

CHEMICAL HERITAGE FOUNDATION

**JAY T. LAST**

Transcript of an Interview  
Conducted by

David C. Brock

at

Beverly Hills, California

on

21 June 2004

(With Subsequent Corrections and Additions)

## **ACKNOWLEDGEMENT**

This oral history is part of a series supported by grants from the Gordon and Betty Moor Foundation. This series is an important resource for the history of semiconductor electronics, documenting the life and career of Gordon E. Moore, including his experiences and those of others in Shockley Semiconductor, Fairchild Semiconductor, Intel, as well as contexts beyond the semiconductor industry.

This oral history is made possible through the generosity of  
the Gordon and Betty Moore Foundation.

CHEMICAL HERITAGE FOUNDATION

Oral History Program  
FINAL RELEASE FORM

This document contains my understanding and agreement with Chemical Heritage Foundation with respect to my participation in the audio-recorded interview conducted by

David C. Brock on 21 June 2004.

I have read the transcript supplied by Chemical Heritage Foundation.

1. The audio recording, corrected transcript, photographs, and memorabilia (collectively called the "Work") will be maintained by Chemical Heritage Foundation and made available in accordance with general policies for research and other scholarly purposes.
2. I hereby grant, assign, and transfer to Chemical Heritage Foundation all right, title, and interest in the Work, including the literary rights and the copyright, except that I shall retain the right to copy, use, and publish the Work in part or in full until my death.
3. The manuscript may be read and the audio recording(s) heard by scholars approved by Chemical Heritage Foundation subject to the restrictions listed below. The scholar pledges not to quote from, cite, or reproduce by any means this material except with the written permission of Chemical Heritage Foundation.
4. I wish to place the conditions that I have checked below upon the use of this interview. I understand that Chemical Heritage Foundation will enforce my wishes until the time of my death, when any restrictions will be removed.

**Please check one:**

a.  \_\_\_\_\_

**No restrictions for access.**

**NOTE:** Users citing this interview for purposes of publication are obliged under the terms of the Chemical Heritage Foundation Oral History Program to obtain permission from Chemical Heritage Foundation, Philadelphia, Pennsylvania.

b. \_\_\_\_\_

**Semi-restricted access.** (May view the Work. My permission required to quote, cite, or reproduce.)

c. \_\_\_\_\_

**Restricted access.** (My permission required to view the Work, quote, cite, or reproduce.)

This constitutes my entire and complete understanding.

(Signature) \_\_\_\_\_

Jay T. Last  
Jay T. Last

(Date) \_\_\_\_\_

2/4/07

This interview has been designated as **Free Access**.

One may view, quote from, cite, or reproduce the oral history with the permission of CHF.

**Please note:** Users citing this interview for purposes of publication are obliged under the terms of the Chemical Heritage Foundation Oral History Program to credit CHF using the format below:

Jay T. Last, interview by David C. Brock at Beverly Hills, California, 21 June 2004 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0292).



Chemical Heritage Foundation  
Oral History Program  
315 Chestnut Street  
Philadelphia, Pennsylvania 19106



The Chemical Heritage Foundation (CHF) serves the community of the chemical and molecular sciences, and the wider public, by treasuring the past, educating the present, and inspiring the future. CHF maintains a world-class collection of materials that document the history and heritage of the chemical and molecular sciences, technologies, and industries; encourages research in CHF collections; and carries out a program of outreach and interpretation in order to advance an understanding of the role of the chemical and molecular sciences, technologies, and industries in shaping society.

## JAY T. LAST

1929 Born in Butler, Pennsylvania on 18 October

### Education

1951 B.S., optics, University of Rochester  
1956 Ph.D., physics, Massachusetts Institute of Technology

### Professional Experience

1956-1957 Shockley Semiconductor Laboratory, Mountain View, California  
Senior Technical Staff

1957-1959 Fairchild Semiconductor, Palo Alto, California  
Senior Technical Staff; Co-Founder  
1959-1961 Head of Integrated Circuit Development

1961-1966 Amelco Corporation, Gardena, California  
Director, Research and Development; Co-Founder

1966-1974 Teledyne Technologies, Inc., Gardena, California  
Vice President, Research and Development

1980-present Archeological Conservancy, Albuquerque, New Mexico  
President

1980-present Sierra Monitor Corporation, Milpitas, California  
Director

1982-present Hillcrest Press, Inc., Santa Ana, California  
President

1998-present Think Outside, Inc., San Jose, California  
Member, Board of Directors

### Honors

1999 Hutchinson Medal, University of Rochester

## ABSTRACT

**Jay T. Last** begins the interview with a description of his family background and youth during the Great Depression and World War II. He reviews his undergraduate education at the University of Rochester and his graduate work in the von Hippel lab at Massachusetts Institute of Technology. There he completed doctoral research on the structure of barium titanate under an IBM fellowship. He was later invited to join Shockley Semiconductor Laboratory. He soon departed as one of the “Traitorous Eight” to form Fairchild Semiconductor, where he focused on the etching process for the mesa transistor. During this time, Last formed a close friendship with Jean A. Hoerni and began collecting African art. Last then supervised the creation of the integrated circuit. In 1961, he left Fairchild Semiconductor to join Teledyne to create more elaborate circuits. Teledyne mass-produced complex circuits for military, private corporations, and internal use. Last reviews the business climate of Silicon Valley that supported numerous spin-offs and discusses the dynamics of the American and international semiconductor industries. He then recounts his private investments, including that in Intel Corporation, and relates Gordon E. Moore’s contributions to Intel Corporation. Last concludes with his personal involvement with the Archeological Conservancy, his African art collection, and publishing.

## INTERVIEWER

**David C. Brock** is a senior research fellow with the Center for Contemporary History and Policy of the Chemical Heritage Foundation. As an historian of science and technology, he specializes in oral history, the history of instrumentation, and the history of semiconductor science, technology, and industry. Brock has studied the philosophy, sociology, and history of science at Brown University, the University of Edinburgh, and Princeton University (respectively and chronologically). His most recent publication is *Understanding Moore’s Law: Four Decades of Innovation* (Philadelphia: Chemical Heritage Press), 2006, which he edited and to which he contributed.

## TABLE OF CONTENTS

- 1 Childhood  
Family History. Literary Interest. High School. Frank Preston. Hitchhiking to California. Independence as Youth. World War II.
- 13 Education  
University of Rochester, Optics. Kodak Eastman Company. Massachusetts Institute of Technology. Arthur von Hippel. Graduate Research. IBM Fellowship. Independence as Researcher. Research at the Metalografiska Institute. Career Choices. William B. Shockley. Hiring Practices.
- 36 Shockley Semiconductor Laboratory  
Compartmentalization of Research. Development of Processes. William B. Shockley's Management Style. Personal Relationships Among Fairchild Co-founders. Plan to Form Fairchild Semiconductor. Obtaining Financing. Arthur J. Rock.
- 56 Fairchild Semiconductor  
Founding Fairchild Semiconductor. Planar Process. Weekly Meetings. Edward Baldwin. Finances. Rock Climbing. African Art Collection. Integrated Circuit at Fairchild Semiconductor. Production of Integrated Circuit. Management Structure of Fairchild Semiconductor. Contributions of Jean A. Hoerni.
- 84 Teledyne Incorporated  
Founding of Teledyne Incorporated. Gordon E. Moore. Structure of Teledyne Incorporated. Analog Integrated Circuits. Kyocera Corporation. Financial Issues. Semiconductor Industry. Amelco Corporation. Products. Leaving Teledyne Incorporated. Venture Investments of Jay T. Last.
- 114 Conclusion  
Socialization with Fairchild Co-founders. Investing in Intel Corporation. Gordon E. Moore. Material Technology and Semiconductor Innovation. Education. Art Collection. Archeological Conservancy. Academic Writing.
- 127 Index

## NOTES

1. Charles Kittel, *Introduction to Solid State Physics* (New York: Wiley, 1953).
2. Frederick Seitz, *The Modern Theory of Solids* (New York: McGraw Hill, 1940).
3. Victor F. Weisskopf, *The Privilege of Being a Physicist* (New York: W. H. Freeman and Company, 1988).
4. J. T. Last, "Infrared-Absorption Studies on Barium Titanate and Related Materials," *Physical Review* 105, no. 6 (1957): 1740-1750.
5. John Steinbeck, *Cannery Row* (New York: Viking Press, 1945).
6. W. Shockley and J. T. Last, "Statistics of the Charge Distribution for a Localized Flaw in a Semiconductor," *Physical Review* 107, no. 2 (1957): 392-396.
7. William Shockley, *Electrons and Holes in Semiconductors with Applications to Transistor Electronics* (New York: D. Van Nostrand Company, Inc., 1963).
8. Frederick Seitz, *On the Frontier: My Life in Science* (New York: AIP Press, 1994).
9. J. A. Hoerni, "Method of Manufacturing Semiconductor Devices," U.S. Patent # 3,025,589. Issued 20 March 1962.
10. Gordon T. McClelland and Jay T. Last, *California Orange Box Labels: An Illustrated History* (Santa Ana, California: Hillcrest Press, 1985).
11. R. N. Noyce, "Semiconductor Device and Lead Structure," U.S. Patent # 2,981,877. Issued 25 April 1961.
12. Charles E. Sporck and Richard Molay, *Spinoff: A Personal History of the Industry that Changed the World*, (Lake Saranac Press, 2001).
13. J. T. Last, "Two communications revolutions," *Proceedings of the Institute of Electrical and Electronics Engineers* 86, no. 1 (1998): 170-175.



## INDEX

### A

Allison, David, 51-52, 59, 69, 109  
Amelco Corporation, 31, 54, 71, 73, 84, 91-96, 98, 100, 104-109  
American Physical Society, 28  
Anderson, Robert, 17  
Antiquities Act, 1909, 123  
Arbuckle, Ernest C., 120  
Archaeological Conservancy, 122  
Art collecting, 28, 71-75, 113, 121-122

### B

Baldwin, Edward, 58, 64, 66-68, 70  
Battey, James, 108  
Bausch & Lomb Inc., 14, 91  
Bay, Thomas, 86  
Beckman Instruments Inc., 23-24, 33-35, 37, 42, 47-51, 57-58, 89  
    Spinco division, 57  
Beckman, Arnold O., 34, 42, 48-49, 57-58  
Bell Telephone Laboratories Inc., 32-36, 40, 50, 53, 58, 61, 111  
Berlant, Anthony, 122  
Bipolar transistor, 105  
Bishop, John, 33  
Blank, Julius, 52, 60, 66  
Bohr, Niels, 21  
Boston, Massachusetts, 19, 28, 31  
Bush, Vannevar, 34  
Butler, Pennsylvania, 1-8, 10, 12-13, 15

### C

California, University of  
    at Berkeley, 91, 107  
    at Los Angeles [UCLA], 72, 117  
Cambridge, Massachusetts, 18-19, 31  
Carter, Dennis L., 56, 83  
Cornell University, 18  
Corning Inc., 109  
Cosmos Club, 34  
Coyle, Arthur "Bud", 53, 84  
Critchlow, Lucille, 6, 9  
Curley, James M., 19

### D

Dayton, Ohio, United States Air Force Base, 95

DeTolley, George Barclay, 36  
Dureya, Les, 58

## **E**

Early, James M., 32, 35  
Eastman Kodak Company, 14-15, 18, 33, 60, 119  
Eastman, George, 13  
Electrons and Holes, 40

## **F**

Fairchild Camera and Instrument Company, 69, 82  
Fairchild Semiconductor, 35, 37, 52-53, 55-70, 72-73, 75-86, 88-90, 93-96, 98, 102-105, 109, 114-117  
Fairchild, Sherman, 55-56, 65, 83  
Field-effect transistor, 95, 104  
Ford Foundation, 81, 123  
Forrester, Jay W., 27  
Fort Monmouth, United States Army base, 95

## **G**

General Electric Company [GE], 32, 39, 90, 100  
Gileo, Alton, 20, 23, 94  
Givens, M. Parker, 17-18  
Glahart, Jay, 7  
Grand Teton Mountains, 53  
Great Depression, 1-2, 10, 18  
Greenler, Robert, 17  
Grinich, Victor H., 37, 48, 52, 58, 65, 69, 76-77  
Grove, Andrew S., 114, 117

## **H**

Haas, Isy, 69, 76, 79-80, 85, 93, 105  
Hanafin, Maurice, 57  
Hanford Nuclear Reservation, Richland, Washington, General Electric Company research facility, 32, 36  
Happ, William, 36, 39, 48, 55  
Harvard University, 18, 46  
Helmer, Arthur, 100  
Hendricks, Robert, 17  
Hilton Head, South Carolina, 3  
Hodgson, Richard, 56, 58, 82-83, 114  
Hoerni, Jean A., 37, 41, 44, 47-50, 52, 55, 59, 62-66, 71, 75, 82-85, 88-90, 92, 95, 102-107, 109, 114, 117  
Horsley, Smoot, 44, 46, 55  
Hughes Semiconductor, 67-68

Huntington, Kay, 17

## **I**

Inamori, Kazuo, 97

Integrated circuit, 63, 69, 75-80, 83-85, 87, 89, 92-93, 95-96, 108-109, 116

Intel Corporation, 86, 88, 114-117

International Business Machines Corporation [IBM], 25-26, 31, 56, 58, 65, 100, 117

Intersil Corporation, 103

## **J**

Jones, R. Victor, 36, 46-48, 52, 58-60, 69, 76-77

## **K**

Kattner, Lionel, 76, 79-80, 109

Kilby, Jack S., 75

Kingslake, Rudolph, 14, 120

Kittel, Charles, 25

Kleiner, Eugene, 41, 52, 54-56, 60, 66, 80-81, 96, 114

Korean War, 14

Kozmetsky, George, 84, 89-90, 92, 99, 102

Kyocera Corporation, 97

## **L**

Lake Erie College, 2

Lanning, Emmy, 50, 51

Lawrence Livermore National Laboratories, 107

LeBlanc, Steven A., 122

Lebanese people, Zaire, 72

Lessard, Jerry, 61

Lewis, Robert, 95-96

*Life* magazine, 78

Litton Industries, Inc., 90, 100

Los Alamos National Laboratory, 11, 19

Los Angeles, California, 84-85, 90, 97, 107-108, 110-111

## **M**

Massachusetts Institute of Technology [MIT], 6, 11, 17-22, 24-25, 27-28, 30-32, 34, 81, 85-86, 89-90, 94, 101, 118, 120

McClelland, Gordon T., 74, 121-122

Mesa transistor, 61-62, 65, 84

Metal oxide semiconductor [MOS], 95, 117

Michael, Mark, 77, 123

Michigan, University of, 18

Mimbres Foundation, 123-124

Mimbres Valley, New Mexico, 122-123

Minuteman ballistic missile program, 80  
Mojave Desert, 71, 92  
Moore, Gordon E., 37-38, 41, 44, 48-49, 52, 59, 62, 75, 78, 80, 85, 87-89, 91, 108, 115-117, 123  
Moore's Law, 108, 114, 118  
Morton, Robert A., 50  
Mount Kilimanjaro, 73  
Mount Popocatepetl, 54  
Mount Whitney, 44  
Murray Hill, New Jersey, 33  
Museum of Modern Art, 28  
Museum of Primitive Art, 71

## **N**

National Semiconductor Corporation, 64, 114  
Nature Conservancy, 123  
New York, New York, 26, 37, 54, 56, 71-72  
Norman, Robert, 69, 76, 79  
North American Aviation Inc., 36  
Noyce, Robert N., 17, 36-37, 39, 44-45, 47, 55-56, 58, 60, 63-66, 71, 75-77, 81-82, 88-89, 93, 96, 98, 111, 114, 116

## **O**

Office of Naval Research, 20, 30

## **P**

Pacific Semiconductors, 94, 111  
Palo Alto, California, 35, 90  
Pentagon, The, 95  
PerkinElmer Inc., 22-23  
Philco Corporation, 39  
Photolithography, 60-61, 80, 119, 121  
Physical Review, 30, 38  
Planar transistor, 62-65, 68, 77, 83  
Poughkeepsie, New York, 26  
Preston, Frank, 6-7, 11, 15, 27, 33  
Princeton University, 25

## **R**

Radio Corporation of America, 39  
Raytheon Company, 68  
Reading, Pennsylvania, 9  
Rheem Semiconductor, 68  
Rickover, Admiral Hyman, 34  
Roberts, C. Sheldon, 44, 47-48, 52, 55-57, 59, 66, 69, 82-84, 95, 110, 114, 117  
Roberts, George, 108, 110

Robson, Robert, 69  
Rochester, New York, 13  
Rochester, University of, 6, 11, 13-14, 16-17, 22, 24, 120  
Rock climbing, 8, 35, 44, 46, 48, 50, 54, 70-71, 73, 103  
Rock, Arthur J., 52-54, 70-71, 84, 89, 102, 114-116, 121  
Rockefeller Foundation, 71, 123

## S

Sah, Chih-Tang, 44  
San Diego, California, 97  
San Francisco Bay, 107  
San Francisco, California, 35, 54, 70-71, 92, 114  
San Jose, California, 8  
Seitz, Frederick, 25, 43  
Semiconductor industry, 97, 103-105, 118-119  
Shannon, Claude, 101  
Shockley Semiconductor Laboratory, 38-39, 41, 43, 47-53, 111  
Shockley, William B., 33-53, 55, 57-59, 69, 117  
Sierra Club, 123  
Signetics Corporation, 108-109  
Silicon Valley, 54, 90, 114  
Singleton, Henry, 84-85, 89-90, 92-93, 95, 97-102, 107-112  
Slater, John C., 25, 32  
Smakula, Alexander, 21, 29  
Smead, Joseph, 100, 107, 113  
Sporck, Charles E., 80, 109, 114  
Stanford University, 51, 57, 91, 95, 120  
Stone, Hayden, 52-56, 58

## T

Tanenbaum, Morris, 35, 118  
Teledyne Inc., 54, 72, 84-86, 89-97, 99-112, 114, 117, 119, 121  
Texas Instruments Inc. [TI], 39, 75-76, 81, 87-88, 102  
The Privilege of Being a Physicist, 25  
Trammel Crow Company, 109  
Transistor, 27, 39-40, 53, 58, 61-62, 65, 69, 75, 77, 79, 81, 83, 89, 94, 98, 104, 107, 109, 118  
Transitron Inc., 39

## U

Udall, Stuart, 123  
Union Carbide Corporation, 102, 105

## V

Valdez, Leo, 36, 38, 42, 44  
Varian Associates, 67

von Hippel, Arthur, 19-21, 23-24, 26, 32, 82

## **W**

Wall Street Journal, 67

Weisenstern, Mark, 76

Weisskopf, Victor, 25

Westinghouse Electric Corporation, 96

Wiesner, Jerry, 90

Wilson, Tech, 100-101, 113

Woods Hole, Massachusetts, 46

World War II, 1, 10-11, 13-14, 18-21, 39, 90, 123

## **Y**

Yellowstone National Park, 123

Young, Charles E., 26, 117

## **Z**

Zeiss Microscopes, Inc., 21