A review of the book: "Turing's Cathedral: The origins of the digital universe", George Dyson (Pantheon Books, 2012).

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1. Introduction

The title of this book is very appropriated for the year 2012, the centenary of the birth of Alan Turing. The gist of the book tells the history of the early development of digital computers. As the author says in the preface, the book is not about predicting the future of the digital universe, but on understanding how it began. The author is the son of the physicist Freeman Dyson, and as a child he lived in the atmosphere of Princeton's Institute for Advanced Study, where his father was working at the time. This fact makes the book to emphasize the developments of the computer science at Princeton.

The book covers a large range of topics, as it can be seeing in the synopsis below. One of the main backbones in the book is the creation and first steps of the *Institute for Advanced Study* (from now on IAS), and the efforts and success of John von Newmann to establish in the IAS a line of research on computer science.The book covers topics like: the race between the initial digital computers, the important roll played by the US Army in the development of the support for digital computers, the cosmological and biological applications to digital computers and the spread of computers to Europe in the late 50's. In spite of the title of the book, characters as John von Neumann, have a more prominent role through the whole book than Alan Turing. The point of view of Dyson is stated at the beginning of Turing's biographic chapter: *The history of digital computing can be divided into an Old Testament, whose prophets, led by Leibniz, supplied the logic, and a New Testament whose prophets, led by von Neumann, built the machines. Alan Turing arrived in between.*

Most of the chapters in the book start with either a biographical description of a relevant persone for the period under consideration, or about the daily life at the IAS, and then the chapter goes into a more technical exposition of particular events in the history of the early digital computers development. At the beginning of the book there is a useful list of 79 people that appear in the book, each one with a short biography.

A minor drawback of the book is that to fully grasp the meaning of some technical descriptions, the reader needs a basic knowledge of how a computer works and some engineering issues.

An interesting feature of the book are the selected sentences at the beginning of each chapter, for instance the chapter about the MANIAC, it starts with the following sentence from John von Neumann: *Let the whole outside world consist of a long paper tape.*

2. Chapter-by-chapter synopsis

The reader should be adviced not to skip the Preface and the Acknowledgements and read them as an integral part of the text, otherwise the reader will miss some important information to the book. In **Chapter 1**, Dyson gives a quick retrospective introduction to the digital computing history, starting from a 1953 experiment by Nils Barricelly at the IAS (more about the experiment in Chapter 15)

Chapter 2 and **3** go into explaining the creation of the IAS at Princeton, and describes at length the biography of the two people that where fundamental in the existence of the IAS, Oswald Veblen and the first director Abraham Flexner. From today perspective, it is interesting to read the words of Veblen about the creation of the Institute: *The main funds of such an institute should be used for the salaries of men and women whose business is mathematical research.* There is also a description on how they selected the first group of scientists and staff at the IAS.

Chapter 4 presents the biography of John von Neumann up to the starting of the cold war. In the middle of the chapter, there is a digression to explain Gödel incompleteness theorem and what was the impact on the mathematical community and in particular for von Neumann himself.

Chapter 5, presents the background for the firsts all purpose digital computers. The chapter start with a short bibliographic sketch of V. Zworykin, the head of RCA Laboratory at Princeton, which will push the construction of the *selectron* an all-digital, random access storage tube that would be one of the key components in the first digital computers. Then Dyson goes to describe the construction of the ENIAC, by Eckert and Mauchly. How the construction of the ENIAC was pushed and payed by the US Army to compute ballistic's tables. The legal battle to determine the patents rights of key elements of the ENIAC, which ended by legal settlement recognizing that three years before starting the construction of the ENIAC, as John Atanassof had demonstrated a digital computer to Mauchly. A particularly interesting passage is the impact that ENIAC had on John von Neumann, the first time he visited the machine and his subsequent involvement with the ENIAC, up to his celebrated report *First draft of a report on the EDVAC*. Dyson goes into an interesting comment on the fact that the report did not recognized or mention any influence from Eckert-Mauchly or Turing. It is a bit odd that in this chapter the author does not mention the Colossus, which it is consider to be the first digital computer, although it was not universal. Colossus appears in later chapters in relation with the cryptographic effort at Blechley Park.

After a preamble of daily life at the IAS, one of the main points described in **Chapter 6** is

the arrival and activity of Kurt Gödel at the IAS, and his relationship with von Neumann.
Chapter 7 sketches the biography of Julian Bigelow, the electrical engineer hired by the IAS to carry out von Neumann computer project. Dyson goes at length to explain the difficulties of von Neumann to start a computing project at the IAS, and the initial opposition to the computer project of some of the big names at the IAS, like A. Einstein.
Chapter 8 goes at length to the improvements in digital memory and I/O devices that were implemented for the MANIAC computer (the von Neumann's child at the IAS). The chapter also comments the race between the IAS and the computer team at the University of Manchester for improving the storage abilities of digital machines.
Chapters 9, 10, 11, 12 deal with different early applications for the first digital computers. Each of the chapters is by itself a nice historical note. In Chapter 9, Dyson describes the project to obtain reliable computer solutions for numerical weather prediction. The automatic weather forecast project was launched at the IAS in the late 40's, under the advice of von Neumann. To carry out the project, the IAS recruited a team of meteorologists, headed by Philip Thompson. The chapter presents a enlightening account of whether forecast from 1910 until the late 60's. Chapters 10 and 11 deals with the application of ENIAC to the early cold war effort, in particular to the development of the H-bomb. The chapters also include biographic sketches of Klári von Neumann (John's wife and one of the programers for ENIAC), Stanislaw Ulam, Edward Teller, as well as a description of Metropolis's Monte-Carlo method and its early application to implement simulations with digital computers. Chapter 12 presents Nils Barricelli mathematical models for biology and evolution and the use of digital-computers to simulate those models.
Chapter 13 presents the biography and main contributions of Alan Turing. In particular the chapter covers the Universal Turing Machine and the halting problem, Turing important participation to decrypt the Enigma and the lasting impact of his philosophical paper on the topic of machine intelligence that sparked the field of Artificial Intelligence.
Chapter 14 describes on the downfall of the von Neumann's computer project at the IAS, because the commitement of von Neumann to the Atomic Energy Commission, to follow with a detailed account of von Neumann last days.
Chapter 15 deals with the work of von Neumann on the theory self-replicating automata, inspired on the previous work of Barricelli described in Chapter 12, the chapter goes further into issues such as the existence of extraterrestrial life.
Chapter 16 reflects on the experiments involving digital computers that where going on in the mid-50's, and their implication for the future of computing.
Chapter 17 is a beautiful "philosophical.esssay on computing. The chapter takes its name *The Tale of the Big Computer* from a dystrophic novel from a Swedish astrophysicist and computer scientist, Hannes Alfvén. In Alfvén's book written in 1966, *computers take over the world to eliminate two of the world's greatest threats: nuclear weapons and politicians.* A highly recommended book, although it is Personally I enjoyed very much this chapter and I would not spoil the fun to the future reader.
The final **Chapter 18** Presents a biographical follow-up of the life and fate of some of the

main characters and machines that play an relevant role in the book, after the 60's, when the book ends its historical account the historical account. For the machines the ENIAC, the MANIAC, and Julian Bigelow, Oscar Veblen, Lewis Richardson, Robert Oppenheimer, Stan Ulam, Klári von Neumann, etc.

3. Conclusions

Turing's Cathedral is written in an absorbing way, which hooks the reader's interest. I would recommend this book, to all scientists dealing with computers, and in particular for computer scientists, mathematicians and physicists, even if some computer scientists may not completely agree with a few details. Although through the book the Universal Turing Machine plays an important role, I find the title a bit misleading.