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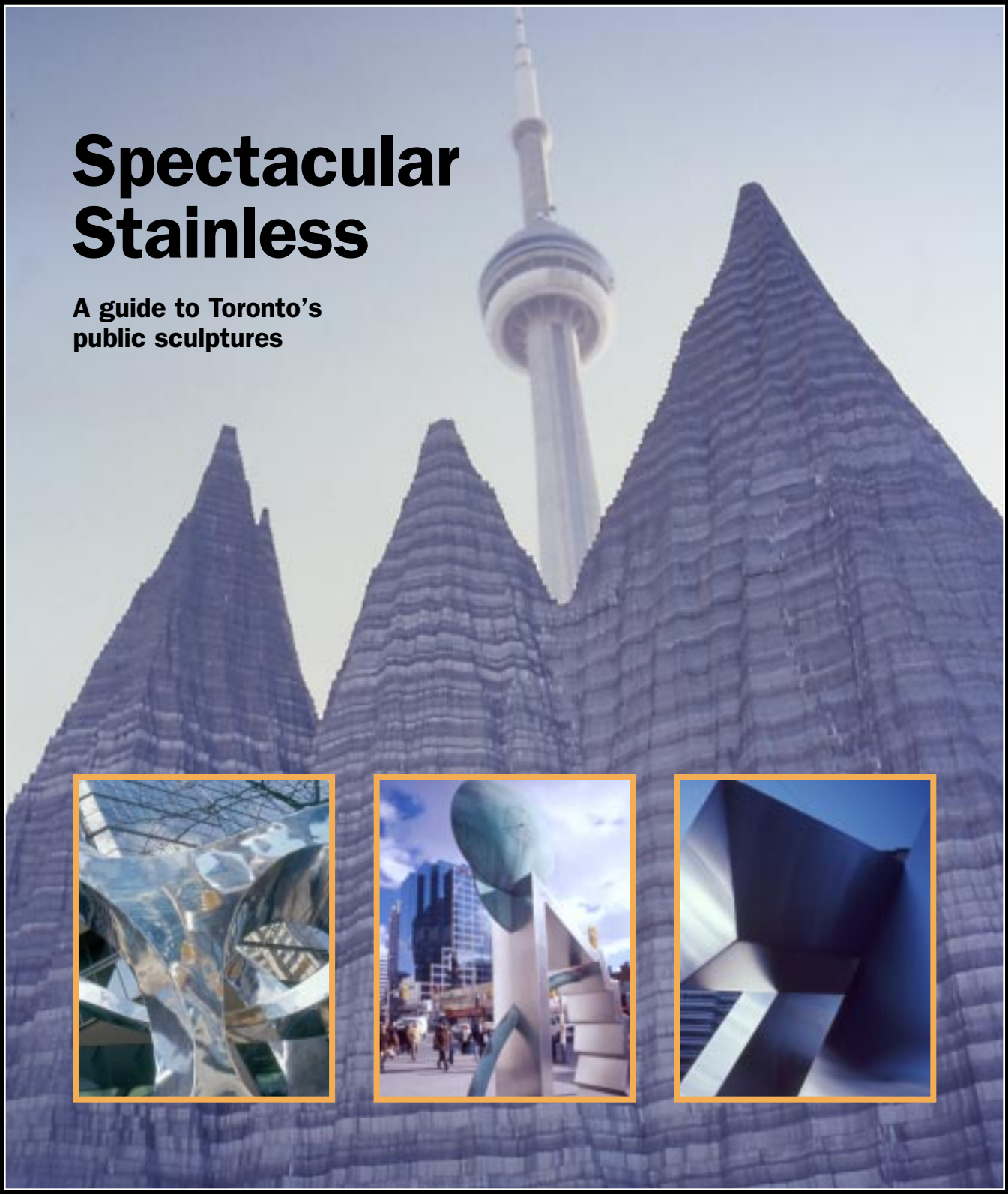

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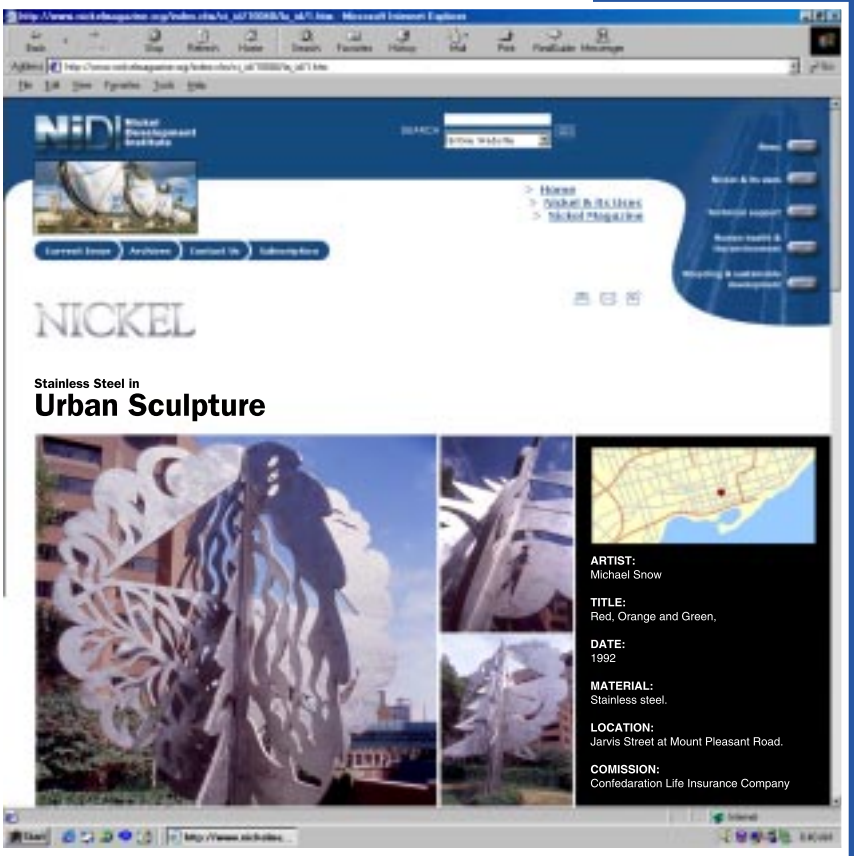

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Our future energy needs

SUPPLYING THE ELECTRICITY THAT DRIVES OUR GLOBAL ECONOMY IS a complex business. There is more pressure on industry to generate electricity efficiently (with a minimum of waste) and in a way that is environmentally responsible (by decreasing the emissions of greenhouse gases). High nickel alloys and other superalloys often have the great advantage of maintaining their strength and being resistant to corrosion at high temperatures, which is why they figure prominently in most of the technologies used today by power-generating companies. As reported in this issue, the direction the industry is taking suggests demand for nickel-containing alloys is likely to increase in accordance with the demand for electricity-generating technology.

Devices made of nickel metal hydride may some day store hydrogen onboard cars that are powered by fuel cells, such as this model from Honda.

BALLARD ENERGY SYSTEMS

Consider the new flue gas desulphurization units being developed in the United States. The rate at which these units are being constructed requires massive amounts of high nickel alloys, according to Robert McIlvaine, an expert who tracks air pollution control markets worldwide. A full report on his prognostications and the implications they have for nickel begins on page 11.

Whereas today's power-generating technology requires heat- and corrosion-resistant materials, including a range of widely-used nickel alloys, the new high-efficiency, near-zero-emission power plants envisioned for the near-future require materials that do not yet even exist. These technologies, collectively referred to as 'advanced energy systems,' include coal-fired ultra-supercritical (USC) steam cycles, combined cycle systems based on gasification (IGCC) and fluid bed combustion (PFBC), indirect fired cycles (HiPPS slagging furnace) and waste-to-energy plants. Each is unique, though all will be characterized by substantially higher thermal efficiencies than are found in today's commercial plants.

The temperatures of hot gases generated in these plants will be significantly higher than they are today. Therefore, there will be a greater need for materials that have the strength and heat- and corrosion-resistance necessary for long-term, reliable service at such temperatures. The research and development of these materials are a multi-national, multi-million-dollar undertaking. Several joint government/industry initiatives in Europe, Japan and the U.S. are aimed at finding and testing new materials for advanced energy systems. Many of the materials contain nickel, and the technical challenges facing researchers in this area are daunting. To meet them, it is essential that researchers from around the world congregate and share their knowledge. A recent workshop in the U.K. provided such a forum, and our consultant, Gerry Sorell, was there to assess their findings. His report begins on page 7.

One particularly promising area for electricity-generating companies is fuel cell technology, though here, as well, there is no shortage of obstacles and challenges. In particular, researchers are faced with finding a safe and reliable method of storing bulky, potentially hazardous hydrogen gas. Fortunately, Shell is preparing for this new "hydrogen economy" by teaming up with two other companies to develop advanced hydrogen storage devices, in which nickel metal hydrides figure prominently. A report on this initiative begins on page 5.

What this all points to is the essential role of nickel-containing materials in ensuring that our energy needs continue to be met.

Patrick Whiteway

On the Cover: *Mountain* by Anish Kapoor, stainless steel, 1995. Inset (left to right) *Pas de trois* by Russel K. Jaques, stainless steel, granite, 1984. *Full Moon* by Wendell Castle, stainless steel, bronze, 1988. *Meeting Place* by Kosso Eloul, stainless steel, 1984. Photos by Tom Skudra

inuse

THE LATEST NICKEL APPLICATIONS WORLDWIDE

SPIKE could live another 50 years thanks to the stainless steel cap being fitted here.

SOUTHERN ALBERTA INSTITUTE OF TECHNOLOGY

Stainless Steel to the Rescue

Elephant fitted with stainless steel tusk caps to prevent infection

When an elephant at the Calgary Zoo cracked one of its tusks, it took some mammoth dental work and a pair of custom-made stainless steel caps to put things right. Instructors at the Southern Alberta Institute of Technology (SAIT) spent hundreds of hours designing and crafting a new set of tusks for Spike, a 20-year-old Asian elephant, from bars of stainless steel S30403, containing typically 10% nickel. In the process, they made history.

"As far as I know, as a cap for a broken or cracked tusk, it's the first time it's been done in stainless steel," says Rob Sadowski, who headed the team from SAIT's manufacturing and automation department that came to Spike's rescue. Although work elephants have been traditionally fitted with brass tusk caps and aluminum has been used to make replacement tusks, Spike's handlers and SAIT's millwrights and machinists agreed that stainless was the best solution. "Aluminum wouldn't be strong enough," Sadowski notes. "Because of Spike's sheer size, when he plays he can do a lot of damage."

Indeed, the 5.5-tonne creature already has, having cracked his left tusk earlier this year while roughhousing with one of his favourite toys - a large tractor tire suspended by a chain. Veterinarians sawed off the broken section but found the crack extended toward the animal's jaw. Had it became infected, the result could be a massive toothache or even death.

The second tusk was cut off for balance, and zookeepers moulded wire mesh around the stumps to get rough measurements of the diameter and curvature of each one. SAIT instructor Roger Watson used the figures to create a three-dimensional computer model, and Spike was fitted with a wooden prototype to ensure a snug fit.

One of Sadowski's tasks was to track down the stainless steel. Corus Metals of Calgary was pleased to oblige, donating about $1,000 worth of 15-centimetre-diameter bar. "It certainly was an offbeat request," says Corus branch manager Girard Windle, who's more accustomed to supplying metals to the Alberta oil patch.

Elephants' tusks curve upward as well as inward and are not a uniform round shape, Sadowski explained, so the caps could not be bored to fit over the stumps. Two stainless bars were split lengthwise, hollowed out and machined to a 13-centimetre-diameter and about 38 centimetres in length. SAIT welding teacher Art Cartwright then welded the two sides of each cap back together.

"There are other stainless steels that are easier to machine [for example, S30300], but they are not readily welded and have unreliable properties in the welded condition," Sadowski says of the S30403. "We were also quite concerned that, once they were welded, that could distort them quite a bit and we may not be able to slide them on if there was a lot of distortion from the heat."

The finished caps, each weighing about 14 kilograms, were fitted and secured with epoxy in an operation that attracted international media attention. Spike could live another 50 years, and his shiny new tusks should withstand any punishment he can mete out. "I can't see them breaking or denting," Sadowski says. "They're certainly stronger than the ivory."

MORE INFO: www.nickelmagazine.org/1002/4.htm

Safe Hydrogen Storage

Metal hydrides could potentially play a leading role in a hydrogen economy

STORING BULKY HYDROGEN onboard transportation vehicles is a major challenge for the hydrogen economy envisioned for the 21st century.

Shell is preparing for a new "hydrogen economy" by teaming up with two other major companies to develop products that use metal hydrides to store hydrogen.

The initiative puts metal hydrides, including some that use nickel, at the forefront of efforts to establish safe and reliable hydrogen storage, one of the weakest links in the chain from research to commercial application of fuel cell technology.

The advantages of using nickel in these types of applications include the metal's good hydrogen storage properties and tolerance of impurities.

As fuel cell development progresses worldwide, hydrogen, which creates few or no emissions, promises to become a clean energy source for everything from cars to power plants.

But storing hydrogen is a challenge. The gas takes up a lot of space (for example, the amount required to run an electric car on a fuel cell for 400 kilometres would fill a balloon 5 metres in diameter), and compression, the obvious solution at first glance, can be dangerous because of hydrogen's volatility.

So the race is on to develop a new means of storage that is both safe and convenient. HERA Hydrogen Storage Systems, a joint venture between Shell Hydrogen, Gesellschaft für Elektrometallurgie (GfE) and Hydro-Quebec, believes the future lies with metal hydrides, which are binary compounds formed by hydrogen and another element (usually more electro-positive) or group, such as sodium hydride or methyl hydride.

Metal hydrides literally trap hydrogen within the alloy, much like a sponge absorbs water. When heat is applied, the gas is released. Hydrides are capable of storing hydrogen at two or three times the density of compressed gas and will desorb the hydrogen at roughly the same pressure required for storage.

U.S.-based Ergenics currently offers safe, low-pressure storage of hydrogen in canisters that can be charged and discharged more than 100,000 times. The units use Ergenics' patented Hy-Stor 208 alloy, $MNi_{4\cdot5}Al_{0\cdot5}$.

But to improve the performance of these storage systems, researchers must find ways to increase the proportion of hydrogen in the hydrides, whilst maintaining the reversibility of the reaction within a reasonable temperature and pressure range. Many alloys form hydrides with up to 9% hydrogen but will release the gas only at extreme temperatures.

HERA's research team is scrutinizing three main groups of alloys: magnesium-based high temperature hydrides, chemical hydrides, and medium-temperature alanates.

Although metal hydrides are generally too heavy for use in mobile applications such as cars and buses, they show promise for stationary power generation for homes and businesses, says Marc Hubert, director of business development at HERA. For example, the magnesium hydrides can store up to 6.5% hydrogen.

Another potential solution is composite alloys that combine the best storage properties of two different metals. For example, magnesium has been mixed with hydrides that show fast kinetics, such as $LaNi_5$. In this case, nickel acts as a catalyst for the dissociation of molecular hydrogen.

MORE INFO: www.nickelmagazine.org/1002/5.htm

The Finer Details

Electroformed nickel lead frames offer several advantages to an industry where miniturization is paramount

Well-established nickel electroforming technology is now being used to produce lead frames for the electronics industry.

Micro-metal component specialists Tecan Components of Weymouth, Dorset, U.K., for example, has refined and improved the process to produce lead-frames in any volume to an extremely high level of accuracy.

Traditionally, lead-frames were made by mechanical punching and photochemical etching methods. These are excellent for high-volume production, but have accuracy limitations that cannot satisfy the increasingly finer requirements of the electronics packaging industry.

Electroforming enables parts to be produced at half the original size or with double the lead capacity for the same "footprint." These refinements allow fine-pitch dimensions and tolerances that were previously unattainable or prohibitively expensive to be achieved on a routine basis.

Applications of these products, which can also be supplied with a gold finish, include low and high lead-count semiconductors and other multi-lead component requirements fulfilling the needs of the full spectrum of the electronics market. These electroformed nickel products are suitable for all production and assembly techniques including loose parts, waffle trays and tape or reel.

New nickel electroforming facilities recently installed at Tecan Components enable them to supply high quality product for any desired quantity from rapid prototyping through small batch sample quantities.

More info: www.nickelmagazine.org/1002/5b.htm

BALLARD ENERGY SYSTEMS

Saved From the Scrap Heap

Vancouver museum refurbishes Ben Franklin *submersible used to study the Gulf Stream in 1969*

AFTER TWO YEARS of hard work the staff and volunteers at the Vancouver Maritime Museum have returned the Ben Franklin to its original condition.

"Vessels large may venture more, but little boats should keep near shore," Benjamin Franklin (1706-90) once observed in his *Poor Richard's Almanac,* and while the 14.5-metre-long submersible named for the American statesmen and inventor hardly rates as a little boat, it has not ventured from shore in more than three decades.

The 130-tonne sub, with a hull formed from thick plates of high-strength steel, completed the first major underwater survey of the Gulf Stream in 1969 but has spent most of its life dismantled and relegated to a corner of a North Vancouver shipyard. It was in danger of being scrapped when the Vancouver Maritime Museum took on the task of refurbishing it for display.

"I know submersibles, and the thought of acquiring the sub just seemed like a pipe dream," says James Delgado, the museum's executive director, who was offered the *Ben Franklin* in December 1999. "I didn't need eight hours, which is what I was given to make a decision."

Built in Switzerland in the late 1960s, the submersible was purchased by businessman John Horton and shipped to Vancouver in 1971. While Horton's plan to modify the vessel for commercial work off the British Columbia coast never materialized, he donated the $15,000 needed to haul it by truck and barge to the museum site.

"It was still in good shape," reports Delgado, an underwater archaeologist. "There was some mild corrosion where the vessel had been resting on a wooden pallet for thirty years. That cleaned up beautifully. There was no rust, just peeling paint and moss growth, that kind of thing." The interior also suffered little corrosion even though about 10 tonnes of rainwater had accumulated through an open hatch. "It took us a year to dry," he notes.

Ben Franklin's hull is fashioned from plates of 3.5-centimetre-thick steel capable of withstanding pressures at depths of up to 600 metres. The submarine division of Grumman Aircraft Engineering Corp. of Bethpage, New York, U.S.A., teamed up with deep-ocean explorer Jacques Piccard to commission the vessel from the Swiss firm Giovanola Brothers (now Giovanola Technologies).

The cylindrical hull, with an outside diameter of 3.1 metres, was built of welded sections of Aldur 55/68D, a high-strength steel alloy made by the Austrian firm Voest, containing 1.6% manganese. Each end is capped with rounded hemispheres formed from six welded plates of Welmonil, a hardenable steel produced by Hoag of Germany with a nickel content of between 0.8 and 1.8%. When the submersible was built in the 1960s, Welmonil did not have grade numbers for its alloys, but this alloy would now be designated Welmonil 43. Both alloys can withstand pressures exceeding 48 megapascals.

REASSEMBLED, 30 years after running aground.

The sub was christened in honour of Franklin, who studied the Gulf Stream during Atlantic crossings in the late 1700s. With Piccard and five other researchers aboard, it left Florida and remained submerged in the Gulf Stream for more than 30 days, drifting with the current 2,700 kilometres before surfacing off Nova Scotia. Operating at an average depth of 200 metres, the crew took detailed measurements of temperature, velocity and salinity, and descended to 540 metres to study the ocean bottom. The National Aeronautics and Space Administration in the United States installed cameras to record the crew's physical and psychological adjustment to a long period in a closed environment, and these data have been used to plan space missions.

The *Ben Franklin* was used to study underwater geology and the impact of industrial waste dumped off the U.S. eastern seaboard, but its career was short. Damaged in 1970 after breaking free of its mooring and running aground on a reef, the sub was disassembled for shipment to Vancouver the following year.

Staff and volunteers at the Vancouver Maritime Museum invested two years and $60,000 in donated materials to reassemble and restore the vessel. The hull has been scraped, stripped, and returned to its original gleaming white with yellow trim, and the submersible should be on public display by the end of 2002.

MORE INFO: www.nickelmagazine.org/1002/6.htm

VANCOUVER MARITIME MUSEUM

OLD WAYS of generating electricity need to be improved.

Calling for a Revolution

Breakthroughs in key areas are needed to move new power generation concepts from the drawing board to reality

The high-efficiency, ultra-low-emission power plants envisioned for the near future will release significantly less harmful emissions to the natural environment. However, they will require heat- and corrosion-resistant materials that do not exist today. These advanced energy systems will have substantially higher thermal efficiencies compared to today's commercial plants.

This translates into higher hot gas path temperatures and a greater need for materials possessing the requisite strength, heat and corrosion resistance for long-term, reliable service at higher temperatures.

Such innovations are not restricted to the development of materials with better mechanical properties and corrosion resistance, but extend to innovations in design concepts, materials synthesis, fabrication methods, monitoring-control inspection techniques, and life assessment/prediction. There are a lot of things to consider.

Major programs aimed at furthering these initiatives are ongoing in Europe, the U.S. and Japan, and were discussed at the Third International Workshop on Life Cycle Issues in Advanced Energy Systems, held in Woburn, U.K., in June 2002.

The total cost, shared by government and industry in the U.S., Europe and Japan, for ongoing materials-related research and testing in support of advanced energy systems totals several hundred million dollars annually.

The European Union (EU) has two multifaceted R&D efforts in progress—the COST and THERMIE programs. The former is targeted at a 650° C/300 bar (50% efficiency) ultra-supercritical (USC) steam cycle plant; the latter, at a 700° C/375 bar (55% efficiency) plant. Key areas of concern are advanced materials for steam generators and turbines. Although the base-case fuel is coal, consideration will be given to biomass co-firing in order to minimize greenhouse gas emissions. Strength and corrosion considerations in advanced USC plants will require replacement of iron-based with nickel-based alloys for highest temperature components.

Another Europe-based program addressing materials needs is being conducted by the UK Advanced Power Generation Task Force, which is focusing on cleaner coal systems, gasification, fuel cells, and CO_2 capture technologies.

Materials R&D programs in the U.S., the cost of which are mostly shared by the U.S. Department of Energy (DOE) and the private sector, are slanted toward radically advanced energy technologies. The ambitious goals are enunciated in DOE's VISION 21 strategy for developing the technology basis for high-efficiency, ultra-clean, fuel-flexible, cost-effective energy systems by 2015.

Technologies include gasification, fluid bed combustion, externally fired cycles, hot gas cleanup, fuel cells and carbon storage. Materials systems under development embrace structural materials (for example, high-temperature alloys, ceramics and coatings for heat exchangers and gas turbines), as well as functional materials (such as ceramic membranes for gas separation and fuel cell components).

Materials R&D in Japan continues its heavy emphasis in support of high-efficiency USC power generation, exemplified by collaborative METI and NIMS projects for developing stronger ferritic steels. Other government-industry collaborations have succeeded in developing high-strength austenitic stainless steels for high-temperature power generation equipment. Under NEDO auspices, new austenitic steels, targeted specifically for high-efficiency waste-to-energy plants, are being evaluated.

Corrosion-related issues discussed at the workshop included materials performance in modern power plants and data from laboratory and pilot-plant tests. The prevalent corrosion modes experienced in high-temperature combustion-gasification environments, often in combination, are oxidation, sulfidation, chloridation, carburization and molten salt attack. Also encountered in some advanced energy system environments are nitridation and metal dusting attack. "Breakaway" corrosion was identified as a particularly troublesome manifestation of high-temperature oxidation-sulfidation, characterized by a sudden steep increase in attack after extended exposures. Models are being developed to predict the onset of breakaway.

The workshop was co-sponsored by the Electric Power Research Institute (EPRI), Oak Ridge National Laboratory (ORNL), Cranfield University's Power Generation Technology Centre, and the European Commission's JRC Institute for Energy. Invited participants were from 12 countries and included prominent materials-corrosion scientists and engineers, among them NiDI consultant Jerry Sorell.

MORE INFO: www.nickelmagazine.org/1002/7.htm

WARREN GRETZ/NATIONAL RENEWABLE ENERGY LABORATORY, GOLDEN COLORADO

Stainless Steel in Urban Sculpture

BY GARY MICHAEL DAULT

Marble and bronze may have the upper hand historically, but the single most advantageous material available to today's sculptor is stainless steel. Stainless is strong and easy to maintain, its reflectibility is highly sensuous, and it responds to detailing, articulation and nuance Indeed, it is a medium which the sculptor can use as delicately and precisely as a painter uses paint.

The city of Toronto, Canada, features numerous examples of stainless steel used artistically in public sculpture.

The goal of the city's former Percent for Public Art Plan, established in 1985 and remaining in place until the new City of Toronto's "Official Plan" is adopted, is to "enhance and humanize both specific sites and the City in general" and to create "harmonious relationships between public open spaces, streets and development projects." This is to be done by the allocation of one percent of the gross construction costs of a project to public art. The percent for public art plans are "required for all proposed developments [except for public housing developments] with a gross area of 20,000 square metres or more". The new City of Toronto official plan draft policies, adds to that by "encouraging the inclusion of public art in all significant private sector developments across the city".

Anne and Patrick Poirier, *Memoire du futur,* 1992, Polished steel and stone. The Municipality of Metropolitan Toronto/Marathon Realty Corp.

TOM SKUDRA

One of my favourite public art works in the city is the witty and ironic *Memoire du futur* (1992) by the French husband-and-wife team of Anne and Patrick Poirier. Situated in the lobby of Metro Hall on King Street West, this enormous, seismically misaligned Greek Pillar, with its individual drums stacked up into a wobbly pile (as if the column had fallen and been hastily and precariously put back together again) is like a piece of antique jewelry. The fact that each of the column's stacked drums is luxuriously coated in shiny stainless steel transforms the work from a reminiscence of the cultural past into a luxurious (if precarious) object—a work of fragile, evanescent beauty. If this is a "memory of the future," then the future is clearly glamorous but unstable. I don't know when I've seen stainless steel so cunningly employed. Here, the very seductiveness, the narcissism, of its surface is integral to the meaning of the work.

Renowned Canadian sculptor and filmmaker Michael Snow employs stainless steel to similarly witty effect in his *Red, Orange and Green,* a complex stainless steel "tree" installed beside the Confederation Life Insurance Company at Jarvis Street and Mount Pleasant Road. Using stainless steel not only for its strength but for its reflectibility, Snow assumes that the only fall colours this tree will display will be those reflected in it from its surroundings and from passing traffic. On the other hand, it will obviously remain steadfastly colourful all year round, and not just in autumn. The tree literally reflects the seasons. And everything else.

One of the sculptors most devoted to the use of stainless steel in sculpture was Kosso Eloul (1920-1996). In work after work, he folded sheet steel into airy volumes that, once they were welded together, assumed their new role as heavy masses. Leaning together or balanced, one upon the other, they are suggestive of the slabs at Stonehenge. One of the best was *Meeting Place,* installed (admittedly under rather cramped conditions) at the entrance of the Crown Life

Ted Bieler *Mudra*, 1974.
Government of Ontario

Eldon Garnet *Time and a Clock*, 1990 (top). Kosso Eloul, *Meeting Place,* 1984 stainless steel. Crown Life Insurance Company (middle). Michael Snow *Red, Orange and Green*, 1992 stainless steel. Confedaration Life Insurance Company (bottom).

Insurance Company at Bloor Street East and Church Street.

I used to argue with Kosso that one cannot pass off volumes (in this case, stainless steel shells welded and bolted together) as ponderous, slabby masses, but he always remained cheerfully unmoved by my point of view. He must have been doing something right, since he ended by making more public sculptures—and making more of them from stainless steel—than anybody else in Canada.

What is so important about using stainless steel is that it is wonderfully ductile and folds beautifully. A case in point is the 11-metre stainless steel work *Triad,* by Toronto artist and teacher Ted Bieler. It is at 123 Front Street West at University Avenue and was commissioned in 1984 by the Marathon Realty Company Limited to mark Toronto's Sesquicentennial. Its upwardly proliferating, *origami*-like folds aptly symbolize the city's rapid and continuing growth.

Toronto-based artist Eldon Garnet is one of the most inventive designers of public sculpture in Canada. Normally working with stone, wood and bronze (he frequently casts full-size human figures), Garnet turned to the flexibility of stainless steel for what was certainly one of his most ambitious projects—a three-part, architecturally scaled installation called *Time: And a Clock* (1990).

The clock part had to do with the first third of the installation— a graceful scroll of sheet-metal letters garlanding a clock installed on the bridge over the Don River and the Don Valley Parkway on Queen Street East. Taking his cue from the early Greek philosopher Heraclitus, who said "you cannot step into the same river twice," Garnet's text reads: "This river I step in is not the river I stand in."

Continuing under the bridge and travelling east on Queen Street brings you to the work's second phase—a four-part meditation on time conducted by means of four texts, composed of stainless steel letters, sunk into the sidewalks of each of the four corners of the Queen-Broadview intersection. One text reads "Distance = Velocity x Time." Another, a favourite with local merchants, proclaims that "Time is money, money is time" The third and fourth say "Too soon free from time" and "Better late than never."

Farther east still on Queen Street, near Empire Avenue, stands the work's third sculptural cluster: four slim steel flagpoles with stainless steel banners "fluttering" from them—that is to say, the banners are cut from sheet stainless steel and shaped to look like cloth banners waving in the wind. A stainless steel letter rides atop each pole (adding up to T-I-M-E), and each of the banners, which are made up of stainless steel letters, addresses, by means of its solitary word, the behaviour of time. The first says "coursing"; "disappearing" and "trembling" are next, and the last says "returning."

Gary Michael Dault is a well-known Toronto writer and art critic. He has written or co-written eight books, including Architecture Canada 1997: The Governor General's Awards for Architecture *(editor and essayist), and is a weekly columnist for the* Globe & Mail.

MORE SCULPTURE ONLINE A printable guide map, showing the location of these and other stainless steel sculpture in the city of Toronto, is available online at www.nickelmagazine.org/sculpture.htm Six photos are shown there of each piece.

TOM SKUDRA

Scrubber Boom

U.S. clean-air initiatives to spur demand for high-nickel alloys used to line flue gas desulpurizations

The Bush administration's "Clear Skies" initiative and federal lawsuits forcing utilities to install pollution controls on aging coal-fired generators should translate into a half-billion dollar market for nickel-rich alloys in the U. S. by 2006, according to an environmental research firm.

In fact, Illinois-based McIlvaine Co. warns that suppliers may have trouble keeping up with increased demand for the corrosion-resistant alloys used to build the scrubbers that reduce sulphur dioxide emissions and the acid rain they cause.

"It's a very positive future," predicts the president, Robert McIlvaine. "The combination of retro-fitting and the new coal-fired plants represents a large opportunity for nickel-alloy suppliers. High-nickel alloys are going to be popular options, and the quantities required are huge, so there may not be enough high-nickel alloys to supply the market."

McIlvaine's firm predicts that the market for corrosion- resistant alloys in the production of flue gas desulphurization units will more than double in the next four years, to US$470 million from US$220 million per year. By 2006 the construction of generating plants in China, Eastern Europe and other regions should translate into a worldwide market for alloys worth about US$1.2 billion, up from about US$400 million currently.

In the U.S., 75 new coal-fired plants are either under construction or being designed, and under environmental laws, all require scrubbers. When, in 1970, the Clean Air Act was introduced, about 400 coal-fired plants were exempted on the understanding they would soon be shut down. "But miraculously, all the plants that were slated to be retired in 1970 got an extra thirty years of life — and they're all still operating," notes McIlvaine. What happened, essentially, was that utilities circumvented the law by repairing and overhauling plants to keep them in operation.

The U.S. Environmental Protection Agency responded by turning to the courts, forcing utilities in Florida, Virginia, New Jersey and Kentucky to install scrubbers on existing plants. President George W. Bush, under the Clear Skies program, announced in July, has backtracked on litigation in favour of a system of pollution-control incentives and emission targets. But the U.S. is still committed to slashing sulphur dioxide emissions from 11 million tons a year to 4.5 million tons in 2010, and to 3 million tons by 2018. And Congress is considering a Democrat-sponsored bill that would force utilities to cut emissions by 75% within six years. Says McIlvaine: "The only question is whether the peak [in demand for scrubbers] is going to be in 2006, 2008 or 2009."

Although the timing of the scrubber boom hinges on politics, North American demand for the technology is already rising. Marsulex Inc., a leading global supplier of flue gas desulphurization systems, says dozens of U.S. utilities and independent power producers have inquired about its products within the past year. "The number of budgetary queries has tripled or quadrupled" and "the ball has started rolling" on orders, says Ruth Miller, marketing manager for Marsulex Power Generation Group in Lebanon, Pa.

McIlvaine believes that the Sept. 11 terrorist attacks will increase demand for more coal-fired generating plants with pollution controls. "Nuclear and natural gas are less safe from terrorist attack than coal," McIlvaine notes, and the war on terrorism in the Middle East is casting a shadow over foreign supplies of oil. "Having our own coal-fired electricity structure is a lot safer."

MARSULEX

MORE INFO: www.nickelmagazine.org/1002/11.htm

A Stainless Showpiece

A major wastewater treatment plant in New York City chooses nickel stainless steel equipment for long service life

CORROSION, abrasion, maintenance and life cycle costs are all key things to consider in specifying stainless steel hardware for wastewater treatment plants. Such considerations are a matter of routine for New York City's Department of Environmental Protection (DEP), which specifies stainless steel for much of the hardware in its wastewater systems.

One such system is the US$2.2 billion Newtown Creek Water Pollution Control Plant in the borough of Brooklyn. The 13-year construction project is designed to handle 1.2 billion litres per day. It will be completed in 2013.

"We have extensive experience with S30400 and S31603 stainless steels in our water supply system, dating back to the 1960s," says Ken Moriarty, chief of the DEP's design services division. "In our water treatment plants we noticed some high rates of failures [in carbon steel components]. Therefore, we thought that with the long service life of stainless steel equipment, we could reduce maintenance and replacement costs."

He adds that the cost of labour, excavation, shutdowns is so enormously expensive that the division does not mind spending a little bit extra for stainless steel in order to increase service volumes. "Much of the division's equipment is in deep, inaccessible sub-surface locations, so it's essential that low-maintenance materials are employed."

"We go through a value engineering process," says Vincent DeSantis, the DEP's director of facilities design. "Quite often stainless steel comes up and it usually survives the life-cycle cost analysis." Which is to say that the total (capital and replacement) cost of a stainless steel component over the life of the project is lower than the total costs of using other materials.

Among the stainless steel hardware used at Newtown Creek are 3,430 metres of blower pipe and 3,426 metres of piping and fixtures. These were fabricated by Felker Brothers Corporation, based in Marshfield, Wisconsin, U.S.A., for Sanitaire, another Wisconsin-based company, which manufactures and supplies aeration equipment for wastewater treatment facilities in the U.S.A. The pipe, worth some $1.8 million, is all S31603 and ranges from 7.6 to 2,400 millimetres in diameter.

The sheet and plate is pickled before being delivered to Felker Brothers. After fabrication and welding, all of the pipe and fittings are immersion-pickled and the stainless steel is passivated by allowing contact with air. Pickle paste is used on spot welds to remove the heat tint, which, because of its inferior corrosion resistance, can lead to corrosion. "We insist on pickling, which is especially important where there are large lags between manufacturing and installation," says Moriarty.

Sanitaire uses S31603 because of its corrosion resistance and structural integrity. It also

JOCK POTTLE/ESTO SANITAIRE

Blower pipes (above and top right) which introduce air into the bottom of the aeration tanks, are all made of S31603 stainless steel because of its corrosion resistance and structural integrity. S31600 stainless steel, with a No. 4 finish was used to clad eight, 11.3-million litre carbon steel digesters.

eliminates the need for periodic maintenance or painting of the piping system. Or as Sanitaire's Don Clement puts it, "stainless steel lasts a very long time."

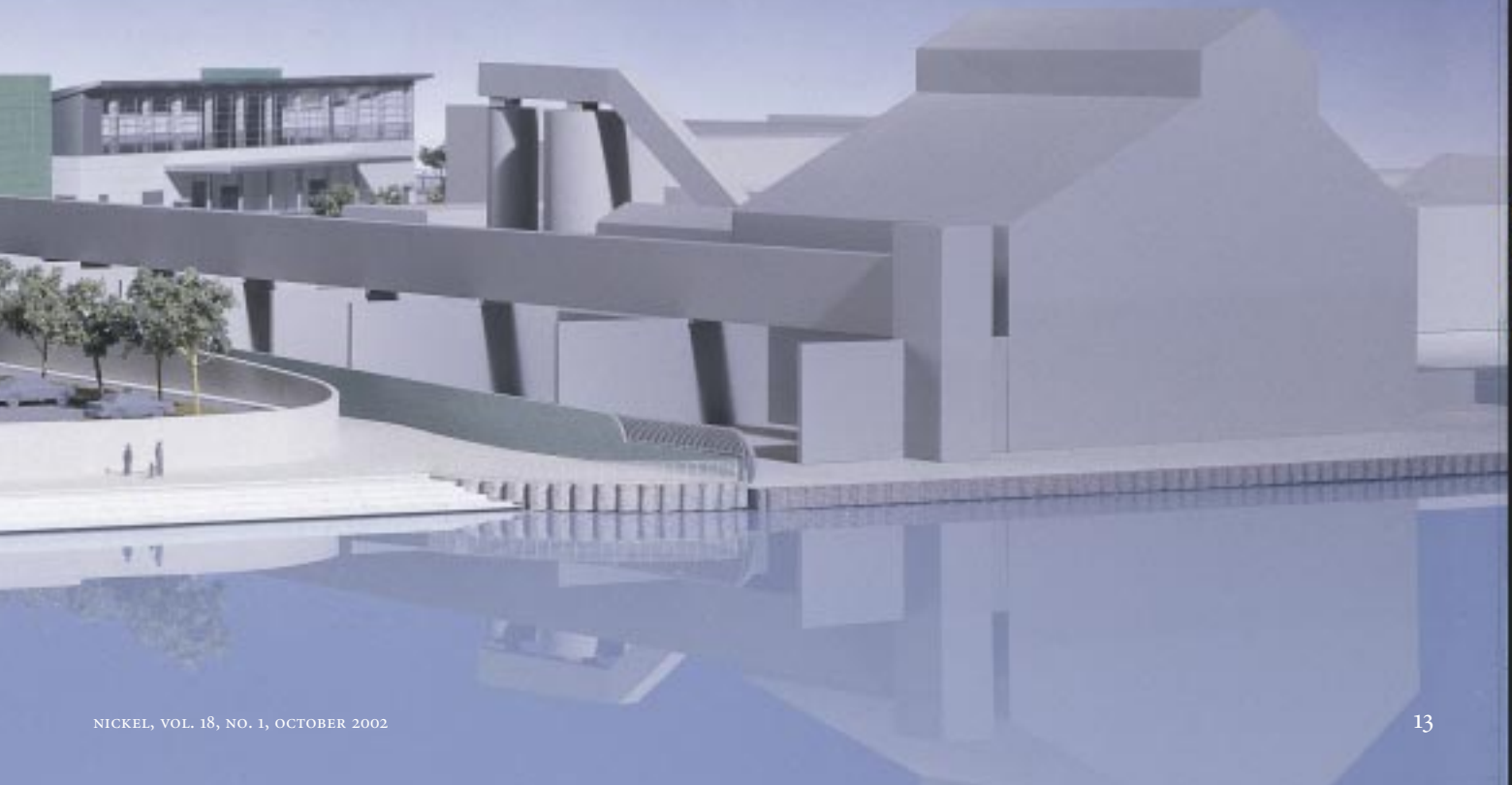
The Bird Machine Company of Walpole, Massachusetts, supplied 24 centrifuges to the project. Centrifugally cast Duplex stainless steel was chosen for its resistance to corrosion and abrasion and for its higher tensile strength, which means less material is required.

Other applications at Newtown Creek include S31600 slide gates and abrasion- and corrosion-resistant stainless steel collector chains in the primary and secondary tanks. "We ordered tonnes of that equipment," says Moriarty, who notes that carbon steel chain failures have caused shutdowns.

Geoff Baldwin, project manager at Newtown Creek, says stainless steel allows maintenance crews to disassemble and reassemble units with considerable ease. He adds that the project boasts some impressive stainless steel architectural features. For example, S31600 stainless steel with a No. 4 finish is used to clad eight, 11.3-million-litre carbon steel digesters. The egg-shaped tanks measure 25.6 metres in diameter and are 27.4 metres high. Six of the building roofs will also be nickel stainless steel, for appearance, low maintenance and longevity. There is also some stainless steel paneling on the outside of the buildings.

Notes Keith Buernke, sales manager for Felker Brothers: "These wastewater facilities are backed by the general population, who realize that stainless steel is the most viable option."

MORE INFO: www.nickelmagazine.org/1002/12.htm



Pulp & Paper Reference

Carbon steel will likely be phased out completely from the alkaline sections of paper-making plants known in the industry as sulphate kraft mills. Replacing it will be a wide range of nickel stainless steels that offer corrosion resistance and therefore longer life.

This is just one of the predictions to be found in *Stainless Steels and Specialty Alloys for Modern Pulp and Paper Mills,* NiDI Reference Book Series No. 11025 which is now available free of charge from the Nickel Development Institute.

The publication summarizes the composition and properties of the common nickel-containing alloys used in the industry and describes their unique characteristics. It also details the use of these alloys in digesters, brown stock washing, chemical recovery, tall oil, air quality control, as well as the sulphite process, pulping, waste paper recycling, bleaching, stock preparation, paper machines, suction rolls and fasteners. Separate chapters are devoted to welding, abrasion and corrosion.

Thirteen knowledgeable industry materials specialists: Arthur Tuthill, Dick Avery, Andrew Garner, Angela Wensley, Bruno Pannese, David Bennett, Max D. Moskal, Craig Reid, Chris Thompson, Donald Bardsely, William Miller, Paul Glogowski and Robert Charlton contributed chapters to this 150-page book. It was prepared by a task force of the Metal Subcommittee of the Technical Association of the Pulp and Paper Industry and was reviewed by a group of international experts. NiDI consultant Arthur Tuthill played a pivotal role as chairman of the task force.

The publication is available free of charge as a digital file (portable document format) from the NiDI web site, or in printed form from the NiDI office nearest you.

Specialist Course offered online

Specialist stainless steel training is now available online, thanks to an initiative of the International Stainless Steel Forum. The ISSF is making use of the latest technology to deliver quality education materials with maximum convenience to employers and employees in the global stainless steel industry.

Students world-wide can now enroll in the Stainless Steel Specialist Course, download study materials and take their exams online at the stainless steel portal - www.worldstainless.org.

ISSF Secretary General Dr Staffan Malm says undertaking the course represents a solid investment for both individuals and their organizations. "Students can be confident of achieving a substantial knowledge-base on which to build a successful career in the industry or in their design or specification discipline. By completing the course they become an increasingly valuable asset for their employers, with well-developed skills and the confidence to intelligently handle stainless steel."

THE ISSF'S new online course uses tested educational methods to present engineering and metallurgy knowledge of stainless steel.

Greater understanding of the material gives graduates the potential for increased job satisfaction and advancement, while companies benefit from a better-informed, more capable and highly skilled workforce. Given that stainless materials are valuable and mistakes can be costly, it is vital that workers have the knowledge to handle stainless steel correctly. A workforce with specialized knowledge puts organizations in the best position to avoid cost over-runs and delays, as well as building customer confidence throughout the supply chain.

Students receive detailed information on the properties and performance of stainless steel and comprehensive fabrication guidelines.

The course has 16 modules covering: the mechanical properties of stainless steels, surface finishes, fabrication, cutting, welding and joining, machining, designing, casting, forging, pipe and tube, cold forming, deep drawing and high temperature applications.

Stainless Pipe Approved in the U.S.

Stainless steel piping has been accepted for use in both the plumbing and residential codes of the International Code Council in the United States. Acceptance was made official at the council's meeting in Fort Worth, Texas. Confirmation will appear in the 2003 editions of the codes, thus permitting state and local building authorities and inspectors to more readily accept it.

UNS details

Details of the chemical compositions (in percent by weight) of the 4 nickel-containing alloys and stainless steels mentioned in this issue of *Nickel*.

Alloy	C	Cr	Mn	Mo	N	Ni	P	S	Si	V
S30403 p.4	0.030 max	18.00-20.00	2.00 max	-	-	8.00-12.00	0.045 max	0.030 max	1.00 max	-
S31603 p. 12	0.030 max	16.00-18.00	2.00 max	2.00-3.00	-	10.00-14.00	0.045 max	0.030 max	1.00 max	-
S30300 p. 4	0.15 max	17.00-19.00	2.00 max	0.60 max	-	8.00–10.00	0.20 max	0.15 max	1.00 max	-
Welmonil 43 p. 6	0.15 max	-	1.20-1.50	0.20-0.50	0.020 max	1.20-1.80	0.030	0.025	0.20-0.50	0.06-0.13

NiDI Appointments

Dr. Sally Williams, European Director, Health & Environment

LONDON OFFICE—**Dr. Sally Williams** has been seconded by Inco Limited to the Nickel Development Institute for a three-year period.

Sally holds a degree in Medicine from the University of Wales; she is a Fellow of the Royal College of Physicians, an Associate of the faculty of Occupational Medicine and is a certified General Practitioner. Sally has worked for Inco Europe for the past ten years, providing occupational health services at the Inco nickel and precious metals refineries in the UK and at the Jinco nickel salts production plant in China. She also provided advice on product stewardship, health and environmental science, and European regulatory affairs.

In recent years, Sally has chaired the Scientific Advisory Committee of NiPERA and the Health Group of Eurometaux. She will continue to lead the nickel industry activity in connection with the nickel risk assessment, currently being undertaken by the Danish Environmental Protection Agency on behalf of the EU Member States.

Sally will be located at both NiDI's London Office and Inco's nickel refinery, Clydach.

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Bernie Swarbrick, Mgr, Environmental Programs

TORONTO OFFICE—**Bernard Swarbrick** will be seconded by Falconbridge Limited to NiDI as Manager, Environmental Programs, for a two-year period.

For the past three years Bernie managed environmental strategic processes at Falconbridge's Raglan Operations in northern Quebec, Canada and the implementation of ISO 14000 at all of the companies Canadian operations.

Bernie will be located in NiDI's head office in Toronto and will manage NiDI programs related to the life cycle of nickel and nickel-containing products including end-of life issues such as municipal solid wastes, industrial wastes and recycling.

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Akira Ono, Mgr, NiDI Japan

TOKYO OFFICE—With the retirement of Ichiro Doi in June, NiDI has appointed **Akira Ono** to manage NiDI's programs and activities in Japan.

Akira holds a Master of Engineering degree in metallurgy from Kyushu University and joined Sumitomo Metal Mining Co. Ltd. in 1969. He has held positions of increasing responsibility in Sumitomo's nickel-producing operations, as Senior Metallurgist for the Non-Ferrous Metals Division and most recently as General Manager of the Safety and Environment Control Department. He will be based in Tokyo.

COMING EVENTS

Chemical Processes

NICKEL ALLOYS and High-Alloy Special Stainless Steels in the Chemical Process Industry will be held October 29-30, 2002 in Dresden, Germany. This is a joint seminar sponsored by: Institut fur Korrosionsschutz Dresden GmbH, Krupp VDM GmbH, Nickel Development Institute (NiDI) and Voest-Alpine Grobblech GmbH. The paper "High-alloy special stainless steels and nickel alloys for wet corrosive applications," will be delivered by NiDI consultant Dr-Ing. U. Huebner. Please contact: Mrs. Rehme, Institut fur Korrosionsschutz Dresden GmbH, Gostritzer Strasse 61 - 63, Dresden, Germany, D-01217. Tel: + 49 351 8 71 00 Fax: + 49 351 8 71 71 50 E-mail: info@iks-dresden.de Web Site: www.iks-dresden.de

THE 2ND CHINA INTERNATIONAL CORROSION CONTROL CONFERENCE will be held in Beijing, China on November 5-8, 2002. This is only the second such conference to be held in China. The first, in 1999, attracted about 450 people. A total of 250 papers are expected to be delivered on: new anti-corrosion technologies, products, materials, theories and processes in the petrochemical, gas, power and pharmaceutical industries. The working languages of the conference will be English and Chinese. Please contact: China Chemical Anticorrosion Technology Association, No. 1, Liupukang Street, Xicheng District, Beijing 100011, P.R. China, Tel: +88 10 62044366, Fax: +86 10 62044373, E-mail: panxj@ccata.org.cn

BRITISH CONFERENCE To celebrate the 90th anniversary of the discovery of stainless steel by Sheffield metallurgist, Harry Brearley, the British Stainless Steel Association (BSSA) will hold its annual conference in Sheffield, U.K. April 3-4, 2003. The theme of the conference will be "Stainless Solutions for a Sustainable Future" and will feature visits to the facilities of AvestaPolarit. Contact: BSSA, Light Trades House, 3, Melbourne Avenue, Sheffield S10 2QJ, U.K. Tel: 44 (0) 114 290 0888. Fax: 44 (0) 114 290 0897. E-mail: enquiry@bssa.org.uk

STAINLESS STEEL CONFERENCE New developments and trends in the markets and applications of stainless steel in India will be the focus of a two-day conference in Mumbai, India on December 6 & 7, 2002. Contact: Ramesh Gopal, Indian Stainless Steel Development Association, K-36 (FF), Hauz Khas Enclave, New Delhi - 110 016, India. Tel: 91 11 686 5631. Fax: 91 11 686 3376. E-mail: nidissda@del13.vsnl.net.in

@www.nidi.org

NiDI has launched three new web portals:

- **Automotive:** For information on the use of nickel in the automotive industry: www.nickelinautos.org
- **Architecture:** For news, NiDI literature, events and links on the use of nickel stainless steels in architecture: www.stainlessarchitecture.org
- **Water:** For NiDI literature, a North American buyers' guide, news, events and links on the use of stainless steel in the water industry: www.stainlesswater.org

TIM PELLING WARREN GRETZ/NATIONAL RENEWABLE ENERGY LABORATORY

A Spire to Inspire

Stainless steel spire to rise above historic Dublin

Dublin's lord mayor, Michael Mulcahy, calls it a "spire to inspire." He is referring to *The Monument of Light,* a sleek, 125-metre stainless steel monument being erected to mark the dawn of the new millennium.

Pointing skyward over the historic Irish capital like an enormous needle, the monument is being built at a cost of 4 million euros and is the focal point of a project aimed at rejuvenating the O'Connell Street district, Dublin's traditional shopping and cultural hub. More commonly known as the O'Connell Street Spire, the monument was designed by Ian Ritchie Architects of London, which won a competition to replace *Nelson's Pillar,* a 19th-century memorial to the British admiral, which was destroyed in 1966.

Industeel UK of Worcester, a division of Luxemburg-based steel giant Arcelor Group, will supply 130 tonnes of hot-rolled S31603 stainless steel to create the spire. In all 86 rectangular plates are needed, varying in size from 4.7 x 2 metres to 0.5 x 0.45 metre and ranging in thickness from 20 to 35 millimetres. The spire tapers from a three-metre diameter at the base to just 15 centimetres in diameter at the tip, which will house a powerful light.

Industeel's plant in Le Creusot, France, has produced the plates, which were beveled, shaped to radius and finely polished for shipment to Radley Engineering of Ireland, and assembled into conical sections of between 12 and 18 metres that will be stacked and welded together on-site.

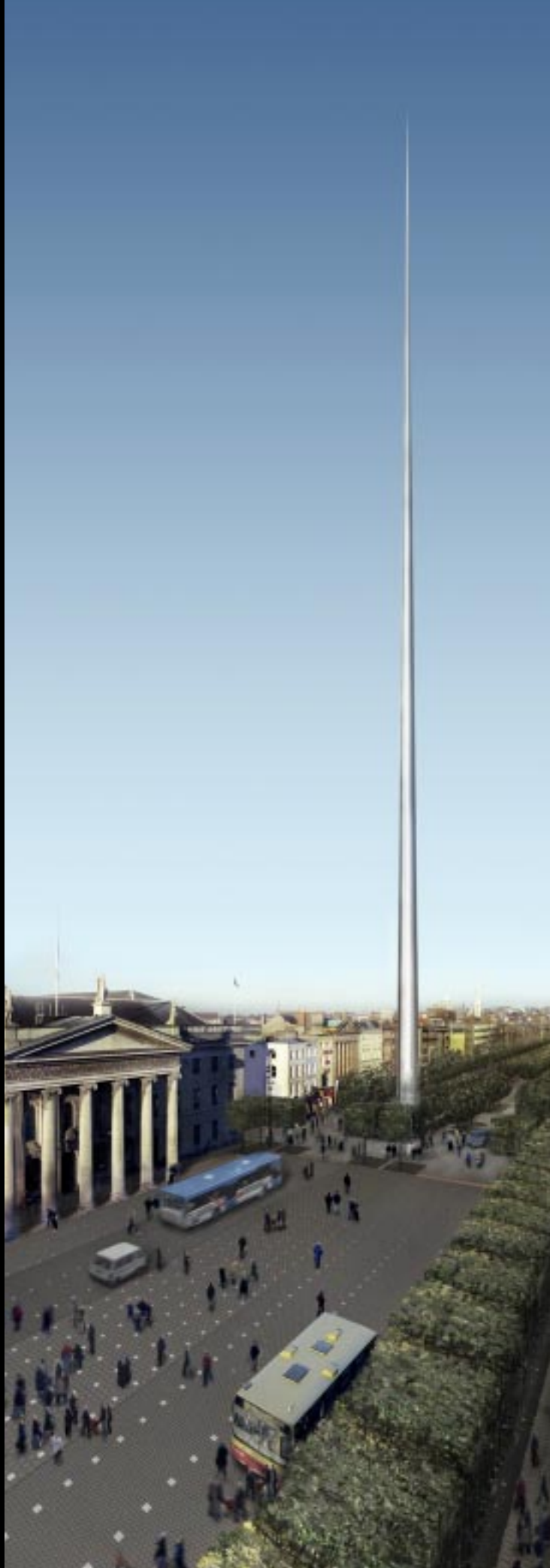
"The external finish is so important," notes Industeel UK director Joseph Connor. "There will be a uniform finish so that there will be no obvious signs at all that the thing is built in sections. It will be as if it is a single piece of stainless."

Much of the surface was "shot-peened" (that is, subjected to a controlled stream of stainless steel shot), so as to produce a dull finish that will reduce glare. "The shot-peened finish will provide soft, diffuse reflections of the light of Dublin's sky," says Anne Graham, project manager for the O'Connell Street Integrated Area Plan. The bottom 12 metres of the spire will retain its mirrored finish but will be etched with an abstract design to improve resistance to dirt and graffiti.

Stainless steel was chosen for its corrosion resistance, structural behaviour and visual/sculptural qualities, adds Graham. The spire has been designed to last at least 130 years.

The new monument is not without controversy. Detractors claim the spire will be a hazard to aircraft, a magnet for publicity- seeking climbers, and a poor fit for O'Connell Street's 1920s architecture. But supporters insist it is destined to become a centrepiece as the city forges ahead with revitalization plans for an area that fell on hard times in the 1960s. Ireland's prime minister, Bertie Ahern, says the addition of a granite-paved plaza, a tree-lined boulevard, and cafes and kiosks has the potential to make O'Connell Street one of the world's great thoroughfares.

More info: www.nickelmagazine.org/1002/16.htm



COMPUTER RENDERINGS COURTESY OF CITY OF DUBLIN