

HOWARD K. WORNER: PIONEER, INVENTOR AND ROMANTIC

"Celebrating Howard Worner's Achievements in Science and Engineering"

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Howard K. Worner: Pioneer, Inventor and Romantic

I had the great privilege to pursue graduate studies in London where, not only did I study under one of the great metallurgical thermochemists of this century, Denys Richardson, but I was exposed to theatre. The boy from the Canadian prairies had only heard of Alec Guinness, Margaret Rutherford, Ralph Richardson, Vanessa Redgrave and the greatest actor of this century, Olivier. But London, and especially the Old Vic, offered the splendid opportunity to absorb their art. I saw Olivier twice, in *The Merchant of Venice* (he played the Moor) and Strindberg's *Dance of Death* and was riveted by the understated, superbly controlled power of his performances and by his grace on stage. Not long ago, I read a penetrating newspaper article on Olivier in which an appreciative theatre critic analyzed Olivier's greatness in terms of romanticism, heroism and optimism. These are words that describe many great men and women—people who stand out because of their attitude to the human condition, to living, and cause them to achieve. These are certainly attributes that characterize Howard Worner's unique career and set him apart as a great man.

These characteristics cannot be learned—they are in the essence of the person. One cannot learn to be romantic any more than one can learn heroism or optimism. And so for Howard Worner's romanticism, heroism and optimism come naturally.

Howard has heroic qualities because he has always been a risk taker, at least as other would see it. Of course, to Howard the risks of working in a broad range of research fields—just think of them: the creep of high-purity lead, dental alloys, materials for prosthetic devices, foundry technology, titanium production, iron and steelmaking, nonferrous production, microwave-stimulated smelting and processing for the environment—are not risks at all. Howard Worner is that most special of people for whom all things are possible. These people do not accept barriers to what can be done; they have a restless intellect that roams the land of ideas drawing them together to formulate new concepts and new ways of thinking. This is the essence of creativity and invention, underpinned also by optimism and romanticism.

To Howard, there were no risks in shifting from his academic post as Professor of Metallurgy and Dean of Engineering at the University of Melbourne to become BHP's first Research Director and to establish the Central Research Laboratories near Newcastle—there were only opportunities. Nor were there risks in becoming Research Director at CRA then eventually returning to academe at the University of Wollongong. They were successively, and successfully, new stages in his life to be seized

as opportunities to determine what was possible. How fortunate the Australian academic and industrial communities are to have this hero in their midst.

To Howard, there were no risks in conceiving, piloting and attempting to commercialize the WORCRA process. Ever the romantic, Howard first conceived the idea of how continuous ironmaking might be integrated with continuous steelmaking, while gardening one Saturday afternoon! He then had the temerity to present his concept of the furnace to achieve continuous operation at the AusIMM Annual General Meeting in 1961. As Howard himself described the furnace, it looked something like a submarine. The concept was not torpedoed but it was submerged in vigorous debate. The idea was that molten pig iron would flow into the furnace and would react with iron ore, reductant and limestone fed vertically through the shaft. As the metal flowed, reactions and the heat balance would be aided by the injection of oxygen or by combustion of fuel. Chemical Engineers would call Howard's reactor a concurrent flow vessel because the metal and slag moved in the same direction. Later, successive reactor designs springing from Howard's fertile, restless mind would depend on the counterflow of metal, or matte, and slag.

There were many sound reasons for Howard to be seeking the Holy Grail of a continuous steelmaking process, notwithstanding the difficulty of the task. If one examines the flow sheet of iron and steel production, one finds many processes working in series to convert raw materials, whether steel scrap or iron ore, coal or coke, into rolled finished products like sheet, plate and rod. In an integrated steel plant, such as BHP Port Kembla Works, the production of molten steel from raw materials is accomplished with five processes: sinter plant, coke oven, blast furnace, hot-metal treatment and basic oxygen furnace. What is more, three of these processes are batch operations, in which material in the solid or liquid state, is treated discontinuously, literally in batches, like baking a cake, as opposed to the continuous treatment that Howard Worner envisaged. Batch operations, however, require material to be transferred into and out of process vessels like the coke oven and basic oxygen furnace requiring the use of handling equipment and allowing the escape of fugitive emissions. What economies and efficiencies might be effected, while reducing the environmental impact of the operation, if the five processes could be combined into a single (or multiple) continuous reactor(s), as conceptualized by Howard Worner. His dream of a continuous steelmaking process was more than a lofty idea, conceived while gardening, because it was shaped

by many of the underlying technological thrusts of this century: production efficiency, quality and environmental impact.

The conversion of a batch to continuous steel process has never been more dramatic, in its impact, than the development of the continuous casting of steel to replace the batch casting of steel ingots in the later half of this century. Indeed I have been fortunate to have undertaken research on continuous casting for over two decades. The result of this remarkable continuous solidification process has been increased yield, reduced cost and improved quality. The conversion of batch steel processes into continuous operations is not only within our grasp, but it is achievable. What is more, recent developments in the continuous casting of thin slabs, 50 mm thick, and the implementation of this process by mini mills relying on the electric-furnace melting of scrap and direct-reduced iron, promises to transform the steelmaking landscape utterly, and could prove to be the demise of some integrated steel mills, especially in North America.

Howard Wornor's dream of developing a continuous steelmaking process finally was not successful in a commercial sense. But he pointed the way and, perhaps more importantly, gave impetus to the flywheel of technology change which soon may spin off new commercial processes like HISMELT, under development of CRA and influenced by Howard through professionals he inspired, for continuous iron and steelmaking. All of these elements were at work in the single-mindedness of his purpose: optimism, heroism and romanticism.

But the restless intellect was not content only to pursue continuous processing for the production of iron and steel. To quote from one of Howard's recent papers, "My mind was tremendously stimulated: I began to think of applications to lead, nickel and copper concentrates and, possibly, bulk concentrates where (instead of carbon and silicon) sulfur and iron would be the internal fuels". It was at this time as well that Howard "began to cogitate about the advantage of having the slag flow in the opposite direction to matte or metal." Frustrated in his relentless pursuit of the Holy Grail, Howard found his way to CRA and to the construction of a WORCRA furnace at Cockle Creek, where tests were conducted over time on the smelting of copper, nickel and lead concentrates. Later a large pilot plant was installed at Port Kembla where oxygen enrichment was applied to copper smelting. Howard Wornor understood intuitively that the dead hand of nitrogen could be lifted from the continuous process.

Even the innovator, Howard tested tuyeres and lances to inject concentrates and oxidizing gas into the fiery baths in his furnace, but settled on top blowing lances because they offered greater ease of operation at the time. Later he would remark on what alternatives might have been possible if the shrouded tuyere invented by Savard and Lee in Canada had

been perfected to permit another dimension of flexibility in the injection of gas and solids into the bath. Today top blowing lances are used in commercial processes like Mitsubishi and Isamelt, the latter involving a special design developed in Australia. Among other variables, furnace shape also was evaluated by Howard Wornor and his team.

In briefly recounting this history of bath smelting pioneered by Howard Wornor, it is easy to forget the obstacles and raw difficulties along the way. There is the difficulty of fire and fumes and dust. Molten steel at 1600 degrees Celsius or matte at 1300 degrees Celsius indeed are liquids and flow like water, but they are highly corrosive, subject to freezing (sensitive to the heat balance) and are downright dangerous. A person can be killed by a mistake or an accident. There is the difficulty of size. Howard and his teams worked on the pilot scale of tons per hour where finally new processes must be baptized by fire. There were not laboratory experiments conducted with grams of material contained in a platinum crucible. There are obstacles of securing financial support to pursue process innovations on such a scale, requiring millions rather than thousands of dollars. That Howard Wornor was able to convince senior executives of BHP and CRA to back his work is a measure of his single-mindedness and persuasiveness. There are difficulties created by the skeptics who confidently contradict what has been achieved by stating that the process cannot work thermodynamically. These are the people schooled in free energies and solution thermodynamics who do not understand the invention of process kinetics: mixing, phase separation, mass transfer and heat flow. The hero, the optimist and the romantic sees each difficulty, each obstacle as a life challenge to be met and overcome. And by that process, he becomes the pioneer and inventor.

Looking back on these singular achievements of Howard Wornor I have been wont to dub him the "Father of Bath Smelting." However, I have thought better of it after reading a newspaper article about a fellow brought before the court in a paternity suit. When asked by a judge, "Are you the father of this child?", he replied, "Yes, your honor, but there were many others."

By nature, Howard Wornor is a person who looks forward. And even though the bath smelting processes he sought so hard to develop and commercialize have not come to fruition, he has drawn lessons from this experience for the future. Now he has set his sights on adapting his furnaces to address environmental problems like the treatment of waste. After founding the Microwave Applications Research Centre at the University of Wollongong, he undertook the successful development of a continuous microwave sterilizer of sewage sludge. But then he went on to show that similar sterilization effects could be achieved by adding steelplant dusts, lime and a trace of flocculent to raw, heavy, metal-

contaminated sludge. The settled sludge, together with more steel plant dust and lime, can be treated in the furnace seen on the screen. Other waste carbonaceous materials like pulped paper, lake weeds and algae or finely shredded plastics can be incorporated into the furnace feed for treatment. The furnace simultaneously would melt oily sludge, shredded steel with adherent plastics, cloth or paper, and crushed drums contaminated with residual organic liquids. His most recent work in this field of processing for the environment, is with Molten Metals Technologies in the U.S.A., who are developing bath reactors to treat hazardous waste. Once again, or perhaps I should say, as usual, Howard Womer is ahead of his time and is leading the way. As one of his furnacemen said in a recent article in the Bulletin in Howard, "We're going where no man's been before. Our job is to make Howard smile."

What else do we have to learn from this pioneer, romantic and inventor? From his life and career to date, Howard Womer is a strong believer in the creation of wealth and the achievement of national prosperity by the engine of industry. He is not simply a creative, gifted researcher, he is a person who seeks new processes that will work in industry to make products like iron, steel, copper or cad, or to treat wastes, as we have just witnessed. Let us not forget that wealth is created by making products that have the desired properties, including cost, for the national and global marketplace. Products are made by processes. And this industrial civility must be pursued within an environmentally acceptable envelope.

The challenge of wealth creation is especially vital as the world has emerged from the Cold War and a protracted, biting recession. Certainly in North America, as military spending is scaled back, society is asking how the conversion of words into plowshares will enhance prosperity. TMS continues to grapple with this issue at the present time.

By the example of his career, Howard Womer has lessons to teach the university in the same vein. Universities, particularly professional faculties like engineering, have a responsibility to society for wealth creation and prosperity, no less than that of industry. Society would not tolerate a faculty of medical professionals whose expertise rested solely in hangnails when people are dying from AIDS, cancer and heart disease. Neither would society accept engineering faculties who are remote from the creation of wealth through their work in the laboratory or in the classroom. In the field of metals and materials, universities have the responsibility of integrating process engineering, materials properties and design in research and teaching with a steady eye on the environmental implications of processes and products, including recycling. Even a quick review of materials science

and engineering departments reveals that there is much to be done in the unification of this field.

Through his bridging of the academic and industrial communities so effectively, Howard Womer has taught us the need increasingly to transfer knowledge from academe to industry. Traditionally this transfer has been effected through the graduates who enter industry or through seminars and short courses. But the greater challenge is to render sophisticated knowledge sufficiently user friendly that it can be absorbed and used by hourly workers on the shop floor where finally wealth is created. The development of artificial intelligence, especially expert systems coupled to powerful personal computers, is rendering this dream possible.

And by his career, Howard Womer has taught us about the solitudes that men create--the solitudes between steel and aluminum and copper, the solitudes between the university and industry, the solitudes between the young and the old, the solitudes between nations, the solitudes between the rich and the poor. Howard has taught us about these solitudes because for him, they do not exist. To Howard the world is a continuum as much as his hobby of mineral collecting flows naturally from his work. We must begin to share Howard's vision if we are to make the world a better place. The old ways, the traditional solitudes do not work and now are roadblocks to progress.

Finally nothing is more important to Howard Womer than people--beginning with his bride of 60 years, Rilda, his equally talented brothers, his children and grandchildren, his students of whom he is immensely proud, his colleagues and friends. He teaches us that the successful university professor loves students, nurtures them during their studies, inspires them with ideas and by example, and watches their careers with interest and optimism. Howard teaches us that passing the torch to the next generation of professionals begins with lighting the candle of dreams and all that is possible in our talented young people.