Learning the Hard Way

A History 1843-1980 of Software Engineering

Fred Brooks

University of North Carolina at Chapel Hill

brooks@cs.unc.edu

Disclaimer

I've tried to get dates right,
but I do not claim
to be giving the
first published or operational
occurrence of a big idea.
Don't cite my dates.

Disclaimer 2

The pictures do not represent what we '60's & 70's innovators look like today.

Uphill Both Ways '44-'51

- Hand-coding on paper
- In binary, octal for short
- Octal op codes
- Octal addresses
- Absolute addresses
- Transfer to paper tape, cards, punched-film

A Slow Insight

A Program	Programming System
Program Product	Programming System Product

The Mythical Man-Month

1. Program 1843

- Ada Lovelace
- Charles Babbage's Analytical Engine

2. Software Product '51

- *Software Product* = *A* program to be used by other than the author
  - Generalization
  - Testing
  - Documentation
  - On-going maintenance

3. Software System '56

- *Software System=A* system of many separate programs working together
  - Interfaces
  - System integration and test

GM-NAA I-O (Batch) Operating System '56

- Robert Patrick (GM), Owen Mock (NAA), George Ryckman (GM)
- Components
  - Input translator for cards, tape, multiple languages
  - SHARE Assembly program, later FORTRAN
  - Compute monitor (abort on errors, dump memory)
  - Accounting package
  - Output converter (to decimal) tape. (Hand-carried off)
- 10-fold improvement in jobs/hour
- Shorter turn-around on average
- Professional operators; programmers programmed
- No idle machine time

- 40 copies distributed; no support

4. Software System Product '59

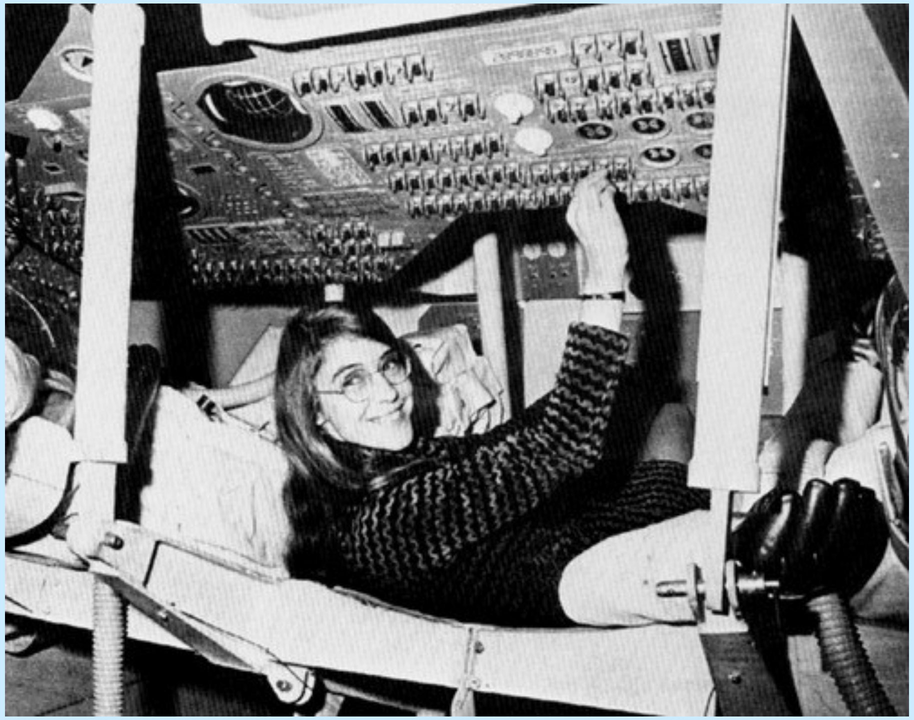
A software system designed to be distributed to (and supported for) many users

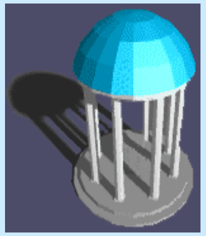
- SHARE Operating System '59
  - Based on GM-NAA I-O Operating System
  - Distributed by IBM
  - Maintained by IBM

Software Engineering

The discipline of making *software products*

Name coined by
Margaret Hamilton ~'66





Big Ideas of the '40's

- Programmable computers
  - Babbage 1843
  - Zuse '41
  - Aiken '44
  - Kilburn '48
  - Wilkes '49
- Stored Program—von Neumann

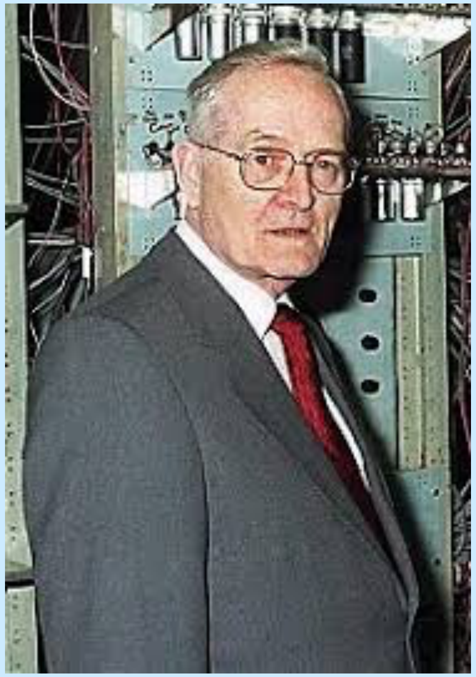
Stored Program

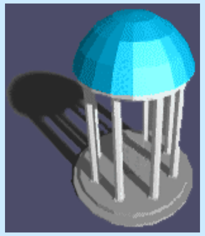
Conceived it

John von Neumann '46

Built it

Tom Kilburn '48, Maurice Wilkes '49





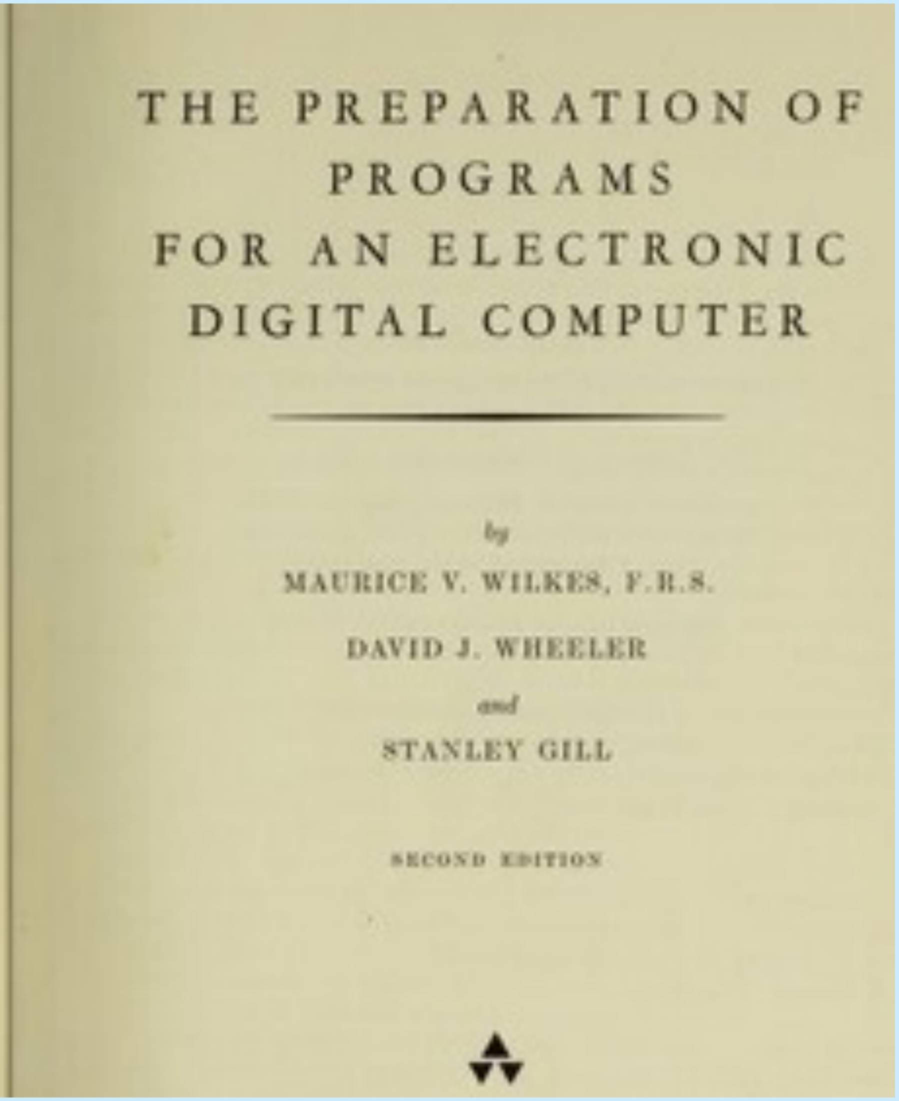
Big Ideas of '50's — 1

- Closed Subroutines
  - 'Wheeler Jump' calling sequence
- Input-Output Libraries
- Symbolic Assembler

- Sir Maurice Wilkes, F.R.S.
- David Wheeler, F.R.S.
- Stanley Gill

University of Cambridge

The Most Important Book in the History of Software '51



THE PREPARATION OF PROGRAMS FOR AN ELECTRONIC DIGITAL COMPUTER

by

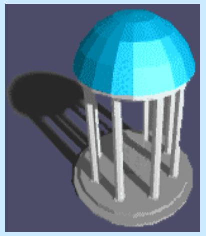
MAURICE V. WILKES, F.R.S.

DAVID J. WHEELER

and

STANLEY GILL

SECOND EDITION



Big Ideas of '50's — 2

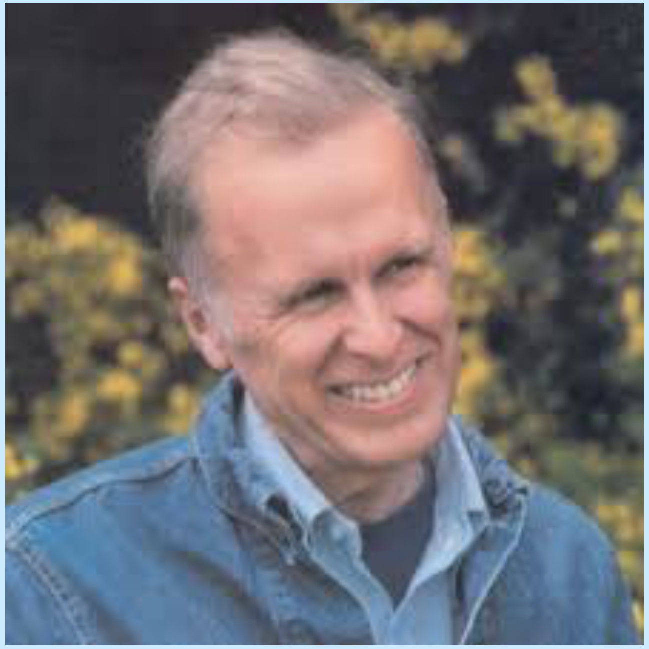
- Compilers
- Operating Systems
- Terminals and Communications
- Graphical Displays
- Block-structured programming
  - Algol '58

Compilers

FORTRAN '56

Optimized Run-time

John Backus



FLOW-MATIC '59

An English-like Language

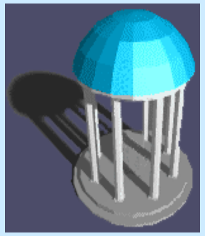
RDML Grace Murray Hopper

Terminals, Communications, Graphical Displays '53

MIT Whirlwind I '51

Cape Cod prototype air defense system '53

SAGE
Air Defense System '58

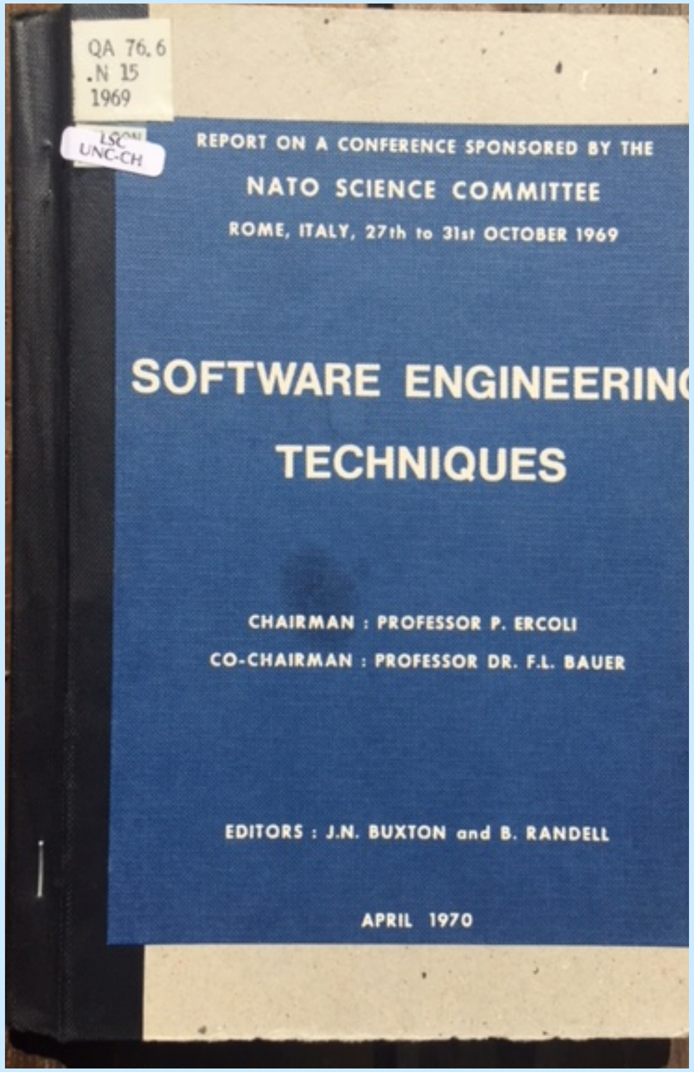


Big Ideas of the '60's — 1

- Software engineering as engineering
  - NATO Conferences '68, '69
- Multiprogramming
- Time-sharing

The NATO Conferences '68,'69

- Fritz Bauer idea
- "Provocative name"
- '68 Conference
  - Enthusiastic participants
  - About software crisis
  - Enphasized management
- '69 Conference
  - Aimed to be more technical
  - Was much more fractious



QA 76.6
.N 15
1969

LSC
UNC-CH

REPORT ON A CONFERENCE SPONSORED BY THE

NATO SCIENCE COMMITTEE

ROME, ITALY, 27th to 31st OCTOBER 1969

SOFTWARE ENGINEERIN

TECHNIQUES

CHAIRMAN : PROFESSOR P. ERCOLI

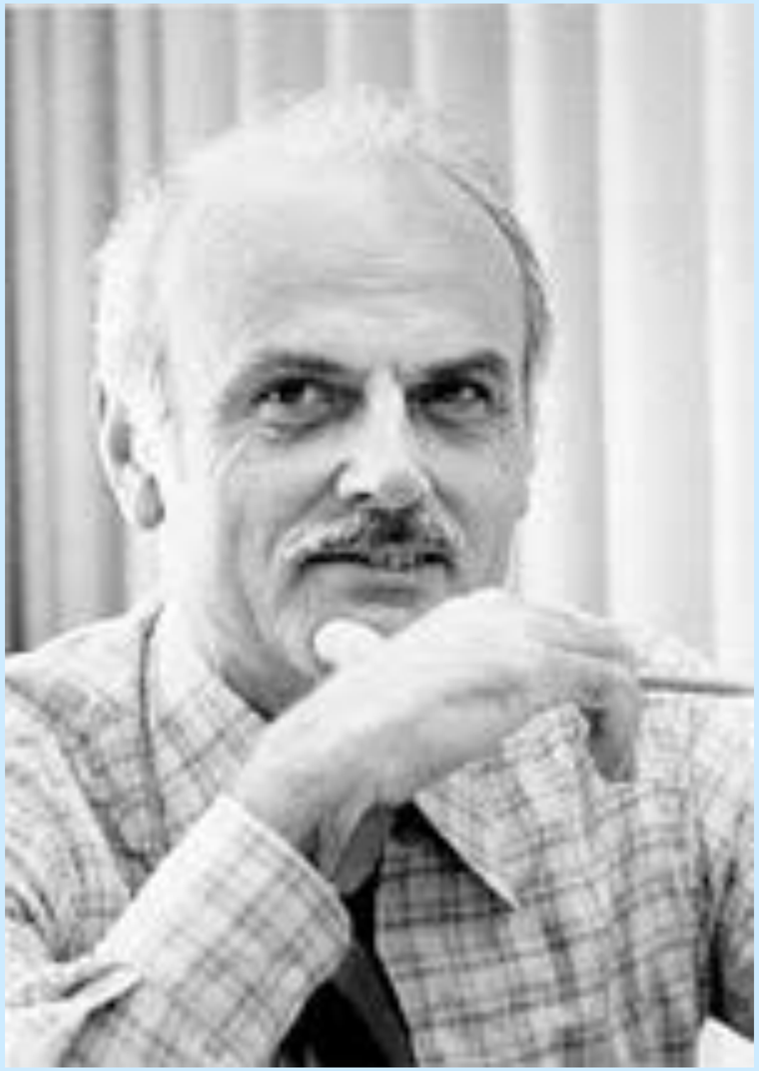
CO-CHAIRMAN : PROFESSOR DR. F.L. BAUER

EDITORS : J.N. BUXTON and B. RANDELL

APRIL 1970

Stretch Multiprogramming OS '58-9 Ted Codd

- Designed for efficient compute-I/O overlap, not yet time-sharing
- Enabled by STRETCH supervisory hardware:
  - Interruption
  - Clock
  - Memory protection
  - Privileged ops



Time Sharing OS's

ATLAS Supervisor '62

Tom Kilburn

- On Manchester ATLAS
- First memory paging OS
- Enabled interactive debugging

MIT CTSS '62

Fernando Corbato

- On IBM 7090
- Precursor of MULTICS
  - On GE 645
  - Many important ideas

Big Ideas of the ‘60’s — 2

- Classes, inheritance
- Database systems
- Proofs and Axioms

Classes, Inheritance, Object-Orientation. '67

Simula 67

Kristen Nygaard

Ole-Johan Dahl

Database Systems '65

Integrated Data Store '65

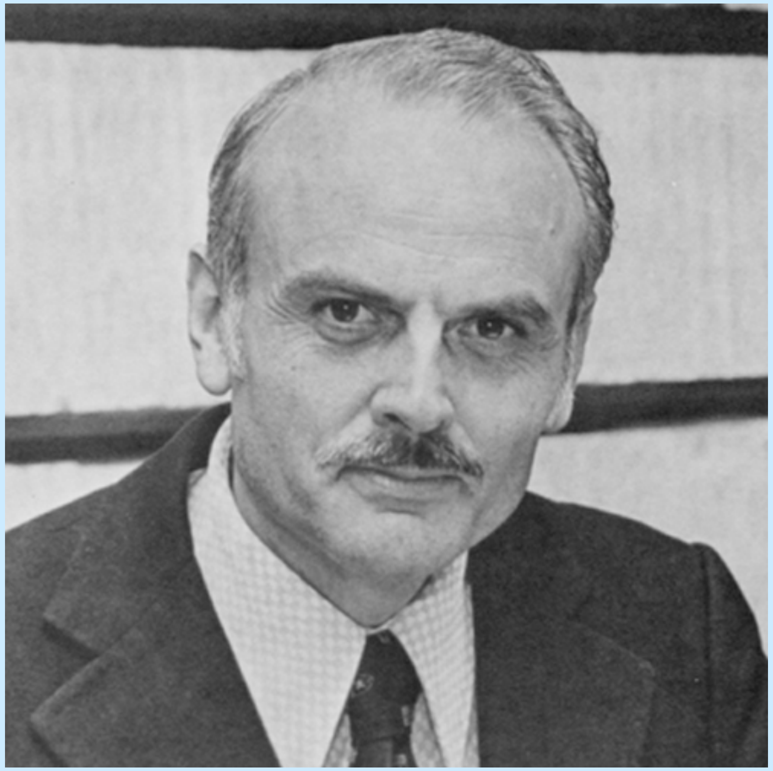
Charles Bachman

Navigational DB Model

ORACLE '79

Ted Codd

Relational Model '70



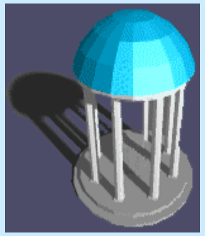
Proofs and Axioms '67

Robert Floyd '67

"Assigning Meanings to Programs"

Sir Anthony Hoare '69

"An Axiomatic Basis for Computer Programming"



Big Ideas of the '70's

- Information hiding, modules, abstract data types
- Top-down, incremental build, stepwise refinement
- Inspections
- Software engineering management

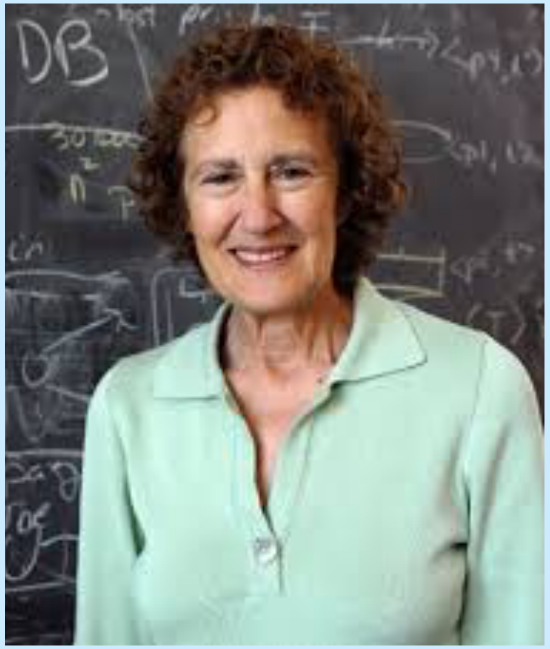
Information Hiding, Modules, Abstract Data Types ?

David Parnas '71

- Information hiding
- Modules

Barbara Liskov '74

- Abstract data types



Top-Down, Incremental Build, Stepwise Refinement '71

Harlan Mills '71

Niklaus Wirth '71

Inspections

A formal process

Outside team of several inspectors

Code reading line-by-line

Work against a set of specific requirements

Inspectors watch for defects and requirement failures

Michael E. Fagan

Software Engineering Management

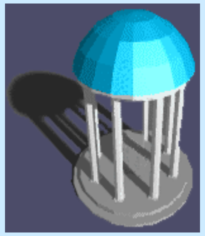
- Several early papers
- *The Mythical Man-Month*
- Requirements verifying and validating

Requirements Verifying and Validating '79

- Verification: "Am I getting the requirements right?"
- Completeness,
- Consistency
- Feasibility: Cost, Schedule
- Testability

- Validation: "Am I building the right product?"

Barry Boehm



“No Silver Bullet” ‘85, Refired

- Software is *Essentially* hard to build
  - Complexity is inherent
  - Conformity to hardware and world
  - Changeability (looks easy to change)
  - Invisibility
- “There is no single development in technology or management which alone promises a 10X gain in 10 years” is again true 30 years later

Resources

- Grady Booch ACM Webinar
- https://learning.acm.org/webinars
  "History of Software Engineering"
- Selby, *Software Engineering: Barry W. Boehm's Lifetime Contributions to Software Development, Management, and Research*
- Hoffman & Weiss, *Software Fundamentals: Collected Papers of David L. Parnas*