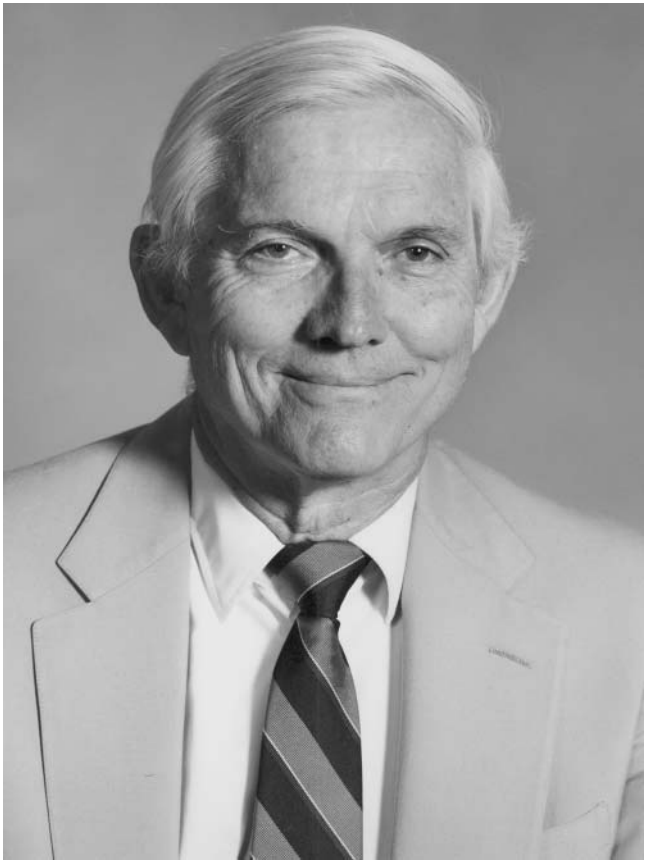

JOSEPH B. MOORE

1926–2006

Elected in 1986

"For contributions to the technology of rapid solidification, and for the development of gas-turbine-engine materials.

BY BERNARD L. KOFF

JOSEPH MOORE, one of the nation's foremost leading pioneers in materials development for gas turbines and rocket engines, died on January 7, 2006, at the age of seventy nine. Prior to retirement in 1991, he served as Director, Materials Engineering & Technology, Pratt & Whitney Group, United Technologies Corp. His career spanned 37 years. He was renowned worldwide for his contributions to the science and processing of materials which led to major improvements in turbine and rocket reliability and operability. He is survived by his sister, Jane Kiger, and by his sons Robert and Albert, and daughters Donna, Katherine, and Nancy.

Joe grew up in Tuscaloosa, Alabama, was an avid sports fan, attended prep school at Baylor, and entered the V-12 program at Rice before serving in the Navy. He is a graduate of University of Alabama with a B.S. in Aeronautical Engineering (1948) and an M.S. in Mechanical Engineering (1955). He specialized in Metallurgy and Materials Engineering, was a devoted University of Alabama football fan and a music lover of both opera and old time jazz.

His career started with the General Electric Aircraft Engine Division in 1954 as a metallurgist, focusing on an emerging new class of materials known as heat-resistant, precipitation hardening superalloys. His particular interest was to understand the relationship of microstructure to thermal exposure and

mechanical strength, and how alloying and processing could alter behavior. The alloy René 41, still considered to be a workhorse high-temperature material for forged turbine components, was a result of his early exploits. Recognizing that this class of materials was yet in its infancy, he joined the Wyman-Gordon Co. in 1957 as Supervisor of Vacuum Melting to understand process behavior. In 1960, he joined the Southern Research Institute as Senior Scientist to further his knowledge of microstructure-property relationships. During this time, he integrated the use of statistical analysis to determine behavioral trends from what was known as partial factorial experimentation — a means whereby large dimensioned experimental grids could be reduced in size to shorten the time and cost of data acquisition.

In 1961, opportunity knocked with the opening of Pratt and Whitney's Florida Research and Development Laboratory — a facility dedicated at that time to develop technologies for new concepts in rocket and jet engines. Joe's expertise was perfect for this need and he joined as Metallurgical Supervisor with the immediate task of organizing and equipping a team to develop materials which could operate 200°F–600°F hotter than ever before. A natural born leader, Joe proactively worked with engine designers, manufacturers, and project engineers to clearly define and understand requirements to advance the state of art in materials set against specific goals. The results were dramatic and the materials contributions were subsequently cited as "key enabling technologies." These technologies were used in the successful development of the revolutionary, continuously afterburning J58 power plant used in the Mach 3+ SR-71 reconnaissance aircraft, best known as the Blackbird.

In 1976, Joe was promoted to Director, Materials Operations and held this position with increasing responsibility until retirement. His organization grew as did his acclaim. Some of his more well-known accomplishments include:

- precision, equiaxed superalloy castings for improved strength and heat resistant turbine airfoils
- ingot casting and forging procedures to ensure rim-to-bore property uniformity for large turbine disks

- adaptation of highly innovative inert gas powder metallurgy technologies to reduce process defects leading to fatigue in complex heat resistant alloys
- alloying and processing superalloys to retard crack propagation in highly stressed turbine components subjected to high cyclic strain
- superplastic forming of otherwise unworkable superalloys for engine components, and
- rapid solidification to enable alloying of metals without chemical segregation.

The equiaxed cast alloy IN 100 was first used for the J58 engine turbine blades at a time when cast turbine blades were not considered useful because of low fatigue strength. Multiple forging procedures were also developed to provide uniform cross-section strength for Astroloy which was the strongest but difficult to forge superalloy turbine disk material. Inert powder processing went on to become the foundation corner stone for all superalloy powder metallurgy engine components.

Superplastic deformation enabled forming superalloys otherwise impossible to forge, and opened the door for alloys with higher strength, ductility, and resistance to fatigue. This innovative isothermal forging process was named "Gatorizing" and produced the first successful powder metallurgy turbine disks operated in a gas turbine. Joe assigned this name to honor the Florida alligators roaming outside the facility and so that people would remember where it happened. The high bypass PW-4084 turbofan engine for the B-777 aircraft uses "Gatorized" processing for the uncooled low pressure turbine driveshaft to develop the torque to drive the fan and low pressure compressor.

Mr. Moore and his colleagues continued to develop and experiment with rapid solidification to further advance alloys in aluminum, iron base materials, and nickel superalloys. Considerable effort was made to produce a non-oxidizing Niobium alloy for uncooled turbine blades operating at 2700°F but was not successful. However, the rapid solidification process was successful in developing a non-burning titanium alloy for jet engine components up to 1200°F, some 500°F higher than current titanium alloys.

I'm sure that if Joe were here today, he'd want to try again to produce a turbine blade alloy higher than 2400°F which is the incipient melting temperature for current nickel based alloys.

In 1972, Pratt & Whitney presented the George Mead Gold Medal for the invention of Gatorizing to both Joe and his close associate Roy Athey. The Air Force considered this among the most significant developments in the past 60 years. In 1986, Joe was elected to the National Academy of Engineering for his contributions to metallurgy and materials processing.

Mr. Moore holds 6 patents used worldwide and produced 12 publications associated with gas turbine and rocket engine applications.

He was a member of the American Society for Metals and served on numerous government, university, industry boards, and committees including the National Research Council. He also provided support to universities for curriculum guidance in metallurgy and related subjects.

Mr. Moore was a very practical "hands on" engineer who displayed great insight of current situations which provided a key to his pioneering foresight. One of his comments was "seeing is believing" when presenting to the metallurgical community the results of his research and development. He was a joy and inspiration to work with.