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Guest Editorial

Jubilee Review: The 65 Years of the ASME Machine Design Award (1958–2023)

As the most prestigious award in the field of machine design, the ASME Machine Design Award relishes its prestige and prominence. In the past 65 years since its inception in 1958, 60 eminent scholars have received this honor. This paper reviews the history of this prestigious award, including a summary of the contributions to the field of all 60 recipients, and acts as an archival document. Reviewing these awards in the past 65 years by following the tracks of its recipients elucidates developments in the field and significant contributions to the advancement of knowledge in machine design. In particular, novel contributions and remarkable achievements in the fields of mechanical engineering and machine design and development are recorded. This should be of interest to those interested in the study and in the historical development of mechanical engineering, particularly in machine design. [DOI: 10.1115/1.4062347]

Keywords: machine design, gear and cam design, design theory and methodology, mechanism and robotics, machine theory, mechanism theory, dynamics, modern kinematics, fatigue and failure, vibration and noise

1 Introduction

The ASME Machine Design Award, the highest accolade in the machine design field, recognizes individuals who have made pioneering and groundbreaking contributions to this area. Since its inception in 1958 [1], 60 eminent scholars with outstanding achievements in their respective professional fields have received this honor. Their contributions embrace a broad spectrum of 16 subfields including design automation, design for manufacturing, lifecycle analysis and design, design theory and methodology, mechanism and robotics, mechatronics and embedded systems, engineering computing and information science, computing and nonlinear dynamics, micro-nano systems, medical devices, power transmission, reliability, stress analysis and failure prevention, vehicle design, fasteners and connections, design education, vibration and noise, among others.

This paper records the award recipients in the past 65 years, upon dividing awardees into three groups of two-decade periods. A summary of the recipients for every two decades period is provided at the beginning of each section, followed by a detailed description of the significant achievements of each recipient. Conclusions are provided at the end of the paper.

2 First Twenty Years: ASME Machine Design Award (1958–1978)

2.1 Summary. In the first two decades from 1958 to 1978 (vacant in 1973), a total of 19 eminent scholars were bestowed with the award [1]. These scholars were recognized for their outstanding contributions to gear research, editorial work for 12 editions of the globally prevalent *Kent's Mechanical Engineers' Handbook*, publication of *Mathematical Engineering Analysis*, as well as the publications in fields such as vibration and noise, mechanism and mechanical design, roller bearings, cutting devices, mechanical transmission, machine fatigue and in methodologies in human musculoskeletal mathematical model, high-order polynomials, dynamics, and others. These recipients are internationally renowned scholars in machine design across diverse domains. Notably, among the recipients are the earliest organizers as Allen Hall and Colin Carmichael of the *Mechanisms Conference*, initiated in 1953, the inventor of the mountain bulldozer Robert LeTourneau, the inventor of fluid stepper actuators Walton Musser, the inventor of the electric scorer, and the father of the hard-disk drive Reynold Johnson, the inventor of prosthetic biomechanics Charles Radcliffe, and the father of modern kinematics Ferdinand Freudenstein.

2.2 Achievements of the Recipients of the First Twenty Years. *The 1959 recipient Charles E. Crede* (Fig. 1), FASME,[1] FASA,[2] is distinguished for his outstanding contributions to shock and vibration technology. He was employed as a civilian engineer at the Navy Department Bureau of Ships in Washington, D.C., and quickly became a leading expert in protecting shipborne equipment of naval warfare against severe shocks. He then moved to the Naval Research Laboratory in 1944, where he organized and directed the first Shock and Vibration Division. Before he joined Caltech, he was the vice president of Barry Controls Inc. In addition, he was the leading figure in Air Force design for underground missile launching sites and for the National Aeronautics and Space Administration (NASA) investigations of shock and vibration problems in rockets [2]. He authored the monograph *Vibration and Shock Isolation* by John Wiley & Sons in 1951 [3] and a three-

[1]Fellow of American Society of Mechanical Engineers (FASME).
[2]Fellow of Acoustical Society of America (FASA).

Fig. 1 1959 Recipient: Charles E. Crede

volume *Shock and Vibration Handbook*, the foremost authoritative source of information in the field, in 1961 by McGraw-Hill Book Inc. Furthermore, he was the national vice president of the ASME and Chair of numerous American Standards Association (ASA) committees. He passed away on December 29, 1964, at the age of 51.

The 1960 recipient Rudolph E. Peterson (Fig. 2), FASME, is distinguished for his remarkable achievements in the prevention of failure in machine and structure parts that occur owing to fatigue loading and brittle fracture. For the last 50 years, he has been widely recognized as Mr. Stress Concentration [4]. He joined Westinghouse Electric Corporation in 1926 and became the Head of the Mechanical Department in 1931. He published over 60 papers and authored monographs *Stress Concentration Design Factors* [5] and *Stress Concentration Factors* [6] in 1953 and 1974, respectively, both by John Wiley. He served as the first Chair of the Fatigue Strength Committee in the American Society for Testing and Materials (1946–1959), Chair of the Applied Mechanics Division in ASME, Chair of the American Standards Association Committee on Symbols for Mechanics in ASME, President of the Society of Experimental Mechanics (SEM) (1948–1948), and Chair of the Employment Security Administration. In addition, he was the founder of the Westinghouse Advanced Mechanics School at the University of Pittsburg in 1956. The "R. E. Peterson Award" [7], an award for the best applications paper published in Experimental Mechanics, was named in his honor in 1973 by SEM. He passed away in 1982, at the age of 78.

Fig. 2 1960 Recipient: Rudolph E. Peterson

The 1961 recipient Robert G. LeTourneau (Fig. 3) is distinguished for his leading development of large, efficient earthmoving equipment. He obtained more than 300 invention patents including patents for bulldozers, dredgers, portable cranes, rollers, scrapers, dump wagons, bridge spans, logging equipment, mobile sea platform for oil exploration, electric wheels, etc. His first U.S. patent was the Mountain Mover [8] in 1922, the first effective earthmoving scraper that can be operated by a single person using a generator and electric motors to manipulate the scraper blade from the tractor seat. He authored a monograph in 1967 on *Mover of Men and Mountains* by Moody Publisher [9]. In 1929, he founded R. G. LeTourneau, Inc., which provided 70% of the Allies' earthmoving equipment during World War II. He also founded the LeTourneau Technical Institute in 1946, which later became the LeTourneau University in 1989. In addition, he received more than 30 awards and honors in engineering, manufacturing, and heavy equipment development, including the "Frank P. Brown Medal" in 1956 and "Beavers Awards" in 1958, in recognition of his contributions to the earthmoving equipment and heavy construction industry. He passed away on June 1, 1969, at the age of 80.

Fig. 3 1961 Recipient: Robert G. LeTourneau

The 1962 recipient J. F. Downie Smith (Fig. 4) is distinguished for his significant achievements in mechanical engineering research. He contributed to groundbreaking research measuring the thermal conductivities of several liquids in the 1930s. He published a paper in 1936 on *Thermal Conductivity of Liquids* [10], where a general equation was proposed for the thermal conductivity of all nonmetallic liquids at 30 °C and atmospheric pressure. The thermal conductivity of liquids is a function of molecular weight, density, specific heat, viscosity, gas constant, thermal expansion, and compressibility. In addition to his research, he also had a distinctive career in academia and industry. He was the Dean of Engineering (1948–1959) at the Iowa State University and the Vice President of the Carrier Corporation, where he headed its Central Research and Development Division from 1957. Furthermore, he served as the Advisor of the Organic and Fibrous Materials Division of the National Bureau of Standards (1959–1961).

Fig. 4 1962 Recipient: J. F. Downie Smith

The 1963 recipient Colin Carmichael is distinguished for his outstanding contributions to mechanical engineering. He worked on the standardization of dimensions and horsepower ratings of V-Belts and sheaves for industrial and domestic applications, excluding automotive and agricultural types. He was the former Editor-in-Chief of the American trade magazine, *Machine Design,* overseeing several book issues such as *Nonferrous Metals and Bearings*, a straightforward, easy-to-use guide to solving most common design and selection problems pertaining to bearings and lubricants. He was the editor of *Kent's Mechanical Engineers' Handbook* in 1955 with 12 editions published by Wiley Engineering Handbook Series, NY [11]. This handbook was a widely adopted resource for engineers worldwide, offering practical guidance on various engineering topics before designs were computerized. He was also involved in organizing the first U.S. Mechanisms Conference which was held at the Purdue University in 1953 [12]. This conference was later renamed the ASME Mechanisms and Robotics Conference in 2000.

The 1964 recipient Rufus Oldenburger (Fig. 5), FASME, is distinguished for his outstanding research in the exponential trajectory of symbolic dynamics, high-dimensional determinants and matrices, high-order polynomials and their forms, etc. [13]. He published over 110 papers and authored seven monographs and books, including a monograph in 1950 on *Mathematical Engineering Analysis* published by Macmillan [14]. He founded the Automation Control Center at the Purdue University and organized the International Frequency Response Symposium in 1953. He was the first President of the American Automatic Control Council (1956–1960) and played a key role in establishing the International Federation of Automatic Control (IFAC) in 1957. For his contributions to the field of automatic control, he received numerous medals, including the "IFAC Award"

Fig. 5 1964 Recipient: Rufus Oldenburger

for meritorious service in 1959, the "ASME Automatic Control Division Award" in 1961, and the "International Society of Automation Award" for excellence in documentation in 1964. In recognition of his distinctive achievements, the "Rufus Oldenburger Medal" [15] was established in 1968 and awarded by the ASME Automatic Division. This medal is awarded to individuals that have made significant contributions to the field of automatic control. In addition, he was presented with a certificate by the members of the Automatic Control Division that designated him the "Most Honored Member of the Automatic Control Division." He passed away on November 22, 1969, at the age of 61.

The 1965 recipient Arthur M. Wahl (Fig. 6) is distinguished for his outstanding achievements in spring design. His research focused on understanding the stress in helical springs and developing theoretical models to calculate the stress of springs [16]. In addition, he devised the Wahl Formula [17] by comprehensively considering the restrictions imposed by the materials employed and mechanical stresses generated during operations. He published over 65 articles and authored eight books, including the monograph *Mechanical Springs* published by McGraw-Hill Book Inc. in 1963 [18]. This monograph provided a comprehensive overview of spring design and engineering, including detailed information on the materials, manufacturing, and theoretical calculations of springs. In recognition of his achievements, he received the "Junior Award" from ASME and the "Charles Russ Richards Memorial Award" [19] (established in 1944) in 1949, which is a joint award issued by ASME and the Pi Tau Sigma (National Mechanical Engineering Honor Society). This award is given to individuals that have made outstanding achievements in mechanical engineering over 20 years or more after their graduation. He passed away on May 7, 2003, at the age of 101.

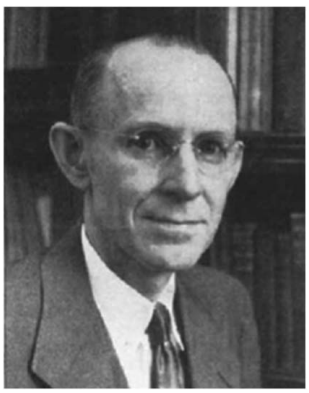

Fig. 6 1965 Recipient: Arthur M. Wahl

Fig. 7 1966 Recipient: Beno Sternlicht

The 1966 recipient Beno Sternlicht (Fig. 7), FASME, Member of the National Academy of Engineering (NAE), is distinguished for pioneering novel turbomachinery developments, energy recovery and propulsion systems, and the world's first Brayton cycle closed-loop gas-bearing turbomachinery. He co-authored a book with O. Pinkus in 1961 on *Theory of Hydrodynamic Lubrication* by McGraw-Hill Book Inc. [20]. In addition to his engineering work, he was the co-founder of Mechanical Technology Inc., a company that manufactured testing and measuring instruments, and served as the Chair of the Comfortex Corp. In addition, he served as the Chair of the NASA Committee on Space Power and Propulsion (1972–1975) [21]. He was also a passionate advocate for technological development in the developing world. He founded and served as the President of the Volunteers in Technical Assistance (VITA), a nonprofit organization that has been offering technological and engineering support to developing nations for the past 43 years. He was also a consultant to Israel, India, and the People's Republic of China on energy issues. His contributions to engineering were widely recognized during his lifetime. He passed away on May 6, 2012, at the age of 84.

The 1967 recipient Ernest Wildhaber (Fig. 8) is distinguished for his eminent achievements in the field of gear manufacture and design. He was a gear inventor with 279 patents. His numerous patents and significant contributions to the field have exerted a lasting impact on modern vehicles and machinery. The hypoid gear drive, which he invented and developed, remains prevalent used today, and his theoretical development of the hypoid gear drive has prevented problems, including singularities and undercutting [22]. He also invented the Revacycle method, a highly effective method for fabricating straight bevel gears [23]. He was a consultant at Sier Bath, where he helped to develop the Vari-Crown gear coupling, and served as an engineering consultant at Gleason Works, where he began the most successful period of his career as a creative engineer and inventor. He passed away in 1979, at the age of 86.

Fig. 8 1967 Recipient: Ernest Wildhaber

The 1968 recipient C. Walton Musser (Fig. 9) is distinguished for his outstanding developmental contributions to the gear drive and stepper actuator. As a research consultant to the U.S. Department of Defense at Frankford Arsenal (1941–1956), he worked on various projects related to defense technology, including the development of the recoilless rifle and various aircraft safety devices, such as the cartridge riven catapult, canopy jettison system, and parachute release device used during World War II. In addition to his work on defense technology, he also made significant contributions to the field of engineering. He invented the strain wave gear drive, which is widely used in robots, and the world's first fluid stepper actuator [24]. He was co-sponsored by the U.S. Government, General Motors, Olin Mathieson, and the United Shoe Machinery Corporation. He won the "Commendation for Exceptional Civilian Service" award from the U.S. War Department, which is the highest civilian award in the U.S. Army. He passed away on June 8, 1998, at the age of 89.

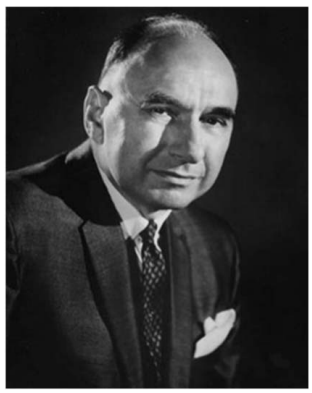

Fig. 9 1968 Recipient: C. Walton Musser

The 1969 recipient Eugene I. (Ivan) Radzimovsky (Fig. 10) is distinguished for his significant achievements in the field of

Fig. 10 1969 Recipient: Eugene I. Radzimovsky

engineering mechanics. He is particularly known for his work in the areas of endurance under variable contact stresses, hydrodynamic theory of lubrication, dynamic strength of screw connections, efficiency theory of planetary transmissions, analysis and synthesis of the nonevolving force profile, dynamics of force transmissions, and gear transmissions. He authored a monograph in 1959 on *Lubrication of Bearings: Theoretical Principles and Design* [25]. This monograph served as a textbook for engineering graduate students, providing them with the knowledge and tools necessary to design and service bearings. In this research, he emphasized the importance of identifying operating conditions, machine requirements, and other constraints to develop effective design criteria based on the basic theory of hydrodynamic lubrication. In 1940, he was awarded the "State Prize of the Academy of Sciences of the Ukrainian SSR" for his work on external stresses under dynamic loading. He passed away on May 23, 1975, at the age of 69.

The 1970 recipient Reynold B. Johnson (Fig. 11), IBM[3] Fellow, Member of the NAE, is distinguished for his outstanding contributions to the educational and data processing fields via his numerous ingenious inventions and innovations dating back to the development of the first electric test-scoring machine [26]. In 1937, he invented the IBM 805, a test scoring machine that adopted electrical sensors to detect marks made on an examination paper and converted them into a visual representation of the total net score. Later in his career, he turned his attention to the computer storage system. He established the random-access method of accounting and control, a system that utilizes magnetic disks to store and access data, and he is widely known as the father of the hard-disk drive [27]. He received the "National Medal of Technology" in 1986, the "Computer Pioneer Award" from the Institute of Electrical and Electronics Engineers (IEEE) in 1987, and the "Magnetics Society Award" for Information Storage in 1989. In 1992, the IEEE established the "IEEE Reynold B. Johnson Information Storage Systems Award" [28] to recognize his outstanding contributions to information storage systems. In addition, he received the "Founder's Gold Medal" from the Educational Records Bureau in 1997. He passed away on September 15, 1998, at the age of 92.

Fig. 11 1970 Recipient: Reynold B. Johnson

The 1971 recipient Walter L. Starkey (Fig. 12) is distinguished for his outstanding contributions to fatigue failure and fretting fatigue. He served as Chair of Mechanical Engineering Department at the Ohio State University from 1976 to 1977 and he also served as the National Chair of the ASME Machine Design Division. In 2011, he authored *Evolution Exposed and Intelligent-Design Explained* by Xlibris [29]. In addition to his research, he was renowned in the higher education system for his unique approach to teaching design synthesis, which emphasized practical examples and design principles. His teaching and mentorship inspired several students, including the 1997 recipient, Jack Collins. He was awarded the "Distinguished Service Award" in 1955 for a lifetime of distinguished professional achievements in engineering from the Ohio State University and the "Habel Award" in 1966 for his research, teaching, and community contributions. He passed away on November 11, 2014, at the age of 94.

Fig. 12 1971 Recipient: Walter L. Starkey

The 1972 recipient Ferdinand Freudenstein (Fig. 13), FASME, FNYAS,[4] Member of the NAE, is distinguished for his leadership and research in kinematics and the design of mechanisms, and is known as the father of modern kinematics [30] in the USA. His pioneer work in kinematics began with the introduction of the Freudenstein Equation [31] in his PhD dissertation in 1954. This equation adopts an algebraic method to synthesize a planar four-bar linkage function generator and is widely regarded as a turning point in modern analytical kinematics [32]. Throughout his 42-year tenure at Columbia University, he supervised numerous students who went on to become distinguished professors in several nations. His research results have influenced the teaching and practice of mechanisms and machine theory globally and have also been adopted in various industry applications [33,34]. He was the Conference Chair of the Eighth Biennial ASME Mechanisms Conference held at the Purdue University on October 19–21, 1964 [12]. He received the "Mechanisms Lifelong Contribution Award" (renamed in 2000 as the "Mechanisms and Robotics Award") in 1978 [35] and the "Charles Russ Richards Memorial Award" in 1984 [19]. In 1992, he was awarded the "Egleston Medal" by Columbia University for his distinguished engineering achievements. He served as the advisor to the National Science Foundation (NSF) and the United States Army Research Laboratory. In addition to his remarkable achievements in academia, he also made significant contributions to the industry. He was an industrial consultant at Bell Telephone Laboratories, Designatronics, IBM, Singer Company, Foster Wheeler, Gulf and Western, and General Motors. In recognition of his contributions, a conference was arranged to celebrate his 65th birthday in 1991, which led to the publication of *Modern Kinematics: Developments in the Last Forty Years* [36]. This monograph overviews the historical background and evolution of kinematics over the past four decades, highlighting the impact of his work on the field. He passed away on March 30, 2006, at the age of 79. In the same year (2006), the

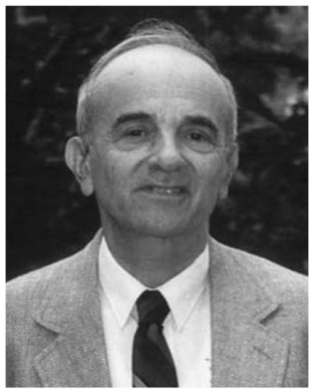

Fig. 13 1972 Recipient: Ferdinand Freudenstein

[3]International Business Machines Corporation (IBM).

[4]Fellow of New York Academy of Sciences (FNYAS).

Freudenstein academic family tree [37] was first presented at the Columbia University in remembrance of Prof. Freudenstein and there were over 500 academic decedents in the academic tree at that time, including the 1975 recipient (George N. Sandor), 1984 recipient (Bernard Roth), 1989 recipient (Arthur G. Erdman), 1994 recipient (Kenneth J. Waldron), 2001 recipient (Steven Dubowsky), 2004 recipient (Sridhar Kota), 2005 recipient (Bahram Ravani), 2009 recipient (J. Michael McCarthy), 2014 recipient (Larry L. Howell), 2017 recipient (S.V. Sreenivasan), and 2019 recipient (Gregory S. Chirikjian).

The 1973 award is vacant.

The 1974 recipient Allen Strickland Hall, Jr. (Fig. 14) is distinguished for his eminent achievements in kinematics and mechanism design. He published more than 40 journal papers and authored seven monographs and books on kinematics, mechanisms, and design and the problems of kinematics and mechanisms. In 1961, he authored the monograph *Kinematics and Linkage Design* by Prentice-Hall [38] and in 1981 the monograph *Notes on Mechanism Analysis* by Balt Publishers [39]. In addition, he co-authored the book *Theory and Problems of Machine Design* by Schaum Publishing Company [40]. Under his supervision, 18 students earned their Ph.D. degrees, with many of them pursuing further research in kinematics and establishing their own teaching professions. He was the former Chair of the Mechanical Engineering Division, American Society for Engineering Education (ASEE), and a former Editor of the Mechanical Engineering News, ASEE. He played a major role in organizing the first U.S. Mechanisms Conference in 1953 [12] and is known as the father of the Mechanisms Conference. The inaugural conference included seven papers that were published in Mechanical Design as part of its proceedings. The first of these papers, *Mechanisms and Their Classification* [41], was authored by him. He was the Conference Chair of the 3rd–7th Mechanisms Conferences (1956–1962). He received several prestigious awards during his lifetime, including the "Mechanisms Lifelong Contribution Award" in 1974 [35] and the "Oklahoma State University Award" in 1977 for his contributions to the Applied Mechanisms Conference. He was a member of the Senate of the Design Engineering Division. At Purdue University, the Allen Hall Lecture was established to honor Allen Strickland Hall. He passed away on January 24, 1999, at the age of 81.

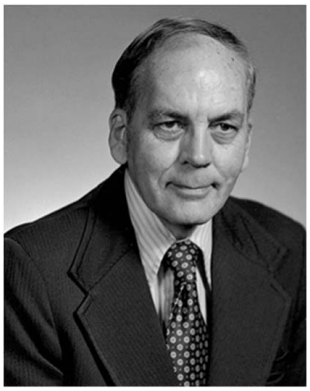

Fig. 14 1974 Recipient: Allen Strickland Hall, Jr.

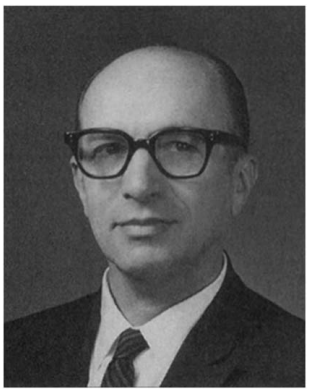

Fig. 15 1975 Recipient: George N. Sandor

The 1975 recipient George N. Sandor (Fig. 15), FASME, Honorary Member of the Hungarian Academy of Sciences (HAS), is distinguished for his outstanding contributions to mechanism theory. As a key contribution to the field, he provided the foundation for utilizing digital computation in linkage synthesis and adopting complex numbers to express the vectorial entities of planar kinematics [42]. He published over 140 articles and co-authored *Advanced Mechanism Design V. 2: Analysis and Synthesis* with A.G. Erdman published by Prentice-Hall in 1984 [43]. He was the Alcoa Foundation Professor of Mechanisms Design (1966–1975), Chair of the Machines and Structures Division (1967–1974), and the Director of the Engineering Design Center at the University of Florida in 1975. He received the "Mechanisms Lifelong Contribution Award" in 1980 [35] and the "OSU Applied Mechanisms Award" and "Doctor Honoris Causa" in Mechanical Engineering at the Technological University of Budapest in 1986. He was also elected as an Honorary Member of HAS. He passed away on April 22, 1996, at the age of 84.

The 1976 recipient Charles W. Radcliffe (Fig. 16), Honorary Member of AAOP,[5] is distinguished for his remarkable contributions to artificial leg fitting techniques. He is widely recognized as the father of prosthetic biomechanics for his leading contributions to the quadrilateral socket, patellar-tendon-bearing (PTB) prosthesis, solid ankle cushion heel (SACH) foot, and four-bar prosthetic knee. He invented the Radcliffe knee and co-authored a book in 1978 on *Kinematics and Mechanisms Design* with C.H. Suh by Wiley [44]. During the time of its publication, the prevailing engineering pedagogy relied on analytical and graphical methods for the planar and spatial mechanisms analyses. However, this book is one of the first textbooks to demonstrate a novel approach that employs numerical methods. He received the "Honorary Membership Award" in 1997 from AAOP and a "Lifetime Achievement Award" at the Hanger Educational Fair in Austin. He passed away on December 6, 2013, at the age of 91.

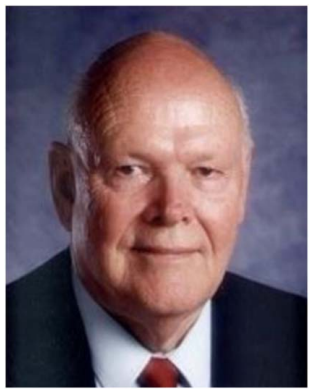

Fig. 16 1976 Recipient: Charles W. Radcliffe

The 1977 recipient Mathew M. Kuts is distinguished for his prominent inventions and obtained over 50 patents in designing various cutting apparatus for cutting a wide range of materials, including rubber bracelets, sheet material, tires, moving tubes, fabric, etc. One of his notable contributions was the *Method and Apparatus for Cutting Rubber Sheets* published in 1959 [45]. This invention provided a method for cutting a sheet of uncured rubber material, which was a crucial step in the manufacturing of rubber products such as tires. Another significant invention was the *Needle Punch Machine and Method* patented in 1970 [46]. This invention addressed the issues of creating a compact, uniformly dense, and interlocked structure of a needled fabric. In 1980, he patented *Fabric Cutter* which was designed for elastomeric fabric materials such as the ply stock used in manufacturing pneumatic tires [47]. This invention improved the efficiency and accuracy of the tire manufacturing process.

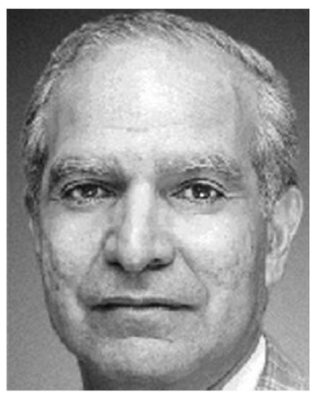

Fig. 17 1978 Recipient: Ali A. Seireg

[5]American Academy of Orthotists and Prosthetists (AAOP).

The 1978 recipient Ali A. Seireg (Fig. 17), Honorary Member of CMES,[6] Foreign Member of Russian Academy of Sciences, is distinguished for his outstanding work in mechanical and biomedical engineering design. He was the first in the world to develop a mathematical model that could predict the forces and interactions between the muscles and joints of the entire human musculoskeletal system when a motion input is introduced. He was the Kaiser Professor at the University of Wisconsin at Madison and the Ebaugh Professor at the University of Florida at Gainesville. Throughout his career, he published over 300 papers and authored seven books. He co-authored *Optimized-Motion Planning: Theory and Implementation* with C. Ahrikencheikh in 1994 [48] and *The Kinematic Geometry of Gearing: A Concurrent Engineering Approach* with D.B. Dooner in 1995 [49] both published by John Wiley & Sons. He was the Editor of the ASME Hybrid Journal on Computers in Mechanical Engineering (CIME). He received the "George Westinghouse Award" of ASEE in 1970, the "Charles Russ Richards Memorial Award" of ASME in 1973 [19], and the "E.P. Connell Award" of the American Gear Manufacturers Association (AGMA) in 1974. In addition, he founded and served as the Chair of the ASME Computer Engineering Division (1980–1981). He also served as the President of the ASME/AGMA Gear Research Institute (1983–1993) and the Chair of the ASME Council on Engineering (1985–1989). He was awarded the "Kuwait Prize" for science in 1987 and the "ASME Design Automation Award" in 1990. He passed away on September 3, 2002, at the age of 74.

3 Second Twenty Years: ASME Machine Design Award (1979–1999)

3.1 Summary. Among the 20 recipients from 1979 to 1999 (vacant in 1998), the recipients' achievements are in the areas of cam design, prevalent software, computer-aided design, bearing structure design, optimization, bearing lubrication, mechanical fatigue, gear design, energy transfer, mechanism synthesis, mechanical design, optimization and mechanical system dynamics. Among them, Joseph Shigley is a leading mechanical designer who has been cited numerous times in mechanical design. In addition, Erskine Crossley is a leading figure in mechanisms, and the founding Vice President of the International Federation for the Promotion of Mechanism and Machine Science (IFToMM). The best paper in *Mechanism and Machine Theory* is named after him. Hans Eschenauer, the recipient of the "European Steel Design Award" from Germany, is among the recipients. Bernard Roth is a leading figure in theoretical kinematics and spent an extensive and thorough effort in generating a comprehensive book on theoretical kinematics that paves a foundation for advanced kinematics. Kenneth Waldron developed a computer-coordinated legged system for the first time, by applying the mechanisms and machine design to robotics.

3.2 Achievements of the Recipients of the Second Twenty Years. *The 1979 recipient Robert R. Slaymaker* is distinguished for his outstanding contributions to bearings as one of the earliest researchers in this field. His research involves using computers to analyze the effects of alterations in speed, power, dimensions, and oil on the behavior of main bearings, crankpin bearings, and wrist pin bushings under dynamic loads, with a focus on identifying potential trouble spots. He authored the monograph *Bearing Lubrication Analysis* by John Wiley and Sons in 1955 [50] to handle sleeve bearings, the most common type of bearing found in machines. The monograph discussed the conditions that contribute to the successful operation of bearings lubricated from an external source, including those without an external lubricant supply. Several actual case studies and numerical examples were included to predict the temperature increase and provide reasons for the wide variety of bearing materials. He authored the monograph *Mechanical Design and Analysis* [51] in 1959, also published by John Wiley and Sons, which introduced a realistic approach to design using industrial case studies. He was granted a patent in 1965 for *Cyclically Operating Piezoelectric Voltage Source* [52], which relates to piezoelectric devices and, more particularly, considers a piezoelectric voltage source in which a piezoelectrically responsive element is slowly compressed and compressive stress is suddenly released to generate an electric potential. He is a professor of machine design at Case Institute of Technology (merged with the Western Reserve University to form Case Western Reserve University in 1967) and a consultant to industrial clients such as Cleveland Graphite Bronze Co., later known as Gould Engine Parts Division in 1969.

The 1980 recipient Merhyle F. Spotts is distinguished for his outstanding contributions to the design of machine elements. He authored the monograph *Design of Machine Elements* by Prentice-Hall in 1948 [53]. In this monograph, he presented a comprehensive survey of machine elements and analytical design methods based on the theories of mechanics and strength of materials. The monograph provided readers with the tools and techniques necessary to facilitate design calculations for a wide range of mechanical elements, including shafts, springs, screws, belts, clutches, brakes, chains, welded and riveted connections, ball and roller bearings, spur gears, helical gears, bevel gears, worm gears, etc. In addition, calculated numerical examples were included to demonstrate the principles that apply to the entire field of mechanical design. The monograph was released in eight editions and was adopted worldwide for decades. He authored the monograph *Dimensioning and Tolerancing for Quantity Production* by Prentice-Hall [54] in 1983. He passed away on June 18, 1994, at the age of 98.

The 1981 recipient Henry O. Fuchs (Fig. 18) is distinguished for his outstanding contributions to the study of fatigue in metals and the development of a manufacturing process that increased their resistance to failure due to fatigue via techniques such as shot peening. He was also known for his innovative work as a mechanical designer and his pioneering use of case studies in engineering education. He served as the President of the Metal Improvement Company (1946–1960) and later became the Director of the Engineering Case Program (1964–1973). In 1980, he co-authored the book *Metal Fatigue in Engineering* [55] with R.I. Stephens, published by John Wiley & Sons. In the same year, he received the third annual "ASME Leonardo da Vinci Award," which is awarded to eminent engineers whose design or invention is recognized as an important advancement in machine design. He passed away on January 17, 1989, at the age of 80. To honor his memory and contributions to the Society of Automotive Engineers (SAE) Fatigue Design & Evaluation Committee, SAE established the annual "Henry O. Fuchs Student Award" in 1991. The award recognizes a graduate or recently graduated student working in the field of fatigue research and applications. Furthermore, Stanford University established the annual "Henry O. Fuchs Memorial Award" in the same year awarded by the Design Group faculty in recognition of outstanding engineering design work, principally at the senior level.

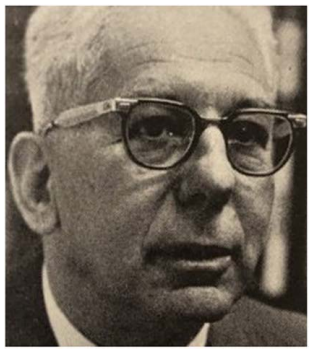

Fig. 18 1981 Recipient: Henry O. Fuchs

The 1982 recipient Delbert Tesar (Fig. 19) is distinguished for his outstanding work on intelligent actuators for robotics as standardized driving modules. His research interests include robotics,

[6]Chinese Mechanical Engineering Society (CMES).

Fig. 19 1982 Recipient: Delbert Tesar

electro-mechanical actuators, embedded intelligence, open architecture vehicles, ships, aircraft, machinery for manufacturing, human rehabilitation systems, and long-duration lunar base habitat operations. He began his research on robotics with an emphasis on open architecture and a generalized criteria-based decision-making structure to plan and achieve the motion of robot manipulators in 1965 and then on intelligent actuators for robotics as standardized driving modules in 1975. He co-authored the book *The Dynamic Synthesis, Analysis, and Design of Modeled Cam Systems* in 1976 with G.K. Matthew, published by Lexington Books [56]. Together with J. Peter Sadler, he was the Papers Review Chair of the 15th Biennial ASME Mechanisms Conference held at Minneapolis, Minnesota, on September 24–27, 1978 [12]. He served as an expert witness of the House Science and Technical Committee for the United States House of Representatives, 1978–1984. He received the "Outstanding Technology Achievement Award" from the Florida Engineering Society in 1982. In addition, he served on the Air Force Science Advisory Board (1982–1986). He has become the Carol Cockrell Curran Chair in Engineering and has been the Director of the Robotics Research Group at the University of Texas at Austin since 1985. He was a member standing committee National Research Council for Space Station (ISSA), 1992–1995, and since 2000, he has been a panel member to review the science for nuclear facilities dismantlement in the National Research Council. He received the "Joseph F. Engelberger Robotics Award" (the most prestigious international robotics honor) for Education from the International Robotic Industries Association in 2005. He was appointed as a member of the U.S. Army Science Board for a third-year term in 2008. To date, he has supervised more than 220 graduate students and postdoctoral researchers. He has written 90 position papers and 230 refereed conference and journal papers, and has also given more than 600 invited lectures. He has obtained more than 30 patents relating to rotary actuators, drives, wheels, gear trains, etc. His work is now documented in 30 major program plans (2800 pages) for open architecture systems for the operation of aircraft, submarines, orthotics, wind turbines, light and heavy commercial vehicles, freight trains, vertical take-off and landing aircraft, educational robots, space and battlefield robots, etc.

The 1983 recipient Edward J. Wellauer is distinguished for his outstanding engineering contributions to the gearing and power transmission industry, particularly in the fields of gear strength and durability ratings. He obtained more than 20 patents relating to vertical right-angle speed reducer, house selective-angle speed-reducer, speed reducer housing or similar article, coupling, flexible coupling, flexible shaft-coupling, flexible grand coupling, serpentine grid flexible coupling, flexible shaft coupling with overload release, pressure-operated frictional coupling, coupling cover, fabricated structure, recirculating cooling system for reduction gear, torsion spring clutch, etc. He proposed a method for calculating the minimum and maximum lengths of the lines of contact for gear drive systems [57] and presented a nomograph to compute the film thickness at the pitch point of helical gears [58]. He contributed to the chapter on the Load Rating of Gears in the monograph *Gear Handbook: The Design, Manufacture, and Application of Gears* edited by D.W. Dudley published in 1962 by McGraw Hill Higher Education [59]. He passed away on January 22, 1998, at the age of 86.

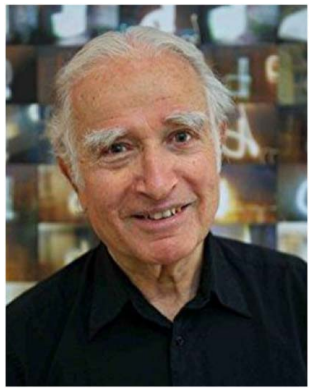

Fig. 20 1984 Recipient: Bernard Roth

The 1984 recipient Bernard Roth (Fig. 20), FASME, is distinguished for his novel contributions to kinematics, dynamics, control, and design of computer-controlled mechanical devices. In kinematics, he studied the mathematical theory of rigid body motions and its application to the design of machines [60–62]. He was the Papers Review Chair of the 10th Biennial ASME Mechanisms Conference held at Georgia Institute of Technology, Atlanta, Georgia on October 7–9, 1968, and the Conference Chair of the 12th Biennial ASME Mechanisms Conference held at San Francisco, CA, on October 9–12, 1972 [12]. He was selected as a member of the Executive Council (1976–1983) and also the President of IFToMM (1980–1983). In 1979, he co-authored the book *Theoretical Kinematics* with O. Bottema published by the North Holland Publishing Company and then in 1990 re-published by Dover Publications, Inc. [63,64]. He received the "Mechanisms Lifelong Contribution Award" in 1982 [35], and the "Joseph F. Engelberger Robotics Award" in 1986, which is presented to individuals for their excellence in technology development and applications, including their education and leadership in the robotics industry [65]. He has received seven Best Paper Awards and the "Melville Medal" from ASME in 1995 for his contributions to the science of kinematics on spatial analog of the planar Burmester theory [66]. In 2000, he received the "ASME Ruth and Joel Spira Outstanding Design Educator Award," an award that recognizes a person who exemplifies the best in furthering engineering design education via vision, interactions with students in the industry, scholarships, and impact on the next generation of engineers, whose actions provide a model for other educators to emulate. In the same year, he received the "IEEE Pioneer in Robotics Award," which recognizes individuals who by virtue of initiating new areas of research, development, or engineering have had a significant impact on developing the robotics and/or automation fields [67]. He was the Honorary Co-Chair of the International Conference on Robotics and Automation in 2007. In 2011, he received the "ASME Mechatronics and Embedded Systems and Applications Achievement Award," and in 2012 the "IEEE Robotics and Automation Award" for his fundamental contributions to robot kinematics, manipulation, and design. In 2012, Columbia University's Engineering School Alumni Association awarded him with the prestigious Egleston Medal for Distinguished Engineering Achievement. In 2015, Roth authored the book *The Achievement Habit: Stop Wishing, Start Doing, and Take Command of Your Life* [68], which is based on his experiences teaching design thinking and innovation at Stanford and provides practical advice for achieving personal and professional goals. He is now a Rodney H. Adams Professor of Engineering at Stanford University, and Academic Director of the Hasso Plattner Institute of Design (founded in 2004 as the co-founder with David M. Kelley). To date, he lectures on advanced kinematics and transformative design.

The 1985 recipient Joseph E. Shigley (Fig. 21), FASME, is distinguished for his outstanding contributions to machine design, including the mechanics of walking vehicles. He conducted research on various topics, such as the design and construction of an automatic twist counter for textile yarns, dynamic cutting forces on sawtooth, and the mechanical and preservative properties of bamboo. He authored eight monographs and books, including *Simulation of Mechanical Systems-An Introduction* [69], *Applied Mechanics of Materials* [70], and *Theory of Machines and Mechanisms* (with John J. Uicker, Jr. and G.R. Pennock) [71–75]. In 1956, he authored the

Fig. 21 1985 Recipient: Joseph E. Shigley

monograph *Machine Design*, which evolved into *Mechanical Engineering Design* [76] (with L.D. Mitchell and H. Saunders). He served as the Papers Review Chair of the 11th Biennial ASME Mechanisms Conference held at Columbus, OH, on November 1–4, 1970 [12]. He received the "Mechanisms Lifelong Contribution Award" [35] in 1974 and the "ASME Worcester Reed Warner Medal" in 1977. He retired from the University of Michigan as Professor Emeritus of Mechanical Engineering in 1978. He was Co-Editor-in-Chief of the renowned *Standard Handbook of Machine Design* with C.R. Mischke and T.H. Brown, Jr. by the McGraw-Hill Book Inc., published in 1986 [77], which won the Award for Outstanding Book in Engineering and Technology (1987) awarded by Association of American Publishers. His monographs have been widely used in the USA and internationally. His contributions have been referenced by nearly every mechanical engineer for the past half-century in terminology, equations, or procedures known as "Shigley." He consulted extensively in the machine design industry, working with companies such as Pacific Mills, Deering-Miliken, Industrial Machine Corp., Owens-Corning, Boeing Aircraft, and The Upjohn Co. He passed away in May 1994, at the age of 84.

The 1986 recipient Atmaram H. Soni (Fig. 22), FASME, is distinguished for his outstanding contributions to kinematics, bioengineering, manufacturing, and robotics. His research included three-dimensional kinematics of the lumbar spine, dynamics of mechanical systems and advanced intelligent flexible assembly systems, etc. He initiated and organized the ASME Flexible Assembly Conference and established the biennial OSU Applied Mechanisms Conference in 1969. He was the Chair of the ASME Mechanical Committee (1972–1978). He authored the monograph *Mechanism Synthesis and Analysis* by McGraw-Hill Book Inc. in 1974 [78]. He was renowned for his contributions to the mechanism and robotics research industry, as well as his services to City, State, and Federal Government. He was appointed Regent Professor at the Oklahoma State University and held the titles of Ohio Eminent Scholar and L.W. Scott Alter Professor at the University of Cincinnati (UC) and the Board Director of the Chartered Institute of Marketing Center. He founded the Center for Advanced Manufacturing Processes at UC and served as its Director [79]. In addition, he received the "Mechanisms Lifelong Contribution Award" [35] in 1994. He passed away on February 8, 2000, at the age of 64.

Fig. 22 1986 Recipient: Atmaram H. Soni

The 1987 recipient Gerard G. Lowen, FASME, dean of mechanical engineering at the City College of New York, is distinguished for his outstanding work on the design and dynamic analysis of machinery and ordnance safety devices. He received patents for the force balancing techniques for complex cyclically moving planar linkages and authored several reports on *Basic Study of Theory of Safety and Arming Devices for Low Velocity Projectiles* [80], *Optimization of Step-up Gear Trains with Different Kinematic Profiles* [81], and *Automated Strength Determination for Involute Fuze Gears* [82] published by Defense Technical Information Center. He was a technical advisor and consultant to various U.S. Army agencies in this field [83]. He was the Conference Chair of the 13th Biennial ASME Mechanisms Conference held at New York, New York on October 6–9, 1974 [12]. He received the "Mechanisms Lifelong Contribution Award" [35] and was named "Outstanding Teacher" of City College of New York in 1984. He was the Chair of the Mechanic Engineering Department at City College of New York (1987–1990), and the Associate Dean of Graduate Studies, Engineering since 1990. He passed away on September 13, 2012, at the age of 90.

The 1988 recipient Hamilton H. Mabie, FASME, is distinguished for his outstanding contributions to kinematics, gears, and rolling element bearings. In addition to his research on kinematics, he also dedicated his work to gears, torque characteristics of instrument ball bearings, environmental effects on the fatigue life of aluminum, and fretting corrosion of roller bearings. In 1957, he co-authored the book *Mechanisms and Dynamics of Machinery* with C.F. Reinholtz published by John Wiley & Sons [84], which covers linkages and mechanisms, cams, standard and nonstandard spur gears, bevel, helical and worm gearing, gear trains, velocity and acceleration analysis using both complex number methods and loop-closure equations, force analysis of machinery using both the superposition and matrix methods, balance of machinery, synthesis including function generation, path generation and body guidance, and the problems of branch, order, and Grashof defects, spatial mechanisms, and robotics. BASIC-language computer programs are listed throughout the monograph to demonstrate the simplicity and power of computer methods. In addition, he was a licensed professional engineer and a Life Fellow of the ASME. He passed away on February 23, 2000, at the age of 85.

The 1989 recipient Arthur G. Erdman (Fig. 23), FASME, FAIMBE,[7] is distinguished for his outstanding contributions to mechanical design, bioengineering plus medical devices, and product design. His primary areas of interest include artificial intelligence, geometry, mechanism, kinematics, and computer vision. He was the Conference Chair of the 15th Biennial ASME Mechanisms Conference held at Minneapolis, Minnesota on September 24–27, 1978 [12]. He received the "Gustus L. Larson Memorial Award" in 1980 for his outstanding achievements in mechanical engineering. He co-authored the book *Mechanism Design: Analysis and Synthesis* with G.N. Sandor in 1984 published by Prentice-Hall [85]. In 1985, he created LINCAGES the linkage interactive computer assisted geometrically enhanced synthesis, a widely adopted mechanism software design package, to assist with the synthesis and analysis of planar four- and six-bar mechanisms. He received the "Mechanisms Lifelong Contribution Award" [35] in 1988. He served as the Chair of the Bioengineering Divisions (1992–1993) and the Publications Committee (2004–2005) of ASME, and the founding Technical Editor of the ASME *Journal of Medical Devices* (2007–2010) [12]. He received the "ASME Ruth and Joel Spira Outstanding Design Educator

Fig. 23 1989 Recipient: Arthur G. Erdman

[7]Fellow of American Institute for Medical and Biological Engineering (FAIMBE).

Award" in 2010, the Tekne Award in the "Innovative Collaboration of the Year," the "Minneapolis/St. Paul Business Journal 2014 Titan of Technology," the "2017 University of Minnesota Entrepreneurship Faculty of the Year Award," and the "ASME Savio L-Y Woo Translational Biomechanics Medal" in 2017 for "translating meritorious bioengineering science to clinical practice via research, education, professional development, and with service to the bioengineering community." He has consulted at over 50 companies in mechanical and product *design*, including Honeywell, Medtronic, Xerox, 3M, Andersen Windows, Proctor and Gamble, Graco, HP, Rollerblade, Sulzer Medica, Gillette, Dell, Abbott (formerly St Jude Medical), and Yamaha. Currently, he holds the Richard C. Jordan Professorship and is a Morse Alumni Distinguished Teaching Professor at the University of Minnesota, where he also serves as the Director of the Earl E. Bakken Medical Devices Center.

The 1990 recipient Charles R. Mischke (Fig. 24), FASME, is distinguished for his outstanding contribution to designing a reliability specification, computer-aided design, and design morphology. He garnered expertise in machinery, kinematics, stochastics of steel, reliability of design, and engineering design methodology. He created the computer-augmented design engineering technique software, and his work in computer-aided design introduced new horizons by providing engineers with the refinement and innovation of formerly complex, time-intensive preliminary design work. He authored monographs *Elements of Mechanical Analysis* by Addison-Wesley in 1963 [86] and *An Introduction to Computer-Aided Design* by Prentice-Hall in 1968 [87]. He served as Division Leader (1972–1982) of the Machines and Systems Unit in the Department of Mechanical Engineering at Iowa State University. He was the recipient of the "Alcoa Foundation Professor" in 1974, the "SAE Ralph R. Teetor Educational Award" in 1977, and the "Outstanding Teaching Award" from the Iowa State University in 1980. He authored the monograph *Mathematical Model Building: An Introduction to Engineering* by Iowa State Pr in 1980 [88] and coedited the well-known *Standard Handbook of Machine Design* with Joseph E. Shigley and T.H. Brown, Jr. published by the McGraw-Hill Book Inc. in 1986 [77]. In addition, he received the "Iowa Legislature Teaching Excellence Award" in 1991, the "ASEE Ralph Coats Roe Award" in 1991, and the "ASEE Centennial Certificate of Recognition" in 1993. He retired from Iowa State University in 1993 as Professor Emeritus of Mechanical Engineering. He passed away on September 10, 2016, at the age of 89.

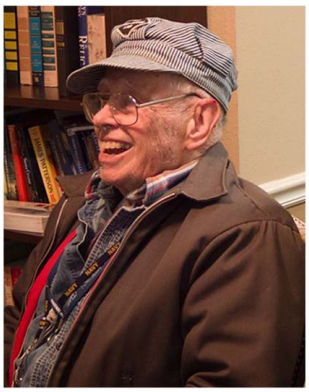

Fig. 24 1990 Recipient: Charles R. Mischke

The 1991 recipient F. R. Erskine Crossley (Fig. 25), FASME, is distinguished for his leading work in the field of dynamics and controls and nonlinearities. He proposed a dynamic model (Hunt-Crossley model) together with Prof. Kenneth Hunt based on Hertz's elastic theory, which is one of the first and most prevalent viscoelastic models used to describe contact interactions in various fields, including mechanical engineering, materials science, and biomechanics [89,90]. As a pioneer in adopting digital computers for "Mechanism Structural Analysis and Type Synthesis" in mechanical design, he led the investigations on the design effects of applying the criteria of three-dimensional kinematics to two-dimensional kinematics in reducing the required accuracy in dimensions [91]. In 1954, he authored the monograph *Dynamics in Machines* published by Ronald Press Company [92] and worked in 1961 as the Editor of *Proceedings of the International Conference for Teachers of Mechanisms—Dynamic Mechanisms and Nonlinear Control Systems* by Shoe String Press [93]. He was the Conference Chair of the 10th Biennial ASME Mechanisms Conference held at Georgia Institute of Technology, Atlanta, Georgia on October 7–9, 1968 [12,94]. He has served as the Vice President of the IFToMM from its inception in 1969 until 1975 [95]. He is the founding Editor-in-Chief of *Mechanism and Machine Theory* (previously known as *Journal of Mechanisms*, 1966–1972, Executive Editor, 1973–1982, Editor Emeritus, 1983–). He received the "Mechanisms Lifelong Contribution Award" [35] in 1976. He retired in 1983 as Professor Emeritus of Civil and Environmental Engineering at the University of Massachusetts, Amherst. In recognition of his great achievements at his 100th birthday, *Mechanism and Machine Theory* dedicated a special issue in his honor (Vol. 89, 2015). In addition, the 14th IFToMM Word Congress (October 26, 2015, Taipei) held a special session on him. The Crossley Award was established in December of 2016 to recognize the scientific excellence of the most successful papers published in *Mechanism and Machine Theory*. He passed away on February 4, 2017, at the age of 101.

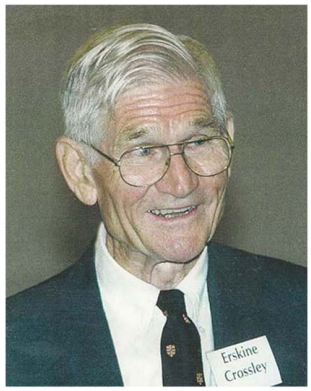

Fig. 25 1991 Recipient: F. R. Erskine Crossley

The 1992 recipient Edward J. Haug, Jr. (Fig. 26) is distinguished for his pioneering work on structural optimization and multibody system dynamics. He founded the University of Iowa (UI) Center for Computer-Aided Design, specializing in virtual prototyping in mechanical system design, and the National Advanced Driving Simulator, the world's most sophisticated simulator for highway safety research and vehicle design. He created the computational program DADS, which enables the industry and government to enhance vehicular dynamic conditions. Ultimately, the program evolved into CADSI, Inc., the first spin-off company at the UI Research Park. He co-authored books with J.S. Arora in 1977 on *Engineering Design Handbook: Computer Aided Design of Mechanical Systems* [96] and in 1979 on *Applied Optimal Design: Mechanical and Structural Systems* [97]. He was the Director of the Center for Computer-Aided Design (1980–1995). He served as the Carver Distinguished Professor of Mechanical Engineering at UI (1990–1998) and Director of the National Advanced Driving Simulator (1992–1998). He is Emeritus Professor at UI and was inducted as the Legacy of Iowa Engineering in 2010 for his exceptional historical contributions toward advancing the College in teaching, research, and service during his engagement with the College.

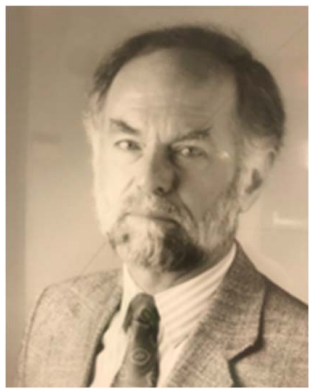

Fig. 26 1992 Recipient: Edward J. Haug, Jr.

The 1993 recipient Charles O. Smith, FASME, FASEE,[8] is distinguished for his outstanding work on engineering materials. He

[8]Fellow of American Society Engineering Education (FASEE).

advocated the extensive use of case studies in engineering materials course instructions including Engineering Materials, Materials and Design, and Advanced Engineering Materials. The used cases included failures in heavy-duty rippers and scrapers for tractors, failures in welded joints in hopper trailers, truck suspension failures, fracture of a large marine gear rim (failure during fabrication), design and fabrication of a seawater test chamber, and development of new steel for rock drills [98]. He authored monographs in 1969 on *The Science of Engineering Materials* by Prentice-Hall [99] to introduce the comprehensive performance and stability of engineering materials, and in 1976 on *Introduction to Reliability in Design* by McGraw-Hill Companies [100], in which he summarized the reliability specification of mechanical products and systematized the existing and similar product reliability technology.

The 1994 recipient Kenneth J. Waldron (Fig. 27), FASME, is distinguished for his outstanding work in machine design and design methodology with a particular focus on robotic and mechatronic systems. His research interests include machine design, mechatronic design, locomotory biomechanics, design of computer-coordinated vehicles, and robotic systems for unstructured environments. He proposed a general method for determining the mobility of any rigid body mechanism using Ball's theory of the instantaneous screw axis [101]. He was the Conference Chair of the 19th Biennial ASME Mechanisms Conference held at Columbus, OH, on October 5–8, 1986 [12]. He received the "ASME Leonardo da Vinci Award" in 1988 and served as the Editor-in-Chief of the *Journal of Mechanical Design-Transactions of the ASME* (1988–1992). In 1989, he co-authored the book *Machines that Walk: The Adaptive Suspension Vehicle* with S.M. Song [102], where the Adaptive Suspension Machine [103] was discussed in depth, which is the first computer controlled legged system designed to operate in completely unstructured terrain. He is the recipient of the "Mechanisms Lifelong Contribution Award" [35] in 1990, and the "Joseph F. Engelberger Robotics Award" in 1997. He served two terms as President of IFToMM (2000–2007). He received the "ASME Ruth and Joel Spira Outstanding Design Educator Award" in 2002 and the "ASME Robert E. Abbott Award" in 2008. He was a Member of the Management Committee of the *IEEE/ASME Transactions on Mechatronics* and Chair of the Systems and Design Group in the Design Engineering Division (founded in 1945 [104]) of ASME (2008–2009). He is the winner of the "Asian Pacific ICT Alliance Award for Industry Applications" in the CAS CROC group in 2015. In 2016, he co-authored the book *Kinematics, Dynamics, and Design of Machinery* [105] with G.L. Kinzel and S.K. Agrawal. He is an Emeritus Professor of Mechanical and Mechatronic Engineering at the University of Technology Sydney and Emeritus Professor of the Design Group in the Department of Mechanical Engineering of Stanford University and a member of Stanford Bio-X.

Fig. 27 1994 Recipient: Kenneth J. Waldron

The 1995 recipient Ray C. Johnson (Fig. 28) is distinguished for his outstanding work on optimum design methods to handle critical industrial design problems with high-speed machinery. He was an Assistant Professor at Yale University from 1958 until 1961. He authored the monograph *Optimum Design of Mechanical Elements* [106] published by John Wiley & Sons, Inc. in 1961 , which covers basic techniques and practical applications for the optimal design of mechanical elements in actual design settings. In 1971, he authored the monograph *Mechanical Design Synthesis with Optimization Applications* [107] by Van Nostrand Reinhold Co. to optimize the kinematic structure with all the characteristics of mechanical elements via the pattern of interconnection. The monographs' topics range from curve fitting, finite differences and equation simplification to the effects of manufacturing errors on product performance, material properties, failure theories, and crucial problem of selecting factors of safety or original design use, to the method of optimum and automated optimal designs and finally optimization problems for both simple and complex mechanical elements. He also contributed to the chapter on numerical methods in the *Standard Handbook of Machine Design* [77] in 1986. He received the "ASME Worcester Reed Warner Medal" in 1993. He is a professor of mechanical engineering at Worcester Polytechnic Institute, where he serves as the Higgins Professor of Mechanical Engineering Emeritus after his retirement in 1994. He also works as a consulting design engineer in the United States.

Fig. 28 1995 Recipient: Ray C. Johnson

The 1996 recipient Hans A. Eschenauer (Fig. 29) is distinguished for his outstanding contributions to applied structural mechanics and computer-aided structural design optimization. His main research activities were focused in the fields of multi-objective, multilevel, topology, and multidisciplinary structural and system optimization. He received the "European Steel Design Award" in 1974. In 1984, he established the Research Laboratory for Applied Structural Optimization. In 1990, he co-authored the book *Multicriteria Design Optimization: Procedures and Applications* [108] with J. Koski and A. Osyczka published by Springer Science & Business Media. In 1992, he became the founder and Head of the Board of the Research Center for Multidisciplinary Analyses and Applied Structural Optimization FOMAAS (a central university institute). He received the "ASME Design Automation Award" in 1995. He retired in the same year while remaining Head of the FOMAAS Board until 1999. In 1996, he co-authored the book *Applied Structural Mechanics: Fundamentals of Elasticity*, *Load-bearing Structures*, *Structural Optimization* [109] with N. Olhoff and W. Schnell published by Springer Science & Business Media. He received the "Ford URP Award" in 2000. He passed away on June 22, 2008, at the age of 78.

Fig. 29 1996 Recipient: Hans A. Eschenauer

The 1997 recipient Jack A. Collins (Fig. 30), FASME, is distinguished for his eminent achievements in the field of failure of materials in mechanical design. He designed the first artificial heart valve, the V-22 Osprey tiltrotor aircraft, crash test dummies, the Lunar Landing Research Vehicle, etc. In 1981, he authored the monograph *Failure of Materials in Mechanical Design: Analysis,*

Fig. 30 1997 Recipient: Jack A. Collins

Prediction, Prevention [110], which covers failure prevention, modes of mechanical failure, strength and deformation of engineering materials, state of stress, relationship between stress and strain, combined stress theories of failure, high and low cycle fatigue, cumulative damage life prediction and fracture control, fatigue analysis and testing, stress concentration, stress rupture in fatigue, fretting, shock and impact, and buckling and instability. In 2009, he co-authored *Mechanical Design of Machine Elements and Machines: A Failure Prevention Perspective* [111] with H.R. Busby and G.H. Staab by John Wiley & Sons, which takes the viewpoint that failure prevention is the cornerstone concept underlying all mechanical design activity. These two monographs remain prevalent at several universities worldwide. He was an engineering consultant for over 50 clients, including NASA, the U.S. Army, the U.S. Air Force, and General Dynamics. He passed away on February 18, 2021, at the age of 91.

The 1998 award is vacant.

The 1999 recipient Panos Y. Papalambros (Fig. 31), FASME, FSAE,[9] Fellow of the Design Society, Member of the NAE, is distinguished for his outstanding work on the design optimization of products and systems. His areas of research include design optimization, large-scale complex system synthesis, automotive systems design, eco-design, and product design. He received the "Tau Beta Pi Outstanding Teacher of the Year Award" (1980–1981), the "Mechanical Engineering and Applied Mechanics (MEAM) Exxon Foundation Award for Outstanding Teaching" (1981–1982), the "MEAM Exxon Foundation Award for Excellence in Research" (1983–1984), the "ASME Young Engineer of the Year Award" (1986), and the "ASME Design Automation Award" for contributions to design optimization and automation in 1998. He co-authored in 1988 the textbook *Principles of Optimal Design: Modeling and Computation* with D.J. Wilde by Cambridge University Press [112–114], highlighting the interplay between the mathematical modeling of design as a decision-making problem and the computational algorithms that will help solve these design optimization problems successfully. This textbook has become a classic reference through three editions (1988, 2000, 2017). He was the recipient of the "JSME Distinguished Achievement Award in Systems and Design" in 2004. From 2006 to 2011 he served as the founding Chair and Director of the University of Michigan interdisciplinary Design Science Doctoral Program. He received the "ASME Ruth and Joel Spira Outstanding Design Educator Award" in 2008. He served as the Technical Editor-in-Chief of the *Journal of Mechanical Design-Transactions of the ASME* (2008–2012). He received the "Stephen S. Attwood Excellence in Engineering Award" from the University of Michigan in 2009, the "ASEE Ralph Coats Roe Award," and the "ASME Robert E. Abbott Award" in 2014. He is the founding Editor-in-Chief of the journal *Design Science* (established in 2015) and served as the President of the Design Society (2017–2019). In 2020, he became one of the recipients of the "ASME Ben C. Sparks Medal." He received the "Best Paper Awards" in ASME Design Automation Conferences (1992, 1995, 2005), in IEEE Electromagnetic Compatibility Symposium (2003), and in the *International Journal of Research in Marketing* (2012) for his authored and co-authored papers. He is a Professor Emeritus in Mechanical Engineering, in Integrative Systems and Design, in Art and Design, and in Architecture, and the James B. Angell Distinguished University Professor Emeritus and Donald C. Graham Professor Emeritus of Engineering at the University of Michigan having retired from the University of Michigan in 2022. He was elected Member of the NAE in 2023 for his "contributions to complex systems optimization and leadership in advancing transformative engineering design research and education."

Fig. 31 1999 Recipient: Panos Y. Papalambros

4 Third Twenty Years: ASME Machine Design Award (2000–2023)

4.1 Summary. The 21 recipients from 2000 to 2023 (vacant in 2011, 2012, and 2021) include experts in the field of screw theory, the highly cited experts with over 20,000 citations to their names, the Assistant Directors for the White House Office of Science and Technology Policy (OSTP), the founding Editor-in-Chief of the *Journal of Mechanisms and Robotics*, the Editor-in-Chief of the *Journal of Mechanical Design,* the Editor-in-Chief of *Robotica*, the Editor-in-Chief of *Wearable Technologies*. Other experts recognized include those with a specialization in fluid mechanics, electromechanical system, mechanical tribology, precision machinery, intelligent drive control, compliant mechanism, and nanomanufacturing, and one with over 100 U.S. patents in the area of nanoscale manufacturing. Among them, there are the former Editor-in-Chief of *Mechanism and Machine Theory*, and the leading experts in robotic mechanisms and reconfigurable mechanisms.

4.2 Achievements of the Recipients of the Third Twenty Years. *The 2000 recipient Joseph Duffy* (Fig. 32) is distinguished for his outstanding contributions to spatial mechanism analysis and screw theory. He authored a monograph *Analysis of Mechanisms and Robot Manipulators* by John Wiley & Sons in 1980 [115], and the monograph *Statics and Kinematics with Applications to Robotics* by Cambridge University Press in 1996 [116], and he co-authored the book *Kinematic Analysis of Robot Manipulators* with C.D. Crane published by Cambridge University Press in 1998 [117]. He was the Conference Chair of the 20th Biennial ASME Mechanisms Conference in 1988. In 1992, he was the recipient of the "ASME DED Mechanisms and Robotics Award" [35]. From 1986 to 2002, Joseph Duffy guided the Center for Intelligent Machines and Robotics' activities, and during this period, several significant contributions were made to the robot end effector, serial manipulator, displacement (orthopedic surgery), kinematics, and parallel manipulator.

Fig. 32 2000 Recipient: Joseph Duffy

[9]Fellow of Society of Automotive Engineers (FSAE).

The 2001 recipient Steven Dubowsky (Fig. 33), FASME, FIEEE,[10] Elected Fellow of the NASA Institute of Advanced Concepts, is distinguished for his outstanding contributions to the development of modeling techniques for manipulator flexibility and the development of optimal and self-learning adaptive control procedures. His research interests include the design and control of high-performance mechatronic systems, with application to space robotics, fuel cell power of field robots and distributed environmental sensors, and the innovative design and control of clean water/clean energy systems. His most cited work was published in the *Journal of Dynamic Systems, Measurement, and Control* in 1979 [118], *International Journal of Robotics Research* in 1985 [119], and *International Journal of Solids and Structures* in 2006 [120]. Prof. Dubowsky was the Conference Chair of the 16th Biennial ASME Mechanisms Conference in 1980 and has served as an advisor and consultant to the NSF, the National Academy of Science/Engineering, the Department of Energy, the U.S. Army, NASA, ESA, and the industry. In 2013, he received the "ASME DED Mechanisms and Robotics Award" [35]. Furthermore, he is a Professor Emeritus of Mechanical Engineering and Professor Emeritus of Aeronautics and Astronautics at Massachusetts Institute of Technology.

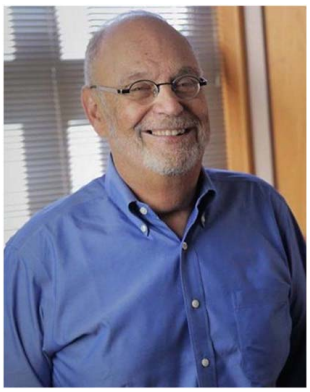

Fig. 33 2001 Recipient: Steven Dubowsky

The 2002 recipient Robert L. Norton (Fig. 34), FASME, Member of the SAE, is distinguished for his outstanding contributions to the design of consumer products and machinery for automated manufacture of products. He has over 50 years' experience in engineering design and manufacturing and over 40 years' experience in teaching mechanical engineering, engineering design, and computer science. He received the "Am. Soc. Training and Development (ASTD) Highest Honors Award" in 1967, the "J. F. Lincoln Foundation Competition Award" in 1969, the "Archie Higdon Distinguished Educator Award" from the ASEE Mechanics Division in 2004, and the "WPI Board of Trustees Award for Outstanding Teaching" in 2005. In 2007, he was selected as the U.S. Professor of the Year by the Council for the Advancement and Support of Education (CASE) and the Carnegie Foundation for the Advancement of Teaching, who jointly present the only national awards for teaching excellence in the United States of America. He received the "Outstanding Career Achievement Award" from Tufts University Graduate School of Arts and Sciences in 2009. In addition, he authored the monograph *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines* published by McGraw-Hill Book Inc. in 2011 [121] and *Machine Design: An Integrated Approach* by Prentice-Hall in 2014 [122]. He also received the "John A. Curtis Outstanding Paper Award" (1984), the "Procter & Gamble Best Paper Award" (1985) for his conference papers, and the "Merle Miller Award" (1986 and 1992) for his authored and co-authored journal papers. He is a Distinguished Professor Emeritus at Worcester Polytechnic Institute.

Fig. 34 2002 Recipient: Robert L. Norton

The 2003 recipient Richard F. Salant (Fig. 35), FASME, FSTLE,[11] Registered Professional Engineer in Georgia, is distinguished for his outstanding contributions to mechanical and lip seals, which are synthetic rubber seals used extensively in automobiles to seal the crankshaft, mechanical transmission, wheel hubs, and other components. They are also utilized in appliances such as washing machines, dishwashers, and several other devices. Hydraulic and pneumatic seals are also lip seals. Because the world is filled with these mass-produced seals, their effective operation is relevant to the environmental health of the planet. Related papers were published in the *Journal of Engineering Tribology* [123], *Journal of Mechanical Engineering Science* [124], *Journal of Tribology* [125], etc. He received the "Henry R. Worthington Medal" in 1996, the "Edmund E. Bisson Award" in 2000, and the "Mayo D. Hersey Award" (for his distinguished and continued contributions to the advancement of lubrication science and engineering) in 2009. He also received the "STLE Frank P. Bussick Award" (2000, 2002, 2005, 2007, and 2008) for his conference papers and the "Sealing Technology Paper Award" (1998) for his co-authored journal papers. Currently, he is the Seals Technical Committee Liaison Chair (2000–present).

Fig. 35 2003 Recipient: Richard F. Salant

The 2004 recipient Sridhar Kota (Fig. 36), FASME, is distinguished for his "eminent achievements in machine design synthesis, including contributions to such diverse fields as rigid body kinematics, compliant mechanisms, MEMS, adaptive structures, and reconfigurable machine design tools." His research interests include bio-inspired engineering design, complaint and shape-adaptive systems, topology, size and shape optimization of complaint mechanisms, design for manufacturability, technology policy, and advanced manufacturing. He published an article *Topological Synthesis of Compliant Mechanisms Using Multi-Criteria* in the *Journal of Mechanical Design-Transactions of the ASME* [126]. He received the "George Wood Award" in 1993, the "Mechanical Engineering Department Teaching Excellence Award" in 1993, the "SAE Ralph Teetor Educational Award" in 1993, the "Mechanical Engineering and Applied Mechanics Teaching Excellence Award" in 1995, the "ASME Leonardo Da Vinci Award" in 1997, and the ASME Swanson Foundation White House Fellowship in 2009–

Fig. 36 2004 Recipient: Sridhar Kota

[10]Fellow of the Institute of Electrical and Electronics Engineers (FIEEE).

[11]Fellow of the Society of Tribologists and Lubrication Engineers (FSTLE).

2012. He was selected to serve as the Assistant Director of Advanced Manufacturing at the White House OSTP (2009–2010). He also received the "Ruth and Joel Spira Outstanding Educator Award" (Society Award 2010), the "Mechanical Engineering Achievement Award" from University of Michigan in 2012, the "University of Michigan Regents' Award" for Distinguished Public Service in 2014, the "Small Business Innovative Research Tibbetts Award" in 2015, and the "University of Michigan Office of Research Distinguished Innovator Award" in 2017. He also received the "Proctor and Gamble Best Paper Award" in Applied Mechanisms and Robotics (1993), the "American Institute for Aeronautics and Astronautics (AIAA) Best Paper Award" (2001), and the "ASME International Design Technical Conferences (IDTC) Best Paper Award" (2009 and 2010) for his conference papers. In addition, he is the Herrick Professor of Engineering, Professor Emeritus of Mechanical Engineering at the University of Michigan, and the founding Executive Director at MForesight: Alliance for Manufacturing Foresight, a national consortium on emerging technologies and advanced manufacturing.

The 2005 recipient Bahram Ravani (Fig. 37), FASME, Honorary Fellow of Mathematics Research Center at University of Wisconsin-Madison, is distinguished for his "consistent and lasting contributions in the geometric and computational aspects of motion design and for advances in the kinematic analysis of mechanisms and robotic systems." His current research interests include robotics and mechatronics, mechanical design and manufacturing including applications of robotics, mechatronics and informatics, intelligent transportation systems and highway safety, and dynamics and biomechanics. He received the "Tenneco Engineering Excellence Incentive Award," and the "Outstanding Young Manufacturing Engineer Award" from the Society of Manufacturing Engineers in 1987. He has served as the Chief Technical Editor of the *Journal of Computing and Information Science* and a Former Chief Technical Editor of *Engineering* and the *Journal of Mechanical Design-Transactions of the ASME* (1990–1994), as well as a past member of the management committee. He received the "ASME Design Automation Award" for sustained and meritorious contributions to the field of Design Automation in 1997, the "Gustus Larson Memorial Award" within 10–20 years of Graduation, and the "ASME Dedicated Service Award" in 2004. He co-authored the book *Matrix Methods in the Design Analysis of Mechanisms and Multibody Systems* by the Cambridge University Press in 2013 [127]. Furthermore, he received the "ASME DED Mechanisms and Robotics Award" in 2018 and is currently a Distinguished Professor at the University of California, Davis.

Fig. 37 2005 Recipient: Bahram Ravani

The 2006 recipient Itzhak Green (Fig. 38), FASME, FSTLE, is distinguished for his "outstanding achievements and dedication to excellence in design education, innovation, service, and research, including cumulative and sustained contributions to analysis, experimental verification, and modeling of machines and triboelements." Dr. Green has focused on the design aspects of the mechanics and dynamics of rotating machinery with a particular emphasis on bearings, seals, viscoelastic seals and dampers, tribology, rotordynamics, and diagnosis. Several of his research have been published in the *Journal of Tribology* [128,129] and other journals. He served on the STLE Board of Directors and chaired the Executive Committee of the ASME, Tribology Division, for two terms.

Fig. 38 2006 Recipient: Itzhak Green

He was the Woodruff School Faculty Fellow (1993–1998) and received the Best Sealing Technology Paper Award (with B. Ruan and R. Salant) in 1998. He also received the "Burt L. Newkirk Award" (1986), the "Walter D. Hodson Award" (2001), the "Frank P. Busick Award" (2004), the "Captain Alfred E. Hunt Memorial Award" (2009), and several other awards for his authored and co-authored papers. He still works at the Georgia Institute of Technology.

The 2007 recipient Steven A. Velinsky (Fig. 39), FASME, is distinguished for his outstanding "research contributions in the mechanical design field, including applied work on the development of machine elements and robotic systems for highway operations, and for his professional leadership with ASME's Design Engineering Division and Systems & Design Group." His research interests include mechanical systems analysis and design. He has been involved in the analysis and design of various systems including wire ropes and cables, vehicles, air bearings, ballscrew mechanisms, eye surgery, and automated highway maintenance and construction machinery. He published papers in journals such as the *Journal of Mechanical Design-Transactions ASME* [130] and *IEEE/ASME Transactions Journal of Mechatronics* [131]. He received the "SAE Ralph R. Teetor Educational Award" in 1986, the "ASME Leonardo Da Vinci Award" in 1996, the "ASME Distinguished Service Award" in 1999, the "California State Department of Transportation's Excellence in Transportation Award" in 2001, the "California Transportation Foundation's Tranny Award" in 2001 and 2002, the "ASME Robert E. Abbott Award" in 2005, and the "Federal Laboratory Consortium (FLC) Award" for Excellence in Technology Transfer from the U.S. Department of Energy in 2012. He is a Distinguished Professor Emeritus at the University of California, Davis.

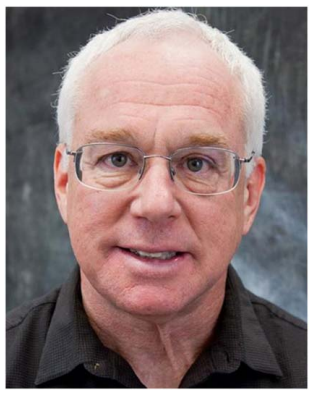

Fig. 39 2007 Recipient: Steven A. Velinsky

The 2008 recipient Alexander H. Slocum (Fig. 40), FASME, Fellow of National Academy of Inventors (NAI), Member of the NAE, is distinguished for his "breakthrough machinery designs and technologies that have extended the limits of machine tools and systems, and for educating a generation of design engineers through his landmark monographs and innovative teaching." Professor Slocum's research focuses on developing fundamental precision machine design principles and then verifying them via experiments that serve as prototypes for consumer and industrial products. He received the "U.S. DoC Bronze Medal Award" in 1986 and the "NSF Presidential Young Investigator" in 1987. He authored the monograph *Precision Machine Design* published by the Society of Manufacturing in 1992 [132]. He received the "NSF Presidential Young Investigator" award in 1987, the "SME Earl E. Walker Outstanding Young Manufacturing Engineer Award" in 1993, the

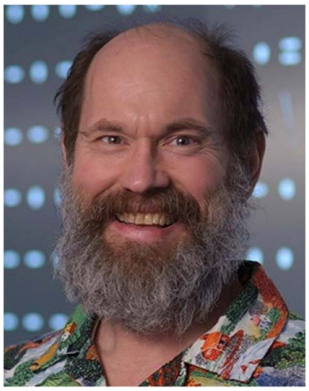

Fig. 40 2008 Recipient: Alexander H. Slocum

"ASCE Thomas Fitch Rowland Prize" in 1994, the "SME Frederick W. Taylor Research Medal" in 1997, the "Martin Luther King Jr. Leadership Award" in 1999, the "Massachusetts Professor of the Year Award" in 2000, the "ASME Leonardo da Vinci Award" in 2004, and the "Arthur Smith Faculty Achievement Award" in 2010. He was selected to serve as the Assistant Director of Advanced Manufacturing at the White House OSTP (2013–2014). He also received the "ASME Thar Energy Award" in 2014, the "Association of Manufacturing Technology Charlie Carter Award" in 2014, the "ASME Ruth and Joel Spira Outstanding Design Educator Award" in 2018, and several R&D 100 Awards. He still works at the Massachusetts Institute of Technology.

The 2009 recipient J. Michael McCarthy (Fig. 41), FASME, is distinguished for his outstanding contributions to the kinematic theory of robots and mechanical systems. His research team is responsible for the Sphinx, Synthetica, and MecGen software packages, which extend computer-aided design to spherical and spatial linkage systems and integrate this process with geometric modeling. He has presented tutorials on the design of linkages and robotic systems at ASME and IEEE conferences. He authored the monograph *Introduction to Theoretical Kinematics* published by MIT Press in 1990 [133]. He was the Papers Review Chair of the 21st Biennial ASME Mechanisms Conference in 1990 and was the Conference Chair of the 24th Biennial ASME Mechanisms Conference in 1996. In addition, he was the former Editor-in-Chief of the *Journal of Mechanical Design-Transactions of the ASME* (2003–2007) and the founding Editor-in-Chief of the *Journal of Mechanisms and Robotics-Transactions of the ASME* (2007–present). He also co-authored the book *Geometric Design of Linkages (Vol. 11)* with G.S. Soh published by Springer Science & Business Media in 2010 [134]. He received the "ASME Outstanding Service Award" in 2008, the "Henry Samueli School of Engineering's 2009 Faribor Maseeh Teaching Award," the "University of California (UCI) Teaching Excellence in Undergraduate Engineering Award" in 2010, the "ASME DED Mechanisms and Robotics Award" in 2011 [35], and the "Robert E. Abbott Lifetime Service Award" from the Design Engineering Division of ASME International in 2013. He is currently a Distinguished Professor at the University of California, Irvine.

Fig. 41 2009 Recipient: J. Michael McCarthy

The 2010 recipient Jahangir S. Rastegar (Fig. 42), FASME, Fellow of the NAI, is distinguished for his "eminent achievements as an inventor and scholar in the field of machine design, particularly in the area of smart actuation and control." His current research interests include kinematics, dynamics, vibration and control related to high-speed and precision machinery, passive and active vibration isolation and vibration damping, and the development and application of smart materials-based actuators. He was the Papers Review Chair of the 26th Biennial ASME Mechanisms and Robotics Conference in 2000 and the Conference Chair of the 31st ASME Mechanisms and Robotics Conference in 2007. He has published articles in journals such as *IEEE/ASME Transactions on Mechatronics* [135] and *IEEE Transactions on Robotics and Automation* [136]. He is the co-founder of Omnitek Partners LLC and currently works at the Stony Brook University.

Fig. 42 2010 Recipient: Jahangir S. Rastegar

The 2011 award is vacant.

The 2012 award is vacant.

The 2013 recipient Clément Gosselin (Fig. 43), FASME, FIEEE, Fellow of the Royal Society of Canada (RSC), Officer of the Order of Canada, is distinguished for his outstanding work in parallel robots and robotics hands. He held the Canada Research Chair in *Robotics and Mechatronics* from 2001 to 2021. He dedicates his work to kinematics, dynamics and control of robotic mechanical systems with a particular emphasis on the mechanics of grasping, kinematics and dynamics of parallel manipulators, and the development of human-friendly robots and haptic devices. He published over 700 papers and graduated over 50 PhDs. He was the Papers Review Chair of the 25th Biennial ASME Mechanisms Conference in 1998. In 2007, he co-authored the book *Type Synthesis of Parallel Mechanisms* with X. Kong published by Springer [137] and in 2008, he co-authored the book *Underactuated Robotic Hands* with L. Birglen and T. Laliberté published by Springer [138]. He received the "Medal of the Governors" and "Gold Medal of the Governor General of Canada" from Université de Sherbrooke in 1985, the "D. W. Ambridge Award" from the McGill University in 1988, the "I.W. Smith Award" from the Canadian Society of Mechanical Engineering for creative engineering in 1993, the "Summa Award" and IEEE International Robotics and Automation Conference (IRAC) "Best Video Award" in 1997, the "ASME DED Mechanisms and Robotics Award" in 2008 [35], and the "IFToMM Award of Merit" in 2019. He was an Associate Editor of the *Journal of Mechanisms and Robotics-Transactions of the ASME* and a Senior Editor of the *IEEE Robotics and Automation Letters*. Currently, he is on the Mechanisms and Robotics Award Subcommittee and leads robotics research at Laval University.

Fig. 43 2013 Recipient: Clément Gosselin

The 2014 recipient Larry L. Howell (Fig. 44), FASME, Associate Academic Vice President of Brigham Young University (BYU), is distinguished for his compliant and origami mechanisms. His research focuses on compliant mechanisms, including origami-inspired mechanisms, microelectromechanical systems, medical devices, space mechanisms, and developable mechanisms. He was elected as an outstanding Professor by graduating Mechanical Engineering seniors of the BYU in 1996 and received the "CAREER Award" from the NSF in 1996–2000, the "Young Scholar Award" (1998–2001), the "Faculty Achievement Award"

Fig. 44 2014 Recipient: Larry L. Howell

(2000), and the "Technology Transfer Award" (2001) from the BYU. He authored the monograph *Compliant Mechanisms* published by John Wiley & Sons in 2001 [139]. He was the Papers Review Chair of the 27th Biennial ASME Mechanisms and Robotics Conference in 2002 and the Conference Chair of the 28th ASME Mechanisms and Robotics Conference in 2004. He received the "Karl G. Maeser Research and Creative Arts Award" from BYU in 2005–2006, the "ASME DED Mechanism and Robotics Award" in 2009 [35], the "Excellence in Scholarship Award" from BYU in 2010, and the Theodore von Kármán Fellow in 2013. He was the Chair of the ASME Mechanisms and Robotics Committee. In 2013, he co-authored the book *Handbook of Compliant Mechanisms* with S.P. Magleby and B.O. Olsen published by John Wiley & Sons [140]. He received the "Karl G. Maeser Distinguished Faculty Lecturer Award" (BYU's highest faculty award) in 2015, the "Vizzies" Overall People's Choice Award in 2015, and the "Outstanding Mechanical Engineer" award (the Alumni Award from Purdue University) in 2016. He also received the "Mechanical Dynamics Inc. Software Award," "Black and Decker Best Paper Award," "Reconfigurable Mechanisms and Robots (ReMAR) Best Paper Award" (2012), "M&R Best Paper Award" (2017, 2019), "Best Application Award" (2018), and the ASME Adaptive Systems, Dynamics, and Controls Technical Committee's "Best Journal Paper Award" (2021) for his co-authored papers. His work in origami-based mechanisms has been featured in museum exhibitions and in popular media outlets, and several of his compliant mechanism patents have been licensed to the industry. In 2019, he was appointed the Associate Academic Vice President at BYU, Provo, UT.

The 2015 recipient Jorge Angeles (Fig. 45), FASME, FIEEE, FCSME,[12] IFToMM Honorary Member , Fellow of the RSC, and Fellow of the Canadian Academy of Engineering, is distinguished for his contributions to kinetostatic isotropy, qualitative synthesis, and model-based design methods. His research is on the design and control of general robotic mechanical systems and their mechanical components, such as drives and sensors. He authored the monographs *Spatial Kinematic Chains: Analysis-Synthesis-Optimization* [141] in 1982 and *Rational Kinematics* in 1988, both published by Springer-Verlag [142]. In addition, he received the "ASME DED Mechanisms and Robotics Award" in 2000 [35]. He was the president (2000–2007) of IFToMM, the *International Federation for the Promotion of Mechanism and Machine Science*. Angeles has received the "A.T. Yang Memorial Award," the "ASME Advanced Vehicle Technology Best Paper Award," and several other awards for his authored and co-authored papers. Angeles authored the book *Fundamentals of Robotic Mechanical Systems: Theory, Methods, Algorithms* published by Springer [143] and co-authored a book *Kinematics of Mechanical Systems: Fundamentals, Analysis and Synthesis (Mathematical Engineering)* with S. Bai, published by Springer in 2007 and re-published in 2022 [144]. He is currently a Professor Emeritus at McGill University.

Fig. 45 2015 Recipient: Jorge Angeles

The 2016 recipient Sunil K. Agrawal (Fig. 46), FASME, FAIMBE,[13] is distinguished for his "seminal contributions to the design of robotic exoskeletons for gait training of stroke patients." He developed a highly visible interdisciplinary program in rehabilitation robotics. Neural disorders, such as stroke and Parkinson's disease, limit the ability of humans to walk and perform daily activities. Pediatric disorders such as cerebral palsy, spina bifida, and Down's syndrome delay the development of children and pose several functional limitations, while old age diminishes the sensory and motor systems. Via a range of pilot and clinical studies involving human subjects, Dr. Agrawal has demonstrated that novel training robots could help humans to relearn, restore, or improve functional movements. He received the "Best All Rounder Student Gold Medal" from the Indian Institute of Technology in 1984, the "Fritz and Dolores Russ Research Award" from Ohio University in 1994, the "Presidential Faculty Fellow Award" from the White House in 1994, and the "Friedrich Wilhelm Bessel Research Award" from the Alexander von Humboldt Foundation in 2002. He was the Papers Review Chair of the 28th ASME Mechanisms and Robotics Conference in 2004 and Conference Chair of the 29th ASME Mechanisms and Robotics Conference in 2005. He also received the "Alexander von Humboldt Foundation U.S. Senior Scientist Award" in 2007. He co-authored the monograph *Optimization of Dynamic Systems* (Vol. 70) with B.C. Fabien published by Springer Science & Business Media in 2013 [145] and co-authored the monograph *Kinematics, Dynamics, and Design of Machinery* with G.L. Kinzel and S.K. Agrawal published by John Wiley & Sons in 2016 [105]. He received the "ASME DED Mechanisms and Robotics Award" in 2016 [35]. In 2018, he co-authored the book *Differentially Flat Systems* with H. Sira-Ramirez published by CRC Press [146]. Currently, he is the founding Editor-in-Chief of the journal *Wearable Technologies* and still works at Columbia University.

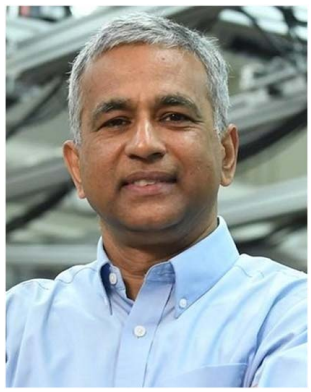

Fig. 46 2016 Recipient: Sunil K. Agrawal

The 2017 recipient S.V. Sreenivasan (Fig. 47), FASME, Member of the NAE, Fellow of the NAI, is distinguished for his outstanding work in developing high throughput nanofabrication techniques that enable applications in mobile electronics, advanced displays, healthcare, and energy sectors. His research focuses on developing high throughput nanofabrication systems that enable applications in the electronics and healthcare sectors. His articles have been published in *ACS Applied Materials & Interfaces* [147], *Microsystems & Nanoengineering* [148], *Proceedings of National Academy of Sciences* [149], etc. He holds over 100 U.S. patents in the area of nanoscale manufacturing. Dr. Sreenivasan is the recipient of several awards, including the "Technology Pioneer Award" by the World Economic Forum in 2005, the "University of Texas Chancellors' Award" for Entrepreneurship in 2007, the "ASME Leonardo da Vinci Award" in 2009, the "TAMEST O'Donnell Award" for

[12]Fellow of the Canadian Society for Mechanical Engineering (FCSME).

[13]Fellow of the American Institute for Medical and Biological Engineering (FAIMBE).

Fig. 47 2017 Recipient: S.V. Sreenivasan

Technology Innovation in 2010, the "ASME William T. Ennor Manufacturing Technology Award" in 2011, the "UT-Austin Inventor of the Year Award" in 2012, the "Distinguished Alumni Award" by the National Institute of Technology at Trichy in India in 2014, and the "Distinguished Alumni Award" by the College of Engineering at The Ohio State University in 2016. He is a co-director of the NASCENT Center (an NSF program funded by the Nanosystems Engineering Research Center), co-founder of the Molecular Imprints Inc. (MII), and incumbent Chief Technologist of Canon Nanotechnologies, Inc. In addition, the display division of MII, his co-founded company, was acquired in 2015 by Magic Leap, Inc., a leader in augmented/mixed reality displays. Currently, he is a David Allen Cockrell Chair in Engineering and Cockrell Family Regents Chair in Engineering at the University of Texas at Austin.

The 2018 recipient John J. Uicker, Jr. (Fig. 48), FASME, is distinguished for his "outstanding contributions to machine design and kinematic research on spatial linkages and robotics." He and his students have developed geometric modeling and computer-aided design techniques for the simulation of solidification in metal castings, thereby facilitating more predictable and cost-effective manufacturing processes. His research program developed a computer software system called the Integrated Mechanisms Program for the kinematic, static, and dynamic simulation of rigid body mechanical systems such as robots and automotive suspensions. He proposed a 4×4 matrix method for the kinematic analysis of linkages in 1964 and proposed the Sheth-Uicker Notation for the kinematic analysis of mechanical linkages in 1971. He has served on several national ASEM and SAE committees and served for several years as the Editor-in-Chief of *Mechanism and Machine Theory* (1973–1977) and is currently Editor Emeritus. He is a founding member of the U.S. Council for the Theory of Mechanism and Machine Science and of IFToMM, the international federation. He received the "ASME DED Mechanisms and Robotics Award" in 2004 [35]. He co-authored the book *Matrix Methods in the Design Analysis of Mechanisms and Multi-body Systems* with B. Ravani and P.N. Sheth published by the Cambridge University Press in 2013 [127] and in 2016, he co-authored the book *Theory of Machines and Mechanisms* with G.R. Pennock and J.E. Shigley published by the Oxford University Press [71–75]. Uicker had been awarded a Senior Fulbright Lectureship as a visiting professor in Cranfield, England. He was a Professor Emeritus of mechanical engineering at the University of Wisconsin-Madison. He passed away on April 25, 2023, at the age of 85.

Fig. 48 2018 Recipient: John J. Uicker, Jr.

The 2019 recipient Gregory S. Chirikjian (Fig. 49), FASME, FIEEE, is distinguished for "introducing paradigms in the design of hyper-redundant and binary-actuated mechanisms, modular self-reconfigurable robots and spherical motors; and for mentoring generations of students and junior faculty in the areas of mechanisms and robotics." He is an American roboticist and applied mathematician, primarily focused on the field of robotics, applications of group theory in various engineering disciplines, and mechanics of biological macromolecules. He published over 300 papers and graduated over 25 PhDs. Dr. Chirikjian was named NSF's Young Investigator in 1993, Presidential Faculty Fellow in 1994, and was a recipient of the "ASME Pi Tau Sigma Gold Medal" in 1996. He co-authored the monograph *Engineering Applications of Noncommutative Harmonic Analysis* by CRC Press with A.B. Kyatkin in 2001 [150] and authored the monograph *Stochastic Models, Information Theory, and Lie Groups, Vols. 1&2* in 2009 and 2011 by Springer Science & Business Media [151,152]. He received the "ASME DED Mechanisms and Robotics Award" in 2014 [35]. In 2016, he authored the monograph *Harmonic Analysis for Engineers and Applied Scientists* by Dover Publications Inc. [153]. He was a Program Director of the U.S. National Robotics Initiative and Editor-in-Chief of *Robotica* between 2005 and 2020. After almost three decades as a professor at Johns Hopkins University, he moved to the National University of Singapore in 2019 as Professor and Head of the Department of Mechanical Engineering, where he has rejuvenated the department by hiring 15 new professors.

Fig. 49 2019 Recipient: Gregory S. Chirikjian

The 2020 recipient Jian S. Dai (Fig. 50), FASME, FIEEE, FIMechE,[14] FRSA,[15] Fellow of the Royal Academy of Engineering (FREng[16]), is distinguished for his "pioneering contributions in establishing the field of reconfigurable mechanisms and the subfield of metamorphic mechanisms; making it possible to bridge the gap between versatile but expensive robots and efficient but nonflexible machines." His research is focused on theoretical kinematics including screw algebra, Lie groups, and Lie algebras [154–160], the fundamental theory of reconfigurable mechanisms and their uses in metamorphic mechanisms, reconfigurable mechanisms, rehabilitation mechanisms, origami mechanisms, walking robots, and multifingered hands. He published over 700 peer-reviewed papers and three authored monographs, including *Geometrical Foundations and Screw Algebra for Mechanisms and Robotics* in 2014 by Higher Education Press [160,161], *Screw Algebra and Lie Groups and Lie Algebra* with first edition in 2014 and second edition in 2020 [162,163], and *Screw Algebra and Kinematic Approaches for Mechanisms and Robotics* in 2023. He co-authored five books, including *Evolutionary*

Fig. 50 2020 Recipient: Jian S. Dai

[14]The Institution of Mechanical Engineers (IMechE), UK.
[15]The Royal Society for Arts and Manufactures (RSA), UK.
[16]The Royal Academy of Engineering (RAE), UK.

Design of Parallel Mechanisms: Kinematics of a Family of Parallel Mechanisms with Centralized Motion with E. Rodriguez Leal by Lambert Academic Publishing [164], *Analysis and Synthesis of Compliant Parallel Mechanisms—Screw Theory Approach* with C. Qiu by Springer [165], and *Sliding-Rolling Contact and In-Hand Manipulation* with L. Cui by World Scientific Publishing [166]. He graduated over 45 PhDs and held over 50 patents. In 2009, he established the prestigious International Triennial Conference Series on Reconfigurable Mechanisms and Robots (ReMAR). He is the Conference Chair of the 36th Mechanisms and Robotics Conference held in Chicago IL, in 2012 [12]. He was the Chair (2010–2012) of the ASME UK & Ireland Section, and the Chair of IFToMM UK (2014–present). He is a founding Associate Editor for the *Journal of Mechanisms and Robotics – Transactions of the ASME* (2009–2018, 2023–present). In 2010, he received King's College London overall "Supervisory Excellence Award." In 2013, he was awarded the CMES "Mechanisms Innovation Award." In 2015, he was the recipient of the "ASME DED Mechanisms and Robotics Award" [35]. Furthermore, he received the "Biennial Mechanisms Committee Best Paper Award" (1998), the "ReMAR Best Paper Award" (2015), the "AT Yang Memorial Award" (2019) for his conference papers, and the "SAGE Best Paper Award" (2009 and 2011) and "Crossley Award" (2018) [167] for his authored and co-authored journal papers. Currently, he is a Subject Editor of *Mechanism and Machine Theory* (2015–present), the Editor-in-Chief of *Robotica* (2020–present) and the Mechanisms and Robotics Awards Chair.

The 2021 award is vacant.

The 2022 recipient Diann Brei (Fig. 51), FASME, is distinguished for her "outstanding contributions in novel device design and for supporting engineering science, as well as for mentoring and building communities in the field of smart materials and structures." She is the first woman to receive this award. Her research focuses on the underlying design science for device innovation using smart materials. She also works on the fundamentals such as the synthesis and analysis of smart material actuation and device architectures from conventional ratcheting and spooling to cutting-edge architectures [168]. She received the "Career Development Award" in 1999, the "Ruth and Joel Spira Outstanding Teaching Award" and "Outstanding Faculty Award" from the University of Michigan in 2001, the "National Multiple Scierosis Society Da Vinci Award" in 2003, the NAE Frontiers in Engineering in 2003 and 2004 (organizer), the "Michigan Road Scholar" in 2005, the "MEAM Teaching Incentive Award," the "Hartwell Award" (with D. Teielbaurm and J. Luntz) in 2008, the "ASME Dedicated Service Award" in 2011, the "Ted Kennedy Family Team Excellence Award" from the University of Michigan in 2011, and the "ASME Distinguished Service Award" in 2012. She co-authored the book *The Psychology of Design* in 2015 [169]. She received the "ASME Adaptive Structures and Material Systems Award" and "Monroe-Brown Foundation Service Excellence Award" in 2018, the "SPIE Smart Structures and Materials Lifetime Achievement Award" in 2019, and the "North Campus Deans' MLK Award" in 2020. She also received the "ASEE Best Paper Award" in 2000, the "International Conference On Adaptive Structures and Technologies Best Paper" and the "Smart Materials, Adaptive Structures And Intelligent Systems Best Paper" in 2008 for her authored and co-authored conference papers. She currently works as a Professor of mechanical engineering at the University of Michigan.

Fig. 51 2022 Recipient: Diann Brei

The 2023 recipient Shapour Azarm (Fig. 52), FASME, Life Member of the ASME, is distinguished for his outstanding work in Design Automation. His research interests include predictive modeling, engineering optimization, and decision analysis. Dr. Azarm is the Founding Director of the Design Decision Support Laboratory (DDSL). He received the "Westinghouse Professorship" in 1988, the "Procter & Gamble Paper Award" in 1989 and 1991, and the "ASEE Faculty Fellowships" in 1994. He was the Conference Chair of the 22nd ASME Design Automation Conference (1996), Chair of the ASME Design Automation Committee (1997), Vice Chair (2005–2006) and Chair (2006–2007) of ASME DED's Executive Committee. In 2007, he received the "ASME Design Automation Award." He served as the Chair of the ASME DED's Advisory Committee (2007–2008). In 2009, he received the "ASME/Ford Best Paper Award." He co-authored the book *An Engineer's Guide to Matlab with Application from Mechanical, Aerospace, Electrical, Civil and Biological Systems Engineering* with E.B. Magrab, B. Balacandran, J.H. Duncan, K.E. Herold and G.C. Walsh in 2011 published by Pearson Education Inc. [170]. In 2013, he was the Chair of the 10th World Congress on Structural and Multidisciplinary Optimization. In 2016, he received the "ASME Robert E. Abbott Award". Dr. Azarm was the Editor-in-Chief of the *Journal of Mechanical Design-Transactions of the ASME* (2013–2017) and the Publications Chair of the ASME DED (2019–2021). In 2023, he published an article *Bi-Objective Surrogate Feasibility Robust Design Optimization Utilizing Expected Non-Dominated Improvement with Relaxation* in the *Journal of Mechanical Design-Transactions of the ASME* [171]. He is currently serving as Vice-Chair of the ASME Technical Committee on Publications and Communication (TCPC).

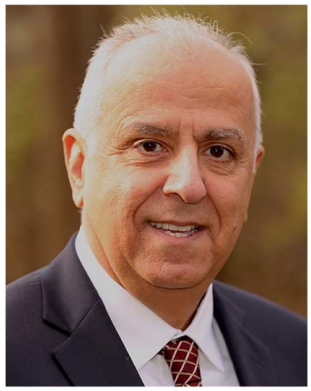

Fig. 52 2023 Recipient: Shapour Azarm

5 Conclusions

In this archival document, we recorded 60 recipients of the ASME Machine Design Award in the past 65 years (Table 1), including their research areas, main contributions, publications, honors, awards, and professional services, thereby archiving the history of this prestigious award. By reviewing the track of the awards, we highlighted their novel contributions and significant developments in the field of mechanical engineering and machine design, and presented some history of international conferences such as the ASME Mechanisms and Robotics Conference, the communities such as IFToMM, and the journals such as the *Journal of Mechanisms and Robotics*, *Journal of Mechanical Design*, *Mechanism and Machine Theory* and *Robotica*. It is beneficial for the entire community and for those interested in mechanical engineering and machine design to have a broader perspective of the historical development in the field. In digging into the foundation of the field through this historical review, this paper presents the history of machine design and the development of this prestigious award that would provide a good grasp of the vision of future developments.

Table 1 Machine Design Award Recipients

1959	Charles E. Crede	1980	Merhyle F. Spotts	2001	Steven Dubowsky
1960	Rudolph E. Peterson	1981	Henry O. Fuchs	2002	Robert L. Norton
1961	Robert G. LeTourneau	1982	Delbert Tesar	2003	Richard F. Salant
1962	J.F. Downie Smith	1983	Edward J. Wellauer	2004	Sridhar Kota
1963	Colin Carmichael	1984	Bernard Roth	2005	Bahram Ravani
1964	Rufus Oldenburger	1985	Joseph E. Shigley	2006	Itzhak Green
1965	Arthur M. Wahl	1986	Atmaram H. Soni	2007	Steven A. Velinsky
1966	Beno Sternlicht	1987	Gerard G. Lowen	2008	Alexander H. Slocum
1967	Ernest Wildhaber	1988	Hamilton H. Mabie	2009	J. Michael McCarthy
1968	C. Walton Musser	1989	Arthur G. Erdman	2010	Jahangir S. Rastegar
1969	Eugene I. Radzimovsky	1990	Charles R. Mischke	2013	Clément Gosselin
1970	Reynold B. Johnson	1991	F.R. Erskine Crossley	2014	Larry L. Howell
1971	Walter L. Starkey	1992	Edward J. Haug, Jr.	2015	Jorge Angeles
1972	Ferdinand Freudenstein	1993	Charles O. Smith	2016	Sunil K. Agrawal
1974	Allen S. Hall, Jr.	1994	Kenneth J. Waldron	2017	S.V. Sreenivasan
1975	George N. Sandor	1995	Ray C. Johnson	2018	John J. Uicker Jr.
1976	Charles W. Radcliffe	1996	Hans A. Eschenauer	2019	Gregory S. Chirikjian
1977	Mathew M. Kuts	1997	Jack A. Collins	2020	Jian S. Dai
1978	Ali A. Seireg	1999	Panos Y. Papalambros	2022	Diann Brei
1979	Robert R. Slaymaker	2000	Joseph Duffy	2023	Shapour Azarm

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Conflict of Interest

There are no conflicts of interest.

Data Availability Statement

No data, models, or code were generated or used for this paper.

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