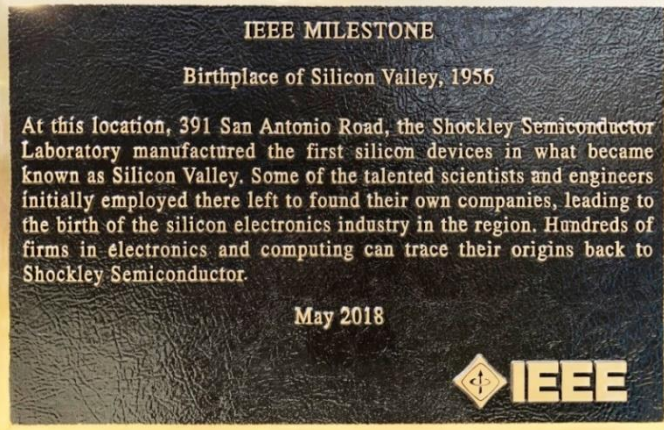


# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley"

### David Diffenderfer Oral History

#### The First Days of Silicon Valley at Shockley Semiconductor



#### Curator's Introduction

David W Diffenderfer has a "Renaissance Man" resume spanning over eight decades. Currently in retirement in his hometown of Sharon, PA, David has been an avid gardener and photographer for most of his life. Describing the 2011 photo at above right: *"I have collected cacti all my life. That flower was one of 58 hybrids I created"*. Of his many professional accomplishments, David proudly highlights his employment at Shockley Semiconductor Lab from 1956 to 1961 as very memorable and personally rewarding. He was hired in person by William Shockley and was one of the first SSL production employees at 391 San Antonio Road, the legendary "[Birthplace of Silicon Valley](#)". The Transistor Museum is grateful to David for his enthusiastic participation in developing this Oral History and providing his personal recollections of working for William Shockley.

#### Just out of High School - Knocking on the Front Door in 1956 and Meeting William Shockley

In the mid 1940's my uncle, John Barr Diffenderfer, was working at RCA on vacuum tubes and told me about a man that was going to replace the radio tube with a solid-state device. My uncle said that this would happen about the time I graduated from high school and that I should look him up. I had a major interest in science and thought about this several times in the ensuing years.

Graduating in 1955 I moved from Sharon Pennsylvania to Mountain View California and entered the College of San Mateo. While commuting to San Mateo for school I passed 391 San Antonio Road and had noticed the activity around the little Quonset hut in the Sears parking lot. One day a sign went up at the front of the building saying Shockley Transistor. That sign jogged my memory and after some time I decided to see if this was the man my uncle had told me about. I cut class and went to the lab and to introduce myself, met Shockley at the front door. He had apparently met or worked with my uncle because he remembered him.



Shockley Semiconductor Laboratory. (Image source: Arnold and Mabel Beckman Foundation)

Above is a photo of the original [Shockley Semiconductor Laboratory](#) site at 391 San Antonio Road in Mountain View CA as it would have appeared in 1956 when a young David Diffenderfer skipped class at the College Of San Mateo and knocked on the door - William Shockley opened that door for David who soon found himself with a job at SSL setting up production equipment to build the newly invented silicon "Shockley Diode". [According to the EE Journal](#), "Shockley Semiconductor Laboratory set up shop in a rented, one-room Quonset hut". The term "Quonset Hut" is often used to refer to the most famous little building in California.

# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley" David W Diffenderfer Oral History

### Shockley Transistor Expands - Then is Sold to Clevite

Shockley gave me one of his famous tests which I failed. It is the cube of 100-ohm resistors and you are to calculate the resistance diagonally through the cube. Guess he liked my approach to the problem because he made me a job offer. I accepted the position and went to work as a metallurgical tech for Dr. Sheldon Roberts.

Expansion to the Beckman Spingo building at Stanford was in progress and I transferred to Dr. G. Smoot Horsley to help set up the production facility there. It was about that time that I received orders from the United States Navy to go for a cruise. I had joined the Navy Reserve in 1954 while in high school and it was an eight-year hitch. I told Bill Shockley that I had to leave, and he was distressed. He asked me what I would prefer, stay in the lab or go! I said I would definitely prefer the lab, but I have this obligation. He took my orders and brought them back to me about a week later, cancelled by President Eisenhower. I was instructed to turn in my Navy equipment at Palo Alto. I had no idea that Shockley was science advisor to the President!

I continued working the early pilot line production line and supervising it. Also worked in the calibration lab. In my view when Clevite took over the lab they had to get rid of the Shockley faithful of which I was one. They laid me off and that night I went to Shockley's home in Los Altos. Shockley asked me what I was going to do. This was the evening of Good Friday and I told him that I intended to go to work on Monday, I just did not know where that would be. He called me on Saturday and told me to see Mr. Bob Dittmore at Stanford Research at some specific time on Monday. I arrived at Stanford Research only to find that I had already been hired in the nuclear physics department. I spent the next five years at Stanford Research working at the Nevada Test Site and another five years with EG&G also at Nevada Test Site.

I owe most of my career to Dr. Shockley and the wonderful people he hired in those early days at the lab. I am honored to have come to know most of them pretty well. Little did I know how this incredible group would impact the entire world in those early days.



[Beckman Facilities Spingo Division](#)

In 1957 Shockley Semiconductor expanded into a shared space in a newly constructed building housing the Beckman Spingo Division, located in Palo Alto near Stanford. David transferred to this site to support production. Of note is that in an effort to improve the low yield of the Shockley diode production processes, this site is [claimed to have set up the first clean laboratory space](#) for semiconductor manufacturing in Silicon Valley.



[New "Unit of Clevite Transistor" Sign at the Original 391 San Antonio Road Building in 1960](#)

In April of 1960, the Clevite Corporation acquired the assets of Shockley Semiconductor of Palo Alto, CA. The Shockley unit, headed by Nobel Prize-winning physicist Dr. William Shockley, became part of Clevite's Transistor Division in Waltham, MA. ([Electronic Design, April 27, 1960](#)). Note the name change above the front entrance of the original Shockley site at 391 San Antonio Road. Shockley Semiconductor became known as "Shockley Transistor, Unit of Clevite Transistor".



# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley"

### David W Diffenderfer Oral History

#### Working at Shockley from 1956-1961

#### Five Years at Silicon Valley's First Semiconductor Company

#### Beckman Instruments Establishes Shockley Semiconductor Lab.

BECKMAN INSTRUMENTS has established the Shockley Semiconductor Laboratory near Stanford University to develop and produce transistors and other semiconductor devices in the field of advanced electronics for automatic production techniques.

Headed by Dr. William Shockley, pioneer in the development of the junction transistor, as director, initial lab members include Drs. G. Smoot Horsley, formerly of Motorola and Bell Laboratories; Leo B. Valdes, formerly of Pacific Semiconductor and Bell Laboratories; William W. Happ, formerly



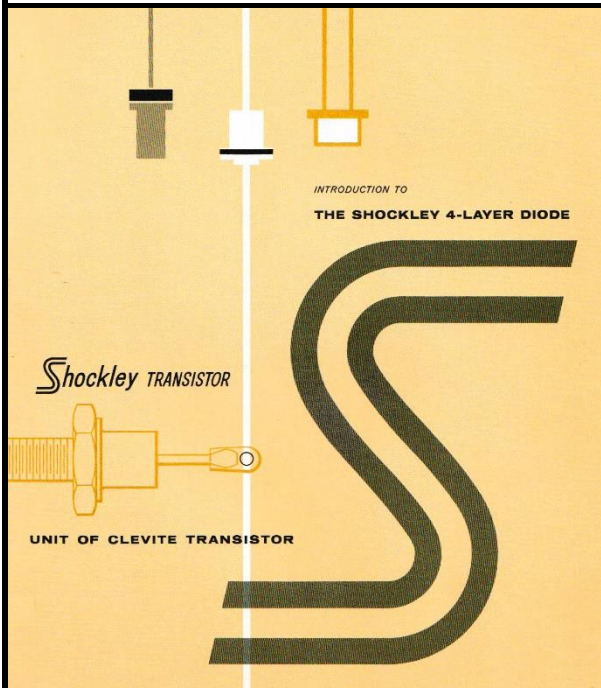
William Shockley  
April, 1956 — ELECTRONICS

of Raytheon and Sylvania and R. V. Jones.

Quartered temporarily in Mountain View, Calif. the group will move into the new \$500,000 research and development center Beckman is building in Stanford Industrial Park for its Spingo division and the Shockley Semiconductor Laboratory.

Completion of the facility is scheduled for August.

Dr. Shockley said that recent developments in physics and chemistry indicate great future expansion for semiconductors. "We have found corresponding phenomena in tran-



Above is the cover of a March 1961 Clevite catalog providing technical and sales information about this new Shockley Transistor Unit of Clevite Transistor. Clevite was moving fast to capitalize on their acquisition of Shockley Transistor. David Diffenderfer was laid off by Clevite and thanks to William Shockley's support started a career in nuclear testing at Stanford Research.

WANTED: MEN, AT LEAST ONE STEP AHEAD FOR

### SILICON DEVICE TECHNOLOGY

With an excellent balance of commercial and military programs, Shockley Transistor Corporation offers important rewards in satisfaction and salary to gifted engineers and scientists who can contribute to the solution of new problems in silicon device research and development.\*

Training equivalent to advanced degree, preferably Ph.D. level, in E.E., physics, chemistry or metallurgy and evidence of productivity through articles, patents or creative Ph.D. thesis required.

Activities include theory and experiment on semiconductor phenomena relevant to device operation, fundamental studies of impurity diffusion, device fabrication techniques including metallurgy and surface chemistry, design of electrical methods and equipment for device evaluation and control of production, applications engineering.

We would like the opportunity to tell you more about the Shockley Transistor Corporation, a wholly owned subsidiary of Beckman Instruments, Inc. which is celebrating 25 achievement years in electronics.

Drop us a brief biographical sketch, indicating your area of interest, and we'll reply promptly. Address R. E. Cunningham, Room 100.

### Shockley TRANSISTOR CORPORATION

A SUBSIDIARY OF BECKMAN INSTRUMENTS, INC.

STANFORD INDUSTRIAL PARK, PALO ALTO, CALIFORNIA

The above ad appeared in the [Feb 1960 IRE Proceedings](#). There are several interesting historical aspects related to this ad. For example, within two months after this ad appeared, Shockley's company was sold by Beckman to Clevite and Shockley soon left the company. (See the actual sales contract at the [Computer History Museum website](#)). Also note that "gifted engineers and scientists" at the Ph.D. level were sought.



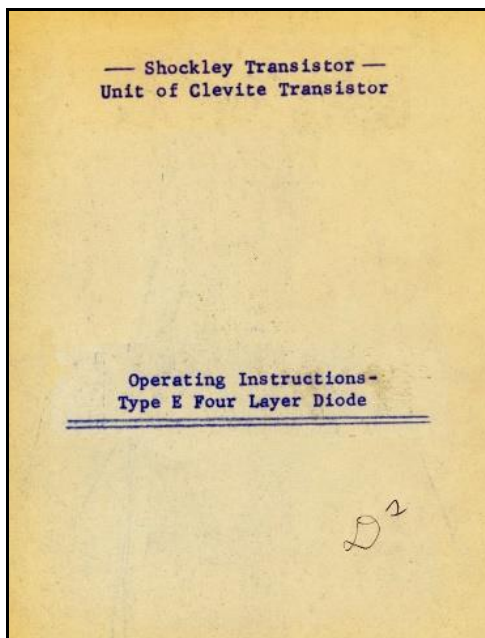
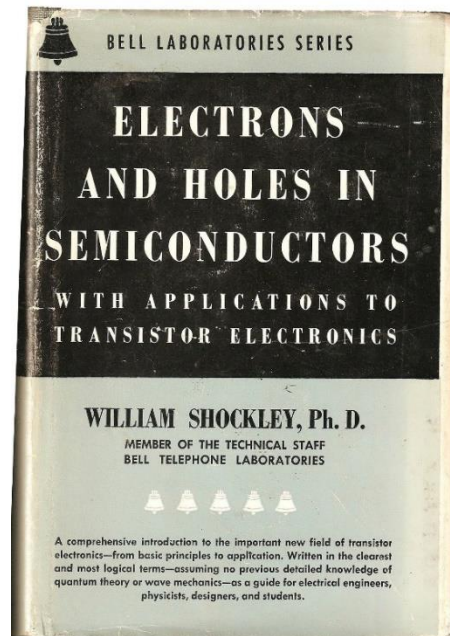
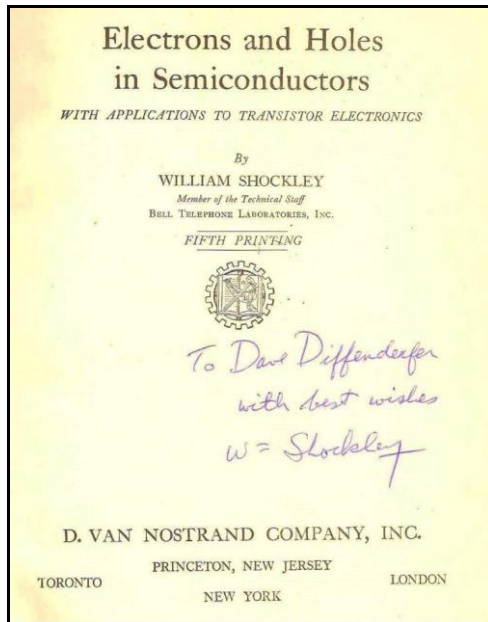


# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley"

### David W Diffenderfer Oral History

#### A Famous Book and Distinctive Signatures



Note the unique "D-Squared" signature on David's personal copy of the Shockley Diode Assembly Cookbook, shown above. According to David, "I admired Shockley's signature W=Shockley and he said, "you can do it also with your D Squared". It stuck and I still use it".

#### Electrons and Holes in Semiconductors

Dr. W. Shockley's new book, *Electrons and Holes in Semiconductors*,\* another in the Bell Laboratories series, is the first comprehensive treatment on the new Transistor electronics. The book develops the concept of the positive hole and its negative counterpart, the excess electron and leads to the development of the theory of semiconductors in a form useful to workers engaged in research and development of Transistors and their applications.

The book is divided into three parts. Part I, entitled "Introduction to Transistor Electronics," reviews the bulk properties of semiconductors, the Transistor as a circuit element, quantitative studies of the hole injection, and the physical theory

of Transistors. In Chapter 2, a number of problems and answers furnished by circuit and development groups of the Laboratories are included to show the orders of magnitude involved in calculations of power gain in various circuits and for signal-to-noise ratios.

Part II, "Descriptive Theory of Semiconductors," discusses the physics of semiconductors, including analogies with circuit theory and applications to Transistor electronics. Part III, "Quantum Mechanical Foundations," continues a discussion of elementary quantum mechanics with circuit theory analogues that aid those readers not having extensive training in theoretical physics. An introduction to statistical mechanics for semiconductors and other topics applicable to the theory of electronic conduction in crystals are also included.

\* D. Van Nostrand Co., New York, 592 pages, \$9.75.

The [January 1951 edition](#) of the Bell labs Record (text above) provided an overview of [Shockley's 1950 book](#) on semiconductors, noting that this publication was "the first comprehensive treatment of Transistor electronics". There was great demand for information on transistors at this time and Shockley was likely the only scientist who had the experience and ability to adequately provide this. The book was very widely read and greatly influenced the first years of transistor technology. David received his personal copy of the book directly from Shockley, including the renowned and unique signature that Shockley used with recognized celebrity beginning in the 1950s. Historical documents with Shockley's signature remain highly prized.



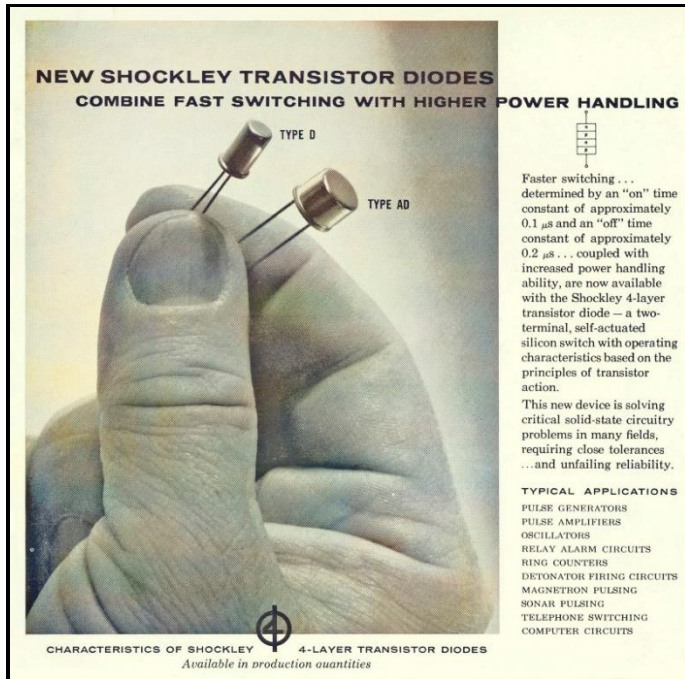
# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley"

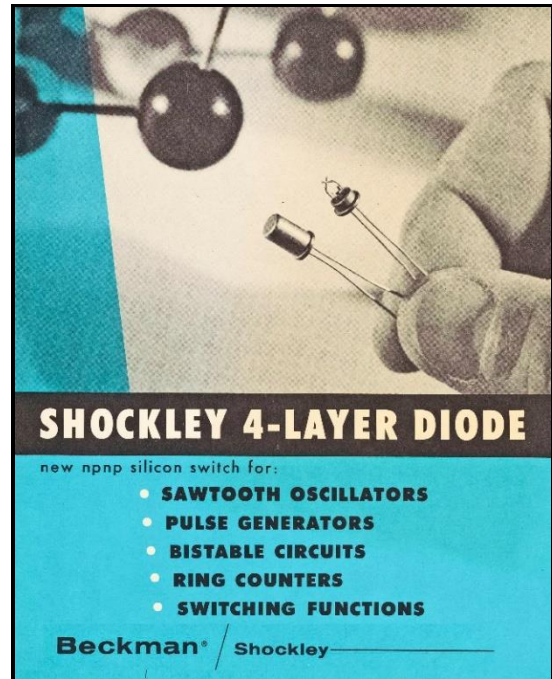
### David W Diffenderfer Oral History

#### What's in a Name?

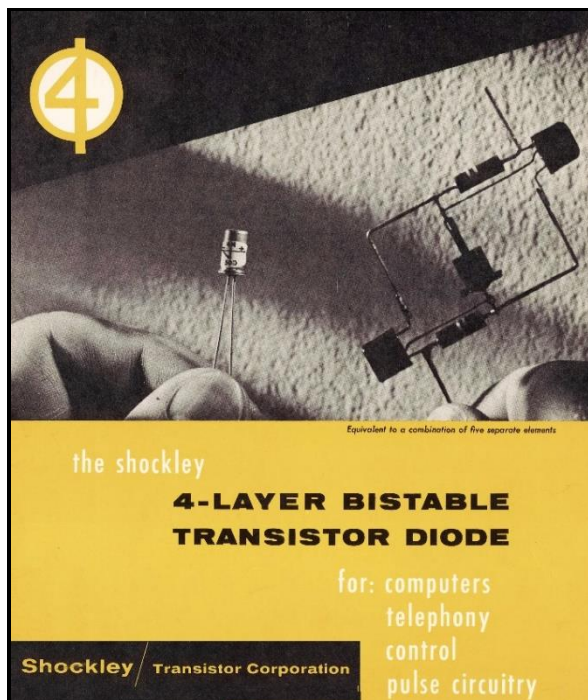
#### Transistor Diode, Shockley Diode, 4-Layer Diode



[1959 Shockley Transistor Ad](#)



[1959 Beckman/Shockley Data Sheet](#)



[1959 Shockley Application Note](#)

1950s data sheets, application notes and ads promoting the Shockley diode did not use consistent terminology for naming the device. For example, the two publications on the left use the term "transistor diode" but the lower left application note also includes an additional clarifier, "4-layer bistable". The above Shockley data sheet doesn't use the term "transistor diode", and instead documents the device as the "Shockley 4-layer diode" (and note in small print "new NPNP silicon switch"). Shockley was also perplexed about what to formally name his device - see the excerpted text below from Shockley's 1959 presentation at the International Convention on Transistors and Associated Semiconductor Devices, 21 May 1959 titled "Transistor Diodes". There seems to be no formal consensus for the name of this unique and historic device!

What can one do to overcome the difficulty arising from lateral resistance in the base layer? I believe that this can be largely overcome, and with some practical advantages, by making devices for which I have coined the misnomer, *transistor-diode*. By definition, a transistor should have a separate control terminal, but the transistor-diode has not, although it works like a transistor, according to my definition—if you define a transistor-diode as in general a 2-terminal device which can turn d.c. power into a.c. power.

● This is not a good name, but I have not thought of a better one.—W. B. S.

Dr. Shockley is with the Shockley Transistor Corporation, California.

# TRANSISTOR MUSEUM™

## **"When I Built Transistor Diodes for William Shockley"** **David W Diffenderfer Oral History**

### **David Shares His Most Memorable Recollections of William Shockley and Working at Shockley Transistor**

#### **Shockley, Sputnik and Khrushchev**

When the Russians launched Sputnik Shockley was very interested. I helped him string an antenna in the Sears parking lot next to the lab so we could monitor Sputnik as it went over with the labs HRO60 receiver. When Khrushchev tried to visit Disney Land and security stopped him, the consolation prize was to tour Shockley Labs. One of our crystal puller techs made a sign that he hung on one of the crystal pullers saying, "Help me, I am a prisoner" in Russian. He was fired. (Curator's Note: [On Monday September 21, 1959 Nikita Khrushchev did visit the San Francisco Bay area](#) - this was unplanned since originally he was to visit Disneyland, but had to reschedule due to security concerns. The visit to Shockley Semiconductor must have occurred on this date, as part of his visit to the IBM facility in San Jose ).

#### **Explosions and Rust**

Just inside the roll up doors at the Spinco building we had a Hydrogen reduction furnace for cleaning the copper headers. The Hydrogen was at about 1000 degrees and kept from the atmosphere by Nitrogen curtains at each end of the furnace. Occasionally a gust of wind would come in thru the roll up doors disturbing the Nitrogen curtains. That furnace would fire headers all over the production area with a loud explosion. Very near the same roll up doors we had wood shelves where we kept Nitric Acid, Hydrofluoric acid in wax bottles, solvents, etc. Some one was putting the jars up and smacked them together breaking the glass. The Nitric acid went to work on the wood making Nitrocellulose and filled the building with red yellow smoke that rusted everything in our building and in Spinco.

#### **Spinco Building Mishaps**

When moving in to the Spinco building they installed a large safe on the second floor. The next morning when we arrived for work the ceiling was hanging down about two feet where the safe had been parked. Floor reinforcing had to be installed before we could go to work. We were using the HP130 scopes on the line to measure the diodes. We bought a Tektronix 454 with cart and preamps to use as sort of a lab standard. It was the prize piece of equipment in that lab. Someone pushed that cart across the upstairs and lost it. It went down the stair well to the first floor.

#### **Down the Drain**

Oh yes! In those days we just poured everything down the drain. After a few years the sewer backed up and they had to dig up California Avenue from the El Camino to the Spinco building and replace the sewers, a distance of perhaps 3/4 mile. I don't know who had to pay for that!

#### **Helping Out the Draftsman**

Dick Gruenwald was a draftsman and a very nice guy. Occasionally we installed a huge capacitor under his drafting table and would slide a copper bar across the terminals. It sounded like a Howitzer! Occasionally we would run a torch very rich and black carbon strings would drop out of the air on his drawings. When brushed they would smear.



# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley"

### David W Diffenderfer Oral History

#### Concluding Comments About My Time Working for William Shockley



Above is a classified ad in the Palo Alto Times from 1956. This is just about the time that Shockley hired David as one of the first technicians to begin the manufacture of four layer diodes at the 391 San Antonio Road building.



These Audio Links are Excerpts from  
A 2011 Transistor Museum Interview  
with David Diffenderfer

Starting at Shockley in 1956.  
An empty building at 391 with plenty of space for  
"Office Chair Races" & "Jag in the Lab"

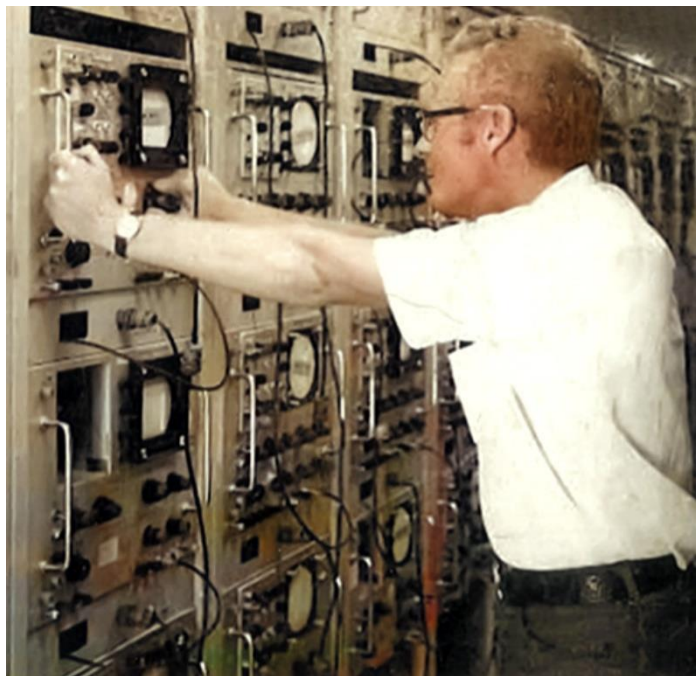
[Audio Clip #1](#)

First Shockley Devices to be Sold.  
Nine 4-Layer Diodes. \$1000 each to Bell Labs.

[Audio Clip #2](#)



Above is a Dec 2023 photo of David. This timeframe is almost 70 years after he was hired to work at SSL in the early days of Silicon Valley. He remains a [very active photographer](#) and notes that the "bolo" he is wearing in this photo is handmade from a 2" silicon crystal originally grown by [Knapic Electro-Physics](#).



After leaving Shockley, David worked in the nuclear engineering field for many years - above is a [1960s photo showing David](#) with nuclear monitoring equipment. David's career has spanned many years and many historic technologies, starting when he was a student at San Mateo College and was hired by William Shockley to build the first transistor diodes.



# TRANSISTOR MUSEUM™

## "When I Built Transistor Diodes for William Shockley"

### David W Diffenderfer Oral History

#### Learning More About Shockley Transistor

##### IMPORTANT PUBLICATIONS WITH INFORMATION ABOUT SHOCKLEY AND THE EARLY DAYS OF SILICON VALLEY

1. [Crystal Fire: The Invention of the Transistor and the Birth of the Information Age](#), by Michael Riordan and Lillian Hoddeson.
2. [History of Semiconductor Engineering](#), by Bo Lojek.

Both these books are invaluable resources in best understanding early transistor technology and the first days of Silicon Valley. This Oral History has used material from these texts - we have included links in all cases to ensure copyright and intellectual property rights are noted. For other copyrighted material used in this Oral History, we have included links to original sources.

##### USEFUL LINKS FOR LEARNING MORE ABOUT SHOCKLEY

1. [Transistor Museum: Shockley PhotoGallery](#)
2. [Transistor Museum: Gene Weckler Oral History](#)
3. [Computer History Museum: "391 San Antonio Rd. A Semiconductor Documentary"](#)
4. [Computer History Museum: Shockley Labs Alumni Reminiscences Recorded Feb 2, 2006.](#)
5. [Computer History Museum: Oral History of Shockley Semiconductor Laboratory Recorded February 27, 2006](#)



Sculpture of Shockley's 4-layer diode on view at 391 San Antonio Road - [\(Copyright Steve Leibson\)](#)



Cutaway version of Shockley's 4-layer diode  
[\(Copyright Steve Leibson\)](#)

The original Shockley Semiconductor Labs building at 391 San Antonio Road in Mountain View was torn down several years ago and replaced with an office building. However, as noted in his excellent [2018 EE Journal article](#), Steve Leibson points out that 391 may be gone but "the Quonset hut isn't forgotten". Steve's photos of the commemorative sculptures now in place at 391 are shown at left and above.