professional engineer in the province of Ontario. He is a member of CNS and of the American Nuclear Society (ANS), and of the American Society of Mechanical Engineers (ASME). He is active within the CNS, being a member of the CNS Communication Committee and having acted as the technical program chairman of the 12th Simulation Symposium.

A.C.D. Wright

David Wright holds M.Sc. (1971) and Ph.D. (1974) degrees in theoretical high-energy Physics from the University of Toronto. Following post-doctoral work at Stanford Linear Accelerator Center and at the University of Alberta, he joined the Thermohydraulics Branch of Atomic Energy of Canada Limited, CANDU Operations, in 1978.

At AECL, in addition to plant-system modelling for safety analysis, David participated in the definition and analysis of safety-related thermohydraulics experiments done under the CANDEV program. He became Section Head in the Thermohydraulics Branch in 1981, and took part in the Safety Report rewrite done for Pt. Lepreau and Gentilly-2 in 1984. Since 1984 he has been a Product Leader for AECL's design review of the CIRENE reactor. Under his leadership, a team of engineers has reviewed the CIRENE safety analysis done in Italy, developed a comprehensive CIRENE plant model, and performed a number of key accident and plant transient analyses. David has also been the Canadian Representative on the Committee on the Safety of Nuclear Installations (CSNI) Task Group on advanced thermohydraulic codes.

M.A. Wright

Mark Wright graduated from the University of Toronto Engineering Science program in 1977, specializing in nuclear and thermal power. Since that time he has worked in the Canadian nuclear community.

At Atomic Energy of Canada Limited, CANDU Operations, for more than 6 years, Mark was involved with many aspects of reactor safety analysis for the CANDU-600 plants, especially loss-of-coolant analysis. He was also heavily involved with the restructuring and rewriting of the 1984 Safety Reports for Point Lepreau and Gentilly-2. In addition, Mark worked on the CANDU-600 improvement program and on the design analysis of the CANDU-300.

Mark has been employed by New Brunswick Power at Point Lepreau for about two years, and is currently involved with reactor safety analysis. Mark is a member of CANDEV working parties (containment, moderator), and is a member of CNS, of the American Nuclear Society (ANS), and of the Canadian Society of Professional Engineers (CSPE). He is also a registered professional engineer in New Brunswick.

C N S Branch Programs

Toronto Branch: The New Superconductors

On November 24, 1987 the CNS Toronto Branch had as their guest speaker Dr. Allan Jacobs, Professor of Physics, University of Toronto. Dr. Jacobs gave a presentation entitled "The New Superconductors." He outlined recent progress in the field, potential applications and qualitative aspects of the phenomenon of superconductivity.

Dr. Jacobs began by discussing a collection of sightings of superconductivity at temperatures up to room temperature. He warned that these results are largely irreproducible and should be viewed with skepticism. (At present the highest reproducible temperature is about 90 K.) These sightings are part of what Dr. Jacobs sees as a combination of opportunism by researchers and sensationalism by the media.

Until recently the highest temperature at which superconductivity was observed was about 23 K in a niobium-germanium alloy. Maintaining this temperature is difficult and requires a bath of liquid helium or liquid hydrogen. Early in 1986 researchers at IBM's Zurich Laboratory discovered a lanthanum barium and copper oxide compound that superconducts at about 30 K. Within a month a compound of yttrium, barium and copper oxide ($YBa_2Cu_3O_x$) was found which superconducts at 90 K. This temperature is easily maintained by a bath of liquid nitrogen which is cheap, safe and easy to use.

Although commercial applications are not imminent, the possibilities are numerous. Apart from replacing conventional conductors in various electronic applications, superconductors' property of perfect diamagnetism may also be exploited. One example of this is a train that levitates above a magnetic track. Dr. Jacobs predicts that the first practical device may be a superconducting quantum interference detector (SQUID). The sensitivity of a SQUID in detecting electromagnetic fields is unmatched by conventional devices.

The presentation was well attended and an enthusiastic question period followed. We look forward to further advances in this rapidly evolving field and wish Dr. Jacobs success in his future endeavours.

B. Maser
Toronto Branch – Secretary

Toronto Branch Financial Statement

(September 1/86 to August 31/87)

The Toronto Branch of the CNS receives funding for its branch activities from the national office. With these funds the branch has sponsored six general meetings over the past year (September 1, 1986 to August 31, 1987). The statements below provide a summary of the Toronto Branch's financial position outlining where members' fees are being spent in support of local activities.

A. BALANCE SHEET

Current Assets:		
Bank Balance	$1270.51	
Petty Cash	60.90	
	$1331.41	

B. INCOME STATEMENT

Revenue:		
Funds forwarded from National Office	$ 500.00	
Bank Interest	81.67	$ 581.67
Expenses:		
Mailing & Photocopying	$ 514.86	
Refreshments	$ 359.75	
Printing Expenses	$ 127.03	
Scientific Excellence Awards	$ 300.00	
Speakers' Expenses	$ 87.00	
General Miscellaneous Expenses (stamps, telephone, etc.)	25.23	$1413.87
NET INCOME		$-832.20

G.J. Sullivan
Vice-Chairman

Ottawa Branch News: Flow Induced Vibrations

Flow induced vibration problems can effect the reliability and performance of nuclear components. Michael Pettigrew of AECL-CRNL began the 1988 seminar year on January 14 for the Ottawa Branch with an excellent overview of this topic.

Canada is a world leader in the study of flow induced vibrations, primarily due to the use of heavy water in CANDU's. Other notable contributors to the field are the French, and lately, the Americans.

Mr. Pettigrew reviewed the various excitation mechanisms for flow induced vibrations, such as fluidelastic instability, periodic wake shedding and random turbulence excitation.

The technology required to avoid such problems includes flow velocity calculations, flow induced vibration analysis and vibration damage prediction.

Actual examples of component failures due to fatigue and fretting wear were described and illustrated, and an interesting video tape of laboratory investigations of several regimes of flow induced vibrations was shown.

As well, the application of flow induced vibration analysis to other industries, such as the chemical industry, was discussed.

Terry Jamieson

Book Reviews

"Once Upon the Future: A Woman's Guide to Tomorrow's Technology," by Jan Zimmerman, Pandora Press, New York and London, 1986, ISBN 0-86358-009-0.

"Once Upon the Future" is definitely one woman's interpretation of the "tyranny" of the direction and application of technology, with an attempt to suggest ways of redirecting technology to have more of a woman's moral content. Correctly so, the preface indicates that the book is an assessment of technology from one feminist's, one woman's, one human being's viewpoint (certainly not the viewpoint shared by this reader).

Zimmerman does not condemn technology itself but rather its development and application. Male dominated decision making processes, she argues, ignore or exclude consideration of the needs of women, ignore the question of social impact and are driven purely by greed for money and / or success. The book is written in three parts, each part intended to address a separate aspect, but linked by the common theme that technology has been applied in a manner discriminatory to women.

Part I, "New Technology, Old Values" argues that technology has been entirely directed by and applied using "old" values and the author's premise is that the interests, concerns and contributions of women are ignored because of these old values. The author suggests that the difficulties women encounter in changing this are: the old social conditioning that directs women away from technical/scientific/mathematical fields; fear of failure; deliberate isolation and fragmenting of women from each other by a male dominated society to ensure barriers exist to concerted action; conditioning of professional women to be "professionals" first and women second; the myth painted by companies that women are making progress.

Male Domination

The author describes in Part I the implications of technology on our personal lives – how we are largely controlled by choices made by male dominated professions, in their own self interests, without contributions from women. (All professions, including legal, medical and media are equally accused.) The author describes how technology is an invasion of our privacy – the individual has little control over decisions affecting his/her private life. Everything from genetic engineering to computer databases invade our private lives. Communication devices have been designed such that they isolate us and reduce our social interaction.

Technology is also accused of further entrenching women in the home, thus ensuring that they continue to do more work for less pay. Despite all the technological developments and despite the number of new jobs created, the claim is made that very few are created for women, especially at the technical level. Those that are created remain at the low end of the wage scale. However, as correctly pointed out, this is not a technological problem that individuals can solve; it is a social problem that demands a collective political solution.

Part II, "The Invisible Tyranny of Things" presents the author's interpretation of why technology has developed and been used in the manner it has and what can be done to redirect it in the future. The "invisible tyranny" is, of course, the male dominance in the marketing and direction of the technology. The author reiterates the theme that technological decisions are largely made by males (which ensures male needs are addressed) using a quantitative approach only without consideration of any qualitative aspects (solely a female trait, she claims). Despite the criticism (repetitive to the point of being tiresome) of the "tyrannical" male control over technology, some positive suggestions are finally tabled whereby women can influence the direction and route of technology. At last the book provides some positive suggestions, diverting from its negativity. And the suggestions are with merit. To have a successful impact on a discriminatory technological economy, women must make greater inroads into scientific and mathematical fields; into the agencies granting funding for technical research; on to research committees; and get involved in new technologies right from the early stages.

Strategies for Women

The last part, Part III, "Tomorrow is a Woman's Issue" concludes the book by suggesting strategies for women to change the technological process to incorporate moral values that, she claims, are exhibited strictly by women – compassion, emotion and common sense, rather than the analytical, calculating, rational male approach driven by greed and power. The author admits finally, after the critical focus throughout on technological direction, that it is not just the direction of technology to be realigned, but since it is so closely meshed with capitalism, politics and economics, the entire political and economic system must be changed. She suggests positive action to change advertising, marketing, distribution, rather than a negative approach, such as boycott action. Interestingly enough, the rules she presents for changing technology are likely those used currently by those she criticizes most – the males. The rules are 1) there are no rules; 2) maintain a healthy respect for the opposition; 3) don't let others set a value on you; 4) in order to make a dollar, a dollar must be spent. In addition (and I don't disagree), a woman must do twice as well as a man to be thought of as half as good. Other strategies noted include setting realistic goals, forming alliances and cooperatives (both practices implemented by engineers who must act as team members); making a commitment to change the educational process to integrate women and the sciences; applying political pressure; getting involved in all aspects throughout the technological process.

Because the focus of the book is so critical of the male influence on the use of technology, the objective of the book, a guide for women, becomes secondary almost to the degree of being lost. Zimmerman does provide some constructive and positive steps for changing things. However, these positive measures are veiled behind the curtain of criticism. As a result, the book loses a lot of its potential punch and credibility. Negativism/criticism dominate the book thereby masking its positive aspects.

Unfortunately, in the concluding chapters, the author reinforces this, reaching a peak in her overly dramatic condemnation of the "evil" element who have controlled technology and who have used it "to exploit the earth, enslave populations and make war," using it "to manipulate, to deny and devalue the female content in us all," and succeeds only in losing credibility and any followers she might have gained. If the reader can overlook this negativism and instead focus on the positive directions outlined in this book, there are some good strategies and suggestions outlined whereby each of us can contribute to the future.

B.L. Kee

"Bhopal: Anatomy of a Crisis," Paul Shrivastava, Ballinger, Cambridge, Mass., 1987.

Anyone interested in industrial and public safety will inevitably be interested in the accident at the Union Carbide plant in Bhopal. The present book provides a very broad survey of the accident with discussion in some depth on many of its implications. Unfortunately, the book is defective in a number of ways and these defects leave it with a credibility problem.

The problems begin right at the beginning, in fact they are reflected in the title itself. The author is obsessed with the word crisis. It occurs again and again throughout the book but without the advantage of being tagged by a clear definition at the point where it is first introduced. In the preface, the author indicates that the purpose of the book is to "initiate a larger program of research in industrial crises." In the first chapter, some time is spent on discussing crises but the result is more confusion rather than more clarification. No explicit definition is given of what the author understands by the term. Instead, the word is used repeatedly in context to (presumably) make its meaning clear. Thus, we encounter the following not very compatible statements.

"The Bhopal crisis was simply an industrial accident – a failure of technology."

"Accidents become crises when subsequent events and the actions of people and organizations with a stake in the outcome combine in unpredictable ways to threaten the social structures involved."

"Crisis in social systems refers to situations that threaten the existing form and structure of the system."

"Industrial crises are man-made disasters caused by industrial activities."

"Significantly, not every industrial accident leads to a crisis and not every industrial crisis is the result of a deadly industrial accident."

Unclear Crises

It is stated that Bhopal, Seveso, Three Mile

Island and Chernobyl all represent crises. From this it might be reasonable to infer that the author regards crises as resulting only from acute occurrences. From this one could infer in turn that there could be no such thing as an environmental crisis or some other situation which was brought about by chronic conditions. Other factors creep in, such as when the author seems to confirm the inference that crises result only from acute problems but at the same time clouds the issue with questions of perception. He cites the contrasting example of car accidents, which never lead to a crisis because the public at large does not perceive them as such. Further contamination of this heuristic definition of crisis occurs when the author cites product sabotage as an example of crisis and makes specific reference to the best known example of this, the Tylenol scare. This incident is characterized as having "created nationwide public alarm and constituted a major public health risk." Chapters 1 and 2 proceed in this fashion and the terms risk, crisis, accident and disaster occur sometimes apparently interchangeably and sometimes not. In the case of the last-mentioned term, the opposite problem appears at one point where the author resorts to rather arbitrary definitions. He defines "natural disaster" as having several distinctive characteristics, one of which is that they are easily identified in time and place. (What about AIDS? Is that a natural disaster? If so, how can it be characterized as to place?)

A more serious criticism is the question of why there is even any concern with the term and the notion of crisis. What positive benefit would result from an understanding of crisis that could not be gained from the more common and better understood concepts of accident or safety? In a later chapter, the author notes the importance of crisis management to corporations. One could hardly argue that this is an entirely valid field of study. Failure to handle a crisis properly can cost a corporation dearly, but in areas not normally associated with safety, such as investor confidence. Nowhere does the author make it clear just why he is interested in the notion of crisis or how he would apply an understanding of it. He only says that crises are different from accidents and that they are things to be avoided. Vagueness such as this can also lead to a drop in reader confidence since one is led to wonder whether the author's use of figures and data incorporates the same imprecision that is apparent in his concepts and definitions.

Making the Case

Chapters 3 and 4 present what is possibly of most interest to the present audience: a description of the accident and of some of its consequences. A good deal of work has obviously gone into this description and in many ways it is the most readable portion of the book. The accident is discussed in terms of "human, organizational and technological" factors and the explanation of the various failures which occurred is clear and to the point. It has to be remembered, however, that there is still, even now, no final report on what happened at Bhopal since the investigation became bogged down in court squabbles. This must have the effect of making any judgment on what occurred tentative.

Chapters 5 and 6 also present very interesting discussions of the way the situation was and is being viewed by three main groups identified by the author: the Indian Government, Union Carbide and the victims and their families. He discusses the question of resolving the continuing crisis both in terms of the way each of these three groups presently views the situation and is trying to bring it to a conclusion which is to its advantage, and in terms of what he considers they should be doing. Chapter 6 presents the conclusions and lessons which can be drawn from the whole situation. According to the author, these fall into three categories: the need for a will to view things differently on the part of all three groups; the need to find alternative methods for resolving disputes; and the need to take actions to prevent accidents and to cope with them when they do occur.

The most sustained and interesting discussion here is the author's comments on what governments should be prepared to do before committing themselves to technologies which could be hazardous in their country's context. Government policy in these cases should be aimed at fostering sustainable economic development (sustainable = manageable? controlled? safe?) and in choosing technologies that fit these requirements. Governments should also ensure that the infrastructure is adequate to deal with any demands that might be imposed by technologies brought into the country. This is perhaps one of the most important points made in the book and it was somewhat disappointing that it was not developed in more detail. This section of Chapter 6 also contains a discussion of what corporations and the communities should do to help prevent a similar accident and to lessen the consequences of such accidents as do occur.

Need for Criticism

As interesting as this final analytical section of the book is, it also needs to be criticized. In illustrating his good point about matching technologies with the available infrastructure (or vice versa) the author uses the example from India of digesters used to produce gas for household energy use from dung. He presents the example in general terms of energy supply, contrasting this cottage technology with central electricity production from sources such as thermal, hydraulic and nuclear. This is an either-or Lovins approach to the problem and ignores the distinction between satisfying immediate human needs at the individual or family level and supplying blocks of energy to larger industrial and commercial sectors. Somewhat later the author points out that there has to be means to ensure that the public is adequately protected from industrial hazards at their source and that some system of zoning also needs to be in place. He then takes the position that the latter of these two should be based on "worst case scenarios." Chernobyl is quoted here, spuriously and with a negative connotation. (". . . as the recent Soviet nuclear disaster suggests, industrial accidents can sometimes affect people who live hundreds of miles away"). The implications of this statement are far from clear. Should the objective be to avoid all "effects" of industrial accidents or to contain them within some limits? What possible use can the phrase "hundreds of miles" have in connection with zoning? How does this example clarify or explain what the author is trying to express?

Similar criticisms apply to an example given earlier in Chapter 5. At that point the author states: "Had Carbide officials been able to view crisis from a broader, social perspective, they might have done more to accept culpability immediately, pay the "price" of the tragedy, and engage in a sincere effort to assist victims. The company might even have escaped with its image intact, as Johnson and Johnson did by promptly protecting consumers in the Tylenol poisoning crisis." This is an unfair and an unhelpful comparison. In the case of Bhopal, there was little that anyone could have done after the fact to protect people. The damage was already done. This is not to try and exonerate those responsible for what could and should have been done before the fact, but the author's attempt to compare two completely dissimilar events and imply on that basis that the performance of one group of people was inadequate, is invidious.

The author suggests a number of things that could be done to make the introduction of technology into the Third World countries less catastrophic. However, many of his examples are drawn, without qualification, from the US: the methods of licensing and approving hazardous waste storage facilities in New Jersey, the advanced development of emergency plans in Louisiana, the use of "Right to Know" and "Right to Act" legislation. It is not at all clear that practices from the most litigious and richest country in the world could or should provide a model for use in some of the poorest countries, with completely different cultures. Unfortunately, the author is silent on this question.

Finally, the unfortunate and unnecessary confusion that can result from using an undefined and possibly unhelpful term such as "crisis" is illustrated in Chapter 6. There the statement is made "... and even if deaths and injuries were inevitable, Bhopal would not have become a worldwide crisis if the different parties had worked together to alleviate after effects." This is almost offensive. Apparently, the avoidance of something called a "crisis" is now the most important objective. People may die but at all costs we must avoid "crises." It would seem that academic abstraction has taken control and pushed aside all the more important considerations.

The Full Lesson

With so much criticism being expended on this book, one might ask why it was reviewed at all. The answer, I think, is quite simple. Bhopal was probably the most serious industrial accident on record and it appears that nearly everything that could have gone wrong or have been done wrong, happened. The very least that can be done is to learn as much as possible from it for everyone's benefit. That benefit can only be realized if the hard work of nailing down and understanding all the details of the accident is

RMC Faculty Position Available

Applications are invited for a faculty position in Nuclear Engineering with the Department of Chemistry and Chemical Engineering, Royal Military College, Kingston, Ontario. This is at the Assistant Professor level, effective 1 July 1988. The successful candidate will be required to teach in English at the undergraduate and graduate levels, and to conduct research. Knowledge of both official languages would be an advantage as would the ability to teach in French.

The department has a SLOWPOKE-2 research reactor. Present areas of research include neutron activation analysis, neutron radiography, nuclear reactor physics, simulation, and in-core fuel management optimization.

A Ph.D. or equivalent is preferred although an appointment at the Lecturer level might be considered for a candidate whose Ph.D. was not yet completed.

Salaries are competitive and in accordance with professional qualifications and experience.

The position is open equally to male and female candidates.

Please send a curriculum vitae, a summary of research interests and the names and addresses of three referees before 31 March 1988 to:

Dr. R.F. Mann, Head, Department of Chemistry and Chemical Engineering, Royal Military College of Canada, Kingston, Ontario K7K 5L0 (613) 541-6272.

Poste d'enseignant à RMC

Les candidatures sont sollicitées pour un poste d'enseignement en Génie Nucléaire au niveau de Professeur Adjoint, à compte du 1 ier juillet, 1988. Il sera requis du candidat choisis d'enseigner en anglais aux niveaux gradué et sous-gradué, et de diriger un programme de recherche. La connaissance des deux langues officielles, tout comme la capacité d'enseigner en français, representent des avantages.

Le département de chimie et de génie chimique est doté d'un réacteur nucléaire de recherche SLOWPOKE-2. Les domaines de la recherche effectuée présentement comprennent l'analyse par activation neutronique, la radiographie neutronique, la physique des réacteurs nucléaires, la simulation et la gestion optimale en-pile du combustible.

Un Ph.D. ou l'équivalent est préféré, quoique l'emploi au niveau de Chargé du cours peut être envisagé pour un candidat dont le programme de doctorat n'est pas encore complété.

Les salaires sont compétitifs et selon les qualifications professionnelles et l'expérience.

Cet emploi est aussi accessible aux femmes qu'aux hommes.

Veuillez bien faire parvenir un curriculum vitae, un résumé des intérêts de recherche et les noms et adresses de trois répondants avant le 31 mars, 1988, à:

M. R.F. Mann, Directeur, Département de Chimie et de Génie Chimique, Royal Military College of Canada, Kingston, Ontario, Canada K7K 5L0 (613) 541-6272.

carried out and distilled down to specific and usable recommendations. "Bhopal: Anatomy of a Crisis" is barely a start in that direction and suffers badly from imprecise language, undefined concepts, arbitrary definitions, incorrect and misleading examples, and poor analogies. It would be doubly tragic if such an approach deflected the investigation of this accident and led to the full lesson not being drawn from it.

Keith Weaver

Conference Report

CANDU Maintenance Conference

The November 22-24 CANDU Maintenance Conference attracted a level of participation that considerably exceeded the expectations of the organizers and reflects growing realization of the importance of this topic. The quantity of papers, as well as their technical quality, was indication enough that this conference was not only timely, but that it should form a model for future and not too infrequent meetings devoted to the exchange of information and experience on how to keep nuclear power plants running safely and reliably. A moment's reflection is enough to remind one that the long-term economic viability of nuclear energy is a function of our ability to maintain the plant – to repair, upgrade, refurbish or replace components and systems – and to do so with minimum disruption of power generating operation. As well this must be accomplished in a manner which minimizes hazards to the people doing the work. Indeed, perhaps this conference's major single achievement was to focus attention on these facts.

The term "maintenance" is a deceptively simple one – indeed it can bring to mind the image of someone wandering around a plant with an oilcan and a spanner – and gives hardly any insight into the variety and importance of the work it refers to. Looking beyond the titles of the various sessions and trying to classify the topics of the papers presented helps. Topics ranged from novel approaches to routine examination and monitoring of well understood pieces of equipment to very large integrated tasks which had never before been attempted. Included were the areas of predictive and preventive maintenance, planning and scheduling of large and small tasks, analysis of costs and impacts of maintenance projects, the inter-organizational and international aspects of maintenance jobs, the role of data handling and documentation, the importance of design for maintenance functions, problems and solutions in radiation protection and the special problems involved in the maintenance of specific items of equipment such as steam generators, heat exchangers, pumps and other rotating equipment.

About a quarter of the fifty-eight papers presented were related to the major maintenance project of retubing Ontario Hydro's Pickering Units 1 and 2. It is probably difficult to conceive of a maintenance-related issue not raised by this work, and the lessons learned from – and vividly illustrated by – the retubing operation. Very generally, the "golden rules" for maintenance would seem to be anticipation, preparation, ingenuity and flexibility.

Anticipation

Anticipation in the maintenance context might be defined as minimizing the number of unpleasant surprises. The world would certainly be a much more convenient place for the operators of nuclear power stations if all components and systems behaved like considerate relations by giving generous and accurate advance notice of their intentions. They are seldom, however, so cooperative. Experience, with both nuclear and conventional plant systems and equipment, and analytic techniques combined with comprehensive monitoring can compensate for this unhelpfulness so that failures may be anticipated as far as possible. Papers presented in this area ranged from a description of a new maintenance forecasting model, through an account of the predictive maintenance program on rotating equipment at the Bruce Heavy Water Plant to discussion of special tooling developed for obtaining pressure tube material samples for deuterium analysis. Related to this was a presentation on available facilities for the handling and examination of such materials and other reactor components at the Chalk River Nuclear Laboratories – facilities which form a *sine qua non* if we are to understand (and hence anticipate) the potential problems that as-yet imperfectly understood phenomena and material behaviour pose.

Another aspect of anticipation perhaps less esoteric than the above, but of no less importance, relates to a phenomenon not unfamiliar to the householder who takes a sick vacuum cleaner in for repair – the "oh, they don't make that one any more" syndrome. This is no trivial matter for nuclear plants which are expected to be operated for forty-year lifetimes (somewhat longer than the average domestic vacuum cleaner) and the question of in-house manufacture of spare and replacement parts is now being addressed.

Preparation

For those who have some familiarity with carrying out major maintenance on their motor cars, the object of preparation is to avoid such situations as "what happened to my three-eighths ring spanner?" or "you aren't going to put that thing in the bath!" Nuclear reactors are much more complicated than motor cars, but the principles remain the same.

Planning and preparation for maintenance in the nuclear context – especially major maintenance – involves a daunting range of tasks of daunting complexity. Setting up the management structure and organization for the work itself is a task of major proportions and vital importance. This area was addressed by papers covering both the retubing project and the major spacer location and repositioning program. It was also clear from an overview of the Pickering 1 and 2 retube shutdown that failure (or inability) to make an early investment in planning and preparation can impose a distinctly more onerous cost later on.

Planning for a major project must also encompass those components or systems that are not themselves going to be worked on – even when sitting around doing nothing, things tend to deteriorate. This aspect was of particular importance for the Pickering retubing project, where the shutdown period will run (for Unit 2) for about 5 years.

Preparation enters a new dimension for major reactor maintenance when it is remembered that at the present time these tasks break new ground. Analysis of tooling requirements and design of special tooling is a major project in itself, and the number of papers dealing with special tools and techniques reflected this. And it became quite clear that (perhaps not unexpectedly) redesign of equipment and revision of technique was an inevitable concomitant of any major reactor maintenance project. It is highly probable that from now (when the oldest commercial CANDU units are approaching the second half of their calculated forty year life) and for the next few years CANDU maintenance will continue to travel up a very steep section of the learning curve.

Integral to the preparation and planning process is planning – so far as possible – for adequate radiation protection and contamination control. These areas were addressed specifically for the retube project in papers on contamination control and shielding and for more general maintenance considerations in discussions of radiation field control and methods of achieving dose reduction through equipment decontamination.

Ingenuity and Flexibility – Preparing for the Unexpected

These qualities, desirable in addressing any enterprise, are absolutely essential in nuclear plant maintenance where the frequency of the unexpected (the "oops factor") is very high. While meticulous (and time consuming) planning does help, the fact is that major nuclear maintenance projects being undertaken for the first time will generate a plentiful crop of unexpected problems which can impose requirements ranging from modifications to tools and procedures to a radical rethink of the whole operation. Clearly advanced planning and project management must do its best to build as much flexibility and independence into the various schedules as is possible and employ their human resources as conservatively as possible so that reserves are available to be applied to help take care of surprises.

Perhaps the best example of a major surprise was the discovery of carbon-14 contamination in the gas annulus of the Pickering 1 and 2 Units. This material, so finely divided that it seemed to behave more like smoke than particles, posed a major challenge to radiation protection and contamination control and added a significant cost in time for the retubing work. This particular problem could indeed be a classic example of the type of challenge major nuclear maintenance operations must meet and the subtitle of a paper on the topic – "Beware thin air" – might not be a bad motto for all those in the nuclear maintenance business to adopt.

Conclusions, Lessons and the Future

The pervasive nature of the maintenance function and the future growth in its importance as more stations reach mid-life were extremely well articulated at this conference. To all attendees a very important lesson should have been driven home – that future maintenance projects must begin to be addressed now, if CANDU nuclear units are to continue to maintain their enviable record of reliability and economy. Investment now pays very handsome future dividends – failure to make that investment imposes a very onerous future burden. It is important that we not give way to the natural human impulse to discount the future.

As ambitious as the conference program was, there were some significant and interesting topics which were not represented. Apart from power reactors and their components, the maintenance aspects of few other portions of the fuel cycle were addressed. No papers in such areas as fuel fabrication, uranium refining, irradiated fuel storage or tritium handling were presented. And representation from the heavy water production side was small, with only two papers presented. These gaps reflect the extent and magnitude of the maintenance topic, rather than indicating shortcomings in the November conference, and perhaps suggest the orientation future maintenance conferences might adopt.

The necessity of keeping on top of maintenance issues, and the impact of good maintenance (or lack of it) on plant availabilities points to the need for further conferences of this sort in the near future. The fine work of the organizers in making the November conference such a success is a good base to build on.

David Mosey
Keith Weaver

Conferences & Meetings

14th Annual Simulation Symposium

Sponsored by Canadian Nuclear Society, to be held **April 24-27, 1988** in Pinawa, Manitoba. For information contact: **V.S. Krishnan, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, R0E 1L0,** (204) 753-2311.

International Topical Meeting of the Safety of Next Generation Power Reactors

Sponsored by ANS; cosponsored by U.S. DOE, CNS et al., to be held **May 1-5, 1988** in Seattle, Washington. For information contact: **Robert Ferguson, Ferguson & Associates, 7601 W. Clearwater, Suite 450, Box 16, Kennewick, Wash. 99336,** (509) 783-1446.

Third Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications

Sponsored by CNS, cosponsored by American Nuclear Society, to be held **May 1-6, 1988** in Toronto, Ontario. For information contact: **C.D. Burnham, CFFTP, 2700 Lakeshore Rd. W., Mississauga, Ontario, L5J 1K3,** (416) 823-6364.

4th Workshop on Analytical Chemistry Related to Canada's Nuclear Industry

Sponsored by AECL, Ontario Hydro and others, to be held **May 15-18, 1988** in Kimberly, Ontario. For information contact: **K.R. Betty, Eldorado Resources Ltd., 360 Albert St., Suite 700, Ottawa, Ontario, K1R 7X7,** (613) 238-5222.

28th Annual International Conference of the CNA and 9th Annual Conference of the CNS

To be held **June 12-15, 1988** in Winnipeg, Manitoba. For information contact CNS office, (416) 977-7620.

Spectrum '88: International Topical Meeting on Nuclear and Hazardous Waste Management

Sponsored by ANS, cosponsored by U.S. DOE, Canadian Nuclear Society and others, to be held **September 11-15, 1988** in Pasco, Washington. For information contact: **Eva Rosinger, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, R0E 1L0,** (204) 753-2311.

The Unfashionable Side

Hot Johns

I want to set the record straight.

Ernest Worthing is a decent chap but occasionally he gets on my wick.

Some of you may have noticed that the technical press has turned decidedly cloacal of late. Just recently there was an item in *New Scientist* relating work on the so-called "low flush" toilet. Others may recall an earlier item which appeared in *Labstracts* and was entitled "The Hot Seat?", being an account of a radioactive toilet discovered in a village on the edge of Dartmoor. This item was reportedly lifted from *The Observer*, and gave the impression that it resulted from a normal public health and safety survey. Similarly, the *New Scientist* article may have been interpreted as just another mild pong in the academic air, a sort of technical fumet or good natured but risqué journalistic dropping.

Wrong. Both of them were clear signs of an industry in inner turmoil, and of indiscretion induced by panic. Both of them also came about because of the work of dear old Worthing, assiduous Worthing, tenacious Worthing, single-minded Worthing unswervingly pursuing his objective. Worthing will go to great lengths to prove a point, just how great, I suspect few people realize.

A recent example offers itself. His Back to Babbage Society is well-known, of course. What is perhaps less well-known is the fierce energy with which he touts the advantages of his steam-driven computer. It is little appreciated that last autumn he issued a challenge to the Aphasia University computing centre in such defamatory terms that they could hardly do other than take it up. So it was Aphasia's PDP-11 against Worthing's home-brew "calculating engine."

A standard problem was agreed upon and entered into the respective machines. Worthing's machine appeared to be superior, and his psychology was definitely the better (he upset Aphasia's operators very badly by repeated blasts on his steam whistle). Unfortunately, through a programming error, his engine worked far into the night and consumed five and a half cords of wood trying to compute log (-1).

The *Labstracts* article is evidence of another project denatured by an excess of Worthing's attentions. This one stemmed originally from our shared horror at the paucity of R&D being performed today in Canada on toilets. The situation is more serious than you might think.

Domestic toilets have not changed in a hundred years. It could be argued that the activities for which they are designed haven't either but this "keep the status quo" approach presupposes that the original design was perfect to start with. However, 'all things in moderation' should be the guiding principle and only modest common sense design changes are needed. Becoming enamoured of ultra-modern designs would be, if anything, even more calamitous since modern specialized toilets are in still greater need of redesign. There are now several unconfirmed reports which indicate that the so-called high-tech toilets developed for the space program can be lethal. Rumours persist that five people were accidentally centrifuged to death while testing prototype models. If true, these rumours would add ominous new connotations to the term "whizzer."

How many times have you been in motels and found that the toilet, sometimes the entire bathroom, has been sterilized by some exotic ray gun, for your safety? Safety indeed! What about the possibility of virulent mutant bacteria being induced by this unexamined process? Have the authorities in charge of public safety thought about the risks of breakdown products from these treatments inducing rashes, boils, and other disorders? They should reflect on these things next time they sit down to their work. That would wipe the complacent smiles off their faces.

But I digress. This was the reason for our interest, entirely altruistic you can be assured. Only, Worthing wasn't content to take the low key approach and gradually build up interest in an R&D program. He blew it. Our researches, carried out on an international scale over several years, indicated several areas where problems existed. The area near Dartmoor was one. Others were just outside Ulm in southern Germany, Agen in southwest France, a remote fishing village on the Tasmanian coast, the village of Bonarlaw in eastern Ontario and a number of locations in the U.S. The objective was to develop a co-ordinated program to cover all these problem areas.

Because of its long experience with hazardous wastes, the nuclear industry was well placed to deal with this problem, as long as it remained on the scientific plane. Worthing's determined burrowings eventually raised it to a political level. Evidently when they were brought face to face with something that reminded them so much of their everyday work, the politicians panicked. The responses in the different countries are revealing.

As might be divined from the *Labstracts* note, the government in Britain chose to cover up. The NRPB was dispatched to Dartmoor with instructions to keep the lid firmly on the matter. The innocuous and deliberately jocular *Labstracts* report was the result. In France, the offending john was blown up by unidentified terrorists. Nobody was injured but several people were marked by flying debris and had to be treated for shock. A large group of demonstrators gathered around the loo in Ulm and ignored repeated requests to disperse. It seems that the police did not fully grasp the nature of the situation here because they kept telling the demonstrators that many additional facilities could be found near the railway station. The van Dieman's Land bog was torched by local liberationists.

The Canadian Prime Minister smiled and said something about "Jobs, jobs, jobs," indicating his fine control of obfuscation, creative ambiguity and ability to manoeuvre in tight corners and small cubicles. In Washington, the President was closeted with other problems and passed the affair to a specially created Task Force. Unfortunately, they had to drop everything when the entire Task Force was stricken with a severe case of Montezuma's Revenge while they were cerebrating at a think tank retreat in the Caribbean. Cries immediately went up about over-zealous field work and the project had to be canned.

Another project gone wrong by Worthing's hand? Only too right! And an interesting piece of work and a good chunk of funding down the drain as well. Good show, Worthing.

Where does the work rest now? I'm afraid only Worthing knows that.

George Bauer

Interested in Contributing to the *CNS Bulletin*?

To submit original articles, letters, FYI items, reviews, calls for papers, etc., contact one of the following:

- J. Nathwani, Editor, *CNS Bulletin*, c/o Ontario Hydro, 700 University Avenue, Toronto, Ontario, M5G 1X6.
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