J. K. BRIMACOMBE

Reflections and Perspectives

IRON & STEEL SOCIETY

TMS

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The J. Keith Brimacombe Prize

Creating a permanent legacy . . .

The J. Keith Brimacombe Prize was designed to do more than merely honor; it is intended that this award speak symbolically of the achievements of its recipients while perpetuating the attributes that Dr. Brimacombe set as standards for his own character and career. Etched in the base of the award are the qualities that give form to the purpose of the man and the award while recognizing the accomplishment of its recipient.

- A creator of new knowledge through research excellence.
- A visionary and innovator for a better global society.
- A world ambassador, integrating science and technology with creative insight.

The depiction of the modern-day Atlas represents a portrait of fortitude. Its dramatic steps evidence an ascent to the top. The Atlas that we know from mythology is a timeless figure symbolizing persistence in the journey. Characteristically, the J. Keith Brimacombe Prize recognizes determination and professional achievement that is forever in style and not easily forgotten.

BRIEF BIOGRAPHY OF J.K. BRIMACOMBE, O.C., F.R.S.C., F.C.A.E.

On October 1st of 1997, J. Keith Brimacombe was appointed the first President and Chief Executive Officer of the Canada Foundation for Innovation. This enterprise, newly established by the Federal Government of Canada, was provided with one billion dollars of funding with the objective of strengthening the nations research infrastructure in universities, and hospitals. Sadly, Dr. Brimacombe was able to serve only three months of his term, and succumbed to a massive heart attack on December 16, 1997, at the age of 54.

Dr. Brimacombe held the Alcan Chair in Materials Process Engineering, The Centre for Metallurgical Process Engineering at the University of British Columbia, prior to his appointment with the Canada Foundation for Innovation. He was born in Nova Scotia, raised in Alberta and received his undergraduate education at U.B.C. obtaining a B.A.Sc. (Hons.) in 1966. With the support of a Commonwealth Fellowship, he travelled to England and studied under one of the great metallurgical thermochemists of this century, F.D. Richardson, F.R.S., at Imperial College of Science and Technology in the University of London where he received a Ph.D. in 1970. Subsequently he was awarded the D.Sc. (Eng.) in 1986 by the University of London and an Honorary Doctorate of Engineering degree in 1994 by the Colorado School of Mines. He returned to the University of British Columbia in 1970 to establish courses and a research programme in metallurgical process engineering. He remained at U.B.C. achieving the rank of Professor in 1979, Stelco Professor of Process Metallurgy (a chair endowed by Stelco) in 1980, Stelco/NSERC Professor (a chair endowed by Stelco and NSERC) in 1985 and the Alcan Chair in 1992. One of the finest metallurgical engineers on the world stage in this century, Dr. Brimacombe pioneered the application of mathematical models, industrial and laboratory measurements, to shed light on complex metallurgical processes spanning both the ferrous and non-ferrous industries during his twenty-seven year career at the University of British Columbia. For his ground-breaking research he earned the reputation of being one of the most innovative intellectual giants in the field for which he earned global recognition.

During his tenure at U.B.C. he built a large collaborative research group in metallurgical process engineering consisting of about seventy faculty, graduate students, research engineers and technicians. Much of the research was conducted in close collaboration with Canadian companies such as Stelco, Hatch Associates, Algoma Steel, Western Canada Steel, Sidbec-Dosco, Ivaco, Cominco, Noranda, Inco, Alcan, Domtar, Canadian Liquid Air and Liquid Carbonic. The thrust of the research was the development and improvement of metallurgical processes such as continuous casting of steel, flash smelting of lead and copper converting, rotary kilns, and microstructural engineering of steel and aluminum, and D.C. casting processes. This body of work led to three hundred publications and nine patents as well as two books. In 1985, in cooperation with faculty colleagues, he founded the Centre for Metallurgical Process Engineering and was named its Director at U.B.C. The purpose of the Centre is to strengthen the interdisciplinary approach to metallurgical process research and to broaden the field of application to materials other than metals. For this body of research he was awarded the

B.C. Science and Engineering Gold Medal (1985) and the Ernest C. Manning Prize (1987) and before that the E.W.R. Steacie Memorial Fellowship (1979) from NSERC. He also received the following awards: TMS-AIME Charles Herty Award (1973 and 1987), AMS Marcus A. Grossmann Award (1976), TMS Extractive Metallurgy Science Award (1979, 1987 and 1989), ISS John Chipman Award (1979, 1985 and 1996), TMS Champion H. Mathewson Gold Medal (1980), ISS Robert Woolston Hunt Silver Medal (1980, 1983 and 1993), ASM Henry Marion Howe Medal (1980 and 1985), TMS Extractive Metallurgy Technology Award (1983 and 1991), the Williams Prize of the Metals Society (U.K.) (1983), the ISS Mechanical Working and Steel Processing Conference Meritorious Award (1986 and 1996), the ASM Canadian Council Lectureship (1986) and the CIM Metallurgical Society Alcan Award (1988). In 1981 he delivered the Arnold Markey Lecture to the Steel Bar Mill Association. In 1987 he was made a Distinguished Member of the Iron and Steel Society and a Fellow of the Royal Society of Canada. In 1988 he became a Fellow of the CIM and in 1989 he delivered the TMS Extractive Metallurgy Lecture while being awarded Fellowship in TMS. Also in 1989, he was awarded the Izaak Walton Killam Prize for Engineering by the Canada Council, joined the Board of Directors of Sherritt Gordon Ltd., received the Bell Canada Corporate-Higher Education Award and was appointed an Officer of the Order of Canada. In 1990 he received the Meritorious Achievement Award of the Association of Professional Engineers of British Columbia and a UBC Killam Research Prize. In 1992 he was honoured with the Commemorative Medal for the 125th Anniversary of Canadian Confederation and in 1993 delivered the Howe Memorial Lecture of the Iron and Steel Society and became Fellow of the Canadian Academy of Engineering. In 1994 he presented the D.K.C. MacDonald Memorial Lecture; and in 1995, he was the Inland Steel Lecturer at Northwestern University and received the Ablett Prize of the Institute of Materials. In 1996 he delivered the ASM Edward DeMille Campbell Memorial Lecture and in 1997 received the AIME Distinguished Service, and was elected a Foreign Associate of the National Academy of Engineering. In June 1997, he received Canada's highest scientific honour, the Canada Gold Medal in Science and Engineering from the Natural Sciences and Engineering Research Council of Canada. In 1998, Dr. Brimacombe was posthumously awarded the Benjamin Fairless Award by the AIME and the Inco Medal by the CIM at their centennial celebration.

Beyond the quest to generate knowledge and train young people he was driven by the desire to see the fruits of his research implemented in industry. Not satisfied that publications in peer reviewed journals are an effective means of reaching out to the shop floor, where knowledge implementation creates wealth, he worked tirelessly at the University-Industry interface to make the transfer of knowledge to industry a reality. A gifted speaker, he was renowned for his ability to translate complex research results to changes that are required to the process for improved quality and/or productivity. Thus he was sought after by the global metallurgical industry and presented over fifty courses in companies in every continent. A course on continuous casting of steel offered annually in Vancouver, under his directorship attracted participants from around the world. He seized the opportunities provided by the revolution in computer technology to help further the transfer of knowledge, and since the early eighties drove the development of user-friendly mathematical models as a means of transferring research results to industry. Brimacombe was also been instrumental in developing "smart" systems for the transfer of knowledge and spearheaded the development of an expert system for diagnosing defects in steel billets which is being marketed commercially. A recent project involving Canadian companies is the development of a "Smart Process" in which knowledge is made to work in the process through the use of an on-line expert system and sensors.

He gave unreservedly of his time to professional societies which are a vehicle for knowledge transfer and professional development of materials engineers. He was the only professional who was President of the three major societies serving materials engineers in North America; The Met. Soc. of CIM in Canada in 1985, The TMS of the American Institute of Mining, Metallurgy and Petroleum Engineers (AIME) in 1993 and the Iron and Steel Society of AIME in 1995. His enthusiasm for professional societies was infectious and has led to the initiation of a very dynamic student chapter at UBC.

He served on the Killam Research Fellowships Committee of the Canada Council from 1982 to 1985 where he initiated the Killam Prize in Engineering and worked on other committees of the Canadian Council of Professional Engineers, the Science Council of British Columbia and the Canadian Steel Industry Research Association. He served on the Boards of the Iron and Steel Society and the Minerals, Metals and Materials Society (TMS) in the U.S.A. He served on numerous committees in these societies including Joint Commission and Board of Review of Metallurgical Transactions, Book Publishing Committee, Awards Committee, Extractive Metallurgy Sub-committee, Nominating Committee and Long Range Planning Committee. In 1989 he assumed responsibilities as Founding Chairman of the TMS Extraction and Processing Division, in 1993-4 was TMS President and in 1994-5 was Founding President of the TMS Foundation. In 1990 he was named as an Eminent Scientist to the Board of Directors of the Ontario Centre for Materials Research. In 1995 he was Chairman of the Science Policy Committee of the Royal Society of Canada and was a member of the National Materials Advisory Board (U.S.A.). In 1996 he was elected Vice President of the Academy of Science of the Royal Society of Canada and was appointed to the Board of the United Engineering Trust. He served on the Board of Trustees of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) since 1993; had he lived, he would have become President of AIME in 1999.

J.K. BRIMACOMBE

December 7, 1943–December 16, 1997

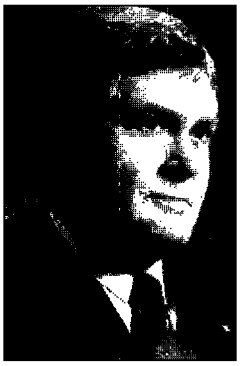
"Life is no brief candle to me...
it is a sort of splendid torch
which I am permitted to hold for a moment...
I want to make it burn as brightly as possible
before handing it on to future generations."

TMS President
1993

ISS President
1995

Presidential Perspective

ON VOLUNTEERS



What would the world be like without volunteers? No Boy Scouts or Girl Guides. No Little League. No Big Sisters or Big Brothers. No Parent-Teacher Associations. No Cancer Society. The world is incalculably a better place for the selfless work and time of volunteers in all walks of life. But volunteers offer more than work and time; collectively, they are strands of goodness in the human condition that wrap around the Earth and make it a more caring place.

Why do volunteers reach out and touch others with their special talents and love? For some, it may be a life experience such as the loss of a loved one to a disease like cancer or AIDS, or a near brush with death themselves. For others, it is the memory of a special coach or mentor who revealed hidden talents and changed their lives, kindling the desire to pass on the legacy to the next generation of young people. Yet others volunteer for the sheer joy it brings to lend a helping hand. Through giving, one receives. Each volunteer seeks, in his or her own way, to make the world a better place.

And what about TMS? Where would our Society be without volunteers? Quite simply, it would not exist. While it is true that we have a splendid staff at TMS headquarters, managed expertly by Alexander R. Scott, they cannot run our Society by themselves. The effective operation of TMS, focused on the needs of the materials professional, also relies on a cadre of volunteers around the world who are dedicated to the well-being of the profession and the industry it serves. One need only scan this issue of *JOM* to appreciate the work of our volunteers. Volunteers write articles and reviews. Volunteers from each of the TMS divisions advise the editorial staff. Volunteers work on technical committees of the divisions and on the divisional councils to organize the symposia, publications, and continuing education programs. Volunteers serve on the TMS Board of Directors and are concerned with student affairs, professional development, honors and awards, and TMS finances, as well as the areas indicated above. It is these volunteers from the grassroots of the materials profession, working closely with the TMS staff, who are the strength of the Society. TMS is member focused and member driven.

Our TMS volunteers are all the more special because they are working under greater pressure in a period of retrenchment and restructuring. The industries, universities, and government institutions are asking that more be done with less and are reducing staff, cutting travel and conference budgets, and downsizing infrastructure support. Research budgets are being squeezed. Consequently, the sacrifices the TMS volunteers are making have increased, leaving less time for leisure and much-needed relaxation, less time with the family, and, in some instances, causing personal financial sacrifices. These circumstances of today spotlight the work of our volunteers and the companies and institutions who permit them to be involved actively with TMS.

It is not only the volunteer professionals who are feeling the pressure of doing more, but so too is our TMS staff. Inevitably, some of the pressure is transferred to them to undertake more tasks on top of existing workloads. And so we are all working harder. Our volunteers and our staff, I know, will continue drawing upon the reservoir of good will and cooperation, accumulated over time, as we work together to build the TMS of tomorrow.

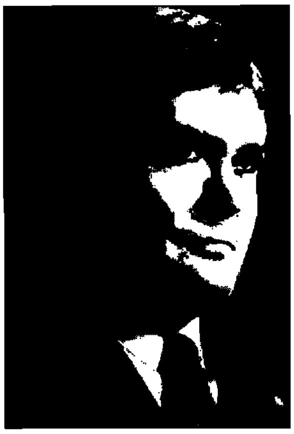
But for all the pressures on TMS volunteers, there are abundant rewards. There is the opportunity to meet other professionals with the same commitment in a global network, to address concerns and to work toward a shared vision of what is possible and what should be. These are the same people who, in future endeavors, one can call upon for advice and involvement—not as strangers, but as colleagues. There is the reward of achievement in the building of programs for materials professionals—nothing less than a home—where the only impediment is our creativity. And there is the opportunity to fulfill one's professional obligation to strengthen our industry for wealth creation and prosperity. We have an obligation to present and future generations to leave a legacy for their children and their children's children.

Our TMS volunteers have contributed so much. To me, it is awe inspiring. But we cannot let up, because there is much to do. I salute you all!

J. Keith Brimacombe

THE SPIRIT OF SPRING

Editor's Note: The following is the first in a series of editorials that J. Keith Brimacombe has agreed to write for *JOM* during his term as president of the Society. President Brimacombe is the Alcan Chair in Materials Process Engineering at the University of British Columbia in Vancouver, Canada.



There is a rhythm to the seasons that reflects the human condition: birth in the spring, growth in the summer, the harvest of autumn, and the solitude of winter as nature takes pause. In North America, as I write this, it is springtime, and we again marvel at the renewed fertility of nature as the earth yields life once more—crocuses, daffodils, tulips, grass sprouts, and new leaves. The springtime of nature is joined by the springtime of the human mind as schools and universities give to society the fresh intellect of new young graduates who have been challenged, and changed, by their studies. It is an invigorating time, a point of renewal as the planet turns.

It is also springtime in the world order. The Cold War has finally ended, not with a fanfare but in confusion. Not so much a victory of one system over another but a triumph of the human spirit which struggles to be free. The cold winter of human suppression is slowly giving way to the spring of the individual and all that can be achieved—but the changing of these seasons promises to be painful.

In this spring of the next millennium, the challenges are daunting. Sustenance and growth of the human spirit require a measure of prosperity—grinding poverty and crushing debt loads are not conducive to the unleashing of the intellect and the full achievement of human potential. Thus, the greatest challenge confronting world society today continues to be the creation of wealth within the fragile yolk sac of our earthly environment.

At last, turning swords into plowshares, and defense spending into true wealth creation for nondestructive purposes, gives this springtime a chance to achieve full bloom as never before. The emerging young graduates who bring so much promise, and the practicing professionals, have an obligation to society to work unflinchingly on wealth creation—not just for themselves, but for society at large. Yet it remains a matter of self-interest. If any nation is to be great, it must have the resources to provide for the health and education of its people. This fundamental truth appears frequently to have been lost.

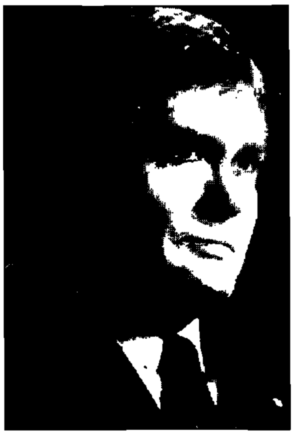
In the minerals, metals, and materials world, TMS is embracing the challenge of wealth creation through its emphasis on the integration of properties, processes, design, and environmental impact. It is axiomatic that wealth creation from minerals, metals, and materials flows from the manufacture of products, with the desired properties and function, that can be sold at a profit in the global marketplace. It is not enough to understand the properties of materials or processes qualitatively, but the process-product linkage must be known quantitatively. In achieving this linkage, processes can be improved, changed, and optimized to increase efficiency and reduce production costs. Such concerns are less important in the manufacture of swords but they are decidedly so in the production of plowshares. This is an important lesson of the Post-Cold War era.

TMS is assuming a lead as well in the university education of undergraduates and postgraduates in materials science and engineering. It is now abundantly clear that many universities are searching for optimum curricula to prepare the graduating student intellectually with the knowledge and approach to tackle the problems and opportunities of industry. TMS, through its symposia, publications, and short courses, is a resource to the university community to achieve its collective goal.

In this springtime of our existence, we have much to do as professionals in the production and use of materials. Wealth creation within an environmentally sensitive envelope must be at the top of the list.

J. Keith Brimacombe
1993 President of TMS

WE ARE THE WORLD



The earth is at our feet . . . a skin enveloping a molten embryo shrouded by the vapor—air. We walk on an eggshell that occasionally cracks and erupts beneath us, driven by the forces of gravity and friction. The skin has shifted and separated to create continents and oceans. A guiding hand has been at work to draw life from the water and, by gradual evolution, to bring us to the human condition. The Earth is our mother.

Our response to this reality has been both Darwinian and enigmatic. The human race that, somehow, emerged from the primordial soup has continued in its evolution, yet lost sight of its origins. We spend an inordinate amount of time defining our differences, whether they be based on gender, race, color, or religion. Inexplicably, we are driven to delineate differences among countries, nationalities, and peoples. We reinforce the need to be different by creating solitudes at every turn, whether they be between classes of materials or between our universities and industry. Perhaps, inevitably, we are isolationists. And all the while, the basics of the human condition prevail—people seeking to improve themselves and make the world a better place.

Our challenge as professionals is to embrace the globe in its entirety; as citizens of the Earth, the challenge is to hold fast to an international vision just as we must understand the materials world as a whole. The barriers separating us geographically and intellectually must be dismantled because the world has changed and the old ways do not work. As the home of minerals, metals, and materials professionals, TMS accepts this global challenge. After all, its members can be found in 77 countries; currently about one-third of all new members enter the TMS world from outside the United States. They bring precious riches of intellect, knowledge, energy, dedication, and experience to enliven and strengthen our professional world. So many become personal friends.

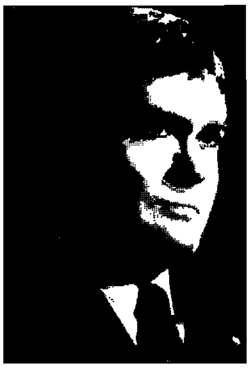
As your president, I shall be traveling the globe this year to visit many countries and materials societies to renew our international commitment. TMS is not only dedicated to serving its international members, but to doing so by cooperating with materials societies in their countries. Already, with our executive director, Alexander Scott, I have visited the Institute of Materials and the Institution of Mining and Metallurgy in the United Kingdom and the Deutsche Gesellshaft für Materialkunde e.V. and the Gesellshaft Deutscher Metalhütten und Bergleute e.V. in Germany to strengthen interaction in programming, publications, and continuing education. The spirit of international cooperation has been pervasive and warming. At the time of this publication, I will be winging across the Pacific Ocean to Australia to meet with the president of the Australasian Institute of Mining and Metallurgy and to visit two TMS student chapters at the Universities of South Australia and Wollongong. At the end of August, Alex and I will meet with the Canadian Institute of Mining, Metallurgy, and Petroleum in Quebec City, Canada; following that visit, I will address two conferences in Mexico. Later I will meet our counterpart societies in Japan and South Africa.

Underpinning this outreach are the energetic activities of the TMS International Affairs Committee. Under the leadership of TMS Past President Ronald Miller, Thomas Mackey, and Michael Koch, the committee is organizing a session titled The Role of Technical Societies in This Changing World. It comprises papers from six international materials societies followed by a panel discussion and is scheduled to be held during the 1994 TMS Annual Meeting in San Francisco, California. This is a first, and it is a measure of the cooperative spirit that joins us for the benefit of our members.

In the months and years ahead, we must continue to build international cooperation on these foundations. TMS will be a force to dismantle the barriers that artificially separate us on Mother Earth—for the common good of our profession and of all humankind.

J. Keith Brimacombe
1993 President of TMS

PASSING THE TORCH



Deep within each of us simmers the desire to nurture. Perhaps it begins when, as children, we seek a pet to care for, to talk to about things that adults do not understand, to cherish. There is nothing quite like the bond between a child and pet because it is both simple and profound. As we grow, we begin to understand the beauty of friendship and we nurture relationships that touch, sustain, and change us while we give of ourselves. With time, our own children are born, helpless and blind, and are placed in our hands to care for. The responsibility is awesome as we nurture these new beings through life's early stages and watch in wonder (and sometimes with dread) as the child grows, as we did, to become his or her own person with dreams and promise.

Nurturing does not end with our own children. There are the dedicated teachers at schools and universities who not only educate, but inspire young minds and release their creative energy. There are the Little League coaches who devote precious free time to aspiring Babe Ruths who can barely hold a bat, but who, one day, could shatter major league records. There are the selfless men and women who give freely of their time and talent to work with young people struggling with physical, mental, or emotional challenges. It is the stuff of inspiration.

Nurturing is at the core of professional development as well. In the progression from school to university to a professional career, young talent can be aided and shaped, or impeded. There are so many challenges. There is the cost of a university education—fees, books, and living expenses. There are questions of what to study and how to adapt one's talents to a chosen career path—uncertainties that color one's life. The challenges continue in the workplace, where learning does not stop and one is expected to contribute to society. At each stage, if fortunate, the young professional is influenced by mentors who help show the way. They are nurturers of a profession, passing the torch from one generation to the next.

As a society of professionals, TMS understands its special responsibilities in the nurturing of young people who renew and vitalize the minerals, metals, and materials profession. The Society has established a network of student chapters—many that are joint chapters with ASM International—at universities primarily in the United States, but increasingly in other countries as well. The chapters offer the students a window to the materials world and an opportunity to attend TMS conferences and purchase books at reduced rates. Students are encouraged to participate in the Student Forum on Careers in Materials Science and Engineering, held annually during TMS/ASM Materials Week, where they meet practicing materials professionals. To attract young people to the minerals, metals, and materials community, TMS has developed a colorful, informative booklet that describes activities and opportunities in the materials profession. TMS is heavily involved in the accreditation of materials programs at U.S. universities and in the development and administration of the Professional Engineer examination. Several TMS technical divisions have created new scholarships to recognize excellence in our TMS student members.

But TMS wants to do more in the nurturing of our budding young professionals. The vehicle is the newly established TMS Foundation, which initially will focus on three activities: expanding the scholarship program, developing the materials curriculum at universities (with emphasis on design questions to augment the new MDMD materials design competition), and the growth of young professionals, in which mentors will play a special role. To achieve its laudable goals, the TMS Foundation will need your support financially and through personal involvement. As TMS President, I hope that I may count on that support to nurture and strengthen the materials profession through the Foundation. Passing the torch to the next generation of materials professionals begins with lighting the candle of dreams and all that is possible in our talented young people.

J. Keith Brimacombe
1993 President of TMS

Presidential Perspective

THE POWER OF KNOWLEDGE

Over the broad sweep of time, the progress of civilization has been defined by the use of materials—from the Stone Age through the Bronze Age to the Iron Age and now to the Materials Age. It is remarkable to think that humankind has moved, by virtue of serendipity, intelligence, and experience, from the hewing of naturally gathered stone to the tailor-making of sophisticated metal alloys and optoelectronic oxides. Each development in this technological march through time has inexorably contributed to the knowledge pool of materials properties and processes, which today is vast and accelerating in its growth.

The intelligent person, who early in the last century might have comprehended most scientific and engineering knowledge, today struggles to understand a fraction of the knowledge within a specialty. The materials scientist focusing on structure and properties is unaware of developments in process analysis. The aluminum expert does not know of the advances in steelmaking. Perhaps inevitably in the continuum of the materials knowledge pool, we have defined boundaries around specific subjects to cope with the increasing complexity of the atomic world. And, in so doing, we have put ourselves into boxes.

TMS must unleash the full power of knowledge by dismantling the barriers that have been built around materials subjects and to forge linkages among them—a daunting task. To address the many dimensions of the materials world, TMS recently reorganized into five technical divisions, each of which is home to numerous specialty technical committees. Thus, if TMS is to integrate knowledge across subject lines, we must work tirelessly to integrate the activities of the technical committees in programming, publications, and continuing education. We must see what we can learn from each other. The power of knowledge stems not just from its depth, but also from its breadth.

A recent new activity in knowledge integration is the establishment of the Breaking Down the Walls symposium series spearheaded by the Extraction & Processing Division (EPD). The series comprises international interdisciplinary symposia designed to bring together the producers of light metals, base metals, ferrous metals, and other materials to learn of developments in each other's fields. The series was launched with the Savard/Lee International Symposium on Bath Smelting held during October 1992 in Montreal, Canada, as the TMS Fall Meeting for Extraction and Processing, which was held in cooperation with the Iron and Steel Society and the Canadian Institute of Mining, Metallurgy, and Petroleum. The second symposium, now being organized for 1995, addresses the engineering of quality in materials casting processes. The symposia are unique in that all papers are invited from world experts and there are no parallel sessions to detract from the central purpose of knowledge integration. The Savard/Lee symposium, with 180 attendees, received rave reviews and augured well for the series. The need is real.

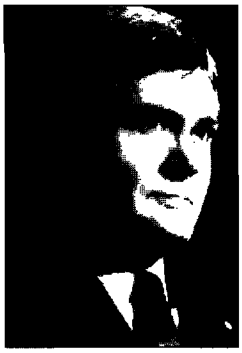
There are many other examples of TMS at work to integrate knowledge, such as in the environmental field where Recycling '95 is drawing upon expertise in several divisions to address the reuse of different materials. Similarly, the International Symposium on Processing for the Minimization and Treatment of Wastes, scheduled for the 1994 TMS Annual Meeting, requires many disciplines to examine issues of critical importance to society today. The perspectives of individual specialists are being combined to search the depth and breadth of the field.

And we should not forget *JOM*, which appears monthly in our mail. Under the stewardship of its editor, James Robinson, *JOM* is a unifying force in the materials field. Reflecting the breadth of TMS, from processing across the broad flow sheets of production operations to the structure and properties of materials, *JOM* is a meeting place for our TMS professionals. Its reviews, commentaries, articles, and news items on a monthly basis break down the walls that we naturally create. Materials of different types come together, different processing routes are explored, and design and manufacturing are integrated with materials properties and reuse.

TMS has much to do to empower the materials professional with knowledge, and we are getting there, underpinned by your efforts.

J. Keith Brimacombe

OUR CHILDREN'S LEGACY



The essentials of human existence have not changed. We need air to breathe, water to drink, food to eat, and shelter from the elements. But, with the passage of time, the pursuit of basic needs has become more complex. The simple gathering of wild plant life and the hunting of animals gradually gave way to the cultivation of land for crops and the domestication of animals for food and clothing. The collection of native copper from outcrops was transformed by the discovery—some 6,000 years ago—that malachite could be smelted with fire into the malleable metal. By the addition of tin, copper became bronze, with its superior properties for weapons, tools, receptacles, and ornaments. Then came iron and eventually steel. With each empirical step, humans became increasingly clever at exploiting the reductive power of carbon, the melting point of fluxes, and the refractory character of oxides for casting molds. In the last century of this millennium, we have added ceramic powder to metal to create a new class of materials—composites. We have created nickel-based superalloys for jet engines, new classes of steels for high-strength applications, and new ceramic materials for high-temperature duty. We know how to grow single crystals of semiconductors and how to build electronic materials atom by atom. It is all very clever.

But in the drive to develop these new materials and to minimize the cost of production, we have been creating a "throw-away" society. Thus, the challenge today is to be as clever at minimizing our impact on the environment as we have been about creating new materials and products. There are many dimensions to the challenge. Clearly, there is the technological dimension in the form of new benign materials production processes as well as processes to treat waste, remediate contaminated soil, and recycle materials with minimal degradation of properties. Also, there is the development of fully recyclable materials and the design of fully recyclable products. There is the legal dimension encompassing environmental regulations, which range from the definition of standards for safe discharge to the treatment of hazardous or toxic wastes. There is the dimension of public perception as to what is acceptable—incineration versus landfills or the accumulation of tires in a farmer's field versus combustion as fuel in a rotary cement kiln. Each dimension has equal weight in the environmental equation. Neglecting any one can prevent the adoption of a valuable technology. And underlying all of these factors is the international dimension, because we share the air that sweeps over our lands and the oceans that ebb on our shores.

TMS accepts this challenge. As the leading professional society in minerals, metals, and materials, TMS is committed to assembling the vast array of talents of its members to explore the dimensions of materials production. It is not only a challenge, but a professional responsibility to society. TMS is uniquely suited to meet the environmental imperative because its members, drawn from industry, universities, and government, are engaged in the broad flow sheets of materials production operations. The Extraction & Processing Division (EPD) is populated with extractive metallurgists and materials production engineers who endeavor daily to make metals, ceramics, and a host of other materials. The Light Metals Division (LMD) concentrates the talents of professionals producing aluminum, magnesium, and other metals that are increasingly utilized in transportation and container applications. The recycling of these metals in quantity is a major achievement. In cooperation with the EPD and LMD, the Structural Materials Division and the Electronic, Magnetic & Photonic Materials Division are exploring the production and use of materials within a sustainable envelope. The Materials Design & Manufacturing Division has the challenge of designing products for which recyclability is on an equal footing with performance. Recyclability has become an inherent property of materials and their resultant products.

Let us work together in the professional spirit that has coalesced into TMS to nurture the planet that has nurtured generations over the millennia—for our children, their children, and their children's children. Our legacy to them must be fresh air to breathe, clean water to drink, an abundance of food to eat, and shelter from the cold. Let us show them how clever we truly are.

J. Keith Brimacombe

Presidential Perspective

THE WARP AND WOOF

Humanity is woven from the souls of men and women—the warp and woof of life's fabric. The threads of the male and female spirit are profoundly different, and the tapestry is constantly changing. In days long past, men were the warriors, and women—the child bearers—were the keepers of the hearth. With industrialization, men (and children) performed manual labor in the mines and factories while women largely tended the home fires. Time passed and civilization progressed, but the differences between men and women worked against the "fairer sex." Early in this century, women were denied a vote in free elections because they were not considered equal to men—a belief that has died hard. The fabric in life's tapestry was flawed fundamentally and humankind suffered. Men—still warriors but with different weapons and armor—orchestrated World Wars I and II, the Korean War, and a thousand other conflicts, while women bore the young men who died in the muck of the trenches; on the beaches; in the jungles, skies, and watery depths; and in countless lonely places. It would seem that women are the nurturers of life and men are its destroyers—a hard judgment. Perhaps it is time that life's fabric was woven from threads that mutually enliven the human tapestry in which the color and strength of one thread meshes with the warmth and texture of another, in a vibrant balance.

And the time has never been more opportune than now. Advances in machine design, automation, robotics, computer technology, and artificial intelligence have separated performance in the workplace from the physical strength of an individual, while elevating the importance of the mind. If women are perceived to be physically weaker than men, it has never mattered less than now, especially in a professional sense, as "mind-facturing" replaces "manufacturing" ("manu" is Latin for "hand")—mind over matter, brain over brawn. Not surprisingly, women have become a major force in law, medicine, and business, with proportional numbers in university programs leading to key positions—though not yet proportionately—in supreme courts and board rooms. Engineering would appear to be the holdout that fewer women choose as a profession, perhaps because of biases against mathematics and the physical sciences fostered in high school, perhaps due to a lack of role models, and perhaps, misguidedly, as a result of the perception of a need for physical strength. The engineering profession—specifically the materials community—has been diminished by these discouragements.

But, as it must, the wind of change is shifting over the materials landscape. More young women are finding their way into the materials field, a factor never clearer than at the TMS Student Forum on Careers held during TMS/ASM Materials Week '93. Here, female students were evident in number, especially in the executive ranks of their respective TMS student chapters. What an exhilarating experience to sense that the warp and woof of human potential were meshing into the professional tapestry.

TMS must be the weaver, offering—to young men and women alike—support, encouragement, and enrichment of their careers in materials. It is vital, at the same time, that while young women are encouraged, it is not at the expense of young men of equal talent. Equal opportunities should lead to equal opportunities. Young women who achieve need to know that they are on an equal footing with young men, and vice versa.

We have come a long way from the time of warriors and hearth keepers. The journey cannot end until women and men are full partners in the materials endeavor. TMS will be guardian of the loom.

J. Keith Brimacombe
1993 TMS President

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A Letter to the Membership

December 1992

As the next millennium approaches, the world of minerals, metals, and materials is inexorably changing at an accelerating pace, driven by knowledge of atomic structure and the power of the transistor. The advances have been truly remarkable as extraordinary materials now can be tailor-made, atom-by-atom, to achieve specific properties for new applications. At the same time, the secrets of existing and new processes have been unraveled with the aid of the digital computer, which has placed unimagined calculation power in the hands of the process engineer. Humankind has come a long way from the simple use of animal skin, stone, and wood.

Yet while modern materials and processes remain central to the progress of the human race, society is making other demands. The environment and prosperity are at the top of the list under the umbrella of "sustainable development." It is no longer acceptable that minerals, metals, and materials are simply produced and used, but, where feasible, they must be recycled while the processes involved and product designs must reckon with sustainability yardsticks. What was once considered as waste destined for discharge or landfill must be re-examined and means found to create value-added by-products whenever possible. Prosperity—the companion issue—must flow from global competitiveness based on a strong linkage between materials properties and processes and between materials properties and product design and manufacture. Thus, the world of minerals, metals, and materials for the foreseeable future will be an integration of properties, environmentally sensitive processes, recycling, and intelligent product design and manufacture.

TMS is uniquely structured to embrace this dawning reality and to provide for you, the professional, the technical programming, publications, and continuing education needed to keep abreast of this rapid change. As your TMS President in 1993, I fully intend to strengthen the work of our five technical divisions, which will explore and delineate these emerging issues. The TMS divisions—the Electronic, Magnetic & Photonic Materials Division (EMPMD), the Extraction & Processing Division (EPD), the Light Metals Division (LMD), the Materials Design & Manufacturing Division (MDMD), and the Structural Materials Division (SMD)—have already served the profession well—a tribute to the dedicated and talented TMS members who have worked so effectively in the years past. Now, we must build on existing interdivisional activities to lay bare the linkages among materials properties, processes, and product design and manufacture in the context of sustainability. We must also continue to build bridges with other societies with common goals, all for the benefit of our members, our industries, and the global village. Breaking down the walls between solitudes is never easy, but it is the only way.

TMS exists to serve our profession, the future of which depends utterly on the strength of its members. As your President, I am anxious, therefore, to foster the education of young people who will enter our profession. Thus, with

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your consent, I intend to establish a TMS endowment to create new opportunities, via scholarships and other programs, that attract the best young men and women into the profession. In this way, TMS will be working actively to build a future for our members and their industries. The endowment currently is at a formative stage and would benefit from your ideas, which I welcome.

TMS is an international society. Its membership spans the globe and, thanks to the pioneering efforts of former TMS President Frank Nolfi, strong relationships with societies in other countries have been forged. One of my goals is to strengthen these ties further and, thereby, to build upon what has already been accomplished; the '93 TMS-MMIJ (Mining and Materials Processing Institute of Japan) International Conference on Processing Materials for Properties in Hawaii is but one recent example. Speaking personally, I have valued the work and friendship of international colleagues who share common aims of serving our profession globally.

There are many other ideas I plan to pursue, but space does not permit them to be articulated. In looking to the year ahead, I am mindful of the outstanding contributions of my predecessors like Gordon Geiger, Ron Miller, Bert Westwood, and so many other dedicated professionals working at all levels of TMS who have created the society that serves you today. I am also mindful of the fundamental importance of your involvement in TMS if we are to build on the good work of others in the pursuit of our mission. Thus, I warmly encourage you to become an active participant in our committees, whether organizing conferences or supporting student affairs. I can assure you it will be a rewarding experience.

Finally, I can promise you that I will serve you as your President to the full extent of my abilities in the short year that lies ahead. I look forward to the privilege of meeting many of you in the following months.

Sincerely,

J. Keith Brimacombe
1993 TMS President

Meeting the Challenge of Wealth Creation

Editor's Note: The following is the text of TMS President J. Keith Brimacombe's address to the Society at the 1993 Annual Meeting Dinner and Awards Banquet. In future issues of *JOM*, President Brimacombe will further discuss these and other themes related to materials science and engineering in a series of commentaries.

TMS exists to serve its members—the professionals making a difference in the minerals, metals, and materials community. The major thrust of TMS is to strengthen its members and the materials industry by empowering them with knowledge through its symposia, publications, and continuing education programs. The advances that the materials community has made in the last decade are impressive, as we have learned to create new materials atom by atom; but, as we approach the next millennium, society is demanding that these advances be converted into prosperity—the creation of wealth that is the wellspring of jobs and an enhanced quality of life—all within an environmentally sensitive envelope.

As professionals with an obligation to society, we must meet this challenge head on, embrace it, and transform it from goal into reality.

The creation of wealth stems utterly from the making of products that are in demand globally because they meet a need and possess required properties that are reproducible at a competitive, but profitable, price. But products are not made without processes—the engine of transformation of raw materials, whether virgin or recycled, into a newly sought form. And, thus, at the heart of prosperity is knowledge of materials properties and the processes that transform them. TMS, with its five divisions spanning processing to the manufacturing of metals, ceramics, electronic materials, and composites, is uniquely structured to embrace this challenge. TMS reflects the needs of our industry and the professionals who will make it happen.

And so, what do we plan to do in the coming year? First, we will build on the ideas, energy, and initiatives of the many dedicated professionals who have worked so effectively for their profession through TMS. The operating divisions that reach into the grassroots of our profession will be empowered to strengthen their activities recognizing the needs of society to create wealth through the process-product linkage and to do so while protecting the environment. Because the future of our profession depends utterly on the youth of today and tomorrow, we will be developing "Passing the Torch," a program for the creation of scholarships named after our distinguished members, to assist and inspire our fledgling young professionals in their education. We are developing a foundation to create new opportunities for our profession and to strengthen our industry. We will forge stronger links with international societies to enhance symposia, publications, and continuing education for the benefit of our members. We will foster interdisciplinary links with other societies in the creation of a new kind of symposium that draws upon the strengths of widely different fields. We have much to learn from each other.

In closing, I wish to thank all of you most warmly for attending this most important occasion in the life of TMS and our profession. I also want to express my sincere congratulations to our award recipients honored here tonight for their splendid achievements. You have set a high standard and are an inspiration to all who would achieve.

J. Keith Brimacombe
1993 President of TMS

"Prosperity into the Next Millennium Built on the Process Engineering of Materials"

As engineers and scientists concerned with the materials field, we cannot solve all of the global problems at once. But certainly, it is our professional responsibility to tackle the issues of wealth creation and the environment through the application of knowledge flowing from our research and experience. Therefore it is appropriate, and timely, to be holding this conference on "Processing Materials for Properties," because real wealth creation depends fundamentally on the manufacture of products via processes—and materials are at the heart of this activity.

The question, of course, is how to process materials for properties most effectively to create wealth, i.e., at the lowest cost with minimum impact on the environment. The answer lies in the nature of the flowsheets of materials production and in the fundamental behavior of processes and materials. What emerges is the process engineering paradigm which embraces an interdisciplinary view of materials production driven by the goal of quantitatively establishing the linkage between the process and the properties of the product it makes at every stage in a flowsheet. This vision includes not only primary products, but also by-products, or so-called waste products and their fate or use. Thus in this plenary lecture, I should like to underscore the theme, which I have delineated previously, of a unified approach to the production and use of materials underpinned by knowledge and propelled by the desire to create wealth. As shall be seen, the generation of knowledge on process and materials behavior is not sufficient by itself but the transfer of knowledge to, and its implementation in, industry, the engine of wealth creation, are equally vital.

The reality of the process flowsheets is that the unit operations are complex; and, even in established production lines, may be poorly understood. The forces at work in a given process are numerous—gravity, stirring, deformation, temperature gradients, concentration gradients and thermodynamics—acting frequently on three or more phases at the same time. Owing to the complexity, the processes have been slow to yield up their secrets.

Perhaps in response to the complexity, or because the human condition favors classification, the materials processing field has been fragmented by dividing the flowsheets into extraction, dominated by materials in the fluid state, at the front end, and thermomechanical processing in the solid state, further downstream, with solidification processes (if applied) somewhere in the middle. The field has been fragmented further by isolating one material class from another, e.g., metals from polymers, and even by creating solitudes within a materials class, e.g., steel, copper, and aluminum. Not surprisingly, the extraction area (formerly extractive metallurgy) and chemical engineering have gravitated toward one another due to the role of chemical reactions and transport phenomena in the earlier stages of many materials flowsheets. Separately the solid-state area (formerly physical metallurgy) has much in common with mechanical engineering but a union of the disciplines has been slow in the pursuit of the engineering of microstructure and properties, as well as of design. Thus, while the flowsheets of materials production cry out for integration of existing disciplines to address the realities of the day, our approach from our individual "boxes" is woefully piecemeal. This situation must change if wealth creation, and prosperity, through materials processing is to be exploited fully within a reasonable time frame.

As time progresses, an imperative will be to simplify flowsheets by introducing new processes which replace existing unit operations. Nowhere is this more apparent than in the steel industry which is developing a new generation of bath smelting processes for the production of molten iron to supplant the sinter plant, coke ovens and blast furnace; meanwhile recently implemented thin slab casting simplifies reheating and eliminates rough rolling operations. The driving forces for flowsheet simplification and process optimization, obviously are cost, product quality and environmental control.

Forging the linkage quantitatively between processes and products indeed is at the heart of process engineering. Materials products must meet customer specifications of properties like strength, toughness, fatigue resistance, hardness and thermal conductivity, depending on the application. Quality specifications including freedom from defects, chemical homogeneity, dimensional tolerances and consistency of properties also loom large. Impacting on the product characteristics are the design of the process, operation parameters and maintenance. It is the responsibility of the process engineer to understand the relationship between a given process and its product(s) at every stage in a process flowsheet. Only then can the design, operation and maintenance of a process be rationalized to maximize production, product quality and profit—lest prosperity be forgotten.

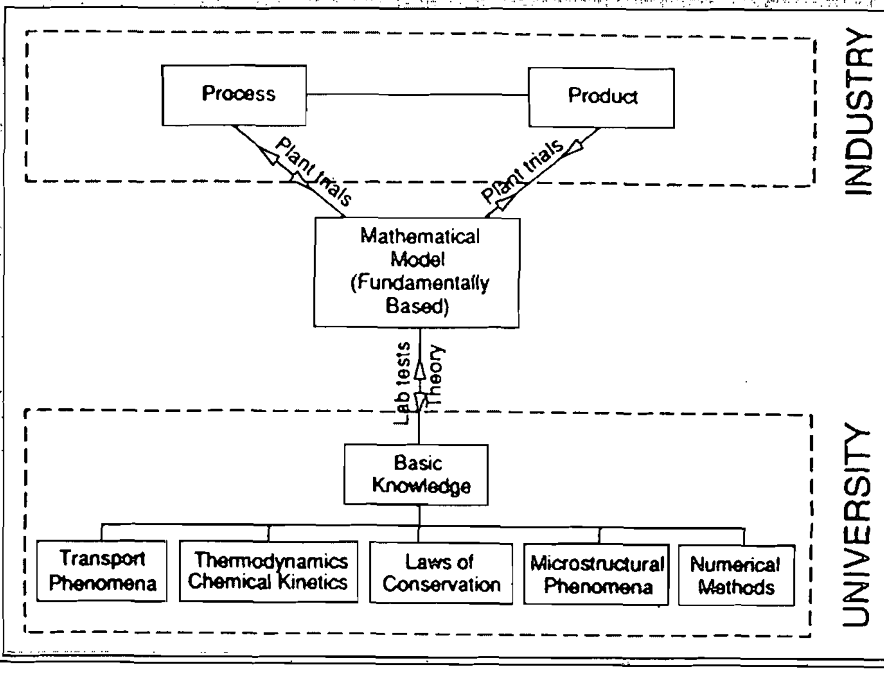
In pursuit of his goal, the process engineer may follow several paths. There is the empirical path which, if taken, requires the correlation of measured product properties to measured process parameters. There is the theoretical path which the process engineer may choose when armed with the secrets of the process together with the fundamentals of conservation, thermodynamics, transport phenomena, solid mechanics, microstructural kinetics and so on. The latter path has only been opened for passage realistically since the 1960s when the digital computer, with its computational power, could embrace the mathematical framework of the process and yield numerical solutions to complex problems that defied more elegant analytical treatment. Realistically neither path, in isolation, is the route to the goal of the process engineer. Both paths need to be taken, with frequent excursions back and forth between the two.

There is a third path down which the process engineer must proceed as well, to characterize the properties of materials, often by measurement but within a theoretical framework. The properties may be thermodynamic or kinetic in nature involving any number of phases. In the liquid state, the kinematic viscosity, surface tension or solution behavior may be important while in the solid state, grain growth, recrystallization and phase transformations may command attention. During solidification, the thermal diffusivity, shrinkage coefficient and ductility of a material may be paramount. The third path necessarily must be linked to the other two because materials properties must be incorporated into mathematical models of the process and must be comprehended to interpret process measurements often via computer analysis. The integration of process measurements, theory and the characterization of materials properties is a fundamental of process engineering.

Figure 3 depicts the paths among the elements of process engineering. Thus the computer model, rooted in fundamentals, is seen to be at the crossroads between basic knowledge and the process-product linkage. It is central to the creation of wealth and prosperity.

Each of us desires, perhaps, to be an expert in all aspects of process engineering but it is not possible in the vast ocean of knowledge that exists today. The engineer who is at home with concepts of turbulent fluid flow and radiative heat transfer is unlikely to fathom the depths of phase transformations as austenite decomposes to pearlite in steel, or the dislocations generated in a single crystal stressed by differential cooling. The challenge of process engineering is not only to integrate processes, products and basic knowledge but also to bridge the traditional disciplines of chemical metallurgy, physical metallurgy, materials science, chemical engineering and mechanical engineering (this is not an exclusive list) in doing so. Chemical metallurgy and chemical engineering would be expected to join forces in the earlier stages of a materials production flowsheet followed by physical metallurgy/materials science and mechanical engineering further downstream as indicated earlier. This integration of engineering disciplines is another fundamental.

Process engineering, as viewed from the perspective of Figure 3, also is a bridge between the two traditional solitudes—industry, the creator of wealth, and academe, the bastion of knowledge. The computer model incorporates the basics of conservation and the laws of physics and chemistry mathematically—the stuff of undergraduate education. The computer model, properly formulated and validated, predicts product properties reliably as a function of process conditions—the stuff of process optimization and prosperity. Thus the engine of knowledge generation is coupled to the engine of wealth creation.



If process engineering is central to wealth creation through the manufacture of materials products, it might be presumed that the discipline is a vital component of university education in teaching and research. Remarkably such is not the case. A survey of universities in North America quickly reveals that the field of Materials Science and Engineering is dominated by the characterization of materials properties/behavior at the expense of process engineering. Dislocation climb is ascendant over materials flow in a rolling or extrusion operation. Even worse has been the swing to so-called advanced materials, lionized by the military, away from conventional materia's like metals and concrete. It is as if knowledge of the properties and processing of the latter materials was complete. Nothing was left to learn.

The truth is just the opposite, especially with respect to process engineering. Having neglected the subject on the production of metals over decades, materials scientists and engineers are now proceeding down the same predictable course. Processes for the extraction, refining, solidification, and shaping of metals that remain only partially understood are giving way intellectually to materials processes which are even less well fathomed. What is missing in the materials science and engineering field is balance—between conventional and advanced materials, between property characterization and processing, and between science and engineering. Also missing in our research and teaching is the finiteness of materials, viz. recyclability, and the impact of processes on the environment. Society is demanding that wealth creation, via materials or any other route, be pursued within an environmentally friendly envelope. Thus the plastic automobile will become a commercial success only to the extent that the hydrocarbon-based material can be recycled and not simply combusted when the life of the product has ended. Viewed in the context of recyclability, the commodity metals that no longer appeal to the materials research community, have taken on a new life. What we need is balance, pure and simple.

What has caused us at universities to lose sight of the realities of materials processing and properties? Perhaps the answer lies in the smoldering embers of metallurgy. Although metals—iron, copper, bronze, and steel—profoundly shaped the course of civilization over millennia, we have been incapable of defining the engineering discipline that underpins them. Unlike chemical engineering that grew organically as a professional discipline in support of the chemical process industry and mechanical engineering that emerged to draw together the knowledge needed for mechanical design of automobiles, aircraft, and manufacturing systems, metallurgy and its successor—materials science and engineering—have not matured to the stage of an engineering discipline. We have been caught up in atoms and structures and free energies while losing sight of heat losses and evaporation and dust formation. Apparently we have not seen the need, as professionals, to harness knowledge for wealth creation.

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