The Elmer A. Sperry Award

FOR ADVANCING THE ART OF TRANSPORTATION

The Elmer A. Sperry Award

The Elmer A. Sperry Award shall be given in recognition of a distinguished engineering contribution which, through application, proved in actual service, has advanced the art of transportation whether by land, sea, air, or space

Presentation of

The Elmer A. Sperry Award

For 2021

TO

MICHIMASA FUJINO

In recognition of his singular achievement of research and development of new technologies for business aviation including the Over-the-Wing Engine Mount and Natural Laminar Flow airfoil, and the introduction to the market of commercial aircraft based on these technologies through the formation of HondaJet.

REPRESENTED BY THE

American Society of Mechanical Engineers
Institute of Electrical and Electronics Engineers
SAE International
Society of Naval Architects and Marine Engineers
American Institute of Aeronautics and Astronautics
American Society of Civil Engineers

Given at the 2022 AIAA AVIATION Forum


AIAA
The World's Forum for Aerospace Leadership
Aircraft Design Award
AIAA
declare that
chimasa Fujino

Michimasa Fujino

Michimasa Fujino holds a Bachelor of Science degree and Doctorate degree in aeronautical engineering from the University of Tokyo. Dr. Fujino joined Honda Motor in 1984. He spent the first two years of his career in the automobile research division working on the development of a new electrical control steering system. Dr. Fujino was then assigned to Honda's aviation research division. In 1986, Dr. Fujino and the Honda aviation team were dispatched to the United States to conduct advanced aeronautics research with the Mississippi State University's Raspet Flight Research Center. The team developed two experimental aircraft, the MH-01 turboprop and the MH-02 twin-engine light jet. Building on this experience, in 1997 Dr. Fujino began work on an entirely new aircraft, which would become the HondaJet.

After spending ten years in the United States, Dr. Fujino believed that there was great potential for Honda to enter the aviation industry by offering a high-performance light jet. Specifically, he thought if Honda introduced an airplane with both high fuel efficiency and high speed that did not sacrifice cabin volume and luggage space, they could break into the business jet market. Dr. Fujino achieved this goal from a technical standpoint by developing an over-wing engine configuration, which allowed for a larger and quieter cabin by removing the engines from the rear of the fuselage to over the wing. His new design also featured a number of other innovations for a general aviation aircraft, including a Natural-Laminar Flow wing, Natural-Laminar Flow fuselage nose, all-composite fuselage, and highly integrated, state of art glass cockpit.

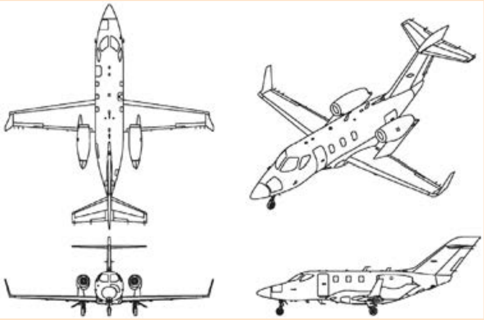
In 2000, Dr. Fujino and a small team of engineers began work on the HondaJet prototype at the Piedmont International Airport in Greensboro, North Carolina. On December 3, 2003, the proof-of-concept HondaJet conducted its first successful test flight. In 2006, Dr. Fujino was able to convince then-Honda CEO, Takeo Fukui, to commercialize the HondaJet program. Honda created Honda Aircraft Company, with Dr. Fujino appointed as company president and CEO. Between 2006 and 2015, Dr. Fujino focused on the dual tasks of developing a company and organization. Then his goal expanded from advanced aeronautical research to FAA Type Certification and production to commercialize the HondaJet in the market. Deliveries of the HondaJet officially began in late 2015 after FAA type-certification was obtained. HondaJet is the most technologically advanced light business jet and became the most delivered business jet in its class for four consecutive years from 2017.

Dr. Fujino has received several awards for his contributions to aeronautical research and design. He received the American Institute of Aeronautics and Astronautics (AIAA) Reed Aeronautics Award in 2021 as well as the AIAA Foundation Award for Excellence in 2018. In 2015, he was inducted into the Living Legends of Aviation after winning the "Aviation Industry Leader of the Year Award" the previous year. In 2014, Dr. Fujino received the International Council of the Aeronautical Sciences (ICAS) "Award for Innovation in Aeronautics." He received the SAE International "Clarence L. (Kelly) Johnson Aerospace Vehicle Design and Development Award" in 2013, and the American Institute of Aeronautics and Astronautics (AIAA) "Aircraft Design Award" in 2012.

Dr. Fujino is currently a Fellow in several international organizations, including the American Institute of Aeronautics and Astronautics, the Royal Aeronautical Society, and SAE International. He is also an international member of the National Academy of Engineering.

Aerodynamic Achievement on Over-the-Wing-Engine-Mount Configuration (OTWEM)

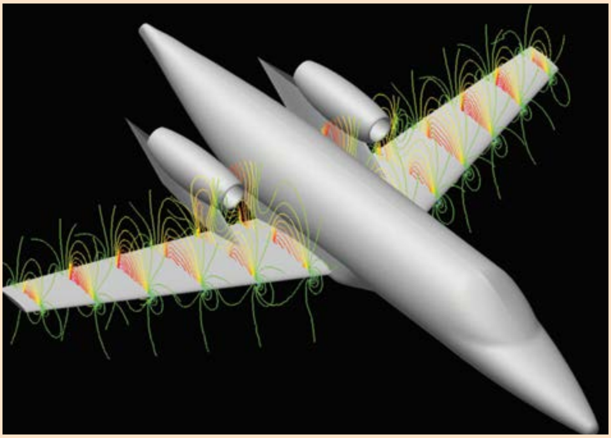
Locating the engine over the wing was the major design decision by Dr. Fujino in the development of the HondaJet configuration (Figure 1).



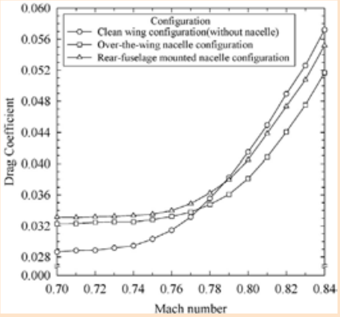
(Figure 1: HondaJet general arrangement)

Business jet designs have engines mounted on the rear fuselage. Mounting the engines on the wings can eliminate the carry-through structure required to mount the engines on the rear fuselage. This allows the fuselage internal space to be maximized without increasing the size of the fuselage. Since light business jet designs are very close to the ground, it is impossible to install the engine under the wing. To mount the engine over the wing, however, involves significant technical challenge both from the aerodynamic and aeroelastic standpoints for a high-speed jet aircraft. In general, locating the engine nacelle over the wing causes unfavorable aerodynamic interference and induces a strong shock wave that results in a lower drag divergence Mach number. Also, mounting the engine on the wing significantly changes the vibration characteristics of the original clean wing and, as a result, influences aeroelastic characteristics as well. Dr. Fujino used the concept of aerodynamic interference to hypothesize that a favorable interference could be achieved by optimal positioning of flow fields. Theoretical studies were conducted using a three-dimensional Euler solver to investigate this configuration (Figure 2).

(Figure 2: Off-body pressure contour of the OTWEM configuration)

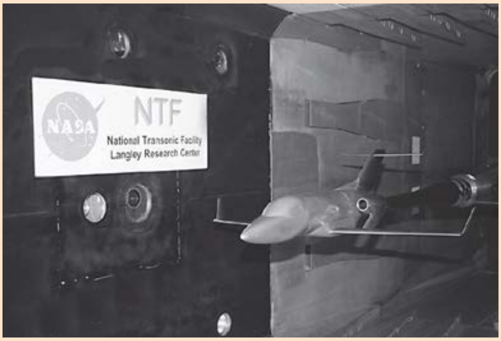


Hundreds of computer simulations were performed for different OTWEM configurations having different nacelle locations relative to the wing. These runs confirmed that there was an effect of chord wise and vertical nacelle locations on wave drag. The simulation results demonstrated that the strength of the shock can be reduced and that drag divergence occurs at a higher Mach number than that for the clean-wing configuration when the nacelle is located at the optimum position relative to the wing (Figure 3).



(Figure 3: Comparison of drag coefficients demonstrating OTWEM configuration benefit on wave drag)

A transonic wind tunnel test was conducted in the Boeing Transonic Wind Tunnel (BTWT) to validate the simulation results. The optimum over-the-wing nacelle configuration exhibits lower drag than the conventional rear-fuselage engine-mount configuration.



The concept of positive interference of the OTWEM configuration was also confirmed at the NASA NTF (National Transonic Facility) at high Mach number and high Reynolds number testing as well (Figure 4). Finally, Dr. Fujino's OTWEM concept obtained patents from many countries such as the US, and Japan, and the European Union.

(Figure 4: Transonic wind tunnel test at NASA NTF)

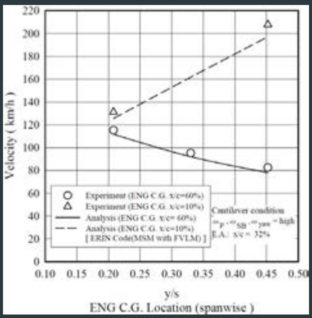
The HondaJet design needed a Natural Laminar Flow (NLF) wing airfoil section to greatly reduce drag. However, an NLF airfoil exhibits high wave drag at high Mach number because of its pressure distribution required for laminar flow. So, it was critical to reduce the upper surface shock wave strength to increase the drag divergence Mach number when using an NLF wing for high speed aircraft. By employing this optimum over-the-wing engine-mount configuration, shock wave strength was greatly reduced, drag divergent Mach number was increased, the laminar flow is maintained under most flight conditions, and the cabin volume is maximized. The final aerodynamic configuration of the HondaJet's OTWEM is based on these theoretical and experimental results.

Aeroelastic Achievement on OTWEM Configuration

Mounting engines on the wing causes complex wing flutter characteristics. The location of the engine mass and the stiffness of the pylon relative to the wing are important in preventing hazardous wing flutter. Positioning the engine ahead of the elastic axis of the wing to increase the flutter speed is a well-known design rule, which has a marked effect on the configuration of modern transport aircraft. For the optimum over-the-wing engine mount configuration, however, the engine is positioned aft of the elastic axis of the wing and the aeroelastic characteristics are, therefore, considered to be critical. In addition, if the nacelles are installed over the wing, aerodynamic interference between the wing and the nacelle may cause unfavorable flutter characteristics, in particular, at transonic speeds. The flutter characteristics of the over-the-wing engine-mount configuration were investigated through extensive theoretical studies and low speed as well as transonic wind-tunnel tests. The engine location relative to the wing was first systematically varied and the effect on the flutter speed was studied theoretically and in the low speed wind tunnel tests (Figure 5).

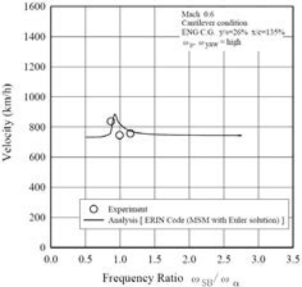
(Figure 5: Low speed wing flutter test)

The general characteristics were evaluated by theoretical analysis and experiments. The study determined the effect of the chordwise and spanwise location of the engine on the flutter speed (Figure 6).



(Figure 6: Effect of engine location on flutter speed)

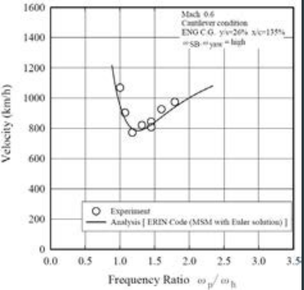
In addition, the engine-pylon vibration characteristics influence the flutter characteristics. The pylon stiffness was then varied to alter the side-bending frequency, yawing frequency, and pitching frequency of the engine-pylon mode. The study showed that the flutter speed is highest when the engine-pylon side bending frequency is close to the uncouple first wing-torsion frequency (about 0.9 to 1.0 times the uncouple first wing-torsion frequency) (Figure 7)



(Figure 7: Effect of engine-pylon side-bending frequency)

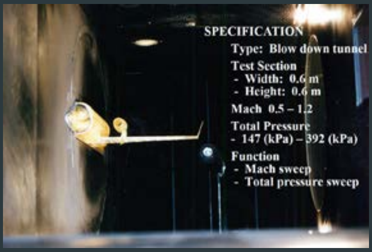
and the flutter speed is lowest when the engine-pylon pitching frequency is about 1.25 times the uncouple first wing-bending frequency (Figure 8).

The effects on the flutter characteristics of the over-the-wing engine mount configuration were thus quantitatively evaluated. Based on these results, the wing stiffness and mass distributions were designed to satisfy the flutter-clearance requirements.



(Figure 8: Effect of engine-pylon pitching frequency)

To investigate the flutter characteristics under the compressible aerodynamic effect of the nacelle for the over-the-wing engine mount configuration, transonic flutter tests were also conducted (Figure 9).



(Figure 9: Transonic flutter test)

These tests show that there is no large flutter speed reduction at the transonic dip or undesirable flutter characteristics for the optimum over-the-wing engine mount configuration.

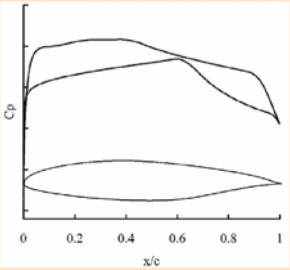
A ground-vibration test was also conducted to measure the vibration modes of the entire aircraft and to establish the correlation with those from the finite element vibration analysis. The aircraft was excited by six electrodynamic shakers, which were attached to the aircraft by flexible rods. The aircraft was placed on specially designed air springs, which decouple the rigid mode of the aircraft. The structural responses were measured by a total of 383 piezoelectric accelerometers attached to the aircraft (Figure 10).

The HondaJet finite element model was tuned by using the frequencies and mode shapes measured from the ground-vibration test to accurately determine the aeroelastic characteristics of the aircraft.

(Figure 10: Ground vibration test).

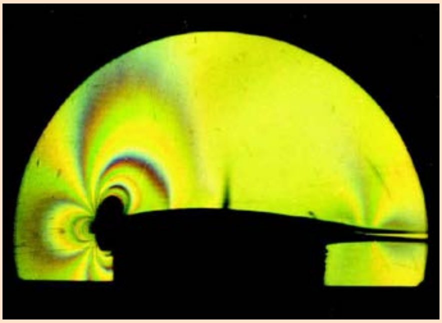
Natural Laminar Flow Wing and Fuselage

To satisfy the requirements of the HondaJet, a new natural-laminar-flow airfoil, the SHM-1, was designed using a conformal-mapping method. The pressure gradient on the upper surface is favorable to about 42% chord, followed by a concave pressure recovery, which represents a compromise between maximum lift, pitching moment, and drag divergence. The pressure gradient along the lower surface is favorable to about 63% chord to reduce drag. The leading-edge geometry was designed to cause transition near the leading edge at high angles of attack to minimize the loss in maximum lift coefficient caused by roughness. The upper-surface trailing-edge geometry was designed to produce a steep pressure gradient and, thereby, induce a small separation. By the incorporation of this new trailing-edge design, the magnitude of the pitching moment at high speeds is greatly reduced. The SHM-1 airfoil and an example of the pressure distribution are shown in Figure 11.



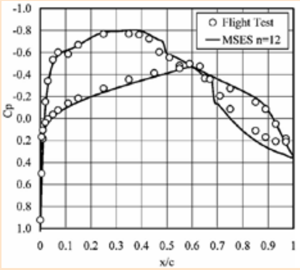
(Figure 11: SHM-1 airfoil pressure distribution)

The airfoil has been tested in low-speed and transonic wind tunnels (Figure 12) as well as full-scale flight testing using a gloved T-33 aircraft (Figure 13).



(Figure 12: Schlieren photograph of SHM-1 airfoil at drag-divergent Mach number during transonic wind tunnel testing)

(Figure 13: Full-scale flight testing using a gloved T-33 aircraft)

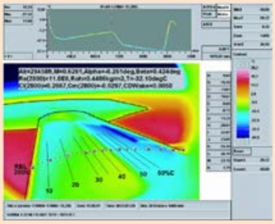


Full-scale flight testing validated the performance of the airfoil at full-scale Reynolds number and Mach number (Figure 14).

(Figure 14: Comparison of theoretical and experimental (flight) pressure distribution)

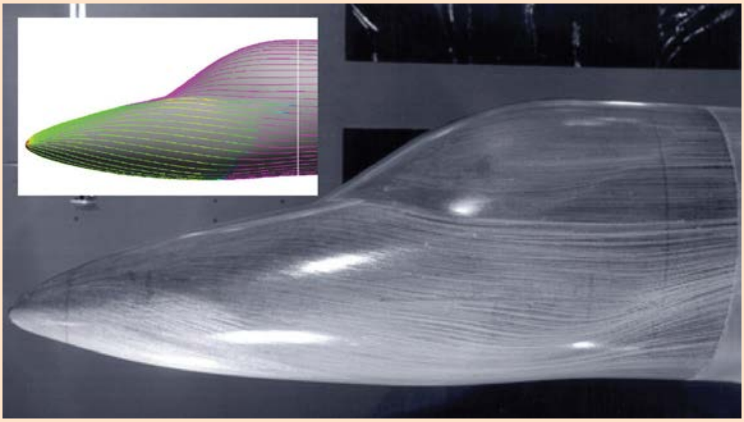
The laminar-to-turbulent boundary layer transitions were visualized in real time using an infrared (IR) camera during the T-33 flight tests (Figure 15).

(Figure 15: In-flight transition measurement using IR flow-visualization technique)



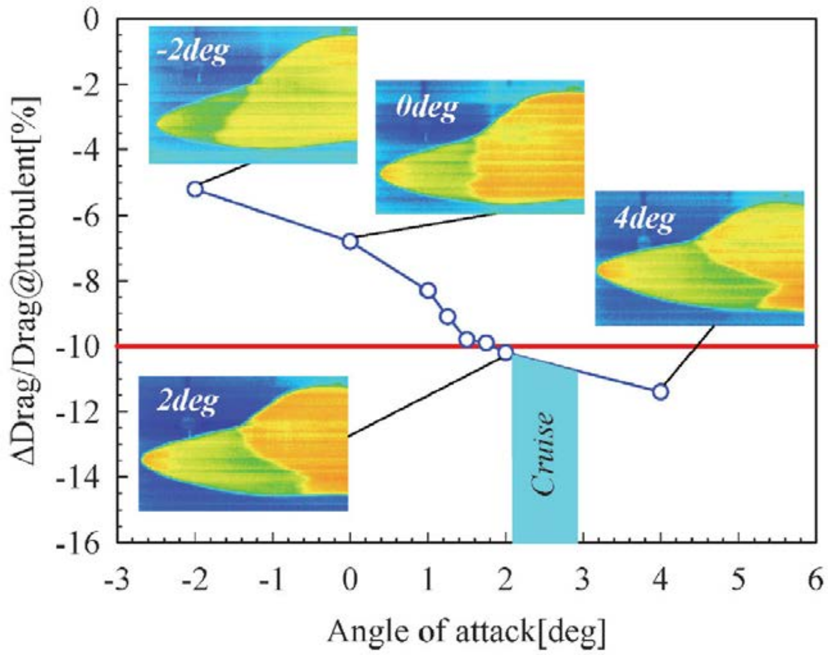
The SHM-1 airfoil exhibits a high maximum lift coefficient with docile stall characteristics and low profile-drag coefficients in cruise and climb.

A natural-laminar-flow, fuselage-nose shape was also developed through extensive theoretical analysis and experiments to reduce the fuselage drag. Using a three-dimensional, panel code with an integral boundary-layer method, the fuselage-nose contours were designed to maximize laminar-flow length by maintaining a favorable pressure gradient and minimizing crossflow instabilities. A 1/3-scale test was conducted in the Honda Low-Speed Wind Tunnel to validate the design. The streamlines on the nose were visualized using the oil flow technique and the observed patterns were compared to those from the theoretical analysis (Figure 16).



(Figure 16: NLF nose flow pattern)

The infrared technique was also used to visualize the laminar flow on the nose at each angle of attack (Figure 17).

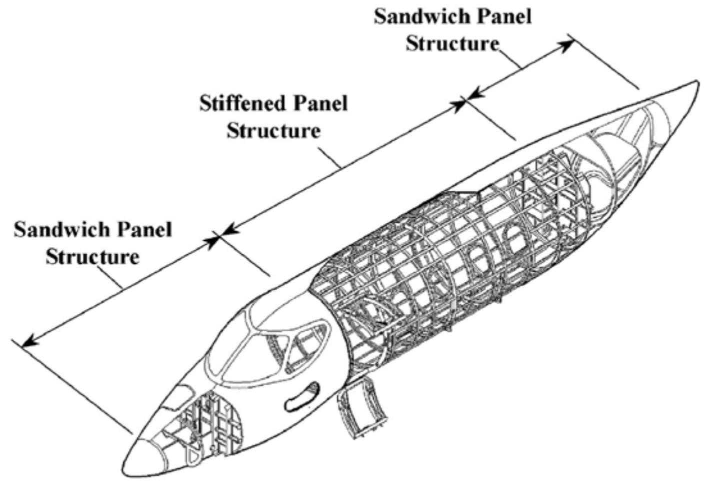


(Figure 17: Drag reduction of NLF nose)

The results show that extensive laminar flow is achieved at climb and cruise angles of attack. By employing a technology of natural-laminar flow nose, the fuselage drag is reduced about 10% compared to that of a turbulent-flow nose fuselage.

Composite Fuselage

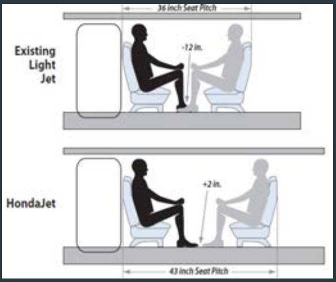
Composite material is now widely used in the aviation industry to reduce structural weight by taking advantage of its superior mechanical properties such as specific strength. However, careful evaluation is needed especially for composite material application for light jets because of its cost and the relative size of the aircraft. The weight benefit is often limited by the necessary minimum gauge of the structure and other design constraints. As a result, it is not always easy to take advantage of the characteristics of composite material for aviation applications. In addition, unique characteristics of composite material, including strength "knock down factor" for hot wet conditions, compression after impact (CAI), and inter-laminar shear strength are design constraints that must be considered, which have negative impacts on actual weight reduction. For the HondaJet structure, composite material is applied mainly to the fuselage taking into account all of the design aspects and constraints described above. The HondaJet's fuselage is constructed entirely of graphite composites. The material is a 350-deg-F cure epoxy pre-preg reinforced by carbon fiber. The matrix is Cytec 5276-1 high-damage-tolerance, epoxy resin, while the reinforcement is TOHO G30-500 high-strength, intermediate-modulus fiber. The cockpit and tail sections are a honeycomb sandwich construction to maintain the compound curves, which are especially important for the laminar-flow nose (Figure 18).



(Figure 18: HondaJet composite fuselage structure)

The sandwich structure also has the advantage of reduced cost due to the ease with which it can be fabricated into complex, three-dimensional contours. An integrally stiffened panel structure is employed for the constant cross-section portion of the cabin. The stiffened panel structure reduces weight because of its high structured efficiency and also maximizes the cabin volume. The general frames and stringers have identical dimensions in the constant cabin section, so the numbers of molds for the frames and stringers are minimized. The constant fuselage section can be easily extended to satisfy future fuselage stretching needed for derivative aircraft design. A feature of the fuselage fabrication is that the sandwich panel and the stiffened panel are co-cured integrally in an autoclave to reduce weight and cost. It was a technical challenge to cure the honeycomb sandwich structure under the pressure (85.3 psi) required for the stiffened panel, but a new method prevents core crushing. Another feature of the HondaJet composite fuselage is the buckling tolerance design that has been adopted to the stiffened panel. Shear buckling is allowed under limit load. The skin thickness and ply orientation of each structural skin bay were designed for optimum stress level and contribute to weight reduction as well. Through the application of composite material for the HondaJet's fuselage, Dr. Fujino achieved lower weight along with both an affordable fabrication cost and the best contour for aerodynamics.

Cabin Comfort



(Figure 19: HondaJet cabin legroom and length)

Dr. Fujino designed the HondaJet cockpit and cabin interior for ergonomics based on extensive research and by applying sophisticated interior design methodologies. The Over-The-Wing Engine Mount reduces cabin noise and vibration, providing customers with a large, relaxing cabin experience and more room for luggage. The HondaJet cabin is approximately 15 percent larger than other jets in its class and the design results in longer cabin length with significantly increased seat pitch at 43 inches and has 14 inches in legroom (Figure 19). External baggage volume (Figure 20) is also up to 50 percent larger than conventional light jets.

(Figure 20: HondaJet external baggage volume)

The HondaJet also features a private, externally serviceable lavatory with a pocket privacy door. The lavatory is large enough to accommodate a vanity and infrared sink. Dr. Fujino's unique patented two skylight windows in the ceiling further enhance the interior's spacious environment (Figure 21). With a total seating capacity of eight passengers, the interior reflects a design philosophy centered around human comfort, and attracts customers with its meticulous attention to detail.

(Figure 21: HondaJet cabin and lavatory design)

Advanced Avionic System

When Dr. Fujino began HondaJet development, business jets still relied on analog or simple digital instruments. To enhance operational safety, Dr. Fujino designed a new, all-glass cockpit for the HondaJet. To develop this new avionics suite, Dr. Fujino partnered with Gary Burrel, who was then president of Garmin International Inc., a manufacturer of GPS devices at that time. As a result of this partnership and design, Garmin began producing avionics equipment for business aviation; today, they are the most highly rated avionics company for general aviation. The HondaJet uses a highly customized avionics suite. The HondaJet cockpit is built for optimum safety based on a thoughtful ergonomic design and state-of-the-art situational awareness. Most flight controls are performed with touch-screen technology, which greatly reduces pilot workload. Several features enhance the standard autopilot function to provided additional assistance to the pilot, such as coupled go-arounds executed after a missed-approach, electronic stability protection, and performance management. The HondaJet has a sophisticated flight deck with three 14-inch landscape displays and two touchscreen controllers that provides pilots with enhanced navigation, flight planning, and system control (Figure 22).

(Figure 22: HondaJet cockpit)

All information from flight and engine instrumentation to navigation, communication, terrain, and traffic data is integrated and digitally presented on two Primary Flight Displays (PFDs) and a Multi-Function Display (MFD). The displays feature 60/40 split screen capability to show multiple information and allow the pilot to customize display views (Figure 23).

(Figure 23: HondaJet cockpit details)

Highly automated systems integrated with the avionics suite further reduce workload and enhance aircraft safety. The HondaJet features automatic ice-protection systems including horizontal tail de-icing with electro-mechanical expulsive devices; tail cone speed brake for safe and efficient descent; automatic, integrated pressurization system; FADEC engine control with cruise speed control; and a stall warning and protection system.

Commercialization

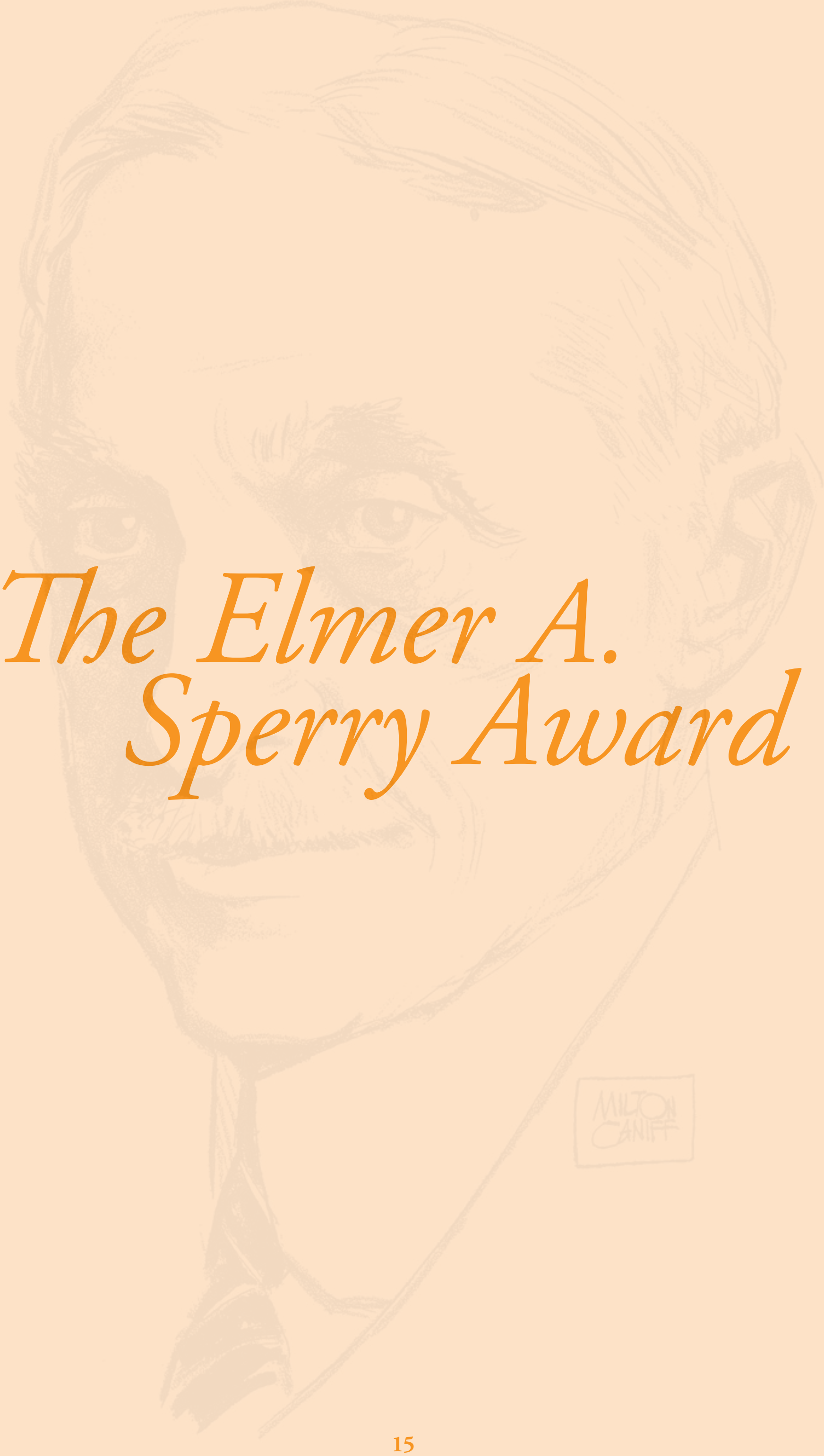
Dr. Fujino led the development of the HondaJet proof of concept, which first flew in December 2003. The HondaJet program was commercialized in 2006. Dr. Fujino was responsible for leading a new aviation company, Honda Aircraft, as it prepared for mass production (Figure 24) and type certification of the HondaJet. After successfully achieving type certification for the HondaJet in late 2015 (Figure 25), Dr. Fujino oversaw the business growth of his company as the HondaJet became the best-selling light jet in its class. Today, the HondaJet is the most delivered business jet in its class for five consecutive years (2017-2021). The HondaJet currently holds 13 type certifications around the world, including, the United States (FAA), Europe (EASA), Mexico (AFAC), Brazil (ANAC), Argentina (ANAC), Panama (AAC), India (DGCA), Japan (JCAB), Canada (TCCA), China (CAAC), Turkey (DGCA), Pakistan (PCAA) and Russia (FATA). Today, HondaJets are in operation around the world and Dr. Fujino's aircraft design is having real-world impact by offering customers new value in performance, comfort, and efficiency and at the same time contributing to lessening the carbon emissions of business aviation.

(Figure 24: HondaJet production assembly facility)

(Figure 25: HondaJet type certifications)

The Overall Achievement

Dr. Fujino holds the singular achievement of developing a new, clean sheet design; introducing new technologies to business aviation such as the Over-the-Wing Engine Mount and Natural Laminar Flow nose and airfoil; developing the design into a viable prototype aircraft; building a company capable of supporting mass production of the new aircraft; and succeeding in the aviation market as a newcomer. Beyond advancing the field of aeronautical engineering and successfully taking the design from prototype stage to commercialization, Dr. Fujino's work has benefitted the larger community by introducing an aircraft that is safer, more comfortable, higher performing, and more fuel efficient.



The Elmer A. Sperry Award

Elmer A. Sperry, 1860–1930

After graduating from the Cortland, N.Y. Normal School in 1880, Sperry had an association with Professor Anthony at Cornell, where he helped wire its first generator. From that experience he conceived his initial invention, an improved electrical generator and arc light. He then opened an electric company in Chicago and continued on to invent major improvements in electric mining equipment, locomotives, streetcars and an electric automobile. He developed gyroscopic stabilizers for ships and aircraft, a successful marine gyro-compass and gyro-controlled steering and fire control systems used on Allied warships during World War I. Sperry also developed an aircraft searchlight and the world's first guided missile. His gyroscopic work resulted in the automatic pilot in 1930. The Elmer A. Sperry Award was established in 1955 to encourage progress in transportation engineering.

The Elmer A. Sperry Award

To commemorate the life and achievements of Elmer Ambrose Sperry, whose genius and perseverance contributed so much to so many types of transportation, the Elmer A. Sperry Award was established by his daughter, Helen (Mrs. Robert Brooke Lea), and his son, Elmer A. Sperry, Jr., in January 1955, the year marking the 25th anniversary of their father's death. Additional gifts from interested individuals and corporations also contribute to the work of the board.

Elmer Sperry's inventions and his activities in many fields of engineering have benefited tremendously all forms of transportation. Land transportation has profited by his pioneer work with the storage battery, his development of one of the first electric automobiles (on which he introduced 4-wheel brakes and self-centering steering), his electric trolley car of improved design (features of its drive and electric braking system are still in use), and his rail flaw detector (which has added an important factor of safety to modern railroading). Sea transportation has been measurably advanced by his gyrocompass (which has freed humans from the uncertainties of the magnetic compass) and by such navigational aids as the course recorder and automatic steering for ships. Air transportation is indebted to him for the airplane gyro-pilot and the other air navigational instruments he and his son, Lawrence, developed together.

The donors of the Elmer A. Sperry Award have stated that its purpose is to encourage progress in the engineering of transportation. Initially, the donors specified that the award recipient should be chosen by a Board of Award representing the four engineering societies in which Elmer A. Sperry was most active:

American Society of Mechanical Engineers (of which he was the 48th president)
American Institute of Electrical Engineers (of which he was a founder member)
Society of Automotive Engineers
Society of Naval Architects and Marine Engineers

In 1960, the participating societies were augmented by the addition of the Institute of Aerospace Sciences. In 1962, upon merging with the Institute of Radio Engineers, the American Institute of Electrical Engineers became known as the Institute of Electrical and Electronics Engineers; and in 1963, the Institute of Aerospace Sciences, upon merger with the American Rocket Society, became the American Institute of Aeronautics and Astronautics. In 1990, the American Society of Civil Engineers became the sixth society to become a member of the Elmer A. Sperry Board of Award. In 2006, the Society of Automotive Engineers changed its name to SAE International.

Important discoveries and engineering advances are often the work of a group, and the donors have further specified that the Elmer A. Sperry Award honor the distinguished contributions of groups as well as individuals.

Since they are confident that future contributions will pave the way for changes in the art of transportation equal at least to those already achieved, the donors have requested that the board from time to time review past awards. This will enable the board in the future to be cognizant of new areas of achievement and to invite participation, if it seems desirable, of additional engineering groups representative of new aspects or modes of transportation.

The Sperry Secretariat

The donors have placed the Elmer A. Sperry Award fund in the custody of the American Society of Mechanical Engineers. This organization is empowered to administer the fund, which has been placed in an interest bearing account whose earnings are used to cover the expenses of the board. A secretariat is administered by the ASME, which has generously donated the time of its staff to assist the Sperry Board in its work.

The Elmer A. Sperry Board of Award welcomes suggestions from the transportation industry and the engineering profession for candidates for consideration for this award.

Previous Elmer A. Sperry Awards

1955 To ***William Francis Gibbs*** and his Associates for design of the S.S. United States.

1956 To ***Donald W. Douglas*** and his Associates for the DC series of air transport planes.

1957 To ***Harold L. Hamilton, Richard M. Dilworth*** and ***Eugene W. Kettering*** and Citation to their Associates for developing the diesel-electric locomotive.

1958 To ***Ferdinand Porsche*** (in memoriam) and ***Heinz Nordhoff*** and Citation to their Associates for development of the Volkswagen automobile.

1959 To ***Sir Geoffrey de Havilland, Major Frank B. Halford*** (in memoriam) and ***Charles C. Walker*** and Citation to their Associates for the first jet-powered passenger aircraft and engines.

1960 To ***Frederick Darcy Braddon*** and Citation to the Engineering Department of the Marine Division of the Sperry Gyroscope Company, for the three-axis gyroscopic navigational reference.

1961 To ***Robert Gilmore LeTourneau*** and Citation to the Research and Development Division, Firestone Tire and Rubber Company, for high speed, large capacity, earth moving equipment and giant size tires.

1962 To ***Lloyd J. Hibbard*** for applying the ignitron rectifier to railroad motive power.

1963 To ***Earl A. Thompson*** and Citations to ***Ralph F. Beck, William L. Carnegie, Walter B. Herndon, Oliver K. Kelley*** and ***Maurice S. Rosenberger*** for design and development of the first notably successful automatic automobile transmission.

1964 To ***Igor Sikorsky*** and ***Michael E. Gluhareff*** and Citation to the Engineering Department of the Sikorsky Aircraft Division, United Aircraft Corporation, for the invention and development of the high-lift helicopter leading to the Skycrane.

1965 To ***Maynard L. Pennell, Richard L. Rouzie, John E. Steiner, William H. Cook*** and ***Richard L. Loesch, Jr.*** and Citation to the Commercial Airplane Division, The Boeing Company, for the concept, design, development, production and practical application of the family of jet transports exemplified by the 707, 720 and 727.

1966 To ***Hideo Shima, Matsutaro Fuji*** and ***Shigenari Oishi*** and Citation to the Japanese National Railways for the design, development and construction of the New Tokaido Line with its many important advances in railroad transportation.

1967 To ***Edward R. Dye*** (in memoriam), ***Hugh DeHaven,*** and ***Robert A. Wolf*** for their contribution to automotive occupant safety and Citation to the research engineers of Cornell Aeronautical Laboratory and the staff of the Crash Injury Research projects of the Cornell University Medical College.

1968 To ***Christopher S. Cockerell*** and ***Richard Stanton-Jones*** and Citation to the men and women of the British Hovercraft Corporation for the design, construction and application of a family of commercially useful Hovercraft.

1969 To ***Douglas C. MacMillan, M. Nielsen*** and ***Edward L. Teale, Jr.*** and Citations to ***Wilbert C. Gumprich*** and the organizations of George G. Sharp, Inc., Babcock and Wilcox Company, and the New York Shipbuilding Corporation for the design and construction of the N.S. Savannah, the first nuclear ship with reactor, to be operated for commercial purposes.

1970 To ***Charles Stark Draper*** and Citations to the personnel of the MIT Instrumentation Laboratories, Delco Electronics Division, General Motors Corporation, and Aero Products Division, Litton Systems, for the successful application of inertial guidance systems to commercial air navigation.

1971 To ***Sedgwick N. Wight*** (in memoriam) and ***George W. Baughman*** and Citations to ***William D. Hailes, Lloyd V. Lewis, Clarence S. Snavely, Herbert A. Wallace,*** and the employees of General Railway Signal Company, and the Signal & Communications Division, Westinghouse Air Brake Company, for development of Centralized Traffic Control on railways.

1972 To ***Leonard S. Hobbs*** and ***Perry W. Pratt*** and the dedicated engineers of the Pratt & Whitney Aircraft Division of United Aircraft Corporation for the design and development of the JT-3 turbo jet engine.

1975 To ***Jerome L. Goldman, Frank A. Nemec*** and ***James J. Henry*** and Citations to the naval architects and marine engineers of Friede and Goldman, Inc. and Alfred W. Schwendtner for revolutionizing marine cargo transport through the design and development of barge carrying cargo vessels.

1977 To ***Clifford L. Eastburg*** and ***Harley J. Urbach*** and Citations to the Railroad Engineering Department of The Timken Company for the development, subsequent improvement, manufacture and application of tapered roller bearings for railroad and industrial uses.

1978 To ***Robert Puiseux*** and Citations to the employees of the Manufacture Française des Pneumatiques Michelin for the development of the radial tire.

1979 To ***Leslie J. Clark*** for his contributions to the conceptualization and initial development of the sea transport of liquefied natural gas.

1980 To ***William M. Allen, Malcolm T. Stamper, Joseph F. Sutter*** and ***Everette L. Webb*** and Citations to the employees of Boeing Commercial Airplane Company for their leadership in the development, successful introduction & acceptance of wide-body jet aircraft for commercial service.

1981 To ***Edward J. Wasp*** for his contributions toward the development and application of long distance pipeline slurry transport of coal and other finely divided solid materials.

1982 To ***Jörg Brenneisen, Ehrhard Futterlieb, Joachim Körber, Edmund Müller, G. Reiner Nill, Manfred Schulz, Herbert Stemmler*** and ***Werner Teich*** for their contributions to the development and application of solid state adjustable frequency induction motor transmission to diesel and electric motor locomotives in heavy freight and passenger service.

1983 To ***Sir George Edwards,*** OM, CBE, FRS; ***General Henri Ziegler,*** CBE, CVO, LM, CG; ***Sir Stanley Hooker,*** CBE, FRS (in memoriam); ***Sir Archibald Russell,*** CBE, FRS; and ***M. André Turcat***, L d'H, CG; commemorating their outstanding international contributions to the successful introduction and subsequent safe service of commercial supersonic aircraft exemplified by the Concorde.

1984 To ***Frederick Aronowitz, Joseph E. Killpatrick, Warren M. Macek*** and ***Theodore J. Podgorski*** for the conception of the principles and development of a ring laser gyroscopic system incorporated in a new series of commercial jet liners and other vehicles.

1985 To ***Richard K. Quinn, Carlton E. Tripp,*** and ***George H. Plude*** for the inclusion of numerous innovative design concepts and an unusual method of construction of the first 1,000-foot self-unloading Great Lakes vessel, the M/V Stewart J. Cort.

1986 To ***George W. Jeffs, Dr. William R. Lucas, Dr. George E. Mueller, George F. Page, Robert F. Thompson*** and ***John F. Yardley*** for significant personal and technical contributions to the concept and achievement of a reusable Space Transportation System.

1987 To ***Harry R. Wetenkamp*** for his contributions toward the development and application of curved plate railroad wheel designs.

1988 To ***J. A. Pierce*** for his pioneering work & technical achievements that led to the establishment of the OMEGA Navigation System, the world's first ground-based global navigation system.

1989 To ***Harold E. Froehlich, Charles B. Momsen, Jr.,*** and ***Allyn C. Vine*** for the invention, development and deployment of the deep-diving submarine, Alvin.

1990 To ***Claud M. Davis, Richard B. Hanrahan, John F. Keeley,*** and ***James H. Mollenauer*** for the conception, design, development and delivery of the Federal Aviation Administration enroute air traffic control system.

1991 To ***Malcom Purcell McLean*** for his pioneering work in revolutionizing cargo transportation through the introduction of intermodal containerization.

1992 To ***Daniel K. Ludwig*** (in memoriam) for the design, development and construction of the modern supertanker.

1993 To ***Heinz Leiber, Wolf-Dieter Jonner*** and ***Hans Jürgen Gerstenmeier*** and Citations to their colleagues in Robert Bosch GmbH for their conception, design and development of the Anti-lock Braking System for application in motor vehicles.

1994 To ***Russell G. Altherr*** for the conception, design and development of a slackfree connector for articulated railroad freight cars.

1996 To ***Thomas G. Butler*** (in memoriam) and ***Richard H. MacNeal*** for the development and mechanization of NASA Structural Analysis (NASTRAN) for widespread utilization as a working tool for finite element computation.

1998 To ***Bradford W. Parkinson*** for leading the concept development and early implementation of the Global Positioning System (GPS) as a breakthrough technology for the precise navigation and position determination of transportation vehicles.

2000 To those individuals who, working at the French National Railroad (SNCF) and ALSTOM between 1965 and 1981, played leading roles in conceiving and creating the initial TGV High Speed Rail System, which opened a new era in passenger rail transportation in France and beyond.

2002 To ***Raymond Pearlson*** for the invention, development and worldwide implementation of a new system for lifting ships out of the water for repair and for launching new ship construction. The simplicity of this concept has allowed both large and small nations to benefit by increasing the efficiency and reducing the cost of shipyard operations.

2004 To ***Josef Becker*** for the invention, development, and worldwide implementation of the Rudderpropeller, a combined propulsion and steering system, which converts engine power into optimum thrust. As the underwater components can be steered through 360 degrees, the full propulsive power can also be used for maneuvering and dynamic positioning of the ship.

2005 To ***Victor Wouk*** for his visionary approach to developing gasoline engine-electric motor hybrid-drive systems for automobiles and his distinguished engineering achievements in the related technologies of small, lightweight, and highly efficient electric power supplies and batteries.

2006 To ***Antony Jameson*** in recognition of his seminal and continuing contributions to the modern design of aircraft through his numerous algorithmic innovations and through the development of the FLO, SYN, and AIRPLANE series of computational fluid dynamics codes.

2007 To ***Robert Cook, Pam Phillips, James White,*** and ***Peter Mahal*** for their seminal work and continuing contributions to aviation through the development of the Engineered Material Arresting System (EMAS) and its installation at many airports.

2008 To ***Thomas P. Stafford, Glynn S. Lunney, Aleksei A. Leonov,*** and ***Konstantin D. Bushuyev*** as leaders of the Apollo-Soyuz mission and as representatives of the Apollo-Soyuz docking interface design team: in recognition of seminal work on spacecraft docking technology and international docking interface methodology.

2009 To ***Boris Popov*** for the development of the ballistic parachute system allowing the safe descent of disabled aircraft.

2010 To ***Takuma Yamaguchi*** for his invention of the ARTICOUPLE, a versatile scheme to connect tugs and barges to form an articulated tug and barge, AT/B, waterborne transportation system operational in rough seas. His initial design has led to the development of many different types of couplers that have resulted in the worldwide use of connected tug and barges for inland waterways, coastal waters and open ocean operation.

2011 To ***Zigmund Bluvband*** and ***Herbert Hecht*** for development and implementation of novel methods and tools for the advancement of dependability and safety in transportation.

2012 To ***John Ward Duckett*** for the development of the Quickchange Movable Barrier.

2013 To ***C. Don Bateman*** for the development of the ground proximity warning system for aircraft.

2014 To ***Bruce G. Collipp, Alden J. Laborde,*** and ***Alan C. McClure*** for the design and development of the semi-submersible platform.

2015 To ***Michael K. Sinnett*** and the ***The Boeing Company 787-8 Development Team*** for pioneering engineering advances including lightweight composite wing and monolithic fuselage construction that have led to significant improvements in fuel efficiency, reduced carbon emission, reduced maintenance costs and increased passenger comfort.

2016 To ***Harri Kulovaara*** for leadership in the engineering and design of the most advanced and trend setting cruise ships, ships that integrated “quantum jumps” in cruise ship safety, operational efficiency, features to suit passengers of “all ages,” and diverse onboard activities. And, for being the driving force behind the Cruise Ship Safety Forum that brings together owners, builders and classification societies to ensure specific targeted areas of safety improvement are developed and implemented.

2017 To ***Bruno Murari*** for his seminal work and leadership in the development of Power Integrated Circuits for the transportation industry.

2018 To ***Panama Canal Authority*** for planning and successfully managing a program to undertake and complete a massive infrastructure project, he “Expansion of the Panama Canal” that required the integration of the most demanding multidisciplinary engineering endeavors.This expansion markedly enhances cargo trade and maritime transportation, with profound economic impacts on a worldwide scale.

2019 To ***George A. (Sandy) Thomson*** in recognition of leading the innovation for water-lubricated main propulsion shaft bearings for marine transport through the application of polymeric compounds.

2020 To ***Dominique Roddier, Christian Cermelli, and Alexia Aubault*** for the development of WindFloat, a floating foundation for offshore wind turbines.

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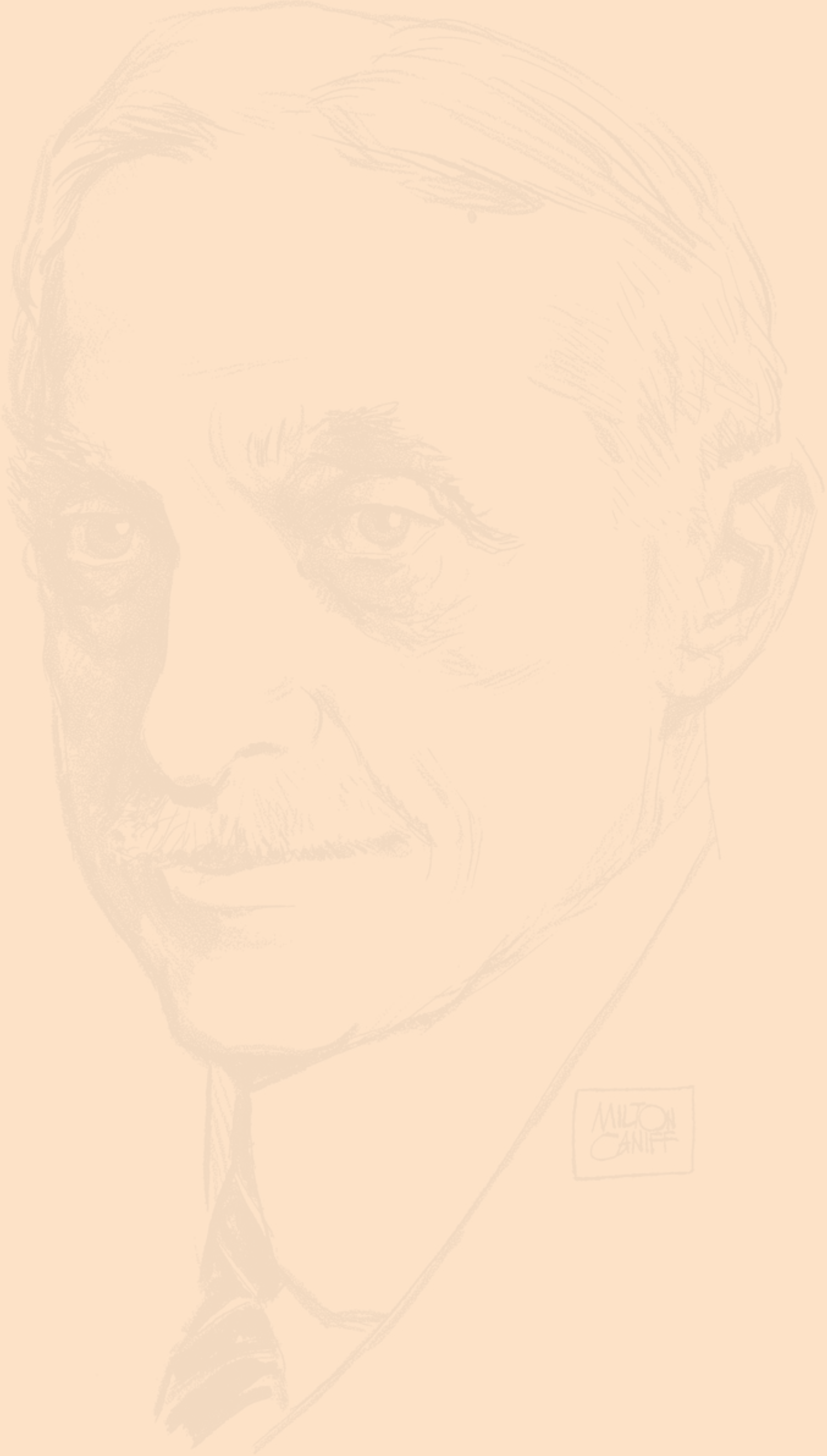
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