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MIT and World War II: Ingredients for a Hot Spot of Invention

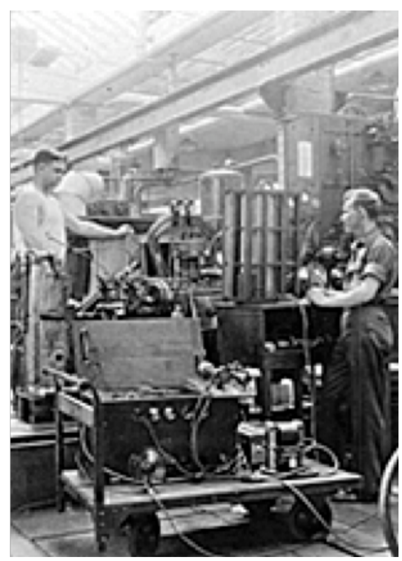
by Joyce Bedi, Senior Historian, Lemelson Center

Karl Taylor Compton (right) appointed Vannevar Bush the first dean of the School of Engineering at MIT in 1932. Courtesy of the MIT Museum.

The region surrounding Cambridge, Massachusetts, is known today as a vibrant place of invention. But an earlier hot spot started to form there in 1930, when Karl Taylor Compton became president of the Massachusetts Institute of Technology (MIT). He transformed the curriculum, raising the profile of science and promoting research partnerships with government.

Compton found a kindred spirit in Vannevar Bush, an electrical engineering professor and mentor to his students, and he named Bush the first dean of the new School of Engineering in 1932. Though Bush left MIT in 1939, he and Compton continued to work together, most notably when Bush became chairman of the newly established National Defense Research Committee (NDRC) in 1940, and later, the Office of Scientific Research and Development (OSRD).

As World War II approached, the links between MIT, the federal government, and the military grew stronger. The campus bustled with a growing network of inventive people and new and expanding research laboratories. Three of these—Charles Stark Draper's instruments lab, the Radiation Laboratory, and Harold Edgerton's strobe lab—contributed directly to the war effort and illustrate how the work of Compton and Bush turned MIT into a hot spot of invention.



Draper (left) in the MIT engine laboratory, 1931. Courtesy of the MIT Museum.

Draper's instruments lab

Charles Stark Draper's love of flying sparked a lifelong interest in navigation and control. Arriving at MIT as an undergraduate in 1922, he later started a small lab to design aircraft and automotive instrumentation. "Here I am in an airplane in the fog," he commented, "and I can't see a thing. I don't know where the hell I am or where I'm going. I don't know whether I'm right side up or wrong side up. I ask myself, 'If you can wear a wristwatch to tell you what time it is, why can't you have something that will tell you where you are with respect to space?'" (1)

Understanding where things are as they travel was essential to the work he was doing in 1940 to increase the accuracy of artillery. The gyroscope, with its ability to resist changes in direction, became a central component in a new type of gunsight that could calculate where the target would be when the shell reached it. Draper's prototype, nicknamed the "shoebox," eventually became the Mark 14 gunsight used on U.S. Navy ships during the war.

An employee pushing a microwave radar dish down a Rad Lab corridor. The name Radiation Laboratory was meant to suggest atomic research (then thought harmless) and conceal the lab's real work. Courtesy of the MIT Museum.

Bush and the Radiation Laboratory

World War II had spread across Europe by 1940 and Great Britain was under German air and sea attack. But a recent British invention, the cavity magnetron, offered the promise of better defense because it made more accurate microwave radar possible. A secret mission of British scientists brought the magnetron to Washington, D.C., to ask the Americans to help advance the new technology.

In response, Bush's NDRC, now one arm of the OSRD, created the Radiation Laboratory to develop radar, and Bush was instrumental in locating the "Rad Lab" at MIT. As historian Michael Dennis points out, "Bush's prewar connections became an integral aspect of the wartime organization of research—as well as one reason why MIT was the largest single recipient of OSRD contracts." (2) Air and surface radars developed by the Rad Lab were pivotal to improved navigation and defense against bombers, V-1 rockets, and submarines.

Edgerton's strobe lab

Harold Edgerton entered MIT in 1926 as a graduate student in Vannevar Bush's electrical engineering department. To study the actions of large electrical motors, Edgerton developed the electronic stroboscope to visually "stop" the motion of operating machinery with short, intense flashes of light. By 1932, Edgerton had turned his experimental apparatus into a commercial product.

In 1939, Major George W. Goddard of the Army Air Forces asked Edgerton if a strobe lamp could be built that would be powerful enough to take photographs at night from a height of a mile. Edgerton gave Goddard a tentative "yes." "[T]he required kind of flash lamp could probably be built," Edgerton speculated. "But there was also a good probability that the lamp would explode ..." (3)

Photos taken with Edgerton's strobe on the dawn of D-day confirmed that the invasion area was quiet. Courtesy of the MIT Museum.

Edgerton and his team overcame the obstacles, however. The system went into service, flying missions from England, and played a role in the D-day invasion. The reconnaissance photographs taken early on June 6, 1944, revealed no massing of troops on the ground. "So those pictures were useful," Edgerton recalled, "they were used all during the war." (4)

What happened to the hot spot after the war?

Draper's lab flourished after the war as the MIT Instrumentation Lab. In response to protests against defense research on campus, however, the lab separated from MIT in 1973 and is now the independent, not-for-profit Charles Stark Draper Laboratory.

The Radiation Laboratory closed at the end of World War II, but its direct descendant, the MIT Research Laboratory of Electronics, was founded on July 1, 1946, as MIT's first interdisciplinary lab.

Edgerton's lab became a treasured MIT institution where Harold Edgerton continued to teach and work until his death in 1990. Fittingly, the strobe lab is now the home of the Edgerton Center, a hands-on educational space.

Today, a new hot spot of invention is thriving in Cambridge. A network of bioscience companies and academic institutes has grown up around Draper Lab, continuing the partnerships among industries, universities, and government fostered by Compton and Bush decades ago.

References:

(1) Quoted in Francis E. Wylie, *MIT in Perspective: A Pictorial History of the Massachusetts Institute of Technology* (Little, Brown, 1975), 169.

(2) Michael Dennis, "Vannevar Bush," *Encyclopaedia Britannica Online*, accessed May 24, 2010.

(3) Harold E. Edgerton, "Night Aerial Photography," *Technology Review* 29, no. 5 (March 1947): 273.

(4) WGBH *Nova*, "Edgerton and His Incredible Seeing Machines." Original broadcast: January 15, 1985.

Notes from the Director: Bottling the Hot Spot

by Arthur Molella, Jerome and Dorothy Lemelson Director

What causes a hot spot of innovation like Cambridge, Massachusetts, or Silicon Valley to form? There clearly is no magic formula, though some of the key ingredients are fairly well known. Successful high-tech regions all seem to share basic advantages: an entrepreneurial culture, strong and committed leadership, a creative workforce, venture capital, governmental and political backing, and, equally important, a major research university, such as a Stanford or MIT, to serve as a core.

There are of course a host of intangible factors (such as the local "cultural richness") that go into the mix as well, making the establishment of high-tech corridors a chancy proposition at best. But, once you have found a successful model, can it be exported? Can one hot spot beget another? The answer seems to be both yes and no. There has been no end of calls for new Silicon Valleys in the United States and around the world. A few have taken hold, but in general the results have been disappointing, to say the least.

Lesser known, but more organized and arguably more successful, have been the attempts to export the winning combination of MIT and Cambridge, specifically to the developing world. Stuart W. Leslie and Robert Kargon have documented three efforts to export the model to India and Iran in the 1960s and 1970s. Emerging from World War II confident in its role as *the* model engineering campus, MIT embarked on a mission to launch new research-oriented technical schools in the two countries, with the expectation that they would also spur technologically driven economic development. The three schools were the Indian Institute of Technology Kanpur, the Birla Institute of Technology and Science, and, in Tehran, the Aryamehr University of Technology (AMUT).

The initiative experienced a mixed record of success. While, to be sure, MIT officials and faculty played a lead role in creating great Indian technical schools, they paid too little attention to connecting the academic experience to Indian culture and tradition. The result was that large numbers of now fairly Westernized graduates emigrated to the United States, rather than staying home to lead India's economic and technological development. On the other hand, AMUT did much better in this regard, primarily because Iranian officials insisted on directing the benefits homeward rather than to the United States (often to the disappointment of MIT officials, who were particularly alarmed by the political implications of Iranian nuclear engineering). In any case, these instances illustrate that exporting hot spots is never a simple matter. Not only must all of the original hot spot ingredients be there, the model also needs to fit into the host culture. (In 2005, the Center hosted a conference on "Cultures of Innovation" that discussed this idea in detail. The report is available on our website.)

Birla Institute of Technology and Science logo. Courtesy of BITS-Pilani.

Efforts to "bottle" and export MIT continue to this day. Last fall, in partnership with MIT, the Masdar Institute of Science and Technology (MIST) opened its doors to students in the new "eco-city" of Masdar in Abu Dhabi, a subject of one of my earlier columns.

I had the pleasure of meeting MIT professor Fred Moavenzadeh, who spearheaded this joint venture in establishing the Arab world's first research-driven, graduate-only science and technology institute. He explained that Abu Dhabi wants to shift from an oil-based economy to a knowledge-based economy focused on clean, sustainable energy. He sees MIST's role in the region similar to that played by MIT as the hub of the Route 128 science-technology innovation complex in Massachusetts. According to Dr. Sultan Ahmed Al Jaber, CEO of the company managing the Masdar initiative, "MIST will insure that Arab youth remain at the cutting-edge of future energy. The Institute will work to develop and promote the region's indigenous human capital." Apparently having learned the lessons of the past, Moavenzadeh insists that MIT will be mostly a silent partner, ensuring that MIST will be of and for the people of Abu Dhabi.

Artist's rendering of the Masdar initiative. Courtesy of the Masdar Initiative Media Center.

From the Collections: Seeing in the Dark

by Joyce Bedi, Senior Historian, Lemelson Center

Edgerton's night aerial photography system. The flash tube (lower center) fits into the reflector at the left. The camera (center), which looks a lot like an oversized 35-mm single-lens reflex camera, is sitting on top of one of the capacitor banks. The serviceman is holding the control box. Courtesy of the MIT Museum.

Many of us who work at the National Museum of American History have a favorite object or two. Mine is part of the photographic history collections. It's a General Electric Mazda FT-17 flash lamp, whose prototype was invented by Harold "Doc" Edgerton at MIT to take aerial reconnaissance photographs at night (and it's on display in the Lemelson Center's showcase exhibition, *Hot Spots of Invention*). Why do I like it? Well, OK, I'm a photography geek. But the tube is elegant yet cool, and it has a great story.

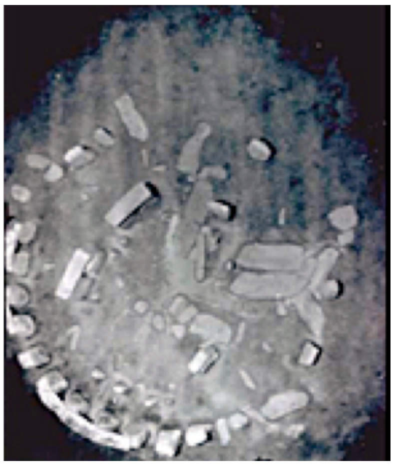
Edgerton had originally invented an electronic stroboscope to study high-speed machinery in motion. But he soon turned his light (and camera) on a vast range of subjects. Applying his solid engineering training, vivid imagination, and good business sense, Edgerton continually adapted and commercialized the technology he had created. In the 1940s, this work took Doc into the sky.

As mentioned above, Major George Goddard of the army's photographic laboratory at Wright Field (now Wright-Patterson Air Force Base) visited Edgerton at MIT in 1939. Goddard had joined the U.S. Army Signal Corps in 1917 and was appointed instructor of aerial photographic interpretation at the School of Military Aeronautics the following year. He knew firsthand both the value and limitations of aerial photography using existing technology. So he asked if Edgerton and his colleagues could build a strobe that would be powerful enough to take photographs from a plane, at night, from a height of a mile. "We can do that," Doc said. "We haven't got it in the house, but we can do that." (1) That confidence produced an electronic flash system for night aerial photography that delivered information impossible to obtain in any other way.

Setting up the strobe (left) and camera (center) at Boston Garden, 1946. Courtesy of the MIT Museum.

The strobe that Doc originally designed to photograph events from the bleachers of Boston Garden provided a technical foundation for his electronic flash for military night aerial photography. But the components of this new flash system were bigger and more powerful than anything Doc had yet built. The flash tube is a tough monster; its 30 inches of strong, quartz glass, coiled into a xenon-filled spiral, withstood the 4,000 volts discharged through it. The tube fit into a reflector mounted in the plane's belly or tail. Banks of capacitors, weighing up to 500 pounds each, were slung on the plane's bomb racks and supplied power to the flash tube. A direct contact synchronized the flash to the equally oversized aerial camera.

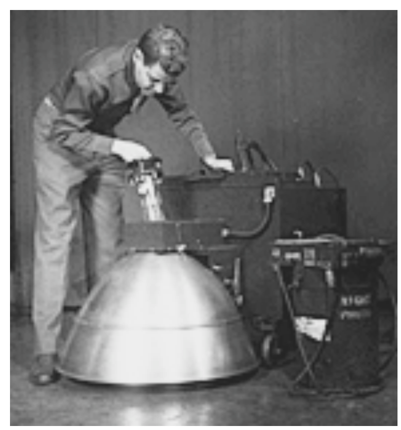
In April 1941, the first experimental unit—camera, capacitors, flash tube, and reflector—was mounted in a B-18 and tested over Boston. But the system's most famous test began on June 5, 1944, when an A-20 equipped with the flash took off for France, ahead of the D-day invasion forces. Doc recorded the results in his laboratory notebook on June 7, 1944: "The A-20 (No 449) went on its first mission on Monday night June 5 arriving at the target on June 6 around 130 am. The target was two road intersections south of Caen. Due to clouds the pictures were taken at 800 ft – 2000 ft. The photos were very good but there was no overlap. Some flack [*sic*] from ground machine guns was encountered at a town named Coustances. Villedieu-les-Poêles was photographed. I stayed up until 5 am to see the negatives out of the dryer." (2)



Stonehenge, 1944. Courtesy of the MIT Museum.

Doc continued to tweak the giant flash system even as it saw use in many more missions during the war. One of my favorite runs, though, took place in August 1944, when Edgerton was testing the flash in England. Stonehenge, standing alone on the Salisbury Plain, proved a perfect subject for his experiments.

The nighttime aerial reconnaissance photography system developed by Edgerton and his colleagues at MIT, in industry, and in the military, was used throughout the war. The adaptation of the flash tube from peacetime photography of things like rodeos in Boston Garden to wartime reconnaissance flights over Europe is a testament to Edgerton's creative mind. Throughout his life, Doc welcomed each new inquiry. "If you don't wake up at 3 o'clock in the morning and want to do something," Edgerton quipped, "why, you're wasting time." (3)



A serviceman inserting the flash tube into the reflector. Courtesy of the MIT Museum.

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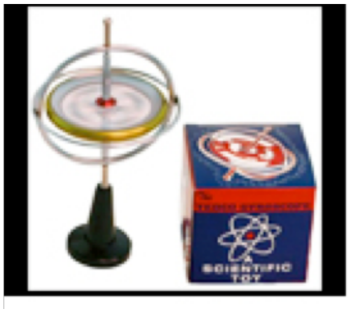
(1) "History of the Strobe Light," Edgerton Hall, MIT, Cambridge, Mass., November 27, 1984. Harold Eugene Edgerton Papers, MC 25, Box 116, Massachusetts Institute of Technology, Institute Archives and Special Collections, Cambridge, Massachusetts.

(2) Notebook 15, 30 Jan. 1944 – 16 Feb. 1945, pp. 23–24, Harold Eugene Edgerton Papers, MC 25, Box 53, Massachusetts Institute of Technology, Institute Archives and Special Collections, Cambridge, Massachusetts.

(3) WGBH *Nova*, "Edgerton and His Incredible Seeing Machines." Original broadcast: January 15, 1985.



Chandler Gyroscope. Courtesy of TEDCO Science and Educational Toys, Inc.

Inventive Ideas for Hands-On Fun: Create a Flying Gyroscope!

by Steve Madewell, Resident Eccentric, Lemelson Center Spark!Lab

Since Jean Bernard Léon Foucault invented the gyroscope in 1852, inventors have continually found new applications for these spinning marvels. The best-known gyroscope is probably the classic toy made by Chandler. Millions of them have been manufactured in Hagerstown, Indiana, since 1917. But gyroscopes are much more than toys. Innovative engineers like Charles Stark “Doc” Draper and his team at the MIT Instrumentation Lab, now Draper Laboratory, adapted special gyroscopes to guide aircraft, submarines, and rockets. In the 1960s, Doc Draper used his knowledge of gyroscopes and aircraft engineering to invent the guidance system that safely sent astronauts to the Moon and back in the Apollo spacecraft.

Today, you can find gyroscopes in devices ranging from the Hubble Space Telescope to video game controllers. To explore gyroscopes further, create and launch your own Flying Gyroscope. Download the activity!

Luis Alvarez in his MIT lab in 1943. Courtesy of Lawrence Berkeley National Laboratory.

Have You Seen?

Luis Alvarez’s childhood interest in mechanics led to an infatuation with physics in college. Later, he put his skills to work as one of several young scientists recruited to help the military during World War II. He designed a radar system that helped pilots land in bad weather, and he also designed a device that fired the atomic bomb.

After the war, Alvarez’s intellectual curiosity and talent for experimentation led him to devise an important tool for physicists. He spent several years developing the liquid hydrogen bubble chamber, which enabled physicists to discover and study tiny particles of matter inside an atom’s nucleus (Donald Glaser won the 1960 Nobel Prize in Physics for inventing the bubble chamber; Alvarez took home the 1968 Nobel Prize in Physics for “his development of the technique of using hydrogen bubble chambers and data analysis”). “Whenever anything has interested me,” he said, “I have instinctively tried to invent a new or better way of doing it.”

Learn more about Luis Alvarez on the *Invention at Play* website.

Liz Lerman. Courtesy of the Liz Lerman Dance Exchange.

Prototype Online—Inventive Voices Podcast: Liz Lerman Nurtures Civic Dialogue and Creativity through Dance

Based in Maryland, the Liz Lerman Dance Exchange works with scientists, historians, and artists to develop dances around cross-disciplinary topics. Liz Lerman compares the invention process with her own creative process, driven by improvisation, testing, collaboration, and questioning, in our latest podcast.

Tune in!

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