



# Edward N. Clarke Papers

## Edward N. Clarke Papers

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Personal Papers

### ABSTRACT:

These are papers of Dr. Edward N. Clarke, co-founder of National Semiconductor Corporation and Director of Research, Associate Dean of Faculty and Director of the Center for Solar Energy at Worcester Polytechnic Institute.

### BIOGRAPHICAL NOTE:

Dr. Clarke was born in Providence, RI in 1925. After high school, he enrolled at Brown University and was also a Naval Reservist in the Navy's V-12 program, an accelerated officer training program during World War II. He received his bachelor's degree in engineering at Brown, and served with the Navy in the Pacific soon after the war ended. He returned to the U.S. and studied at Harvard University, receiving Master's degrees in engineering science and applied physics. He returned to Brown to work toward a doctorate and during that time married his wife, Vivian, who had graduated from Pembroke College.

He received a Ph.D. in Physics from Brown and in 1950 was hired by Sylvania Electric to move Sylvania into the new semiconductor field. He focused on growing single crystals of germanium and the surface properties of germanium, and invented methods for producing semiconductor transistors. In 1956, Dr. Clarke left Sylvania and helped to create the semiconductor division of Sperry Rand, until 1959 when he and his friend and colleague from Sperry Rand, Bernie Rothlein, formed National Semiconductor Corporation and focused on silicon as the primary material of semiconductors. National Semiconductor mass produced the first simple integrated circuit. National supplied semiconductors for military uses including the Minuteman (Intercontinental Ballistic nuclear Missile), and the U.S. Space program, as well as industry.

In 1965, ready for a new challenge, Dr. Clarke came to Worcester Polytechnic Institute as Associate Dean of the Faculty and Director of Research, and later as Associate Dean of Graduate Studies. For eight years, before he retired from WPI in 1995, he created and ran the Center for Solar Energy and taught applications of solar energy with photovoltaics, teaching totally through undergraduate IQP's (Interactive Qualifying Projects). Projects were also expanded to include MQP (Major Qualifying Project) solar racing car projects and IQP's to include electric vehicles.

After retiring, Dr. Clarke continued to work with WPI on energy-related projects. He also became a member of one of Nichols College's Advisory Councils and gave a series of lectures on science and technology. He also lectured on semiconductors at Brown University.

### SCOPE AND CONTENT:

This collection spans the years from 1951 to 2012. The largest amount of material relates to (1) Dr. Clarke's work in the semiconductor field, including inventions, papers and presentations and work at National Semiconductor Corporation; and (2) his work on solar projects at WPI.

The material is organized in six series: Series I: Ph.D. Thesis and Inventions; Series II: Presentations, Papers, Lecture Notes; Series III: National Semiconductor Corporation; Series IV: Work at WPI; Series V: Reflections, Recognition, Life Story; Series VI: Photographs and DVDs.

In 2010 the American Institute of Physics conducted an all-day oral history interview with Dr. Clarke, the transcript of which can be read in Series V. The DVD is in Series VI.

### Container List

Container	Folder	Date	Title
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Note: The inventions were all made while Dr. Clarke was employed by Sylvania Electric Products, Inc. Some were patented and others were not, at least in one case because Sylvania wanted to keep the invention within the company.

**Series I: Ph.D. Thesis and Inventions****Container List**

<b>Container</b>	<b>Folder</b>	<b>Date</b>	<b>Title</b>
Box 01	Folder 01	May 1951	Ph. D. Thesis from Brown University <i>"The Photoelectric Work Functions of and the Low Speed Electron Diffraction from Thin Films of Silver on the (100) Face of a Silver Single Crystal,"</i>
Box 01	Folder 02	August 4, 2012	Inventions by Edward N. Clarke <i>Explanatory note</i>
Box 01	Folder 03	1951, 1952	Inventions by Edward N. Clarke: 3 Patents <i>(1) Methods of Growing Crystals and making Electrical Translators; (2) Method of Forming a Junction Transistor; (3) Method of Introducing Impurities into a Semi-Conductor</i>
Box 01	Folder 04	March 1951	Inventions by Edward N. Clarke <i>(1) A New Method for Studying the Surface Structure of Metals and Semiconductors by means of Low Speed Electron Diffusion; (2) Direct Method for the Production of P-N Barriers in Germanium. (3) Germanium Area Rectifier</i>
Box 01	Folder 05	1951	Inventions by Edward N. Clarke <i>(4) Production of N-P-N and P-N-P Junctions in Germanium; (5) Method for Making Visible the N and P Regions of P-N-P and N-P-N Multiple Junctions as produced by the Pulling-away and Re-dipping Technique</i>
Box 01	Folder 06	1952	Inventions by Edward N. Clarke <i>(6) Production of N-P-N and P-N-P Multiple Junctions in Germanium and Silicon, #5299 pp. 16-17, p. 18, p. 19.</i>
Box 01	Folder 07	1954	Inventions by Edward N. Clarke <i>(7) Control of Germanium Surface Properties; Notes: Field Emission from Germanium, by J. Gruber and E. Clarke; Recent Work on the Properties of Etched and Mechanically disturbed Germanium Surfaces; (8) Stabilization of Germanium Surface -- Final Revision.</i>
Box 01	Folder 08	March 1955	Inventions by Edward N. Clarke <i>(9) An Electrolytic Method for the Detection of Ge Crystal Inhomogeneities including P-N Junctions and Dislocations</i>

## Series II: Presentations, Papers, Lecture Notes

## Container List

Container	Folder	Date	Title
Box 01	Folder 09	January-June 1952	Technical presentations fto attendees of Sylvania's "Germanium Information Meetings" <i>2012 explanation and Presentations 1-5: (1) Significance and validity of resistance measurements; (2) Estimates on the value of silicon as a transistor material; (3) Resistivity and Hall Effect; (4) Measurements of annealed germanium; (5) Program on surface studies</i>
Box 01	Folder 10	July 1952-May 1953	Technical presentations to attendees of Sylvania's "Germanium Inforamation Meetings" <i>Presentations 6-10: (6) Preliminary measurements of field emission currents from germanium; (7) The nature of metal-semiconductor contacts -- conditons for efficient injection of minority carriers into germanium; (8) Preliminary results with field emission microscope; (9) Bulk properties of germanium with a disturbed surface layer; (10) Very preliminary results concerning effects of oxygen in germanium surfaces.</i>
Box 01	Folder 11	June 1953	Invited Paper: Hall and Suhl Effects <i>Presented at Electron Devices Conference, Penn State University</i>
Box 01	Folder 12	May 4, 1954	Invited Paper: Suface Physics of Semiconductors <i>Presented at Physics Colloquium, New York University</i>
Box 01	Folder 13	December 1, 1953	Invited Paper: Physics of Transistors <i>Presented at Student Chapter of AIEE-IRE, Pratt Institute</i>
Box 01	Folder 14	January 1955	Invited Paper: Surface Properties of Germanium <i>Presented at University of Pennsylvania</i>
Box 01	Folder 15	January 1955	Invited Paper: Reduction of the Effect of Water Vapor on Germanium Surface Conductivity <i>Presented at American Physical Society meeting, New York City</i>
Box 01	Folder 16	1954-1955	Published papers <i>"Oxygen and the Surface Energy-Level Structure on Germanium," "Electrical Conductivity of Germanium Surfaces," "Surface Properties of Germanium," "Nature of the Water-Vapor-Induced Excess Current on Grown Germanium."</i>
Box 01	Folder 17	Spring 1959	Lecture notes for EE 343, Theory and Application of Semiconductors <i>At University of Connecticut Graduate Extension Program, Lectures 1-6</i>
Box 01	Folder 18	Spring 1959	Lecture notes for EE 343, Theory and Application of Semiconductors <i>At University of Connecticut Graduate Extension Program, Lectures 7-12</i>

This series includes a brief history written by Dr. Clarke, inventions and other work leading up to the founding of National Semiconductor, important work at National, and some later materials related to National.

These were removed from a binder, but original order and labeling is maintained in the folders.

### Series III: National Semiconductor Corporation

#### Container List

Container	Folder	Date	Title
Box 01	Folder 19	2012	Table of Contents
Box 01	Folder 20	1960	Advertisement -- "the new champ!"
Box 01	Folder 21	written 2008 <i>written by Dr. Clarke</i>	"Insert in Front Cover:" Creation and First Years of National Semiconductor Corp.
Box 01	Folder 22	1951, 1952	Appendix A: Three invention patents <i>Method of Forming a Junction Transistor, Methods of Growing Crystals and Making Electrical Translators, Method of Introducing Impurities into a Semi-Conductor</i>
Box 01	Folder 23	1953-1955	Appendix B: 5 research publications concerned with germanium surfaces
Box 01	Folder 24	c. 1958	Appendix C: Invention and publication of a Fast Silicon Diode Switch <i>Report by E.N. Clarke, S. C. Feng, A. V. Siefert, and P. James</i>
Box 01	Folder 25	1961	Appendix D: Creation of an important standard of measurement for the electronics industry <i>"IRE Standards on solid-State Devices: Measurement of Minority-Carrier Lifetime in Germanium and Silicon by the Method of Photoconductive Decay"</i>
Box 01	Folder 26	1957	Appendix E: Lecture on Physics of Transistors <i>At Yale University</i>
Box 01	Folder 27	1961	Appendix F: Technical information sheet for PNP Silicon Alloy Transistor
Box 01	Folder 28	1960-1965	Appendix G: Product types including NPN Silicon Planar Transistor
Box 01	Folder 29	1962	Appendix H: News Release, Invention and Production of Integrated Chopper
Box 01	Folder 30	1961, 2010	Appendix I: Congratulatory letter re Minuteman Missile and later paper <i>Letter to the Manufacturing Group on the successful test firing from Cape Canaveral of our nation's intercontinental ballistic missile (ICBM) called Minuteman, and a paper presented many years later.</i>
Box 01	Folder 31	C. 1963, 1979	Appendix J: Title page of Danbury Dialogue and photo of founders <i>Title page of Danbury Dialogue 9197() and photocopy of photo of founders of National Semiconductor, with shovels digging at the site of a new plant occupied in 1964.</i>
Box 01	Folder 32	2008	Appendix K: Responses from co-founders of National to Ed Clarke in 2008 <i>Responses from Dick Rau, Bob (Hop) Hopkins, and Bob Koch, those co-founders still alive, with Ed Clarke in 2008. [Bob Koch has since died - 2012]</i>

Box 01	Folder 33	April 5, 2011 <i>price: \$6.5 billion</i>	Appendix L: The Wall Street Journal headline story: Texas Instruments to purchase National
Box 01	Folder 34	May 2012	Insert in back cover of binder: Transistor Technologies by Ed Clarke <i>Chapter on Transistor Technologies by Ed CLarke in the new encyclopedia titled Applied Science, Salem Press, May 2012, ISBN 978-1-58765-781-818.</i>
Box 01	Folder 35	2001-2002	Correspondence with National Semiconductor in 2001 and 2002 <i>Correspondence with managers, plus production information and data. [Note: this was not part of the National Semiconductor binder.]</i>

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### Series IV: Work at WPI

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Container	Folder	Date	Title
Box 02	Folder 01	1974	Paper by Edward N. Clarke <i>"The Role of Technical Universities in Creating New Industry in Scandinavia"</i>
Box 02	Folder 02	1985-1986	WPI Interactions featuring photo and article on Solar Photovoltaic Projects <i>Interactions Vol. VII, with cover photo of Dr. Clarke and article by Dr. Clarke on Solar Photovoltaic Projects</i>
Box 02	Folder 03	February 1972	Article by Dr. Clarke: "WPI" A Center for Environmental Studies" <i>Photocopy of part of WPI Journal, with environmental focus and article by Dr. Clarke</i>
Box 02	Folder 04	Spring 1988, Fall 1990	Articles about solar car races <i>2 issues of WPI Journal, with articles: (1) "A Personal Adventure," about solar car race across Australia, by Edward N. Clarke; and (2) "Riding the Rays," about WPI solar car in U.S. race, by Ruth Trask.</i>
Box 02	Folder 05	1986-1994	Abstracts of Interactive Qualifying Projects (IQPs) advised by Edward N. Clarke
Box 02	Folder 06	March 7, 1990	Talk/paper by Dr. Clarke: "Undergraduate Innovation in Solar Energy Applications"
Box 02	Folder 07	1980-1990	News articles about Dr. Clarke and student projects
Box 02	Folder 08	February 20, 1991	News article about Dr. Clarke and alternative energy, in Worcester Magazine

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### Series V: Reflections, Recognition, Life Story

#### Container List

Container	Folder	Date	Title
Box 02	Folder 09	January 1999-July 2012	"Reflections, Essays, Stories - Concerning Matters of People, of Religion and of Faith" <i>Lenten Season reflections, Immanuel Lutheran Church, by Edward N. Clarke. 2 booklets.</i>

Box 02	Folder 10	2003-2004	Address: "Are Science and Poetry an Odd Couple?" <i>Address by Edward N. Clarke, in Windfall, Writing and Art from the Nichols College Community, plus one page signed poem by Albert Goldbarth</i>
Box 02	Folder 11	1998, 2009	Recognition of Dr. Clarke from Brown University <i>Brown University Alumni Medal citation and article in Brown Engineering Alumni Review, plus congratulatory letter from WPI's President Parish; article on Dr. Clarke in Brown Renaissance Engineer Series</i>
Box 02	Folder 12	September 27, 2010	Transcript of Oral History Interview with Edward N. Clarke <i>conducted by Orville Butler, for American Institute of Physics, Center of History</i>  <i>Note: permission to quote from this must be obtained from the American Institute of Physics.</i>
Box 02	Folder 13	April 24, 1992	Letter from Dr. Clarke's father on occasion of Dr. Clarke's 67th birthday

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### Series VI: Photographs and DVDs

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Container	Folder	Date	Title
Box 02	Folder 14	July 1990	Photographs of GM Sunrayce USA and WPI Starduster <i>Florida-to-Michigan Premium Solar Car Race, featuring the WPI Starduster, also known as the Worcester Rocket</i>
Box 02	Folder 15	July 1990	DVD: "The Worcester Rocket," A Solar Powered Car <i>GM Sunrayce USA</i>
Box 02	Folder 16	2002, 2003	DVDs of three addresses by Dr. Clarke at Nichols College <i>"The Mystery and the Beauty of the Eternal Electron," "Are Science and Poetry an Odd Couple?," "Poetry and Science: Shall the Twain Meet?"</i>
Box 02	Folder 17	September 27, 2010	DVD of Oral History Interview with Edward N. Clarke <i>American Institute of Physics</i>  <i>[Note: permission to use any portion of this must be obtained from the American institute of Physics]</i>