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Editorial

PRINCETON University, Guggenheim Jet Propulsion Laboratory, a weekday around 1:00 a.m., many years ago. Somebody is furiously typing on his manual typewriter machine (with only two fingers); the carriage goes back and forth; new sheets are rapidly fed. The noise eventually stops, and a small man rushes out of his office on the first floor. Dark pants, a large white shirt, papillion tie, no jacket, a smoldering cigarette widely floating in the air, Professor Summerfield holds a sheaf of those fearsome yellow memos containing imperative messages for every member of the Solid Propellant (SP) Group. Abruptly he stops, looks nervously around him in the corridor, checks the lights in the SP lab, takes a look upstairs where graduate student offices are located. He seems surprised and somewhat puzzled... Finally, he shouts in a very interrogative manner: "Where is everybody?"

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This Special Issue of AIAA's *Journal of Propulsion and Power* honors the memory of Professor Martin Summerfield on the third anniversary of his death. A recognized leader in solid-propellant combustion and a pioneer in chemical rocket propulsion in general, Summerfield focused his research activities on gas-phase flame structure and heat feedback to the burning surface under steady and transient conditions. For about three decades, Summerfield represented a primary source of inspiration for many investigators, mainly those working in the areas of energetic-material combustion and chemical rockets. Educated as a physicist, he expertly combined simple physical processes and models into a whole or extensive numerical calculations concept to explain complex combustion processes. (He tended to trust simple experimental facts more than sophisticated mathematical elegance or extensive numerical calculations, labeling theory without concurrent physical evidence "a sheer exercise.") A quick thinking, deeply perceptive, and hard-working individual, Summerfield was often ahead of others in understanding new problems, thanks to his excellent grasp of physics. Highly energetic, clever, and possessing a powerful and broad-based intellect, he could speak with no apparent effort like a "printed book" and capture the attention of any audience while disseminating new ideas and complex technology. He always strove for perfection in his work as a teacher, researcher, and editor, and set the highest standards for all who worked with him (including the Editor-in-Chief of *Journal of Propulsion and Power*!).

Sometimes his standards were too demanding, his perfectionism too insistent, and his pace was too quick, causing discomfort with those surrounding him. One example happened near the Christmas holiday, a former student recalls. Most of the students in the Aerospace and Mechanical Sciences department were about to leave for the holiday period when Summerfield sent one of his famous yellow memos. He requested many of the graduate students at the Guggenheim Laboratory to stay and work on technical reports to meet deadlines with the statement, "Not all graduate students are born equal."

Yet, Summerfield had received from Mother Nature the gift of a unique personality and a variety of talents. His many contributions to aerospace literature have strongly promoted aeronautics in multiple areas. A former colleague recalls him in this scenes. In a crowded lecture hall, a small man gains the attention of the speaker and moves rapidly toward the front clutching a thick sheath of materials in his upraised hand. As he approaches the front, he announces, "I have a few VuGraphs that pertain to this matter!" Then Summerfield presents a sweeping synthesis from the lecture's threads and other sources, and weaves a "new tapestry" that both clarifies and illuminates the subject.

For about a quarter of century under his direction, the SP Group at Princeton University was an international stage: it served as a focal point for students and visitors from all over the world, including scientists from the (at that time) unfriendly Soviet Union. Summerfield's enthusiasm and dedication served as an inspiration to the many who benefited from his knowledge and guidance. His research caused decisive breakthroughs in understanding the complex combustion of the heterogeneous solid propellants used for space propulsion. Although mainly known for his work in solid-propellant combustion, Summerfield started his career in liquid propulsion. As reported in most textbooks, he first highlighted the phenomenon of flow separation in the final portion of slightly over-expanded supersonic gasdynamic nozzles based on investigations made at Aerojet, presented in 1948 and published in *Jet Propulsion* in 1954. Even earlier, in 1947, Summerfield published with Frank J. Malina the paper "The Problem of Escape from the Earth by Rocket" where he first proposed the staging of rockets to overcome the severe mass-ratio constraint of chemical-propulsion engines.

The following anecdote, recalled by Professor Irvin Glassman, a long-time colleague at Princeton University, illustrates Summerfield's breadth of interests and ability to penetrate the essence of a new problem. His Ph.D. thesis in physics at California Institute of Technology (Caltech) was in the field of optics and initially he knew very little about engineering. Karman thought him very bright and brought him into his group. Karman had asked some well-known professors in Caltech's Chemical Engineering Department if it was possible to regeneratively cool liquid-propellant rockets and they concluded it was not. Karman suspected otherwise, so he assigned the problem to Summerfield. Summerfield set to learning about heat transfer. Later he came running into Karman's office and announced he knew how to approach the problem. After he had explained, Karman said, "Congratulations, Martin, you have discovered the Nusselt Number!" Of course, by learning about nucleate-boiling heat transfer, Summerfield was able to show that regenerative cooling was indeed feasible.

AIAA received the best personal and continuous attention from Summerfield, as obvious from the short biography on p. 739. As evidence of his generosity, Professor Summerfield endowed both the Summerfield Book Award (presented annually to the author of the best book recently published by AIAA) and the Summerfield Memorial Fellowship (to encourage graduate studies in the field of combustion and propulsion).

A series of international workshops in solid-propellant combustion and propulsion has been organized yearly by Politecnico di Milano, in Milan, Italy. One of our staff there (Luigi DeLuca) had previous experience with the SP Group at Princeton University, and this was the key to maintaining successful operations with it for years. Our convenient location between the two big countries has permitted Italy to keep communication channels open between American and Russian scientists even during the hard time of global competition. The workshops have a limited number of invited participants and thus promote free technical discussion and know-how exchange in a relaxed atmosphere without frills. The 1997 workshop, focused on combustion and combustor instability, collected some of the best international investigators. It was thought appropriate to dedicate this event to the memory of Summerfield, deceased in the previous year, and select some of the best presentations for publication in a special issue of AIAA's *Journal of Propulsion and Power*.

This issue collects 29 manuscripts authored by many of Summerfield's former students and associates among the Milan workshop participants, as well as other investigators active in energetic-material combustion. It could be used as a quick introduction to a variety of modern problems in the use of energetic materials, as well as a reference for many advanced topics in solid-propellant combustion. It is a token gesture dedicated to a person of sparkling intelligence and an enthusiastic researcher, one who would abruptly find new energy in his veins and new visions in his mind at the end

of a long working day, if he detected only the suspicion of an error or novelty.

Most (19) of the papers contributed analyze different aspects of solid-propellant combustion:

- Five papers are dedicated to modern problems of flame structure for a variety of solid-propellant compositions including pure components (ADN, CL-20, HNF, AP) and mixtures based on nitramines, AP, and AN.
- Two papers examine the difficulties of aluminum combustion in solid propulsion.
- Four papers focus on pressure-driven intrinsic burning stability and/or frequency response function (two theoretical efforts including condensed-phase chemical activity and two experimental investigations by ultrasound or magnetic flowmeter).
- Two papers treat modeling of the new HNF propellant (steady and transient).
- Two papers investigate some special solid rocket motor operations (propagation of entropy waves and underwater ignition).
- Four papers discuss peculiar problems of solid-propellant burning (flame propagation in heated-gas airbag inflators, implementation of Automatic Control Theory to understand solid-propellant burning, use of solid propellants in electrical propulsion, and a survey of capacitive methods to measure burning rates).

Solid-propellant themes are further considered in four technical notes: a survey of experimental studies on solid-rocket-motor high-frequency instability in Russia, suppression of solid-rocket-motor combustion instability by metallic additives, an approximate solution of the hyperbolic heat equation for the heterogeneous-solid-propellant gas-phase ignition theory, and underwater incineration of heterogeneous solid propellants.

The remaining six papers, some from former colleagues at Princeton University, deal with pyrolysis in hybrid propulsion, vaporization of liquid fuels and propellants, internal ballistics of nozzleless rocket motors, combustion thermodynamics of metal-complex oxidizer mixtures, flammability limits of diffusion flames, and combustion instability in a lean-premixed dump combustor.

The variety of international authors and topics contained in this collection proves the effectiveness of the pioneering work of Summerfield in energetic-material combustion. From the initial seed on solid propulsion planted by him, a large plant has grown with branches projecting in many directions: hybrid propulsion, electrical propulsion, metal burning, air bags, gas generators, pyrotechnics, incineration.... Whenever possible, connections of the current investigations with Summerfield's pioneering work have been noted.

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Here we all are, Professor Summerfield, burning the shining flame of the memory of your inspiration and leadership of the Princeton SP Group!

Luigi T. DeLuca, Robert S. Brown, Boris V. Novozhilov
18 July 1999

A Standout of the Millennium

IT is fitting that this issue of the *Journal of Propulsion and Power*, the final issue of this millennium, should be dedicated to the memory of Professor Martin Summerfield, since he was an innovative leader in many fields of propulsion. In addition, he made numerous valuable contributions to publications of technical literature. The editorial (p. 737) and biography (p. 739) mention many of his technical contributions. However, it must be noted that Martin came to Princeton 50 years ago to become the Editor of the *Princeton Series*, and produced 12 books by the Princeton Press on high-speed flow. He also served as Editor-in-Chief of the *Journal of the American Rocket Society*, and was the President of the American Rocket Society during the negotiations for the merger with the IAS that led to the formation of AIAA. Since I was a student of his at the time, many of our discussions were interrupted by phone calls regarding this merger; his role in its success has never been adequately recognized.

The idea for this special issue came from a seminar organized by Luigi DeLuca, one of the many distinguished leaders trained by Professor Summerfield. It was noted that many of the participants had either been educated at Princeton or had visited the Solid Propellant Laboratory there to meet with Martin. As a result, this issue contains papers from that and a later seminar, as well as contributions by students and cohorts at Princeton. Luigi and another long-time friend, Bob Brown, volunteered to serve as guest editors. Needless to say, I took them up on their offer immediately! In addition, Boris Novozhilov agreed to assist with the many Russian authors. I want to express my sincere appreciation to all three of them at this time.

The breadth of the influence of Professor Summerfield can be seen in the range of authors (from eight countries!) who have contributed papers to this issue, as well as in the range of topics of the papers. It is obvious that he was a leader in many fields for the second half of this century.

I have attempted to recognize Luigi, Boris, and Bob for their efforts in assembling this special issue in memory of Martin Summerfield. However, their job required the assistance of all those who served as reviewers. Listing of their names below is only part of the appreciation for their role.

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