Transistor: Story Outline

The goal of this document is to see the transitions in the story and to be able to visual the video — and then write the script. Note that a story outline is a description of what viewers would see on their screens.

Key

> **camA** wide shot with all of rear projection screen
> **camB** medium shot of head and shoulders, with part of screen in background
> **camC** shot of object on small table with me in background, screen appears at an angle.

Note that CamB shorts are not designated very often. Use as is appropriate.

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Introduction

Digital rain: lots of royalty free versions

The video opens with camC shot: a 6” silicon wafer in close up with Bill behind it. The video explains that this is etched with circuit elements, the most prominent the transistor. It is an integrated circuit, which is the most impactful technology of the twentieth century — a triumph of human ingenuity. It is the heart of all computers. Viewers are reminded that a) the silicon is a semiconductor and b) that this circuit works on binary coding. Cut to camA,”digital rain” is on screen. They learn that this video aims to answer the question “how did this silicon-based binary coded” chip arise. On screen is a “net” that shows many of the possible elements that lead to the integrated circuit. Time goes from left to right. Explain how all stories of technological objects are a “mesh” or “net” of events. Share Maitland idea that the unity of history is a seamless web, and that to tell a single story tears this seamless web. Thus, viewers will learn “a” story or sequence of events of how the integrated circuit came about. Viewers learn that I will choose a few threads — and not the usual ones — to partly explain the existence of the monolithic integrated circuit. There are many ways to tell it, but I want to select some of the unknown or less well-known stories — one’s that help remind us that we’re telling only part of the story and that this seamless web exists. {Do I zig-zag through? That is, say we will start in 1711, go to blah, blah, 1938, then back to 1911, then forward. This reminds that there is a net.}

Conductivity

This section start with CamA: on screen is image of Charterhouse. Viewers learn that this story starts with this “retirement” home in the early eighteenth century (1711). The video reveals that in this home a key event occurred that eventually lead to the integrated circuit: The discovery of electrical conductivity. Conductivity is important because obviously electrons zip through an integrated circuit, but also, it revealed the key characteristic of silicon that enabled the solid state electronics revolution. Viewers hear the story of Stephen Gray. This section ends with a description of how sensitive conductivity is, how it range of values (orders of magnitude) equals that of the universe.

Francis Wick

The video turns to early measurements of conductivity that revealed the “strangeness” of silicon as electronic material. Viewers hear the story of Francis Wick and her measurements. She was a careful experimentalist, yet got inconsistent results. She did, for some samples, see a decrease of conductivity with temperature for some of her measurements — very odd for a metal. This section makes the point that the path/development of any technological object along is littered with what we describe as failure, and which we prune from the “tree.” Also, it highlights in some way Wick’s pioneering role in terms of gender. Her observations, and others, compelled a now obscure figure in solid state sciences to try to explain this behavior: A.H. Wilson.

A.H. Wilson & Semiconductors

The video next places Wilson’s work in contest: The unusual electrical behavior meant that the idea of a semiconductor wasn’t even clear. Viewers learn that Nobel Laureate Wolfgang Pauli said semiconductors are a “a filthy mess; who knows whether or not any semiconductors exist”and that textbooks and the major books classified silicon as a metal. Viewers then learn A. H. Wilson’s story: his worked with Heisenberg, Wilson’s discovery of the mechanism of conduction, positive and negative charges, and how impurities are so important. This fully explains Wick’s results. Viewers learn that no one paid attention: “The silence”, he said, “was deafening,” even though Wilson’s explanation lay the secret of silicon’s dominance of technology. This section ends with his disappearance from the world of science — the great John Bardeen (two time Nobel Laureate in Physics) didn’t know what happened to Wilson, even though he ran Britain’s largest company!

Davydov and the Diode

The video turns to two parallel, but unconnected developments that brought us the binary logic that drives a silicon chip: the “0”s and “1”s inside a computer. Viewers are first taken briefly to Russia and learn the story of Davydov and his development of the Diode. They learn that this is a primordial event: with a device where current can or cannot flow you have the potential for a binary logic — although Davydov didn’t focus on this.

Shannon and Boolean Logic

As noted above see Pierce book on signals
Need to return to speed later as the integrated circuit comes about
On TRDAIC: Need to gather papers, Brown talks about reliability, get quotes from Felker

Next, the video turns to the second development: Claude Shannon and his work on one of Vannevar Bush's last mechanical computers. This section describes the fascinating mechanical computers of the late 1930s/early 1940s. Viewers learn of Shannon fascination with the relays of this computer: how he realized they could be used to express logic, especially the Boolean logic developed in the nineteenth century, which Shannon had studied as an undergraduate. The video moves to the nineteenth century and tells the story of George Boole. The emphasis is on his logic work and how it can be represented with a switch and a lightbulb. Viewers learn that using three logical operations - AND, OR, NOT – any logical puzzle can be solved. Viewers are reminded that *this* is what a computer is doing: solving a puzzle – if the letter "A" is pressed, then display a letter "A" on the screen (with, of course, many steps in between). The videos outlines Shannon achievement: developing a method to design and simplify circuits made of relays, which were first used for routing telephone calls. This section closes with a brief mention of how Shannon-like methods were used to create relay computers and, of course, vacuum tube computers – ENIAC is mentioned here. The video points out that viewers think of these computers as large and that when replaced by the devices of the silicon/semiconductor revolution the goal was miniaturization,but,as the video notes, this was not true: the goal was reliability and lower power consumption – and later speed. The video jumps forward to 1952 – getting a little bit ahead – and briefly describes one of the first semiconductor computers (it used diodes for logic and transistors for amplification), which was used in the TRADIC computer in a 1952 military airplane. It quotes its inventor on reliability and power, but notes it was slower the vacuum tube computer. Viewers learn that that the video needs to go back in time a little bit to learn how the desire for lower power usage lead to the invention of the transistor, the key element of the digital age.

Point-Contact Transistor

Here need to delineate the role of Bell Labs in general, that they refined earlier work, but don't take credit away

Viewers hear the story of the invention of the key device of the electronics era – the transistor – by two-time Nobel Laureate John Bardeen, William Shockley, and Walter Brattain at Bell Labs. It places the invention in historical context — Bell Telephone's expansion of its service was hindered by unreliable, power hungry vacuum tubes, so, in response, the trio at Bell Labs invented the transistor, using germanium instead of silicon. The chapter describes the function of the transistor in clear, accessible language using a replica of the first transistor (the point contact transistor). Its original development as an amplifier is illustrated by showing advertisements for its use in transistor radios and hearing aids. To place the idea in context the video notes that the ideas were "in the air" by briefly discussing the near simultaneous development of the transistor in France by two German scientists.

Transistor as Logic
The video turns to how the transistor performs the logic in a computer — how it "captures" the binary logic in the solid state. The video explains how it is related to the amplification, demonstrating with diagram how to create the logic gates AND, OR, and NOT using resistor-transistor logic.

Integrated Circuit/Silicon Production
The video returns to the wafer with transistors etched into it that opened the video. Thus, the video turn to the next great step: the creation of the integrated circuit. The video returns briefly to speed: how miniaturization allows the impulses in a circuit to move quickly. The video notes that this is a whole other section of our web or mesh of the events that lead to the integrated circuit, but I'll focus on one rarely told story, something that lies at the root, that underlies all of the great advances in created the integrated circuit. The video explains that this piece of silicon is a single crystal and is the most pure substance on the earth. Its explains how pure, and then tell the story of Czochanski and how he invented crystal pulling.

Ending
What is the ending?