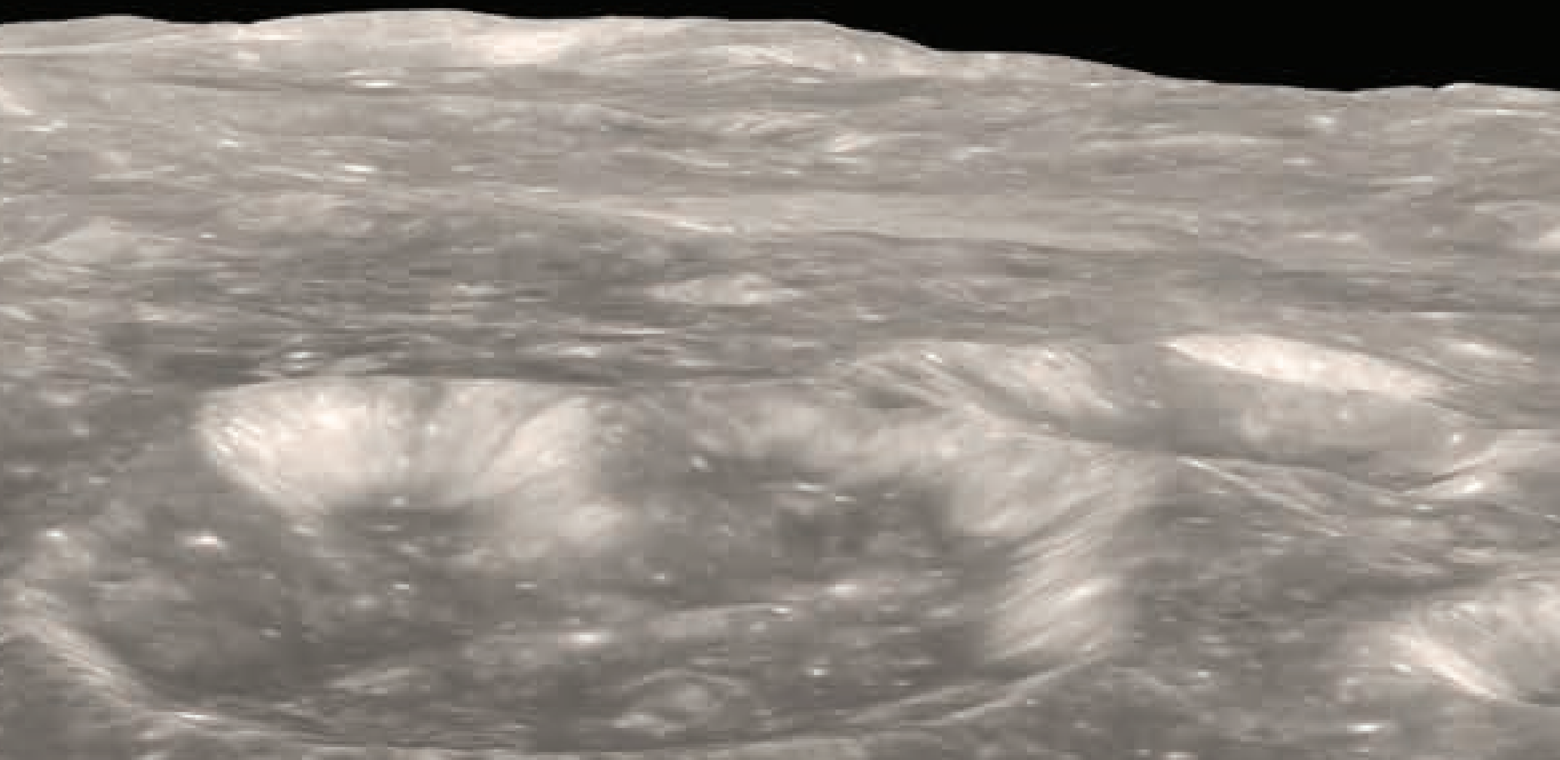
Combined observations of the moon and Earth from two NASA missions.
NASA

OSA Centennial Snapshots

Lasers, Lunar Missions and Legacies

BRIAN J. HAGERTY

Hal Walker Jr.'s journey from the U.S. Navy to NASA to global educator.



Hal Walker Jr. working on the U.S. Ballistic Missile Early Warning System (BMEWS) in Clear, Alaska, USA, ca. 1960.
RCA Corporation

In the 1960s, during the height of the Cold War and the space race, power-electronics technician Hildreth "Hal" Walker Jr. was selected to become KORAD Laser System's field operations manager for the U.S. *Apollo 11* Lunar Laser-Ranging Experiment (LURE). On 20 July 1969, *Apollo 11* astronauts Edwin "Buzz" Aldrin Jr. and Neil Armstrong placed a 10 × 10 array of corner-cube retroreflectors on the surface of the moon. With the array in place, the race was on between teams from the United States and the uninvited Soviet Union—each firing weapons-grade ruby lasers at the same reflectors—to hit that target and detect a return signal, and become the first nation to measure the distance to the moon with a pulse of laser photons.

Enlisted as an electrician's mate, Walker had plenty of opportunities to refine his teenage passion for electronic tinkering into a fully professional set of advanced skills.

On 1 August 1969, after 12 days of engineering and logistical challenges and many errant laser shots, Walker, a former U.S. Navy electrician's mate, was the key man on station at Lick Observatory in California manning his team's 1.2-GW ruby-crystal laser. On that day, he fired KORAD's laser at the moon and received a successful ranging signal—thus beating the Soviets to the punch, and earning Walker a place in engineering history.

Walker's success with the LURE experiment is not where his story ends—or, for that matter, where it begins. Walker had a passion for science and technology from an early age, and he continues to share his passion with others through his work as a global educator.

Ray guns, carriers and aircraft

Little did six-year old Hal Walker Jr. know that the "Buck Rogers" toy ray-gun given to him by his father in 1939 would lead him to a lifetime career in power electronics and laser-beam technology. Although the toy ray-gun only made a metal grinding noise and emitted harmless sparks, young Hal was curious enough to disassemble his favorite toy to learn the magic of the mechanisms inside. His interest in machinery and electronics was further stirred up during regular visits to the neighborhood vacuum-cleaner repair shop, where he watched his childhood friend's father carefully disassemble, diagnose and repair the innovative contraptions.

But before Walker, an African-American man born in segregated Louisiana, could make it to the big leagues of U.S. National Aeronautics and Space Administration (NASA) missions, he had a lot of hard-knocks learning to do and adversity to overcome. His mother had become estranged from his father and later remarried; the new family moved to Los Angeles, California, where Hal would enter junior high school. In shop class, Hal's instructor, Mr. Dietz, recognized his aptitude and work ethic, and encouraged him to expand his craftsman's skills. Fellow students in Hal's neighborhood shared his enthusiasm for

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amateur science, engineering and mechanics, collaborating on projects such as building small motors and crystal oscillator radios.

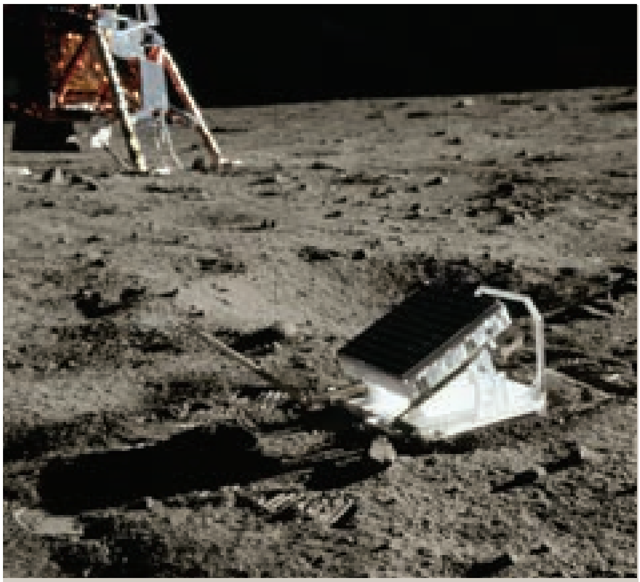
By 1951 Hal Walker had graduated from high school and, with local jobs hard to come by and the Korean War underway, he enlisted in the Navy—a critical first step in his lengthy career in power electronics and leading-edge engineering. Walker was stationed aboard the *USS Rendova*, an aircraft carrier originally commissioned near the end of World War II but newly recommissioned for the Korean conflict. Enlisted as an electrician's mate, Walker had plenty of opportunities to refine his teenage passion for electronic tinkering into a fully professional set of advanced skills. In particular, Walker became a specialist in the safety and operational aspects of high-voltage and high-powered generators, motors and related machinery, like those found in *Rendova*'s power plant, aircraft elevators and radar systems.

At the end of his naval service in 1955, Walker was eligible, under the U.S. government's G.I. Bill, to attend college. He enrolled in electrical engineering classes at Los Angeles City College, which is where he met a recruiter from Douglas Aircraft Company looking for candidates to work on the installation and maintenance of radar systems for its new carrier-based A3D Skywarrior strategic bomber. Unlike the propeller-powered Corsair aircraft onboard the *Rendova*, the Skywarrior was a jet-powered aircraft designed for operation from the new *Forrestal*-class of supercarriers.

Thus Walker's on-the-job training and work ethic continued to earn him ever-higher levels of engineering skills and recognition. With the winding down of the Korean War, however, and layoffs at Douglas Aircraft, Walker was soon unemployed again and thrust into a competitive, sink-or-swim job market.

Sputnik launches a space race

Meanwhile, geopolitical tensions between the United States and the Soviet Union had escalated after the conclusion of World War II and continued to worsen through and beyond the Korean War. When the Soviet Union launched the radio-beacon satellite *Sputnik 1* on 4 October 1957—with a low-earth-orbiting trajectory over the United States and visible by any observer on the ground with binoculars—the threat of a nuclear bomb was paramount in the minds of American citizens, politicians and the military. The United States had dropped nuclear bombs on Japan in 1945 during World War II, so by 1957 the technological advances demonstrated by *Sputnik* made the prospect of Soviet-launched nuclear warfare very real in the minds of the U.S. population.



NASA's lunar laser-ranging: How it works

A laser pulse from a telescope on Earth hits the retroreflector array on the moon. The corner-cube reflectors in the array redirect the laser pulse and send it straight back to the telescope on Earth. Researchers average the round-trip signal to calculate the distance to the moon.

- The average distance from the Earth to the moon is about **385,000 km**
- Dispersion causes the laser beam "footprint" to be about **7 km** in diameter when it reaches the moon, and **20 km** in diameter when it returns to Earth
- Data from lunar laser-ranging show that the moon is receding from Earth at about **3.8 cm** per year.

(Above) *Apollo 11 Eagle* lunar excursion module and LURE retroreflector deployed on the surface of the moon. NASA

U.S. President Dwight Eisenhower, despite publicly assuaging fears by down-playing the significance of *Sputnik*, very quickly declared that the United States must respond with "resourcefulness and vigor" by accelerating its own science and engineering efforts in space technology and establishing U.S. space-based military capabilities. By February 1958, Eisenhower had created the Defense Advanced Research Projects Agency (DAPRA) and, by July 1958, its civilian counterpart, NASA.

The scientific and engineering achievement of LURE—which aimed at using lasers to precisely measure the distance between the Earth and the moon—held huge potential strategic value, both military and commercial.

The Radio Corporation of America (RCA), formed after World War I to commercialize radio technology used in that war, continued to serve as a military contractor through World War II and beyond. Not so coincidentally, then, the only real-time signal recording of *Sputnik 1*'s radio beacon as it flew over the United States was made by RCA. Soon after, RCA ramped up its development of launch-checkout and missile-guidance systems for the Atlas rocket platform.

RCA's sudden interest in boosting its rocket work created an opportunity for the young Hal Walker. He saw an employment ad from RCA that called for contract workers with electrical engineering experience and military clearance. Walker now found himself working as a field engineer on intercontinental ballistic missile systems (ICBMs).

Watching the Soviets from Alaska

In addition to ICBM launch platforms, RCA was the general contractor to the U.S. Air Force for the 474L Ballistic Missile Early Warning System (BMEWS). There were three BMEWS stations, each with the objective of detecting Soviet missile launches via radar: Site I in Thule, Greenland; Site II in Cape Clear, Alaska; and Site III in Fylingdales Moor, England.

Walker was fully engaged in ICBM projects when he received an unsolicited invite from RCA headquarters in New Jersey to join the BMEWS team. The invitation was a testament to Walker's advanced engineering experience and the high marks for job performance that he'd been accumulating since he first joined the Navy. After additional psychiatric testing and security clearances, Walker was selected to join a team of about 1,500 personnel dispatched to the Clear Station, where he would spend the next 18 months working on the world's most advanced radar, computer and power electronics systems.

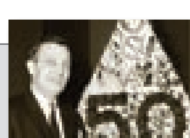
The BMEWS radar and computerized trajectory analysis systems utilized the latest electronics components and mathematical algorithms to calculate the Doppler shift, pattern recognition, and time-of-flight of the powerful radio waves generated by BMEWS and reflected off incoming targets. Ultimately, the goal was not only to quickly detect incoming missiles, but to be able to orchestrate a defensive anti-missile response with precisely controlled launching, pointing, interception and destructive power.

When Walker's BMEWS contract was complete, he was once again out of work. He spent his time between high-tech projects working at short-term manual labor jobs, and by performing as a very capable jazz musician. Neither odd-jobs

OSA Centennial Timeline 1966-75

www.osa.org/100

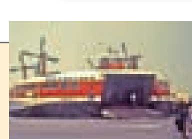
OSA HISTORY



1966
OSA Marks 50 Years of Service; Membership Reaches 4,500

1966
OSA Begins Translating and Publishing *Soviet Journal of Optical Technology*

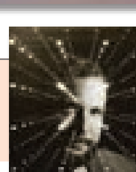
POLITICAL/ SOCIAL



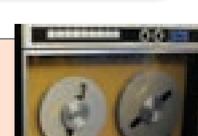
1966
Hovercraft Service on English Channel Begins

1969
U.S. *Apollo 11* Astronauts Armstrong and Aldrin Land on the Moon

SCIENCE/ ENGINEERING



1968
Stephen Benton Invents White-Light Transmission Holography



1969
First Message Sent Over ARPANET, Future Internet

nor jazz performances, though, paid much; so the appeal of power electronics and high-profile military projects continued to keep Walker on the hunt for new opportunities.

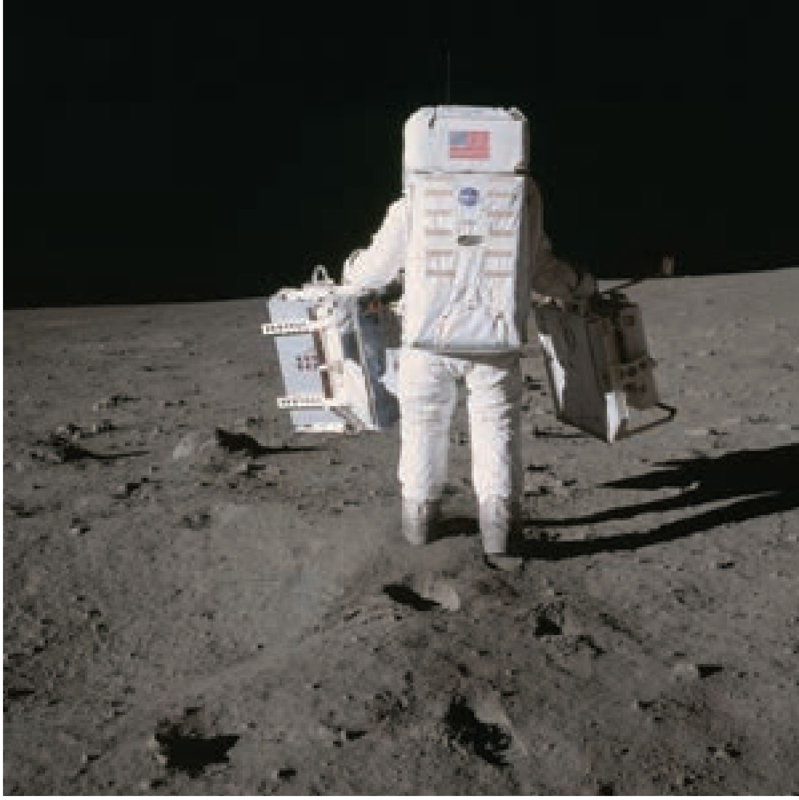
Landing a man—and an array—on the moon

Even as Walker was upping his technical game on these military projects, the political space race between the United States and the Soviet Union continued. On 12 April 1961, the Soviets once again bested the United States, becoming the first country to put a human, Yuri Gagarin, in Earth orbit. A U.S. astronaut, Alan Shepard, became the second human in space less than a month later, on 5 May.

Barely three weeks after that, John F. Kennedy, who had succeeded Eisenhower as U.S. President, made a celebrated address to Congress that probably did more to accelerate the pace of the new science, engineering and aerospace-driven economy than ever before: "I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to Earth. No single project in this period will be more impressive to mankind, or more important for the long-range exploration of space."

Work on NASA's manned space programs continued, now built around Kennedy's lunar vision. John Glenn Jr. orbited Earth in the *Friendship 7* capsule in 1962, followed by the flights of astronauts Scott Carpenter, Walter Schirra Jr. and L. Gordon Cooper in 1963. The two-man flights of the Gemini program were next, followed by the three-man Apollo flights that would ultimately lead to a successful landing of humans on the moon.

In evaluating science experiments for the *Apollo 11* mission, NASA opted to include an Earth-moon ranging



Apollo 11 astronaut Buzz Aldrin carries the laser reflector in his right hand and the seismometer in his left. NASA

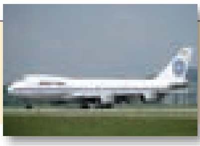
project called the Lunar Laser-Ranging Experiment (LURE), based on high-powered ruby-crystal lasers. The scientific and engineering achievement of LURE—which aimed at using lasers to precisely measure the distance between the Earth and the moon—held huge potential strategic value, both military and commercial. Two contractors were chosen to create the high-powered laser systems that would serve as the Earth-bound component of the LURE project: Spacerays Corporation and KORAD Laser Systems.

To build a gigawatt-power laser suitable for the LURE project, KORAD began a search for a team of people with expertise in materials, manufacturing, and high-voltage and

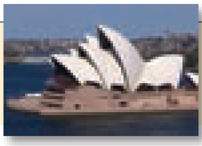
1969
Jarus Quinn Becomes OSA Executive Director

1970
OSA's Meggers Award for Spectroscopy Debuts

1975
First Issue of *Optics News* is Published



1971
First Jumbo Jet Crosses the Atlantic, a Boeing 747 Flown by Pan-Am

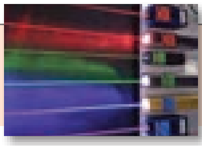


1973
Sydney Opera House Opens

1975
Helsinki Accords Signed

1973
Motorola's Martin Cooper Makes First Handheld Mobile Phone Call

1974
Pack of Wrigley's is First Product Read by a Barcode Scanner



1975
First Commercial Continuous-Wave Semiconductor Laser

Source: Wikimedia Commons, OSA Historical Archives and NSF

NASA flight controllers applaud the splashdown and success of the *Apollo 11* lunar mission.
NASA

high-powered electronics. Because of his power-electronics, testing and manufacturing expertise, Hal Walker became one of those team members, and was soon designated KORAD's field operations manager for the *Apollo 11* LURE project.

The *Eagle* has landed

On 20 July 1969, *Apollo 11* astronauts Neil Armstrong, Michael Collins and Edwin "Buzz" Aldrin Jr. entered the moon's orbit in the command service module (CSM), *Columbia*. Armstrong and Aldrin would then make their way into the mission's lunar excursion module (LEM), the *Eagle*, and begin their legendary descent to the surface. Packed away in the LEM was the moon-based component of the LURE project: the 10 × 10 corner-cube retroreflector array. Among other tasks on the moon, Armstrong and Aldrin would place the reflector array in the desolate plain of the Sea of Tranquility, after which they would return to the LEM to launch and rendezvous with Collins in the orbiting CSM. Once the astronauts had left the lunar surface, the LURE array was cleared for targeting by Walker's team of scientists and engineers and their gigawatt laser back on Earth.

Four U.S.-based teams equipped with high-powered lasers then began a painstaking search for the minuscule retroreflector target nearly a quarter-million miles away—the array's exact coordinates in the Sea of Tranquility being unknown. The teams, each armed with a laser system, were stationed at McDonald Observatory in Texas, Mount Haleakala Observatory in Hawaii, and two laser teams at Lick Observatory in California. Walker's KORAD team was at Lick, along with a competing laser-ranging team from Spacerays. Each KORAD laser system had a unique set of challenges due to the developmental nature of the technology, so it was not a simple matter of firing at will to hit the retroreflector on the moon.

It soon became apparent to the U.S. scientists scrutinizing the Sea of Tranquility, however, that someone else on Earth was also firing ruby-red beams at the moon and attempting to hit the LURE array. Those rogue laser shots, it turned out, were from a team of Soviet scientists, who hoped to achieve an end run around the U.S. groups. There was, of course, no way to stop the Soviet team from trying—but as Walker reports, the American teams were told in no uncertain terms by their NASA and DARPA sponsors, "Don't let the Soviets hit our mirrors!" The race was on between the lunar laser-ranging teams.

A technological triumph

In the end, success depended less on chance than on technological readiness. Some teams encountered catastrophic equipment failures due to the high-powered nanosecond pulses, which literally broke down the molecular structure of the air around the equipment, complete with thunderous bangs and fried electronics. System-design thresholds and even sabotage were also claimed as sources of failure. In other cases, with beam-widths at the surface of the moon dispersed as wide as 7 km, there was just not enough transmitted energy to produce a recognizable signal from the few photons that returned to the Earth.

Success came at last to Walker and his team in the early morning hours of 1 August 1969. A few days earlier, Walker's team's laser had experienced its own catastrophic failure and had to be replaced with a unit from KORAD's labs in Santa Monica, 350 miles south of Lick Observatory. Hal himself raced down Mount Hamilton in a rented car to get to KORAD, pick up the replacement parts, then return to Lick and get the equipment installed and operational for the next round of shots.

The entire team involved in the project—from Earth to the moon and back—had launched a new era of science, engineering and aerospace.

Sure enough, on that fateful day, Hal Walker and his principal science and engineering colleagues from Wesleyan University, James Faller and Irvin Winer, dialed up the power on their crystal-ruby laser, which operated at the brilliant red wavelength of 694.3 nm. The KORAD laser produced 12 J of energy delivered in a 10-ns pulse, yielding 1.2 GW of photonic power. A little over 2.4 seconds later, the round-trip signal was positively recognized by Walker's team! The entire team involved in the project—from Earth to the moon and back—had launched a new era of science, engineering and aerospace.

Global education, global legacies

Walker would soon move from KORAD to the Hughes Aircraft Company's Electro-Optical and Data Systems Group, where he would ultimately retire after a long career in laser-based systems and advanced technology. In retirement, his professional career would serve as the foundation for what has become his most important legacy: inspiring the next generation of young men and women to explore and discover, to learn and to innovate in the fields of science, technology, engineering and mathematics (STEM).

In 1991, Walker and his wife, Dr. Bettye Davis Walker, a former K-12 school principal, university professor and researcher, co-founded the A-MAN International STEM Discovery Center in Inglewood, California. A-MAN specializes in after-school STEM programs for children in the greater Los Angeles area. In 1997, as part of a youth education expedition to South Africa, the Walkers had the opportunity to meet President Nelson Mandela. Impressed with their work, Mandela invited the Walkers to extend their A-MAN programs to his country, which they did.

The A-MAN program now includes more than a dozen STEM centers. Still very active in their early 80s, Hal and Bettye Walker continue to expand their A-MAN programs in the United States and to travel annually to South Africa to open new A-MAN schools, collaborating with the South African National Space Agency and the Ministries of Education and Commerce.

True to the mission of science and engineering exploration, the Walkers are still working with NASA and the Jet Propulsions Labs as "solar-system ambassadors" for youth education and outreach programs conducted through their A-MAN centers, and more recently through their new project, the Hal and Bettye Walker Center for Lifelong Learning and Sustainable Economic Development. OPN

Smithsonian Institution

Teaching the next generation

In 1995, Hal Walker gave presentation for school children called "Lasers and Electromobiles: The Wave of the 21st Century," at the Smithsonian Institution's Lemelson Center for the Study of Invention and Innovation in Washington, D.C., USA. During his talk, students participated in demonstrations of how lasers are used to make music in a CD player, measure the distance to the moon, carry voices over telephone wires, and help doctors heal sick patients.

The presentation and demonstrations are saved in the Smithsonian archives under "Innovative Lives: Hal Walker, The Coherent Light of Persistence."

Brian J. Hagerty (Brian@CopernicaInstitute.com) is executive director of the Copernica Institute and chair of education activities for IEEE Region 6. He also serves on the board of the Hal & Bettye Walker Center for Lifelong Learning and Sustainable Economic Development.

References and Resources

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