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PROFESSOR SPALDING'S PROFOUND IMPACT ON COMPUTATIONAL HEAT TRANSFER

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ABSTRACT

Professor Spalding was an intellectual giant, who made ground-breaking contributions to heat transfer, mass transfer, combustion, turbulence, multi-phase flow, and computational fluid dynamics. His work is noteworthy not only for the amazing variety of subjects he covered but also for the strong impact of his inventions. None of his work makes just an incremental contribution. It is always a significant breakthrough, opening the door to many scientific opportunities that did not exist before. His vision and creativity provided a quantum increase in our scientific understanding and predictive capability.

Even before he made his breakthrough contributions to Computational Fluid Dynamics (CFD), he had made revolutionary advances in combustion, mass transfer, and boundary layer theory. He was always motivated by his desire for a predictive capability, which made his fundamental work extremely useful in practical applications. Whereas most fluid dynamics researchers would be concerned only with fluid flow, Spalding envisaged a general unified framework that included heat and mass transfer, combustion, turbulence, and two-phase flow, as well as the conventional single-phase flow. The strength of his research emanates from his desire and ability to generalize a given concept, formula, or procedure. His work always showed the urge and capability to reach extraordinary heights through bold generalization.

His development of the finite-volume methodology was a brilliant combination of mathematical derivation and physical insight. At the same time, he addressed the issue of computing turbulent flows. He created a framework for the "mathematical models of turbulence", in which he was able to fit simple formulas for turbulent viscosity and also propose advanced models such as the two-equation turbulence models. It is this combination of a calculation method for complex flows and a satisfactory representation of turbulence that made CFD a practical tool for industrial problems. Later, he created CFD techniques for two-phase or multi-phase flows. Here, he interestingly saw the possibility to come up with a new kind of turbulence model. A turbulent flow can be seen as a two-phase flow that is made up of a laminar fluid and a turbulent fluid. Similarly, he proposed a new model for turbulent combustion by considering the fluid as a two-phase mixture of burned and unburned gases. These ideas have the potential to explain and predict certain experimental observations that are beyond the reach of conventional turbulence models.