Celebrating the History of Building 20

For over 50 years, MIT's Building 20 has been the home to a variety of research labs, academic departments, student clubs, machine shops, and administrative offices. Originally built in 1943 as a temporary building for part of the Radiation Laboratory (the major site for wartime radar research and development), the building was supposed to be demolished immediately following the end of World War II. Building 20 will be coming down in 1998 and replaced by a new building.

Building 20, Vassar Street facade, 1997.

Building 20 has lived a long useful life and the intent of this web page is to tell some of its history, describe notable events that happened within its walls, and to recognize the number of groups that have dwelled within it. As the time approaches to say goodbye to the weathered, three-story structure at 18 Vassar Street, it seems appropriate to celebrate Building 20.

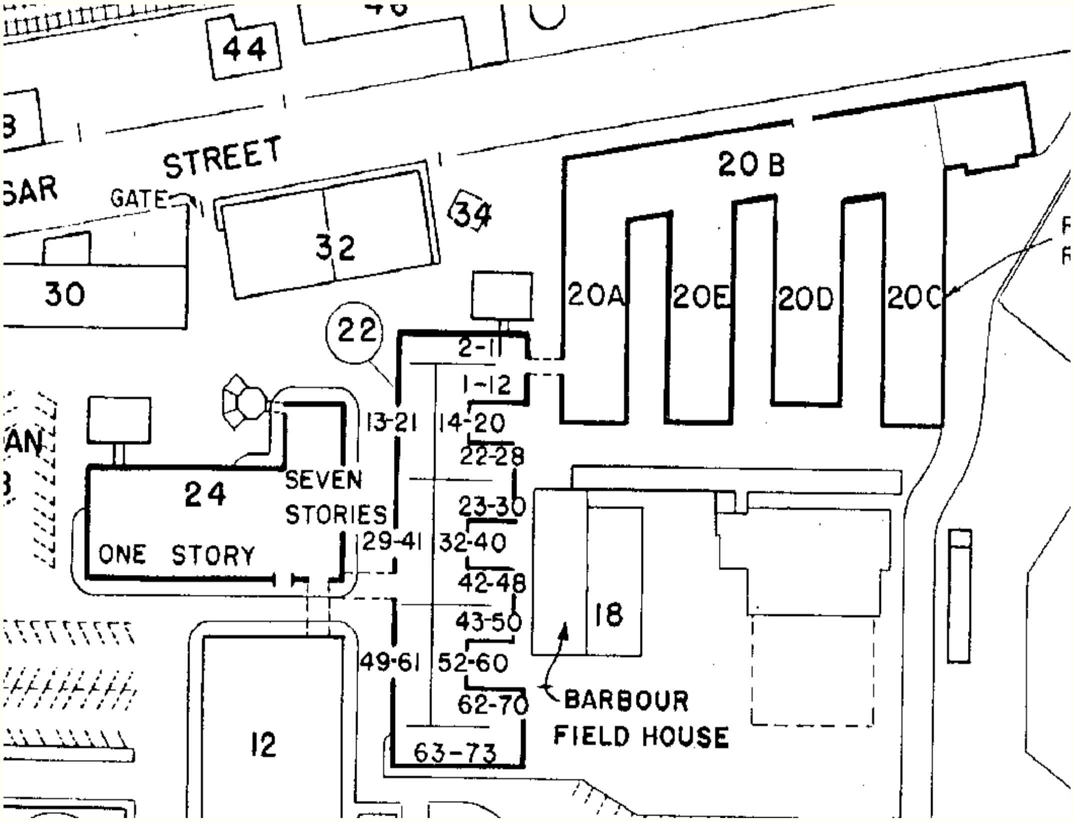
- Design
- History
- Occupants (past and present)
- Quotes and Stories
- Sources (bibliography)
- Timeline
- What's next? (demolition, new building, event to commemorate Building 20)

Main door to Building 20 (Vassar Street entrance).

Last modified: 2 March 1998
Return to Archives

Building 20's Design

It is said that Building 20 was designed in one day. The barracks style is plain, and many people would describe the building as shabby, dingy, or unpretentious. However, as Stewart Brand astutely points out in his book, *How Buildings Learn: What Happens to Buildings After They're Built*, Building 20's lack of style and its low-visibility have allowed its occupants to be wonderfully creative and successful within its walls.



Layout

Building 20 is comprised of six wings. B-wing runs parallel to Vassar Street. Wings A, E, D, and C extend perpendicularly off the south side of B wing, and F wing (the "newest" wing) is an extension off the east end of B-wing. The structure doesn't have a basement; it was built on concrete slabs. Building 20's horizontal design is emphasized by the length of its wings and the fact it stands only three stories tall.

Adaptable space

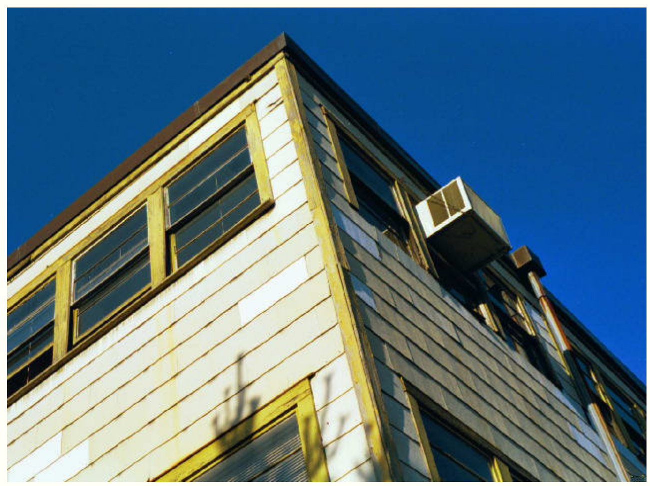
At the time of its construction, steel was scarce, and Building 20 is mainly made of wood. Although the building appears weathered, it is certainly not rickety, the building is capable of supporting loads up to 150 pounds per square foot. Over the years, depending upon their projects, Building 20's occupants have reconfigured their work spaces, sometimes by changing the interior of their rooms or labs, sometimes by expanding into adjacent rooms. Small sheds and other structures that are signs of expansion, are visible in the courtyards in between wings A, E, D, and C. And an on at least one occasion, one professor expanded his lab space vertically. (When Jerrold Zacharias was developing the world's first atomic clock, he arranged to have sections of two floors removed so he could assemble a tall cylinder that was part of his design.) The exposed duct-work and wiring that is clearly visible above most of the hallways is accessible to those who need to rewire computer networks or work on some of the service functions of the building.

Building 20, view of the east side of C Wing, 1997.

View of shed extending of the south end of A Wing."

Working atmosphere in Building 20

Many people believe that the horizontal layout of Building 20 encouraged collaborations. People who met in the lobby, or in one of the long hallways, or on a wooden staircase could easily share information and ideas. Although the unpretentiousness of Building 20 made some people feel like they were being overlooked, it was liberating for other professors who felt freer to be creative and make the most out of the available space. MIT never seemed overly concerned about Building 20 (quite possibly because everyone knew it was a "temporary" building), and MIT generously gave space to new student clubs and new departments. These same units might not have ended up with as much space had they been assigned space in a building located in a heavily- trafficked area of campus.



Detail view of Building 20.

Return to Celebrating the History of Building 20

Celebrating Building 20: History

Building 20 was completed in December 1943 to house part of the Radiation Laboratory (Rad Lab), the successful collaboration between scientists and the military that focused on improving the radar technology that greatly contributed to the Allies' victory in World War II. The Rad Lab designed approximately 50% of the radar used to shoot down enemy bombers and guide Allies' planes during the war.

The Radiation Laboratory was one division of the National Defense Research Committee (NDRC). In June 1940, President Franklin D. Roosevelt authorized Vannevar Bush to chair the NDRC. In early July 1940 Bush formally established five divisions, Armor and ordnance (Division A); Bombs, fuels, gases, chemical problems (Division B); Communications and transportation (Division C); Detection, controls, instruments (Division D); and Patents and inventions (Division E). Karl T. Compton headed Division D, and the detection section focused investigating existing microwave technologies. At the end of the summer, the Microwave Committee found that they were prevented from developing radar that worked on higher frequencies by the absence of equipment that could generate short wavelengths of about 10 cm. However, in September 1940 a British team arrived in the U.S. with a 10cm cavity magnetron. Soon after this, the Radiation Laboratory was established to concentrate on the following three projects: microwave AI (aircraft interpretation), high-accuracy gunlaying radar, and aircraft navigation. L. A. DuBridge was selected to be the director, and MIT was selected to be the location of the Rad Lab.

When the first 48 Rad Lab employees began working on the high priority radar projects, the lab was located in MIT's Building 4 in room 133. By December 1940, a radome had been constructed on the top of Building 6 and the number of employees was increasing. The lab continued to expand and temporary structures were built. In 1941, Building 24 went up. Building 22 was completed in May 1942. (Operations expanded off-campus too, and the Rad Lab used various field stations and air strips.) In the spring of 1943, once again, the Rad Lab faced the need for more space on the MIT campus.

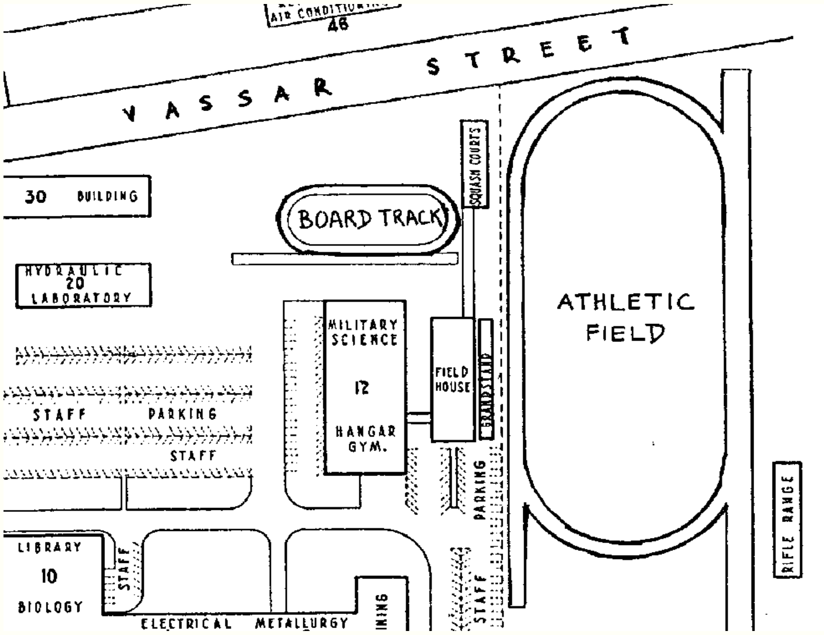
The Radiation Laboratory made contact with the Boston architectural firm McCreery & Theriault. On 2 April 1943, George McCreery, one of the principals of the firm, sent a letter outlining three schemes for the new building to the attention of Dr. A. J. Allen, Director of the

Rad Lab. In the letter (now in the MIT Institute Archives), McCreery refers to the new structure as the "Building 22 Annex." All of the schemes propose a three-story building similar to Building 22 with concrete footings, an "all wood frame...consisting of wood columns and wood girders," and an exterior covered with grey asbestos shingles. The schemes only differed in the size (and, subsequently, the cost) of the new building; scheme A would contain 192,420 square feet, scheme B, 174,320 square feet, and scheme C, 128,400. The location of the proposed building required the relocation of MIT's squash courts, "Board Track," and "the Flame Thrower."

Building 20, as it looked circa 1946. Building 22 is visible in the upper right corner of the image. Photograph courtesy, MIT Museum.

By early May, McCreery & Theriault had refined the scheme for Building 20, and according to two letters dated 1 May 1943, had completed the design for the building, and the PD200, a form required by the federal government. One of the letters clearly outlines the project:

The construction of a three story temporary wood frame building meeting with the requirements of the Radiation Laboratories to be located east of the Radiation Laboratory Building #22, and north of the present M.I.T. Swimming Pool. This structure together with its connecting bridges has a total floor area



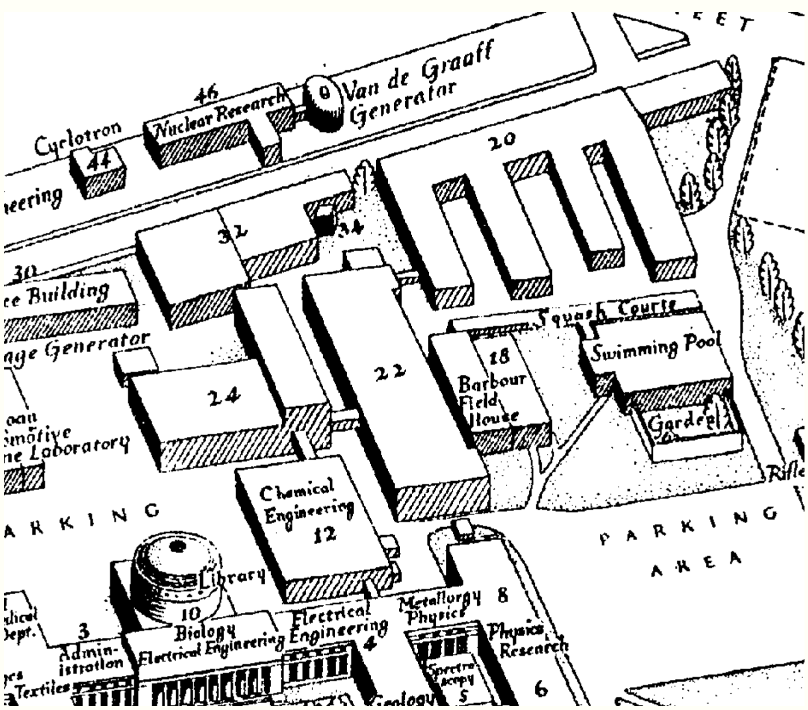
Detail of campus plan, circa 1936, showing the Squash Courts (the rectangular building to the right of the Board Track), and the north end of the Athletic Field, the eventual site of Building 20.

of 196,200 sq. ft.

The estimated cost of the project totalled $1,044,750. This included the cost of Building 20, $848,513, and the estimate for the related projects, $196,239. (The related projects included the relocation of a few campus athletic facilities and the construction a garage and tower section.) Because of the zoning laws of the City of Cambridge, the architects were required to apply to the Cambridge Board of Appeals for a variance to construct the wooden building. A letter from George McCreery from 1946 described the decision of the board:

We received the decision for the Cambridge Board of Appeal on May 5, 1943 allowing us to construct the building as a war measure, the life of said building to be for the duration of the war and six months thereafter.

Construction was completed quickly and in December 1943, when Building 20 was ready for occupancy, portions of nine different divisions of the Radiation Laboratory moved in. These divisions included Transmitter Components, Receiver Components, Ground and Ship, Beacons, and the Business Office.



Detail of campus plan, circa 1946 includes Building 20 and Building 22.

The developments in radar technology made at Rad Lab directly aided the Allies efforts during WWII.

At the height of the war, the Rad Lab employed 3,897 people. The press release dated 14 August 1945 states that during its five year existence, the Rad Lab "pushed research in this field ahead by at least 25 normal peacetime years."

In August 1945, the Rad Lab began making preparations for closing its doors. Plans were under way to bring projects to a close, settle personnel contracts, and publish the technological progress and research findings of the lab in the *Radiation Laboratory Series.* Throughout 1946, the spaces the Rad Lab occupied were cleaned out and the radomes on the roofs were dismantled. However, the buildings were not dismantled. MIT realized that the buildings would be helpful as enrollments increased dramatically. The MIT *President Report,* 1945- 1946, states, "the Institute space occupied by the war projects has been largely recaptured, and the temporary buildings...have been retained by the Institute to aid us in handling the postwar overload of students." Building 22 was converted into a dormitory, and by 1947 it housed approximately 600 students. Building 20 was to remain useful to MIT as the site of machine shops, research labs, and offices.

Even though the end of World War II necessitated the end of the Radiation Laboratory, individuals at MIT, in the military, and in the government, recognized the value of continuing scientific and technological efforts in the fields of electronics and microwave physics. The day after the Radiation Laboratory was officially terminated, 31 December 1945, the Basic Research Division was established, on 1 January 1946. Six months later, the Basic Research Division officially became part of MIT under the newly established Research Laboratory of Electronics (RLE).

A campus plan, dated June 1946, describes Building 20 as a "temporary war research building, now used for peacetime educational and research experiments." Building 20's A wing became the primary campus location of the Research Laboratory of Electronics (RLE). RLE was an interdisciplinary lab initially comprised of five groups: microwave electronics, microwave physics, modern electronic techniques, microwave communication, and electronic aids to computation. Each research group had space in Building 20 and the lab's headquarters were located in 20A-122. Building 20 also became the first home for another interdisciplinary research organization, the Laboratory for Nuclear Science (LNS). Various divisions of LNS were located in Building 20: cosmic ray group (20B-124), cyclotron group (20B- 115), theoretical group (20B-213), and the machine shop (20B- 021). Room 20B-119 was location of the headquarters for LNS, and its purchasing office was found down the hall in 20B-129.

RLE and LNS occupied significant portions of Building 20 until 1957, when Building 26 was completed. Then, the headquarters of both laboratories, and most of their research groups, moved into the Karl T. Compton Labs (Building 26). It is interesting to note that Building 22, a temporary structure (like Building 20), remained standing until the mid-1950s, when it was torn down to make room for Building 26. However, Building 20 continued to be occupied by a variety of departments. As space opened up in the building, it was filled by the expansion of the groups remaining in the building, or, by other labs or offices moving in.

Although RLE and LNS occupied many rooms in Building 20 after the end of World War II, some space in the building was made available to other labs and departments. The Radiation Laboratory was a collaboration between scientists and the military and, after the war, various offices of the armed forces continued to be located in Building 20. For example, the Navy Research Office, the Navy Auditor's Office, and the Navy Development Contractor all were housed in the building. During the 1950s the headquarters for all three ROTC (Reserve Officers Training Corps) programs (Army, Air Force, and

Navy) moved into various rooms in E wing.

Building 20 was the site of the development of MIT's well- known linguistics program. Both Morris Halle and Noam Chomsky had offices in the building for over three decades. In 1976, the Philosophy department administratively merged with the Linguistics program to form the Department of Linguistics and Philosophy. Until the summer of 1997, this department was located in Building 20. Other notable longterm occupants of Building 20 include the Tech Model Railroad Club in 20E-214, the UROP offices (Undergraduate Research Opportunities Program), and Occupational Medical Services (this became the Environmental Medical Services). For several lists of Building 20 occupants (during a few specific years), and a nearly complete list of all Building 20 occupants, please see the Building 20: Occupants page.

History researched and written by Nancy Heywood, 4 March 1998, slightly revised 25 March 1998.

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OCCUPANTS OF BUILDING 20

Many different members of the MIT community have been located in Building 20. The fact that the building has been used by research labs, academic offices, classrooms, student clubs, administrative offices, machine shops, and offices for faculty and graduate students illustrates the adaptable functionality of Building 20.

Occupants of Building 20 in 1953 (from Staff Telephone Directory, compiled by MIT Institute Archives)

- Acoustics Lab (Richard Bolt, director) (20B, 20C, 20F)
- Adhesives Lab
- Air Science Headquarters
- Dynamic Analysis & Control Lab (20D-222 - 20D-224)
- Flight Control Lab (20C-128)
- Guided Missiles Program Office (20C-133)
- Lab for Nuclear Science (20B-119)
- Lab of Lighting Design (part of Architecture Department) (20C-231)
- Office of Naval Research (20E-226)
- Plastics Research Lab (20D-004)
- Radiological Safety Office (20B-234)
- Research Lab of Electronics (20A-20B)

Occupants of Building 20 in 1963 (from Staff Telephone Directory, compiled by MIT Institute Archives)

- Army, Military Science
- Campus Patrol (20C-128)
- Data Processing (20C-220)
- Ice Research Lab (20E-206)
- Industrial Hygiene Lab (20B-245)

- Lab for Nuclear Science, linear accelerator (20D-014)
- MIT Press (20B-120)
- Model Railroad Club (20E-214)
- Occupational Medical Services (20B-238)
- Physics Labs
- Research Corporation (20B-111)
- Research Lab of Electronics

Occupants of Building 20 in 1973 (from Staff Directory, compiled by MIT Institute Archives)

- Atomic Energy Commission, Cambridge Office (20D-224)
- Council for the Arts at MIT (20D-220)
- Dean of School of Humanities & Social Science (20D-204)
- Electromagnetic Compatibility (20B-031)
- Environmental Medical Service (includes Radiation Protection Office) (20B-238)
- Laboratory for Nuclear Science machine shop (20B-018)
- Laboratory Hazards Committee (20B-245)
- Linguistics Department (20C-128)
- MIT-Wellesley Upward Bound Program (20C-006)
- Model Railroad Club (20E-214)
- Physical Plant shipping room (20C-018)
- Research Lab of Electronics machine shop (20A-018)
- Research Lab of Electronics photography (20B-201)
- Research Lab of Electronics publications (20A-122)
- Research Lab of Electronics tool shop (20A-013)
- ROTC: Army, Air Force, and Navy (20E)
- Teaching Intern Program (20C-004)
- UROP (Undergraduate Research Opportunities Program) (20B-141)

The Final Occupants of Building 20 (list compiled Fall 1996):

- Anthropology
- Biotechnology Process Engineering Center
- Cambridge Partnership for Public Education
- Center for Materials Research in Anthropology & Ethnology
- Center for Space Research, Gravity & Cosmology

View of C Wing and F Wing, Building 20, 1997.

- Concourse
- Council on Primary and Secondary Education, TILT (The Institute for Learning and Teaching)
- Earth Atmospheric and Planetary Sciences, Sedimentology Lab
- Center for Environmental Health Sciences, Core Analytic Lab
- Environmental Medical Services
- Foreign Languages & Literature, LATH (Laboratory for Advanced Technology in the Humanities)
- Foreign Languages & Literature, LLARC (Language Learning And Resource Center)
- Graphic Arts
- Health Science and Technology, Biomedical Engineering Center
- Integrated Studies Program
- Laboratory for Nuclear Science
- Linguistics & Philosophy
- MITERS
- MIT Educational Talent Search and Upward Bound
- Model RR Club, Tech (TMRC)
- Music
- Program in Science & Technology for International Security
- Research Lab of Electronics
- ROTC (Army ROTC, Air Force ROTC, Navy ROTC)
- SEVT (Solar Electric Vehicle Team)
- Shipping and receiving room
- Special Community Services (includes MITAC, Quarter Century Club, United Way)
- System Design and Management (moved into the building January 1997)
- Undergraduate Education and Student Affairs (UESA) (includes Counseling and Support, Educational Studies & Research, UROP, Writing Requirement)
- Writing Program

Alphabetical List of Nearly All Occupants of Building 20:

- Acoustics Lab (Richard Bolt, director) [eventually became part of RLE]
- Adhesives Lab
- Air Force Aerospace Studies headquarters [previous name, Air Science and Tactics, now also

known as Air Force ROTC (AFROTC)]

- Anthropology
- Army, ROTC, headquarters (AROTC) [previous name, Military Science]
- Athena Language Learning Project
- Atomic Energy Commission, Cambridge Office
- Biotechnology Process Engineering Center (BPEC)
- Cambridge Partnership for Public Education
- Campus Patrol
- Center for Cognitive Science
- Center for Environmental Health Sciences, Core Analytic Lab
- Center for Materials Research in Anthropology & Ethnology (CMRAE)
- Center for Space Research, Gravitation and Cosmology Group
- Center Screen
- Committee on Academic Computation in the 1990s and Beyond
- Committee on the Writing Requirement
- Computation Center
- Concourse
- Council for the Arts at MIT
- Council on Primary and Secondary Education, TILT (The Institute for Learning and Teaching)
- Data Processing
- Dean of the School of Humanities and Social Science
- Division for Study and Research in Education
- Dynamic Analysis & Control Lab
- Earth Atmospheric and Planetary Sciences, Sedimentology Lab
- Electrical Engineering and Computer Science, labs
- Electrical Engineering, microwave lab
- Electrical Engineering Research Shop
- Electromagnetic Compatibility [previous name, Electromagnetic Lab Compatibility]
- Electronic Research Society, MIT (MITERS)
- Environmental Medical Services (EMS) [previous name, Occupational Medical Services]
- Flight Control Lab
- Foreign Languages & Literature (see: Language Learning And Resource Center)
- Graphic Arts
- Guided Missiles Program Office
- Health Science and Technology, Biomedical Engineering Center
- IBM Computing Group
- Ice Research Lab

- Industrial Hygiene Lab (part of Occupational Medical Services, and then part of Environmental Medical Services)
- Information Processing Center)
- Institute Archives, Building 20 Records Project office
- Integrated Studies Program (ISP)
- International Nutrition Policy and Planning Program
- Joint Computing Group
- Laboratory for Advanced Technology in the Humanities (LATH)
- Laboratory for Nuclear Science
- Laboratory Hazards Committee
- Lab of Lighting Design (part of Architecture Department)
- Language Learning and Research Center (LLARC) [part of Foreign Languages and Literature]
- Linguatrainer Room
- Linguistics
- Linguistics & Philosophy
- Medium Energy Instrumentation Lab
- Meteorology
- Military Science
- MITAC (MIT Activities Committee), [part of Office of Special Community Services]
- MITERS [see: Electronic Research Society, MIT]
- MIT Educational Talent Search
- MIT Press
- Model RR Club, Tech (TMRC)
- Music, classroom
- Music, Piano Lab
- Naval Science, headquarters
- Navy, auditor office
- Navy, Development Contractor
- Neurocomputational Lab
- Numerical Analysis Lab
- Nutritional Biochemistry Labs
- Occupational Medical Services (OMS)
- Office of Naval Research
- Office of Statistical Services
- Office of the Dean for Undergraduate Education
- Patent section
- Physical Plant shipping room

- Physics Labs
- Plastics Research Lab
- Project METEOR
- Project S.A.N.D. Systems Analysis Office
- Project STILE
- Program in Science & Technology for International Security
- Radiation Laboratory (Rad Lab)
- Radiation Protection Office [part of OMS, then part of EMS, previous name, Radiological Safety Office]
- Research Corporation
- Research Lab of Electronics
- ROTC (Army ROTC, Air Force ROTC, Navy ROTC)
- Science, Technology and Society, Program in
- Secondary Technical Education Project (STEP)
- SEVT (Solar Electric Vehicle Team)
- Shakespeare Electronic Archive Project
- Shipping and receiving room
- Special Community Services (includes MITAC, Quarter Century Club, United Way)
- System Design and Management
- Teaching Intern Program
- Technology and Policy Program, student office
- TILT (The Institute for Learning and Teaching)
- Undergraduate Education and Student Affairs (UESA) (includes Counseling and Support, Educational Studies & Research, UROP, Writing Requirement)
- University Film Studies Center
- Upward Bound
- Urban Action
- UROP (Undergraduate Research Opportunities Program)
- Writing Program

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Quotes and Stories About Building 20

Quotes from books and archival sources

- Karl Compton, about MIT retaining the temporary WWII buildings
- Fred Hapgood, about the appearance and status of Building 20
- Albert Hill, about the amount of space RLE occupied in Building 20
- James Killian, about his regard for Building 20
- Jerry Lettvin, about the procreative nature of Building 20
- McCreery & Thierault (architects), describing the design of the building
- McCreery & Thierault (architects), about the building materials
- Julius Stratton, summarizing RLE's space in Building 20
- Jerome Wiesner, about the space available in Building 20
- Jerome Wiesner, about the building as a breeding ground
- Jerrold Zacharias, about the building as a place where things start

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Quotes available on other websites

- MIT's Building 20: The Magical Incubator

  Includes reminiscences and stories from people who worked in the building.
- *RLE Undercurrents*, Volume 9, Number 2, Fall 1997

  Special issue about Building 20 and included many quotes and stories.

The Radiation Laboratory has been demobilized, its staff of 3900 reduced to 15.... And...the Institute space occupied by the war projects has been largely recaptured, and the temporary buildings, built primarily for war work, have been retained by the Institute to aid us in handling the postwar overload of students.

[Karl T. Compton (MIT President, 1930-1948), from *MIT President's Report, 1945-1946*, p. 5]

The edifice is so ugly...that it is impossible not to admire it, if that makes sense; it has 10 times the righteous nerdly swagger of any other building on campus, and at MIT any building holding that title has a natural constituency.

[Fred Hapgood, from his book, *Up the Infinite Corridor: MIT and the Technical Imagination*, Reading, Mass., 1992, 106.]

By choosing Building 20 we [the Research Laboratory of Electronics] probably got twice as much space as we would otherwise [had received] and I think we were all very happy about it.

> [Albert Hill (RLE, Associate Director, 1946-1949; and RLE, Director, 1949-1952), quote from the videotape made for *Generations: The Story of Building 20* an exhibit held in the Compton Gallery in 1980. Videotape now in the MIT Institute Archives, AC 48. MIT. Committee on the Visual Arts, Records, 1945-1980.]

I have a sense of affection and respect for this old building [Building 20] and all that's happened in it over the years.

> [James R. Killian (MIT President, 1948-1959), quote from the videotape made for *Generations: The Story of Building 20* an exhibit held in the Compton Gallery in 1980. Videotape now in the MIT Institute Archives, AC 48. MIT. Committee on the Visual Arts, Records, 1945-1980.]

You might regard it as the womb of the Institute. It is kind of messy, but by God it is procreative!

> [Jerome Y. Lettvin, Professor of Electrical Engineering and Bioengineering, quoted in an article by Simson Garfinkel, "Building 20: The Procreative Eyesore," from *Technology Review*, 94 (November/December 1991), page MIT11.]

A short descriptive outline of the project is as follows: The construction of a three-story temporary wood frame building meeting with the requirements of the Radiation Laboratories to be located east of Radiation Laboratory Building #22, and north of the present M.I.T> Swimming Pool. This structure together with its connecting bridges has a total floor area of 196,200 sq. ft. ....

> [McCreery and Theriault (architects), from AC4, MIT Institute Archives.]

Our floor construction consists of 2" plank, a layer of building paper, an da 2 1/4 face log run birch, beach and maple finish flooring. The exterior walls will have asbestos shingles on the exposed surface, underboarding rock wool insulation bats and 1/4" plywood as the exposed inner surface.

> [McCreery and Theriault (architects), from AC4, MIT Institute Archives.]

Physically the Laboratory occupies approximately 32,000 square feet in Wing A of Building 20.... An additional 5,000 square feet are devoted to the radar and intelligence section of Project Meteor, a development of guidance systems in connection with the M.I.T. guided missiles program, and there is an associated document room containing reports amassed by the Radiation Laboratory. Although our present housing leaves much to be desired, the Laboratory is extraordinarily fortunate in the provision of materials and equipment for instruction and research.

> [Julius A. Stratton (first director of RLE, 1946-1949; and MIT President, 1959-1966), from the report about the RLE in *MIT President's Report, 1946-1947*, p. 155.]

I think that a lot of things were better because of Building 20. You had ample space: a little more than you needed, rather than a little less, which is the normal situation.

> [Jerome Wiesner (RLE, Director, 1952-1961; and MIT President, 1971-1980), quoted in an article by Simson Garfinkel, "Building 20: The Procreative Eyesore," in *Technology Review,* 94 (November/December 1991), page MIT10.]

More than any other facility at MIT it [Building 20] is the breeding ground of new programs.

> [Jerome Wiesner (RLE, Director, 1952-1961; and MIT President, 1971-1980), quote from the videotape made for *Generations: The Story of Building 20* an exhibit held in the Compton Gallery in 1980. Videotape now in the MIT Institute Archives, AC 48. MIT. Committee on the Visual Arts, Records, 1945-1980.]

I think it [Building 20] is a place where things start. We started all sorts of aspects of things...with the military. We started the big Laboratory for Nuclear Science at MIT. We started the Research Laboratory of Electronics. We started what was called the Educational Research Center. ...you not only start things but you also start [them] with a certain independence of mind. It's this attitude that I think you should look for in a place.... It doesn't matter that it's dirty and noisy and hot. The important thing [is] the people.

> [Professor Jerrold Zacharias, (LNS, Director, 1946-1956), quote from the videotape made for *Generations: The Story of Building 20* an exhibit held in the Compton Gallery in 1980. Videotape now in the MIT Institute Archives, AC 48. MIT. Committee on the Visual Arts, Records, 1945-1980.]

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WEBSITES

IEEE History Center. This site's Oral History page includes links to interviews with former Rad Lab employees.

http://www.ieee.org/history_center

MIT Buildings (one page linked to the Guide to Architectural Sources section of the MIT Rotch Library website)

http ://libraries.mit.edu/rotch/architecture/mitb.html

MIT Floorplans

http ://insite.mit.edu/Docs/floorplans/floorplans.html

MIT Space Accounting. (This site includes building and room inventories.)

http://web.mit.edu/ofms-space/www/

MIT's Building 20: The Magical Incubator

http://www- eecs.mit.edu/building/20

RLE undercurrents, Volume 9, Number 2, Fall 1997 (a special issue about Building 20)

http://rleweb.mit.edu/bld20rem.htm

Bibliography compiled by Nancy Heywood, last updated February 1998

Building 20: What's next?

Event to commemorate MIT's Building 20

An event commemorating Building 20 will take place March 26- 27, 1998. It will feature speakers, demonstrations, displays and a banquet. For more information please see the official web site, MIT's Building 20: The Magical Incubator.

Demolition of Building 20

In 1996 MIT announced that Building 20 was to be torn down in early 1998. In January 1997, departments, offices and laboratories began to move out of the building and into newly renovated spaces. Some former Building 20 occupants moved to Building 56, and others will be moving into Building 16. The relocations will be completed in 1998, and then the decommissioning process (including asbestos abatement) will begin in preparation for the demolition of Building 20.

Plans for New Building on Site of Building 20

After the site is cleared, a new 300,000 square foot complex of buildings will be constructed to house the Artificial Intelligence Laboratory, the Department of Electrical Engineering and Computer Science, the Department of Linguistics and Philosophy, and the Laboratory for Computer Science. MIT received a generous $25 million donation towards the new building from an alumnus, Ray Stata, and his wife, Maria. It appears that Frank O. Gehry and Associates will be designing the new building complex. The 28 January 1998 issue of *Tech Talk* indicated that MIT has entered into contract negotiations with Gehry.

Return to opening page of Celebrating the History of Building 20.

MIT Department of Electrical Engineering & Computer Science

MIT's Building 20: The Magical Incubator

1943 - 1998

Building 20 was constructed during the Second World War, and initially served as the home of the Radiation Laboratory. It will be torn down in 1998 to make way for a new complex of buildings to house MIT activities in computer, information, and intelligence systems, to be named after Ray and Maria Stata.

In its 55 years, Building 20 has housed many MIT activities. It was never intended to last this long. "The building was constructed in...1943 as a war building and is of a temporary nature," reads an architect's memo, "...the life of said building to be for the duration of the war and six months thereafter."

Its "temporary nature" permitted its occupants to abuse it in ways that would not be tolerated in a permanent building. If you wanted to run a wire from one lab to another, you didn't ask anybody's permission -- you just got out a screwdriver and poked a hole through the wall. Of course this was in the days before the dangers of asbestos were recognized.

This building cast a spell over those who worked in it. Many former occupants have noted the magical power of the building to bring out the best from those in it, and the very real feeling that this was a special, even a unique, place. At the same time it served as a breeding ground, or incubator, of many research areas, of the minds of its students, and of new organizations. Many MIT laboratories and centers had their origins in Building 20, or else were formed by people who had spent years there.

Stories about Building 20

Occupants of the building have wonderful stories, anecdotes, or reminiscences about life there. You are welcome to read them all!

Commemoration

MIT held a commemoration of Building 20, March 26-27, 1998. This was a reunion for those who have lived in the building during the decades since its erection in 1943, a celebration of all the diverse activities that have gone on in the "plywood palace," and a chance to reflect on how many great activities, at MIT and elsewhere, had their humble beginnings there.

- Information
- Invitation
- Registration form
- Registration list

- Program
- Building 20 denizens say farewell to former home, Tech Talk, April 1, 1998.

Building 20 Records Project

The MIT Institute Archives has established the Building 20 Records Project to preserve records of historical importance that might otherwise be destroyed when offices and labs are moved, and to produce a set of photographs of the building before it is torn down.

Media Laboratory Building 20 Project

A group of eight graduate students from the MIT Media Lab are currently enrolled in "News, Technology, and Community" taught by Walter Bender and Jack Driscoll. For their final class project, they are creating an interactive web site to tell the compelling story of Building 20.

Other Building 20 Information

One of the major occupants of Building 20 was the MIT Research Laboratory of Electronics.

- *RLE Undercurrents*, vol. 9, no. 2 (Fall 1997) was entitled "A Last, Loving Look at an MIT Landmark -- Building 20." This issue, available on-line, includes an extensive set of photographs.
- Selected articles about Building 20 from the publication *RLE Currents*:
  - The Radiation Laboratory, vol. 4, no. 2 (Spring 1991)
  - A Building With Soul: MIT's Building 20, vol. 4, no. 2 (Spring 1991)
  - Farewell to Building 20, vol. 9, no. 2 (Fall 1997)
  - Building 20: Final Curtain Call, vol. 10, no. 1 (Spring 1998)
  - Building 20: For the Record, vol. 10, no. 1 (Spring 1998)

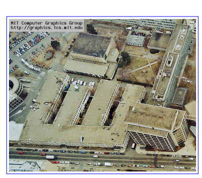
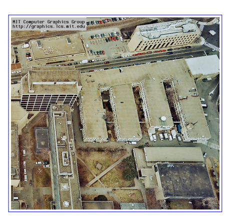
"Celebrating the History of Building 20," by the MIT Archivists, has many photographs and much else of historical interest.

A talk about Building 20 was given to the Boston Chapter of Life Members of IEEE:

- Paul Penfield, Jr., Nancy A. Heywood, and J. Francis Reintjes, **The Legacy of MIT's Building 20,** Boston Section, IEEE; Lexington, MA; March 24, 1998. (The Reflector, vol. XLVI, no. 7, p. 16; March 1, 1998.) Abstract (3091 bytes).

Four aerial photographs from the MIT Computer Graphics Group, taken March 18, 1998:



Building 20: Final Curtain Call

Friends and former occupants of Building 20 gathered on the MIT campus for a two-day program on March 26 and 27, 1998, that celebrated the building's history as MIT's "Magical Incubator." The reunion also focused on plans for the new Stata Complex, which will be built on Building 20's current site. ***For reminiscences of former occupants of Building 20, see*** RLE undercurrents ***Vol. 9, No. 2.***

Hackers festoon a banner on legendary Building 20, announcing its "formal" decommissioning by MIT.

Professor Morris Halle gives an account of Building 20 as the incubator for MIT's linguistics and philosophy programs: "...in spite of its rather unprepossessing exterior, Building 20 was a great luxury: it was like money in the bank that was not immediately needed and could be invested in projects without guaranteed pay-off. And, as we now look back half a century later on the record of these investments, we see that quite a few of them were successful and grew into major scientific enterprises."

MIT President Charles M. Vest addresses the audience at Friday evening's dinner at Walker Memorial, which was held in honor of Raymond S. (SB/SM'57) and Maria Stata. Mr. Stata, founder and chairman of Analog Devices, Inc., is the principal benefactor of a new building complex that will house the computer, intelligence, and information sciences at MIT.

Professor Jerome Y. Lettvin, a Building 20 denizen since 1953, retells the building's history as a womb for bioscience and bioengineering at MIT. "It's a building with a special spirit, a spirit that inspires creativity and the development of new ideas ... Under the benign guidance of RLE administrators, there was always support for the development of new projects."

Professor Louis D. Smullin (Rad Lab and SM'39), Julian J. Bussgang (SM'51), and a friend take a moment to share memories of days gone by in Building 20. Humorously, Professor Smullin remembers when the smell of dead squid pervaded the building after the experimental subjects expired in an overheated tank one hot summer weekend. Mr. Bussgang recalls working as a technician in the laboratory where Henry E. "Pete" Singleton (SB/SM'40, ScD'50) and Leon G. "Jack " Kraft, Jr. (SM'49) were building the first correlator.

Two colleagues from the class of '54 reunite: Charles Freed (SM'54, EE'58) from Lincoln Laboratory and MIT Professor Hermann A. Haus (ScD'54). Professor Haus remembers being hired by Professor Louis D. Smullin (Rad Lab and SM'39) to work in Building 20's Tube Lab in the summer of 1950. He treasures his memories of working in a building where one could open the windows.

MIT Professors Kenneth N. Stevens (ScD'52), Robert M. Fano (Rad Lab and SB'41), and Lawrence S. Frishkopf (PhD'56) reminisce about the old MIT Acoustics Laboratory and the early days of RLE's Speech Communication group. Professor Stevens came to the Acoustics Lab in 1948 as a graduate student. When it closed in 1955, then-RLE Director Jerome B. Wiesner gave permission for its research to be incorporated into RLE.

Dr. Hiroya Fujisaki (SM'59, EE'61) recalls his days in Building 20 as a graduate student and research assistant in RLE's Speech Communication group from 1958 to 1961, and shares them with Mr. Raymond S. Stata (SB/SM'57). Dr. Fujisaki is now a professor at the University of Tokyo and was the longest-traveled participant at the Building 20 celebration.

Building 20: For the Record

If you were unable to attend the Building 20 celebration, you can still rekindle memories of the "plywood palace," long after it is gone.

The building has its own Web site at http://www-eecs.mit.edu/building/20/index.html. From there, you can share anecdotes, look at photographs, and make connections to related Web sites.

In addition, students enrolled in the News, Technology, and Community class are creating another interactive Web site to tell the story of Building 20.

The fall 1997 issue of *RLE undercurrents* (the laboratory's in-house newsletter) featured "A Last, Loving Look at an MIT Landmark–Building 20," which contains interviews with former inhabitants and many photographs of the building.

"The Legacy of MIT's Building 20" by Paul Penfield, Jr., Nancy A. Heywood, and J. Francis Reintjes appeared in the March 1, 1998, issue of *The Reflector* (46 (7): 16).

Finally, the staff of the MIT Institute Archives is working on the Building 20 Records Project to preserve records of historical importance before the building is torn down. The archivists are collecting a set of photographs and other historical information on the building.

More photographs from Building 20's two-day celebration in March are above.

RLE Home Page **RLE Research Groups** **MIT Home Page**

The MIT Radiation Laboratory - RLE's Microwave Heritage

RLE currents Vol. 4, No. 2 (Spring 1991)

Contents:

The MIT Radiation Laboratory

The recent Persian Gulf conflict vividly demonstrated America's high-tech arsenal. Although laser-guided smart weapons and Patriot missiles had not been previously used in actual combat, their superiority on the battlefield was evident. While they may not have single-handedly won the war, they did minimize civilian casualties by accurately pinpointing strategic targets and may have curtailed hostilities by challenging traditional military tactics.

Fifty years ago, the new technology of that era would also change the nature of warfare. Even as fighting raged on, no effort was spared to develop combat-ready microwave radar equipment that eventually gave the Allies a decisive edge in World War II. The remarkable success of this wartime effort depended not only on the goodwill between the U.S. and Britain, but also on an innovative partnership that was taking shape between academia, industry and the government, and the new cooperation that was evolving between physicists, engineers, and other scientists from different academic backgrounds. These fledgling bonds would transform scientific research and how it would be carried out in the future.

Hands Across the Water

Radar, an acronym for radio detection and ranging, had been patented in 1935 by British scientist Sir Robert Watson-Watt for meteorological applications. Watson-Watt and other scientists believed that radar could also be developed into a system to locate objects using transmitted and reflected high-frequency radio waves. The range of an object in the radio wave’s path could be determined by measuring the time it took to transmit and receive the reflected radio waves. This idea had potential for navigation and military applications, especially in determining the distance and altitude of airborne objects.

During the 1920s and '30s, early radar research was being conducted by Germany, France, the United States, and Britain. By the late '30s, the Chain Home network, a ground-based radar network along Britain's east and south coasts, was in operation. Chain Home was a system of antennas that could detect aircraft up to 150 miles away and low-flying planes as they came over the water. Because it removed the element of surprise, the system was crucial during the London Blitz. British fighter planes were also using radar at one-meter wavelength frequencies. But, in 1940, microwave airborne radar was not yet realized.

From left: Professors Julius A. Stratton, Albert G. Hill, and Jerome B. Wiesner have been the inspiring and foresighted builders of the Research Laboratory of Electronics As both RadLab scientists and RLE directors, all three have emphasized the importance of collaboration between government, industry, and academia in broad-based, fundamental research. (1948 Photo by Benjamin Diver)

With Germany threatening, invasion, British scientists aggressively experimented with shorter wavelengths, narrower beams, more compact equipment, and greater power generation to improve their radar capability. Existing radar operated on relatively low frequencies with wavelengths several meters long. The goal was to generate more powerful and narrower beams that operated on shorter wavelengths which could more accurately pinpoint small, airborne targets. The problem was generating enough high power at these shorter (microwave) wavelengths.

In August 1940, the British government dispatched the top-secret Tizard Mission to the United States to exchange information on radar. The mission's members were Sir Henry Tizard, Chairman of the British Aeronautic Research Committee; Sir John Cockcroft, Director of the British Army Air Defense Research and Development Establishment; and Dr. Edward G. "Taffy" Bowen, a cosmic ray researcher from the University of London. The Tizard Mission arrived first in Canada, and then traveled on to Washington, DC, to meet with the U.S. National Defense Research Committee (NDRC).

The NDRC had been conceived by Dr. Vannevar Bush, Dean of Engineering at MIT and scientific advisor to President Franklin Roosevelt; Dr. James Conant, President of Harvard University; and Dr. Karl Taylor Compton, President of MIT. Established in June 1940 as an independent federal agency under Vannevar Bush, the NDRC sought to apply civilian scientific ideas in military operations. NDRC's Section D-1, known as the Microwave Committee, consisted of representatives from industry and was charged with investigating radio detection and countermeasures. Dr. Alfred L. Loomis, lawyer-scientist and MIT Corporation member, headed up the Microwave Committee. (Dr. Loomis also hosted a program for MIT students at his Tuxedo Park, New York, laboratory on microwave radiation and the detection of moving targets using the Doppler effect.)

In September 1940, the Tizard Mission met with representatives from the U.S. Navy and Army, the NDRC, and its Microwave Committee to exchange highly sensitive information on radar. The U.S. Naval Research Laboratory disclosed that it had obtained clear, pulsed echoes from aircraft and from those sprouted the idea for the MIT Radiation Laboratory.

Off to a Fast Start

Initially, Bell Telephone Laboratories' findings had produced shipboard radar. The U.S. Signal Corps had also devised mobile air-warning radar and searchlight-director radar. But, neither country had made substantial progress in airborne radar or high-power transmitters for centimeter wavelengths. In a pivotal meeting with the Microwave Committee, the Tizard Mission revealed the 10-centimeter resonant cavity magnetron invented by British physicists Dr. H.A. Boot and Sir John T. Randall at the University of Birmingham. This magnetron, an efficient, high-power (10-kilowatt) pulsed oscillator that operated at 10-centimeter wavelengths, proved to be the seed that General Electric, Westinghouse, Sperry, and RCA agreed to quickly supply the magnetrons and other components needed. The NDRC, its Microwave Committee, and the Tizard Mission worked out plans for an independent laboratory that would be staffed by civilian and academic scientists from every discipline. Lee A. DuBridge, a nuclear physicist from the University of Rochester, was hired as the laboratory's director on October 16, 1940. On the following day, MIT was chosen as the site for this still unnamed laboratory. Later that month, under the guise of an applied nuclear physics conference at MIT, staff members were recruited. Kenneth T. Bainbridge (SB'25, SM'26), a Harvard physicist, was the first to be enlisted, and the laboratory's first meeting took place on Armistice Day 1940 in MIT's Building 4 Room 133. Finally, a name was chosen. To protect the secrecy of its sensitive work, it was called the Radiation Laboratory. The name conjured thoughts of atomic and nuclear physics, a safe and acceptable field of scientific investigation at that time. It also served as a decoy for the laboratory's real work on sophisticated microwave radar.

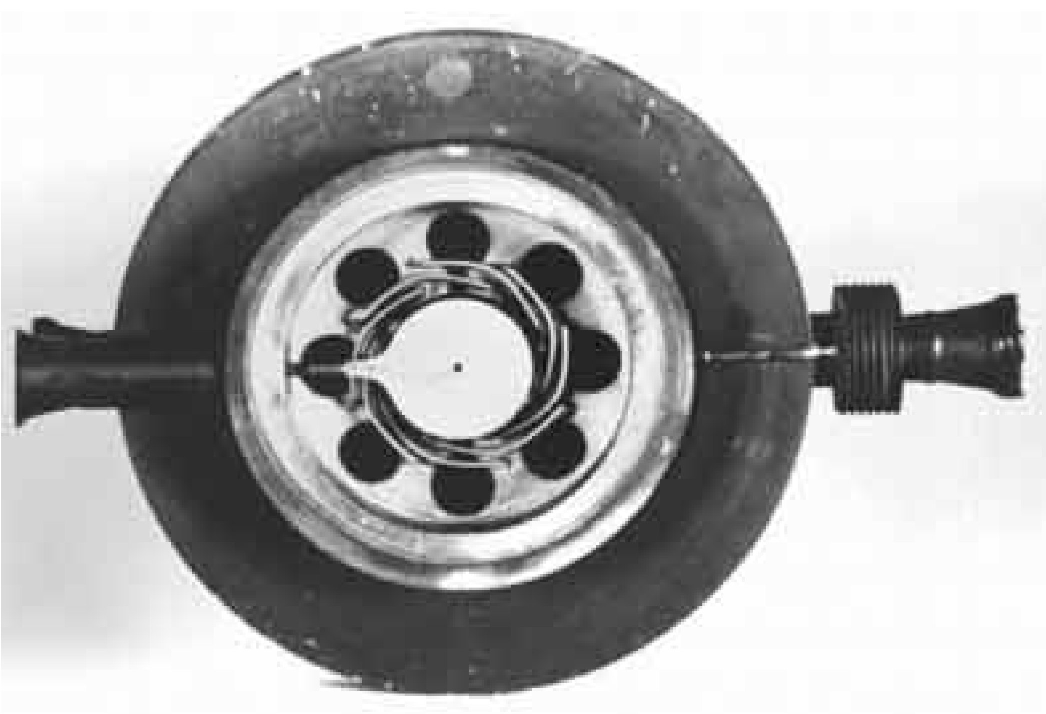
Fourteen months before the U.S. entered World War II, RadLab (as it was known) began its investigation of microwave electronics. Six technical working groups were set up to study different components: pulse modulators, transmitter tubes, antennas, receivers, cathode-ray tubes, and klystrons. The first three projects tackled by RadLab were Britain's top priorities:

Project 1 focused on 10-centimeter airbome intercept microwave radar that could be used by bombers to detect enemy aircraft at night. The first success of Project I came in February 1941, with the detection of buildings in Boston across the Charles River from a two-parabola system on MIT's Building 6. But, as night bombings of London decreased, attention turned to anti-submarine strategies, since German U-boats threatened to cut Britain off from the sea. The experimental airborne intercept project then shifted to aircraft-to-surface vessel detection. Project 1 also spawned experiments in shipborne search and landbased harbor defense systems.

Project II, which developed 10-centimeter ground radar for anti-aircraft gun-laying, began in January 1941. The goal was to produce automatic radar tracking to control the aiming and firing at enemy aircraft. Project II resulted in the production of the highly successful SCR-584 gun-laying radar, which is credited with destroying 85% of the V-1 buzz bombs that were dropped on London.

Project III involved long-range radio navigation for ships and aircraft called LORAN. LORAN enabled crafts to locate themselves using radio frequencies. It improved on Britain's Oboe system for bombing Europe and also guided North Atlantic convoys later in the war. By the end of the war, LORAN covered one-third of the Earth's surface.

On October 9, 1990, IEEE President Eric E. Sumner (left) presorted an Electrical Engineering Milestone commemorative plaque to MIT President Paul E. Gray. The plaque, installed in the corridor outside of MIT room 4-133, RadLab's original office, reads. "The MIT Radiation Laboratory, operated on this site between 1940 and 1945, advanced the Allied war effort by making fundamental contributions to the design and deployment of microwave radar - the first radar system small enough to be operated in aircraft. In the process, the Laboratory's 3900 employees made lasting technological contributions to microwave theory, operational radar, systems engineering, long-range navigation, and control equipment." IEEE established the Milestones program in 1983 to honor accomplishments in electrical and electronics technology. Through this program, the IEEE hopes to increase the understanding of electrical history, among engineers and the public, and to encourage preservation of the historical record of these achievements. The Milestones program is sponsored by the IEEE History, Committee and administered by the Center for the History of Electrical Engineering at Rutgers University. (Photo by John F. Cook)



The resonant cavity magnetron has been described as a "metal ball with protruding glass horns. British physicist Sir Jobn T. Randall and Dr. H.A Boot, working under Professor M.L. Olipbant at the University of Birmingham, deteloped the idea of using the klystron's resonant cavity principle in a magnetron. Several production models of this magnetron were manufactured (with different numbers of cavities) by

British GEC in 1940, and one accompanied the top-secret Tizard Mission to the United States. Thought to have been a six-cavity magnetron, the mission accidentally brought one with eight cavities for demonstration. Thus, British models have six resonant cavities, and American models have eight. In this electronic tube, electrons are generated from a heated cathode and move under the combined force of a radial electric field and an axial magnetic field to produce high-energy microwave radiation in the frequency range from 1-40 gigahertz. The miagnetrons used for radar applications generate pulsed energy while magnetrons for microwave ovens generate continuous radiation. (Photos courtesy MIT Museum)

The Proving Ground

U.S. government and military officials were skeptical of both the civilian scientists and the experimental radar technology. But, on the morning of the Pearl Harbor attack, an Army ground-based long-wavelength radar set at Opana, Oahu, detected Japanese planes as they approached the island. Even though the radar's indications were reported to the officers in command, it was mistakenly believed that the equipment was malfunctioning, and the warnings went unheeded. Consequently, radar gradually gained acceptance as the equipment designed at RadLab proved its accuracy on the battlefields of Europe, Africa, and the Pacific.

In April 1942, Professor Edward L. Bowles was selected as a consultant to Secretary of War Henry Stimson. His first assignment was to assess radar's role in detecting German submarines. Since U-boats would surface at night to attack convoys, they could not be located by sonar defenses. Professor Bowles persuaded the military to use radar in defense of the Atlantic. Radar was installed on escort ships and, working in tandem with sonar, enabled the Allies to track the U-boats above and below the surface. This proved crucial in winning the Battle of the North Atlantic.

The RadLab was not alone in its mission. Other electronic research centers under NDRC sponsorship studied radar and microwaves. Harvard University's Radiation Research Laboratory worked on countermeasure methods and other aspects of electronic warfare. Columbia University's Radiation Laboratory was established in 1942 and headed by RadLab scientist Isidor I. Rabi. Columbia's Rad Lab investigated microwave components such as the tunable X-Band magnetron that operated at frequency ranges above existing devices. Brooklyn Polytechnic Institute's Microwave Research Group worked on measurement techniques and components for microwave systems.

RadLab also contracted with seventy industrial companies to assist in mass producing radar sets. These companies included General Electric, Raytheon, RCA, Westinghouse, Philco, Sperry, and Western Electric. In October 1941, RadLab established its own company, the Research Construction Company (RCC), to manufacture limited quantities of microwave radar systems and components that were not immediately available from industry.

Fire control, airborne radar for blind and precision bombing, ground imaging, beacon bombing radar, bombing reconnaissance, mobile microwave sets, aircraft and ship search radar, and harbor/coastal surveillance-these are only a few of RadLab's other projects. The microwave early warning system had the greatest range and adaptability of all the microwave ground equipment produced at RadLab, and it played a leading role in D-Day operations, as did the SCR-584 fire-control radar. Supporting the laboratory's hardware production was a group devoted to advanced research on microwave propagation and transmission; the theory of noise, antennas, and waveguides; and signal and design problems with the radar systems. This group was headed up by Isidor I. Rabi, who has been acknowledged by many as

RadLab's "scientific heart and soul."

What began as a British-American effort to make microwave radar work, swiftly evolved into a centralized laboratory, committed to understanding the theories behind experimental radar while solving its engineering problems. From 1940-1945, RadLab designed almost half of the radar deployed in World War II, created over 100 different radar systems, and produced $1.5 billion of radar equipment. By the end of the war, over a million magnetrons had been produced by the Allies, some operated at millimeter wavelengths, and others were capable of one-megawatt of power.

RadLab occupied fifteen acres of MIT space, and its field stations included East Boston (Logan) Airport and Deer Island; Orlando, Florida; and Spraycliff, Rhode island. Branches also sprung up on several continents, including the British Branch of the Radiation Laboratory at Malvern, England, and the Advanced Service Base in Paris, France. The RadLab switchboard soon became the largest in Cambridge. Almost 4,000 men and women worked for RadLab-nuclear physicists, chemists, mechanical and electrical engineers, mathematicians, biologists, bankers, lawyers, accountants, secretaries, professors, and students. Nine staff members went on to become Nobel laureates, and two became presidential science advisors.

MIT's research program at the 277-acre Round Hill estate in South Dartmouth, Massachusetts, started in 1923. Colonel Edward Howland Robinson Green offered the use of his property to MIT where radio station WMAF broadcasted early network-like programming. Experiments at Round Hill focused on radio communications, the theory, and application of microwaves, air navigation, and radio and light propagation through fog This program was the forerunner of research that was to take place in the MIT Radiation laboratory In 1936, the property, was given to MIT following Colonel Green's death, and various experiments were carried out there by MIT and Lincoln Laboratory, until the estate was sold in 1964. (Photo courtesy MIT Museum)

A Picture of War

"June 5 was a clear beautiful night. It was a bit windy a little after midnight; the moon was up bright and nearly full. The sea was much calmer than previously. After the operation had started it really was a night to set your blood tingling.

"At 2345 something new appeared on the scope; a kind of target I had never seen before. It was a long streak moving directly south. A second group appeared at 2355 looking almost the same; and at 2356 the first streak turned straight east. I had no longer any doubt that something big was on. At 0010 Squadron Leader Cherry Downes told us the Invasion had started, that we were taking part in it and had to do our job as well as possible."

In this way, as reported by the Laboratory's E.C. Pollard, the invasion of France began. Pollard sat in England at a MEW (microwave early warning radar) scope and watched it. He saw armies of planes arise, form and head down towards France. Strings of planes, 20, 40, and 80 miles long were visible at once. Weaving in and out among these, each one separate and distinct, were the roving fighter planes that furnished cover. This whole air fleet performed a slow orbital movement, swinging down over France, dropping the bombs, swinging up over England again and dispersing. It went on all night and continued the next day. It was a picture of war no man had ever seen before....

Reprinted from *Five Years at the Radiation Laboratory*.

RadLab Ends with a New Beginning

Termination of RadLab was announced on August 14, 1945, and it formally closed on December 31, 1945, leaving behind tons of surplus equipment and a concept for basic research that was to continue in MIT's Research Laboratory of Electronics. The laboratory's technical achievements were recorded in a 28-volume set, the *Radiation Laboratory Series*, published in 1948 by McGraw-Hill, which is still used today by engineers as a definitive reference on microwave theory and techniques.

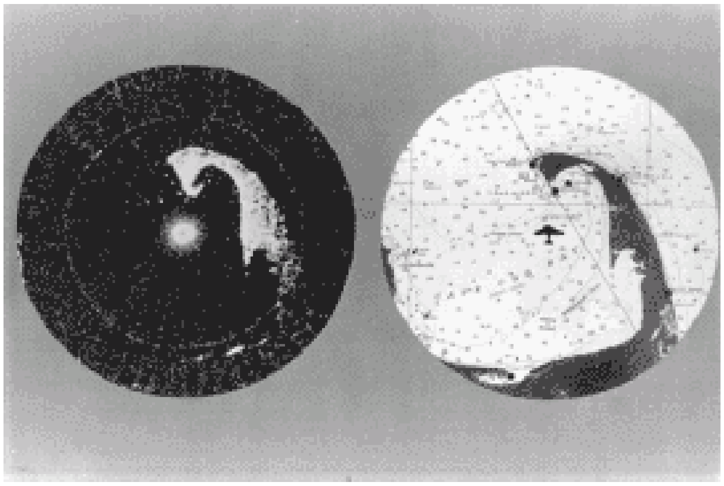
Plans for a peacetime continuation of RadLab had been under consideration since the invasion of Normandy in June 1944. Professor John C. Slater conceived the idea for an electronics laboratory at MIT that would operate jointly under the Department of Physics and the Department of Electrical Engineering. In August 1944, Slater met with MIT President Karl T. Compton, Dean of Science George P. Harrison, and Professors Harold L. Hazen and Julius A. Stratton to discuss these plans. Slater recommended Stratton as director, and in September 1945, Stratton presented a transition plan for the new laboratory. The NRDC had already voted to provide continued funding under the RadLab contract.

On January 1, 1946, a fragment of RadLab was set up as a transitional organization called the Basic Research Division. Under Director Julius A. Stratton and Associate Director Albert G. Hill, it continued investigation on problems in physical electronics that involved cathodes, electronic emission, and gaseous conduction. In microwave physics, the electromagnetic properties of manner at microwave frequencies were studied, and modem techniques were applied to both physics and engineering research. Engineering applications were used in microwave communication studies.

In March 1946, the Department of Defense set up a committee to oversee the transition: Lieutenant Colonel Harold A. Zahl (Army), Commander Emanuel R. Piore (Navy), and Major John W. Marchetti (Air Force). These three were later joined by Mr. John Keto (Army Air Corps) on a technical advisory committee for what was to become the Joint Services Electronics Program (see related article, page 7).

On July 1, 1946, the Basic Research Division was finally incorporated into the new Research Laboratory of Electronics (RLE) at MIT.

RadLab's Microwave Legacy



A plan position indicator scope image of Cape Cod (left), as seen with the experimental airborne search and bombing radar known as X-band AS developed at RadLab. From this 1942 picture, the exact shape of Cape Cod was known for the first time (compare to"map on right). Radar photos such as this one prompted a surprised British RAF dignitary to say, "Gentlemen, this is a turning point in the war. " (Photo courtesy MIT Museum)

The growth of RLE research was boosted by the abundance of microwave components and test equipment left over from the RadLab. Professor George G. Harvey has been credited with inventorying and tagging much of RadLab's surplus equipment, thus ensuring its continued use at RLE. This valuable equipment was coupled with the newly acquired knowledge of microwave measurement techniques plus the backlog of many uninvestigated theoretical and experimental ideas from World War II. RLE scientists and students could now capitalize on shared academic interests, the lab's pooled physical resources, and a new common funding source in the Joint Services Electronics Program.

In 1946, there were five RLE research groups: microwave and physical electronics, microwave physics, communications and related projects, modern electronic techniques applied to physics and engineering, and aids to computation. The microwave studies focused on the generation of powerful radar transmitter pulses, while the activity, in electronic circuits and aids to computation supported work in theoretical design and statistical communication.

Both the microwave and communication interests branched out in many different directions over the years:

Microwave spectroscopy: Professor Malcom W.P. Strandberg studied fundamental atomic resonance phenomena that contributed to the basic knowledge of quantum-mechanical amplifiers. This ultimately led to the invention of devices that could generate coherent radiation by stimulated emission of radiation (the maser and laser).

Research on atomic and molecular beams was another direction that resulted from RLE's initial interest in physical electronics. Professor Jerrold R. Zacharias investigated the resonance phenomena associated with nuclear magnetic moments of elements such as cesium. This work contributed to the first practical demonstration of atomic clocks. Highly accurate standards for time measurement were established using the frequency characteristic of certain atoms, such as cesium, as they were observed in a molecular beam apparatus. The cesium frequency standard is now used commercially and is important in scientific observations and in terrestrial and space navigation systems.

The interest in physical electronics also branched off into solid-state physics, which addressed fundamental problems in condensed matter physics and electronic materials and structures.

Plasma dynamics. Absorption properties of ionized gases in microwave gas discharge experiments conducted by Professor Sanborn C. Brown verified the theory work of Professor William P. Allis and stimulated plasma dynamics research in RLE. There was a special emphasis on radio frequency and microwave gas discharge breakdown and spectroscopy. Initially, the experiments were concerned with low-temperature, low-density plasmas, and progressed to high-temperature, high-density, and hilly ionized plasmas. Studies of plasma resonance phenomena led to a better understanding of high-frequency radio wave transmission, since the upper atmosphere contains layers of ionized gas. Later, there were plasma radiation studies and the first quantitative measurements of cyclotron emission and bremsstrahlung by Professor George Bekefi. The phenomena of wave instabilities were also explored, which led to their first classification. In the '60s and '70s, the generation of coherent electromagnetic radiation and the development of new microwave and millimeter-wave devices also came from this work and ultimately resulted in the building of free-electron lasers. Professor Bruno Coppi later examined the magnetohydrodynamics of hot fusion plasmas and advanced the theory for the highfield tokamak. In 1980, the evolution of plasma research at RLE contributed to the formation of MIT's Plasma Fusion Center.

Linear accelerator and magnetron phasing. The problem of magnetron phasing was addressed by Professor John C. Slater's construction of a small linear accelerator for electrons. The knowledge acquired in RadLab was the basis for his work, and additional techniques were conceived in RLE. Klystrons or other microwave power sources eventually replaced the magnetron in more modern accelerators, but this work was important in perfecting this type, of particle accelerator. In similar studies more closely related to communication and radar applications, Professor Jerome B. Wiesner and graduate student Edward E. David, Jr., (both future Presidential science advisors) investigated transient and steady-state phenomena in phase-locking a magnetron to a more stable source.

Phase-sensitive microwave systems. Missile guidance studies in the late '40s and early '50s included Project Meteor, the code name for a ship-to-air missile research program. Professors Lan Jen Chu, Henry J. Zimmermann, and Campbell L. Searle developed fundamental phase-sensitive microwave systems used in missile guidance. Professor Chu's microwave interferometer used for Project Meteor's homing device led to other studies in phased-array radar systems. Microwave interferometer, was also employed in radio astronomy, where very-long baseline interferometers (VLBI) obtain high angular resolution of distant sources. Professors Bernard F. Burke and Alan H. Barrett have used VLBI to correlate radio signals in stellar maser observations. This work received the 1971 Rumford Prize of the American Academy of Arts and Sciences.

Radio astronomy instrumentation

RadLab's interest in minimizing component and cosmic radio noise stimulated RLE studies of high-performance amplifiers. Many early radio astronomy studies were done with former radar equipment (the dishes used to track targets were now tracking celestial objects with great accuracy), but a variety of new instruments were created as the science evolved. In RLE, Professor Alan H. Barrett used balloon-borne radiometers to measure the oxygen concentration in the atmosphere (OH line), and made microwave observations of Venus in 1962 using radiometers on a NASA Mariner spacecraft. That same year, Professor Louis D. Smullin and Dr. Giorgio Fiocco were the first to bounce a laser beam off the moon's surface.

Optics. Interest in characterizing noise in electronic amplifiers led to the study of optical systems. Although the noise properties of high-speed optical systems are not practical for analog communications, the ability to produce ultrashort optical pulses is important for digital optical communications. Today in RLE, Professors Hermann A. Haus, Erich P. Ippen, and James G. Fujimoto study femtosecond optical phenomena in a variety of materials and exploit this understanding for high-speed optical switching.

Communication sciences. Statistical communication theory and information and coding theory focused on problems in the generation, transmission, and processing of signals. Studies in statistical communication theory (by Professors Norbert Wiener, Yuk Wing Lee, and Jerome B. Wiesner) gave a better understanding of the communication process in the presence of noise and interference, the optimization of system parameters, and new forms of communication systems. Information theory and coding theory (Professors Claude Shannon, Robert Fano, David Huffman, Peter Elias, Robert Gallager, and John Wozencraft) involved quantitative studies of different noisy channels in terms of the rate of information transmitted. The work was initially concerned with channel capacity, and methods were used that approached the theoretical limit on transmission rate. But, as digital data transmission became more important, the emphasis shifted to error rate and the methods to reduce it by, means of error-correcting codes.

The pulsed techniques devised in RadLab were classified information, but in later years they would prove useful in communication technology that used pulses to convey messages. Professor Ernst Guillemin and Dr. Manuel Cerrillo worked on time-domain network synthesis which led to discrete systems and then to pulse techniques in computers. Guillemin and Cerrillo also worked on electronic circuit theory and the basis for circuit synthesis with graduate student John Linvill, who wrote an important thesis on the gain-bandwidth characteristics of amplifiers.

The results from the research projects mentioned above also stimulated MIT's academic program, where new subjects have been introduced in physics, electrical engineering, and other disciplines. Many of these new subjects began as graduate seminars in RLE while the research was in progress.

Riding the Beam from GCA to MLS

Since World War II, radar has been adapted for many purposes, including the navigation of civil aircraft. Highly accurate tracking guidance systems and distance measuring equipment have been used for air traffic control en route or in the airport control area. These systems are especially helpful in bad weather and under heavy traffic conditions.

Early blind-landing systems were studied at MIT's Round Hill program. The RadLab also produced a system for landing airplanes called ground control of approach (GCA). Since most of the GCA equipment was ground-based, the pilot received verbal landing instructions via radio communication. The plane would be detected at a range of 15-20 miles with 10-centimeter search radar, brought on course for landing, and guided down a glide path by the approach controller with a high-precision 3-centimeter system. The first GCA used in combat was at a night-fighter field near Verdun, and was credited with forty landings.

GCA was only one of several airplane navigation systems that was created during the war. Another, the instrument Landing System (ILS), is still used today as a low-approach guidance system to aid pilots in poor visibility. Although ILS is currently the worldwide standard precision approach guidance system, it has several drawbacks: there must be flat terrain over an extended area for accurate ground reflection patterns, flight patterns must be restricted to a single straight approach path, and there are communication problems with multipath interference. ILS is now over-burdened as large metropolitan areas are faced with airport congestion and channel spacing problems.

Professor Jin Au Kong's group in RLE's Electromagnetic Theory and Applications Group is investigating possible improvements using a different system, the Microwave Landing System (MLS). MLS offers several advantages over ILS: flat terrain is not required; shorter, curved flight approaches are permitted that can save fuel and reduce noise; and its channel capacity is five times larger than ILS. Professor Kong's group uses a computer simulation tool called EMSALS (Electromagnetic Simulations Applied to Landing Systems) to model and analyze the frequency, congestion and electromagnetic interference problems from ten metropolitan U.S. areas. Further details of this research can be found in *RLE Progress Report No. 133.*

Professor Jin Au Kong and his students and colleagues in RLE's Center for Electromagnetic Theory and Applications are evaluating a new airport traffic control system, the Microwave Landing System. Professor Kong displays a model of what may someday be the design for airplanes capable of vertical take-offs and Landings using the new, landing system. (Photo by John F Cook)

RadLab Readings

No single book or document has ever been published on RadLab's history, but several sources include it as part of a larger work:

A Century of Electrical Engineering and Computer Science at MIT, 1882-1982, by Karl L. Wildes and Nilo A- Lindgren, touches on the lives of the many individual who were part of RadLab and discusses historically important technological advances within MIT's Department of Electrical Engineering and Computer Science and RLE. (MIT Press, 1985)

Radar Days, by Edward G. Bowen, is an insightful personal history from Dr. Bowen's early involvement in the scientific discoveries of wartime radar in England through the inception and creation of radial. Dr. Bowen was a member of the Tizard Mission and RadLab. (Adam Hilger, 1987)

The MIT Radiation Laboratory Series, edited by Louis N. Ridenour, is an extensive technical documentation of RadLab projects in 28 volumes with an index. The series is now out of print, but is available at many scientific reference libraries including the RLE Document Room.

Five Years at the Radiation Laboratory was published by MIT after the termination of RadLab. This book is the most comprehensive overview of the laboratory, its work, and the people who were part of this unique experience. Originally published with classified information omitted, a limited number of copies has now been reprinted by the Boston chapter of the IEEE Microwave Committee to commemorate the RadLab's 50th anniversary, with much of the restricted information reinstated.

Echoes of War is part of the *NOVA* television series on the Public Broadcasting System. This one-hour program, which was produced in 1989, surveys RadLab's role and the impact of radar in World War 11, and includes interviews with several RadLab members. Videotapes of the program are available through the WGBH Public Video Service by calling (800) 248-8311. Transcripts are also available through NOVA Transcripts, Journal Graphics, 267 Broadway, New York, NY 10007.

by Dorothy A. Fleischer

A Building with Soul

A World War II survivor, Building 20 as it looks today, with the Research Laboratory of Electronics (Building 36) in the background.

"Building 20 is an admixture of all the interesting things at MIT," says Lettvin, a jovial mountain of shivering cerebra who is admired inside Building 20 not for his genius but as a man who first uttered a profanity on television, during a 1961 debate with Timothy Leary ("It made the front page of *Variety,"* Lettvin insists. "You can look it up.")

What's so special about Building 20? Even the MIT Museum had trouble answering that question in 1980, when it organized an exhibit dedicated to the ramshackle "Plywood Palace," the least descript of all the institute's studiously nondescript structures. "Why do we celebrate a building so modest, so meek and indeed so homely in its demeanor?" asked the introduction to the exhibit catalogue.

First off, we celebrate its history. One of several temporary structures thrown up on campus during World War II -- it took less than an afternoon to design -- Building 20 is the only one still standing. Many of MIT's greatest projects, including the wartime radar project and its first interdisciplinary labs started in Building 20, along with many of the institute's leading professors.

Secondly, the building is the kind of academic melting pot that gives university presidents indigestion. Famed linguist and antiwar activist Noam Chomsky works just a few doors away from MIT's ROTC offices, which have decorated one whole wall with a colorful mural of an F-16 fighter.

The music department's piano repair facility -- a "computer-free zone," according to a sign on the

wall--shares a floor with the nuclear science lab's shop room. The model railroad club, which houses the most sophisticated toy train in the world, is just a stone’s throw away from the chemical engineering department's cell culture lab, where a bulletin board message inquires plaintively: "Did anybody use toxic substances in the small Corning spinner flasks? About half of mv cultures died without apparent reason."

After the war many of the heavyweight research projects moved into their own buildings, and Building 20, with its creaky floors and poor ventilation, attracted researchers who couldn't find space elsewhere at MIT. Once they settled in, they fell in love with the place. "It turned out to be absolutely perfect for research," explains Halle, an ebullient bearded scholar who has made Building 20 his home for 37 years. "You can knock down a wall, you can punch out a ceiling, and you could get space. In academics, space is everything."

In the interests of space, Halle's lab launched an "expansionist" raid against the model railroad club's huge two-room suite. The land grab failed because the club argued that its computerized, 200-switch track layout could not be easily moved. Indeed, a move against the club might have set off a revolt among the building's older tenants, who fondly remember the five-cent Cokes dispensed from the club's specially programmed soft drink machine.

Not suprisingly, Building 20 has its own myths.

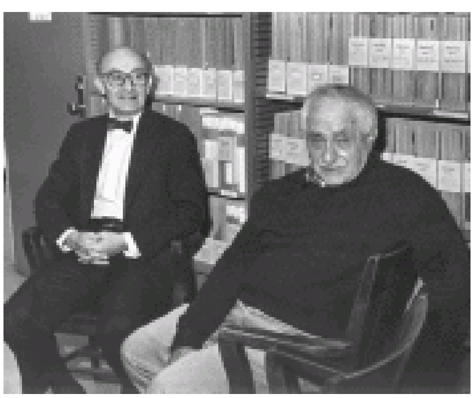
"I know someone who can tell you some hair-raising stories about the early days of microwave," Lettvin says, shoving aside piles of unopened mail to dial his phone. Unfortunately, his contact isn't in.

"Remember the phantom?" Lettvin asks. Indeed, Halle does remember the mysterious, homeless botanist who camped out in a Building 20 storeroom and haunted the building's corridors during the ‘60s and '70s. No one knows how he supported himself, or who his family was. "He turned down a job at the Field Museum in Chicago in order to remain a phantom in Building 20," Lettvin says.

The professors say MIT tried to evict the squatter and lost their case in a Cambridge court. The phantom hung on until 1980, only to drift into oblivion--and into the history of Building 20.

"A Building with Soul" by Alex Beam originally appeared in *The Boston Globe*, June 29, 1988. It is reprinted with permission of *the Boston Globe.*

Please Be Seated



Today, Professor Abraham Bers (left) and Professor Emeritus Louis D. Smullin enjoy, a moment in the DuBridge chair as shown in the photograph below shows imprinted tag still in place. (Photos by John F. Cook)

When MIT Building 22, previously occupied by the RadLab, was razed in 1954, several stray chairs from the RadLab's conference room found a home in Building 20. Graduate student Abraham Bers had just arrived at MIT and was assigned to room 2OB-003, which he shared with the chairs. These wood desk chairs were typical of the World War II period, and were probably considered executive" models since they, had arms. Two chairs displayed name tags stamped with "L.A- DuBridge," MIT's Radiation Laboratory director. Prof. Bers, who was to join the faculty of the Department of Electrical Engineering and Computer Science in 1959, learned the historical significance of that name and has taken care of the chairs ever since. One might say that Professor Bers is the "holder of the DuBridge chairs."

The chairs have since moved several times with Professor Bers, who is a principal investigator in RLE's Plasma Physics Group. they, are now in the library across from his office in Building 38. "I'm not the only one who received support from these chairs," admits Professor Bers with a smile, referring to the many students he has worked with over the years. "They all sat a lot when they were here."

For now, the chairs will remain in his library. In the future, perhaps someone will offer to care for them as Professor Bers has done. Or, the chairs might find a home at the Smithsonian, because, in hindsight, didn't radar put an end to flying by the seat of one's pants?

Director's Message

Professor Jonathan Allen, Director, Research Laboratory of Electronics

The fiftieth anniversary of the founding of the MIT Radiation Laboratory (RadLab) is being celebrated this year, and we are especially pleased to devote this issue of *currents* to a remembrance of that lab, its many accomplishments, and its strong leadership. RLE is the natural continuation. into peacetime of the RadLab style. The extensive array of equipment amassed in the RadLab formed our initial equipment inventory, and our first three directors were associated with the RadLab.

The wartime experience in the RadLab showed that talented people from several disciplines could effectively focus on a variety of fundamental and applied research projects with outstanding results. Many of these investigators acquired new skills in order to solve these problems, and their achievements showed how effective interdisciplinary research can be.

This was the heritage upon which RLE was designed and founded, and the wide variety of research presently found in RLE is ample testimony that the interdisciplinary style of research started in the RadLab continues vigorously. We are extremely proud of our roots, and look forward to extending the RadLab style into the exciting future.

RLE undercurrents - Fall 1997 (vol. 9, no.2)

Building 20

A Last, Loving Look at an MIT Landmark

"For release August 14, 1945.
"Radar Center will close down. Radiation Laboratory, MIT, Cambridge, Mass., world's largest scientific institution of its kind, announced the 'beginning of the end' for war research that lasted almost five years and was conducted in utmost secrecy. Radar devices developed here have had decisive effect in war and introduce principles that will have scores of peacetime uses."
(photo/caption: MIT Museum)

It was a new beginning: World War II was over; the RadLab was closing; and the Basic Research Division, which would later become the Research Laboratory of Electronics (RLE), was just established. Professor George Harvey, later RLE's first associate director and security officer, went through the RadLab equipment, tagging items to save for RLE and the Laboratory for Nuclear Science (LNS). Building 20 hummed with new life, with RLE headquarters moving into the A wing, and LNS and other groups moving into the other wings.

Life in Building 20 was homey with a family-like atmosphere. Any excuse would serve for having a party. People ignored the shabbiness and dirt because the atmosphere encouraged creativity and the exchange of ideas. The building was the only one on campus with its own lunchroom. Two friendly Cambridge ladies served hot dogs, hamburgers, beverages, sandwiches, and desserts. Other conveniences were a machine shop, chemistry shop, glass-blowing shop, tube lab, library, and publications office.

The following links are to the full text of reminiscences of some members of the RLE community, excerpts of which appear in the Fall 1997 issue of ***undercurrents***. In interviewing many of the people who worked and studied here, we were impressed with the fondness pervading their memories.

Our thanks to all who contributed their time and memories, and our special thanks to John F. Cook, whose photographs of the building form the centerpiece of the Fall 1997 issue of ***undercurrents*** and appear throughout this website. All photos shown here are his, except where otherwise noted.

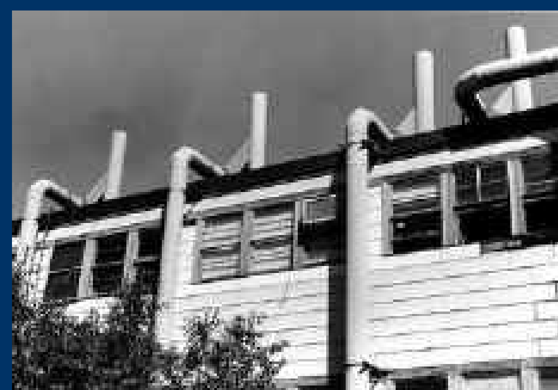
Building 20 Reminiscences

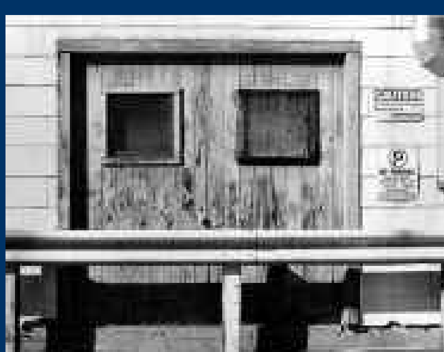
MIT

Remembering Building 20

Photos by John F. Cook

click photos to view larger image



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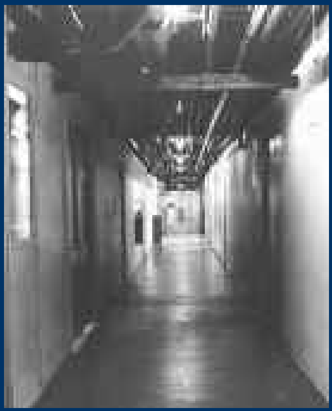

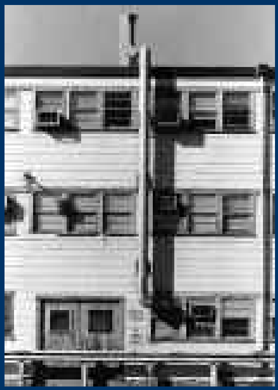

Building 20 Reminiscences

- Dr. Jonathan Allen
- Professor Emeritus Morris Halle
- Richard V. Keyes, Jr.
- Professor Emeritus Robert L. Kyhl
- Neena Lyall
- D. Cosmo Papa
- Dr. Joseph S. Perkell
- Professor Kenneth N. Stevens
- Professor Thomas F. Weiss
- Elaine (Geller) Cook
- Nancy Heywood, MIT Institute Archives
- Professor Emeritus Nelson Y-S. Kiang
- Professor Emeritus Jerome Y. Lettvin
- Professor Alan V. Oppenheim
- Professor William T. Peake
- Professor Emeritus Louis D. Smullin
- Professor Emeritus Malcom W.P. Strandberg

MIT