Charles Babbage, Ada & The Machine

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Providing IT Services for over 20 years for:

- ❑ Project Management, Quality Assurance, Software Estimation & Process Improvements
- ❑ Agile/Scrum, Rational Unified Process (RUP), & Waterfall methodologies
- ❑ Logistics, Health-care, Insurance, Automotive, Telecommunications, Marketing & Financial applications

- Speaker & Author
- Agile Coach, Mentor & Trainer
- Scrum Master, Agile Team Facilitator
- Process Improvement Manager
- Quality Assurance Manager
- Development Manager
- Project Manager
- Metrics Specialist
- Software Estimation Expert
- Software Developer
- Quality Assurance Analyst
- Software Developer
- Biologist

You are what you Do

Charles Babbage

- Born 12/1791, Died 10/1871
- The father (grandfather) of the computer
- Greatly influenced economic theory & practice
- Published on the nature of God & science
- Studied the requirements to establish a modern postal system
- Studied the Paranormal
- Recalculated tables crucial for science engineering & navigation
- Involved in a various social campaigns

Polymath, Mathematician, Philosopher, Inventor, & Mechanical Engineer

Babbage on Scientific Manufacturing

- Wrote “The Economy of Machinery”:
  - Based on factory observations
  - Identified advantages of division of labor
  - Argued for rational factory design
  - Contained ideas for profit sharing
- Cut Labor costs by assigning:
  - High-skill tasks to high-cost workers, and
  - Nominal tasks for lower-paid workers
- Training becomes a fixed costs
- Human capital is restricted to minimizing the time for recovery of training costs

"The triumph of the industrial arts will advance the cause of civilization more rapidly than its warmest advocates could have hoped"

Charles Babbage

The Babbage Principle

Impact On Contemporary Thinking

- Impacted economic, architectural, technology & political thinking:
  - The layout of the 1851 Great Exhibition,
  - Karl Marx & John Stuart Mill,
  - The French engineer & writer on industrial organization Léon Lalanne,
  - Economist Claude Lucien Bergery, reducing the issues to "technology",
  - William Jevons connected Babbage's "economy of labor" with his labor experiments of 1870,
  - The Babbage principle is inherent in Frederick Winslow Taylor's scientific management,
  - Joseph Schumpeter refers to Babbage's book as "a remarkable performance by a remarkable man."
    - Uncle George Everest
    - Husband George Boole, and
    - Augustus De Morgan

Much more than an Engineer

A Polymath

- He published arguments that:
  - God-given natural law removed the need for God's continuous intervention
  - Scripture & nature are not irreconcilable - Genesis is not a literal account
- In "On Tables of the Constants of Nature and Art", identified that exact measurement was the key to the development of machine tools
- Achieved notable results in cryptography, unknown until after his death
- A public Nuisance - Involved in unpopular campaigns against public nuisances:
  - Published on the causes of plate glass window breakage caused by drunks
  - Published on the street nuisances among street music (organ grinders)
  - Joined the anti-hoop-rolling campaign of boys driving iron hoops under horses' legs resulting in thrown riders and injured horses

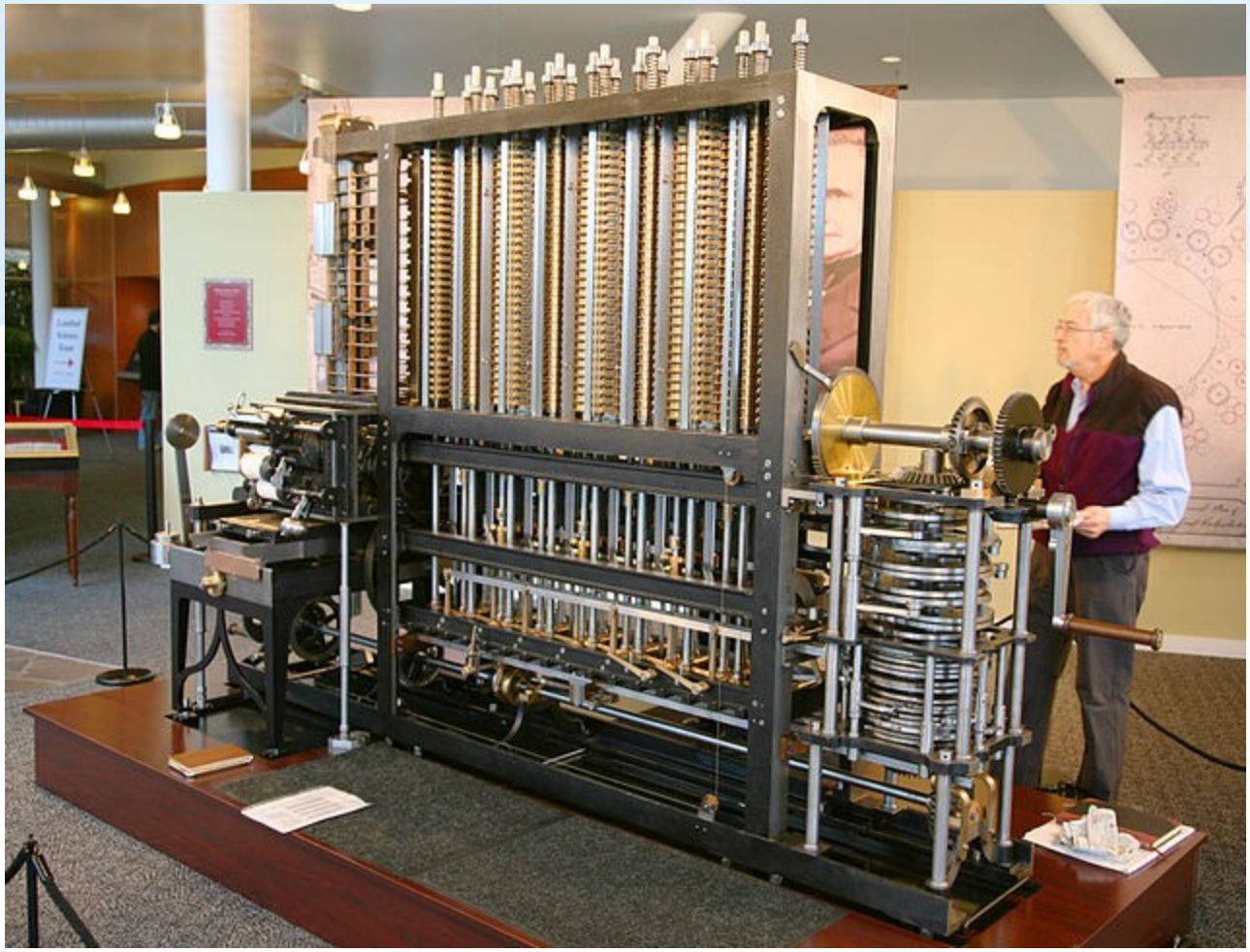
Or a Public Nuisance?

The Difference Engine

- Was made to compute values of polynomial Functions
- Mechanical & unwieldy,
- Made to compute polynomial functions:
  - Returned results up to 31 digits
  - Around 25,000 parts
  - Weighed 15 tons
  - 2.4 meters tall
- Not completed due to funding issues & personality clashes
- Constructed in 1989 – 1991
  - Built to tolerances achievable in 19th century
  - The equivalent of 675 bytes of memory
  - A clock speed of about 7 Hz
- Displayed at the Science Museum in London

In Theory it Worked

The Difference Engine



It Worked!!!

The Analytical Engine

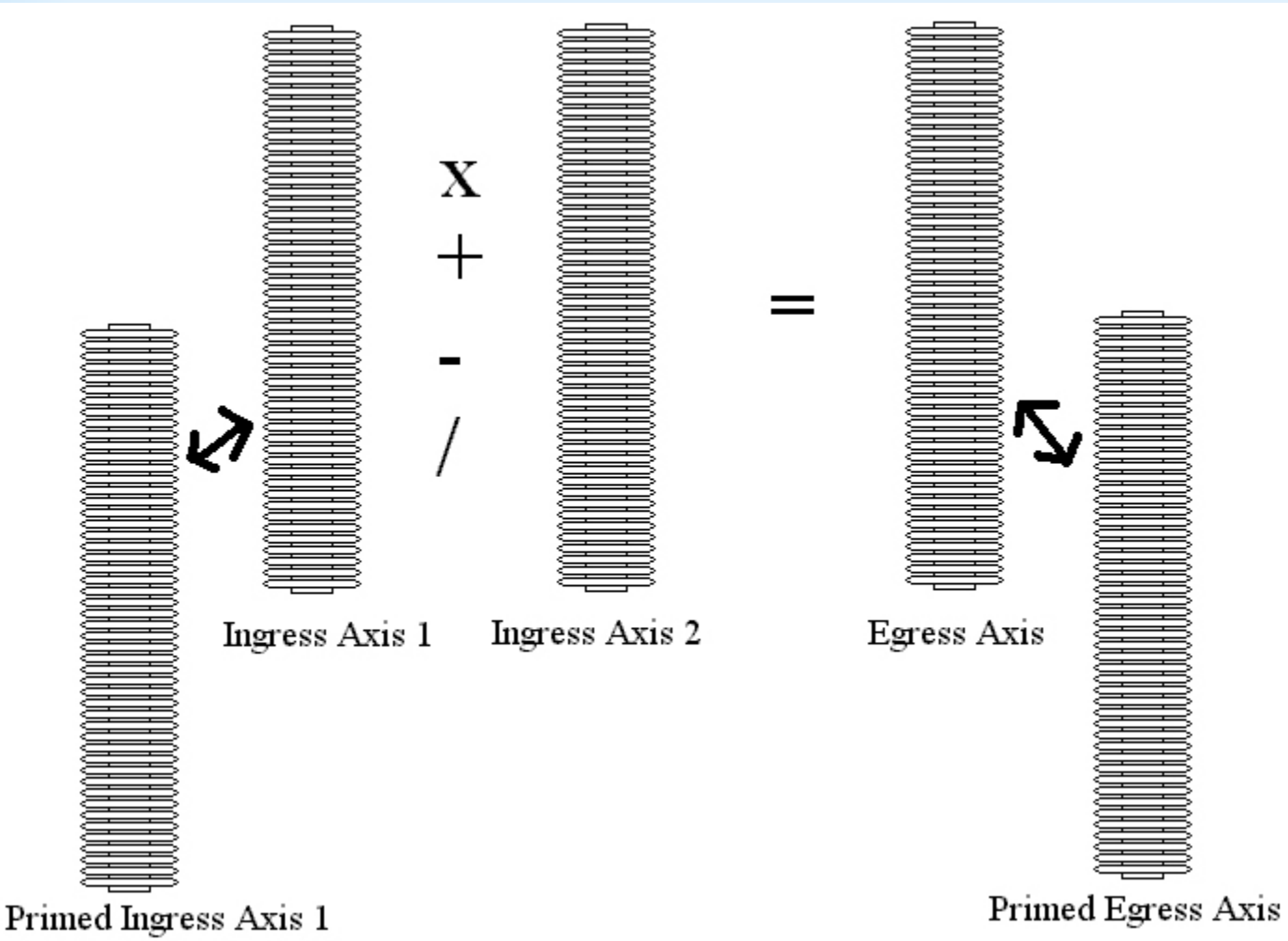
- The Analytical Engine transition mechanized arithmetic to general-purpose computation
- Programmed using loops of Jacquard's punched cards to control a mechanical calculator, which could use as input for preceding computations
- Architecture similar to modern computers:
  - Sequential control,
  - Branching and looping.
  - Data and program memory were separated
  - The operation was instruction-based,
  - The control unit could make conditional jumps, and
  - The machine had a separate I/O unit
- This is the first mechanical device to be Turing-complete
- A succession of designs, tinkered with until he died in 1871
- The Analytical Engine is displayed at the Science Museum (London)

Very nice but can it make coffee?

Analytical Engine

It's Big. It's Bad. It's a Computer!

The Analytical Engine - The Mill



My Creation is Alive!

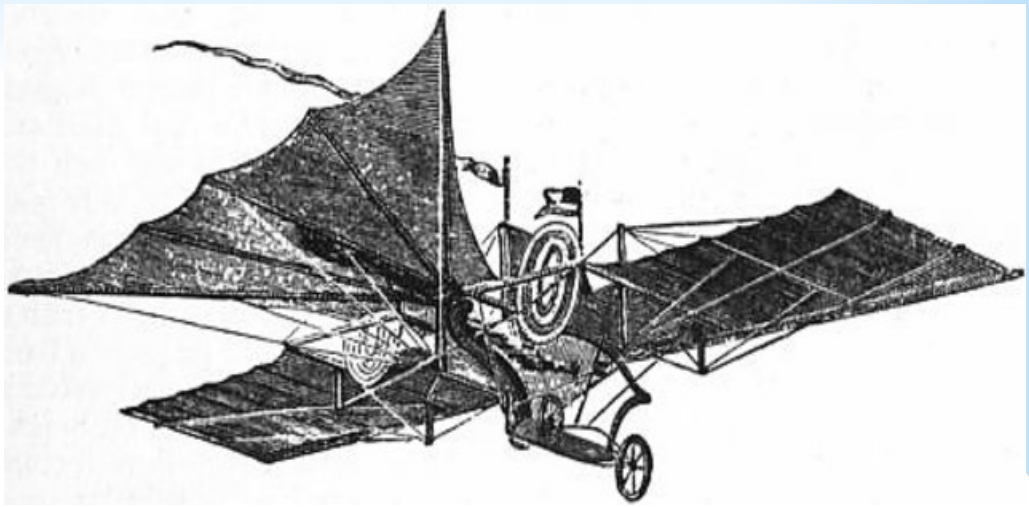
Countess Ada Lovelace

Born 10 December 1815
Died 27 November 1852)
English mathematician and writer
First computer programmer
Daughter of Lord Byron
Died of uterine cancer at 36

The First Code Monkey

Ada - The Early Years

- Lord Byron separated from his wife shortly after her birth
- Died when she was 8 years old
- Ada wasn't close with her mother
- Often left in the care of her maternal grandmother



- At 12 she decided she wanted to fly:
  - Investigated different materials and sizes
  - Examined the anatomy of birds
  - Decided to write a book, Flyology, illustrating, with plates and her findings
  - Decided what equipment she needed
  - The final step was to integrate steam with the "art of flying"

A Steampunk Flying Machine?

Ada - Adult Years

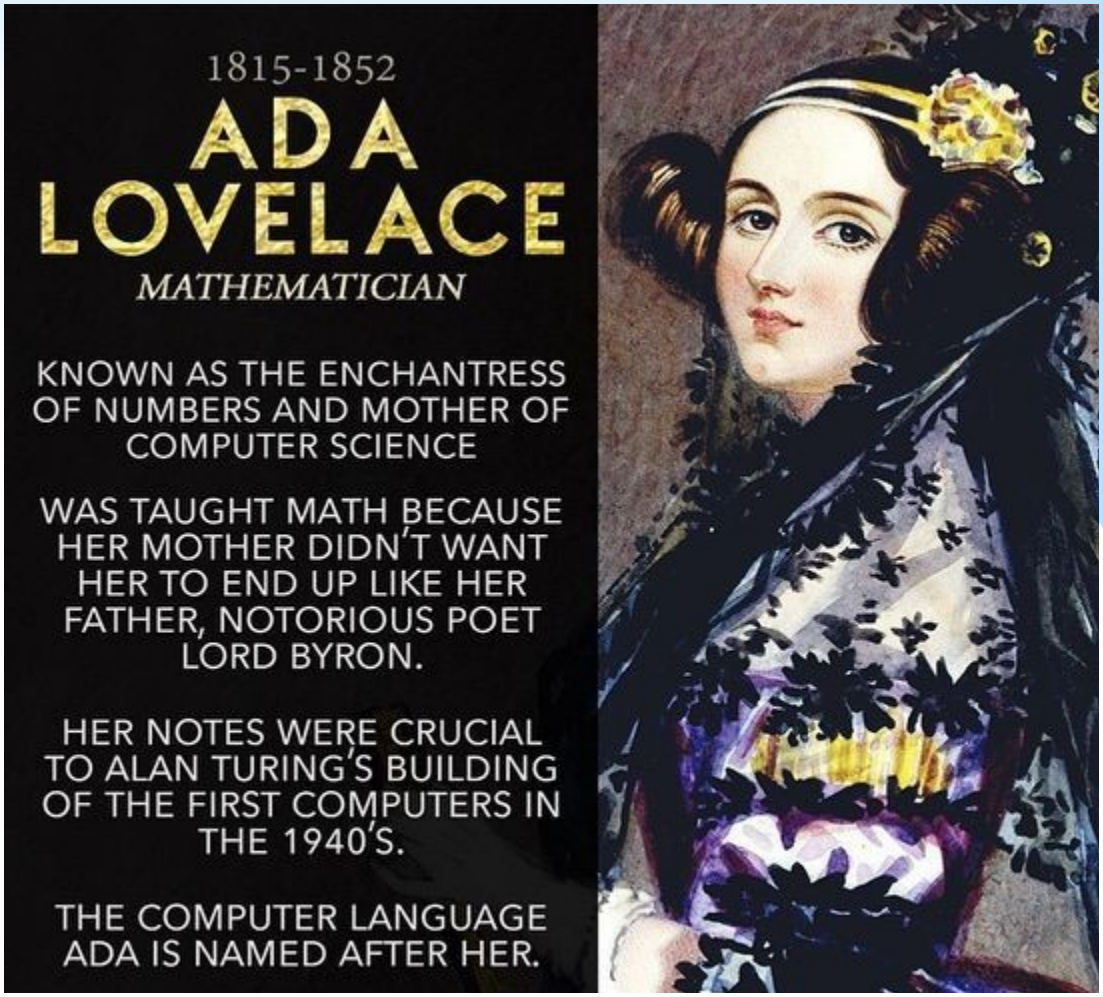
- Introduced her to Charles Baggage
- She corresponded with many scientists, including Somerville, Andrew Crosse, Sir David Brewster, Charles Wheatstone, Michael Faraday, and Charles Dickens
- Husband made Earl of Lovelace
- Ada flirted with Scandals:
  - Had a relaxed approach to extra-marital relationships with men,
  - Lost £3,000 on the ponies
  - She created a mathematical model for placing bets

- Shadowy relationship with Andrew Crosse's son John
- During her final illness, she would panic at the idea of not seeing him

I Have a Fool Proof System

Ada – Maturing Mathematician

- Mathematical abilities emerged at 17
- Private tutors in math & science by:
  - William Frend
  - William King
  - Mary Somerville
  - Augustus De Morgan
- Studies of the Bernoulli numbers helped formulate her algorithm for Babbage's Analytical Engine
- Often questioned basic assumptions



Intuition & Imagination is the Key

The Enchantress of Numbers

- Translated Luigi Menabrea's article on Babbage's Analytical Engine
- In her detailed notes, she:
  - Described how the Analytical Engine worked
  - Emphasized the difference between the Analytical Engine and previous calculating machines
  - Included a method for calculating the Bernoulli numbers
- Due to this she is considered to be the first programmer
- Michael Faraday was a supporter of her writing
- The year she was struck with cancer she was working on the relationship between math & music
- Ada Lovelace died at the age of 36 on 27 November 1852 from uterine cancer

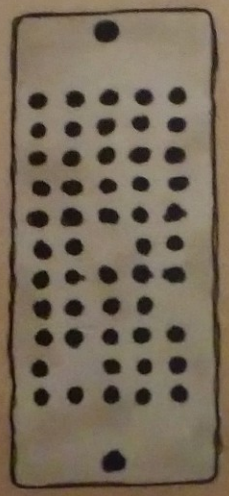
A Promise Cut Short

Bernoulli's Numbers

Analytical Engine, a mechanical computer that he designed but never built. She published it in 1843, a century before the modern computer age.

$$\frac{x}{e^x - 1} = \frac{1}{1 + \frac{x}{2} + \frac{x^2}{2 \cdot 3} + \frac{x^3}{2 \cdot 3 \cdot 4} + \&c.}$$

"I want to put in something about Bernoulli's Number, in one of my Notes, as an example of how an ~~explicit~~ implicit function may be worked out by the engine, without having been worked out by human head and hands first."



A Little Bit of Ada in Your Life

Computation Bernoulli Numbers

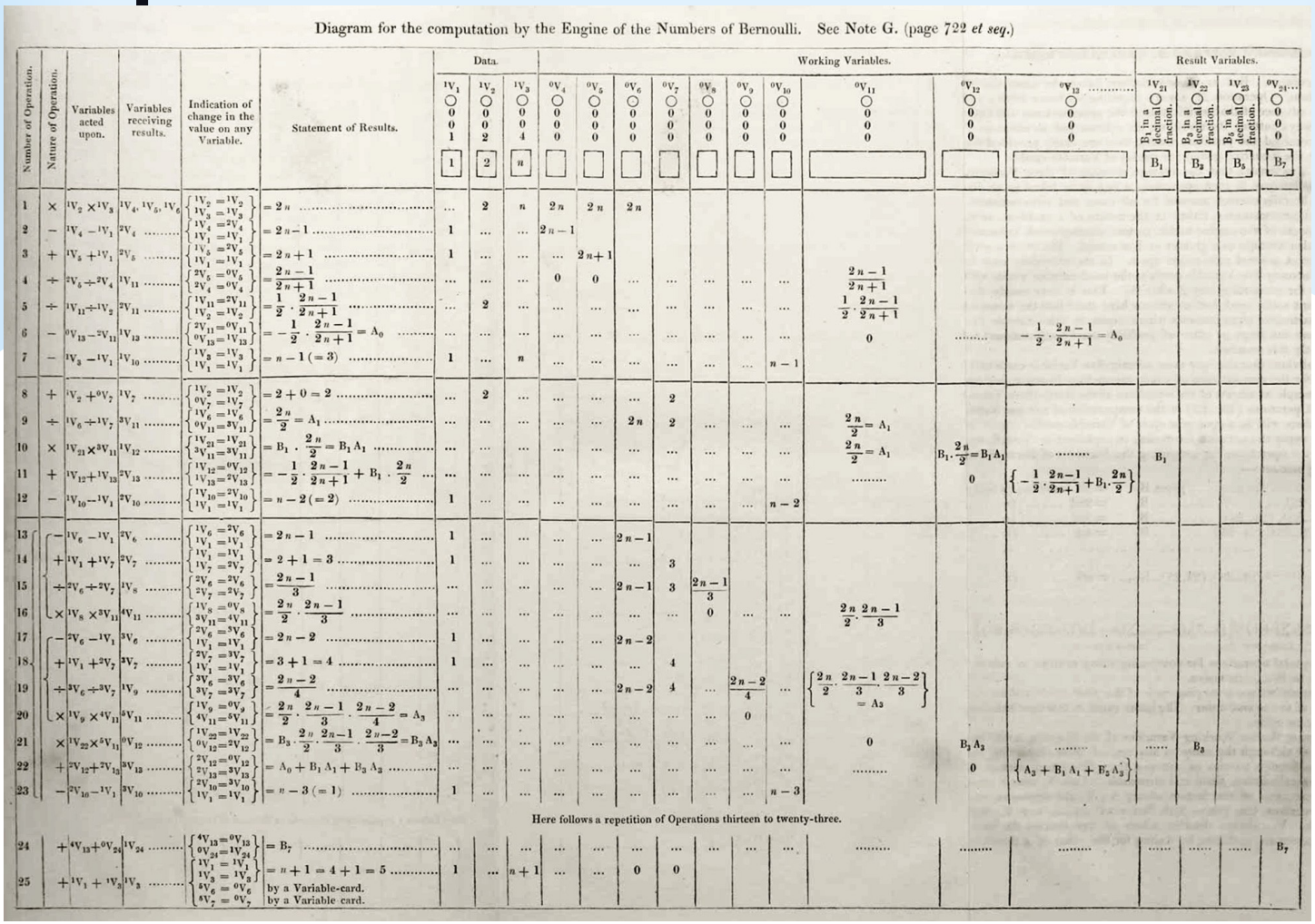


Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 *et seq.*)

Number of Operation.	Nature of Operation.	Variables acted upon.	Variables receiving results.	Indication of change in the value on any Variable.	Statement of Results.	Data. ${}^1V_1$ 1 [1]	Data. ${}^1V_2$ 2 [2]	Data. ${}^1V_3$ 4 [n]	Working Variables. ${}^0V_4$	${}^0V_5$	${}^0V_6$	${}^0V_7$	${}^0V_8$	${}^0V_9$	${}^0V_{10}$	${}^0V_{11}$	${}^0V_{12}$	${}^0V_{13}$	Result Variables. ${}^1V_{21}$ [B_1]	${}^1V_{22}$ [B_2]	${}^1V_{23}$ [B_5]	${}^0V_{24}$ [B_7]
1	×	${}^1V_2 \times {}^1V_3$	${}^1V_4, {}^1V_5, {}^1V_6$	${}^1V_2 = {}^1V_2$, ${}^1V_3 = {}^1V_3$	$= 2n$	...	2	n	$2n$	$2n$	$2n$											
2	−	${}^1V_4 - {}^1V_1$	${}^2V_4$	${}^1V_4 = {}^2V_4$, ${}^1V_1 = {}^1V_1$	$= 2n-1$	1	...	...	$2n-1$													
3	+	${}^1V_5 + {}^1V_1$	${}^2V_5$	${}^1V_5 = {}^2V_5$, ${}^1V_1 = {}^1V_1$	$= 2n+1$	1	...	...	...	$2n+1$												
4	÷	${}^2V_5 \div {}^2V_4$	${}^1V_{11}$	${}^2V_5 = {}^0V_5$, ${}^2V_4 = {}^0V_4$	$= \frac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\frac{2n-1}{2n+1}$						
5	÷	${}^1V_{11} \div {}^1V_2$	${}^2V_{11}$	${}^1V_{11} = {}^2V_{11}$, ${}^1V_2 = {}^1V_2$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\frac{1}{2} \cdot \frac{2n-1}{2n+1}$						
6	−	${}^0V_{13} - {}^2V_{11}$	${}^1V_{13}$	${}^2V_{11} = {}^0V_{11}$, ${}^0V_{13} = {}^1V_{13}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	.....	$-\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$				
7	−	${}^1V_3 - {}^1V_1$	${}^1V_{10}$	${}^1V_3 = {}^1V_3$, ${}^1V_1 = {}^1V_1$	$= n-1\ (=3)$	1	...	n	...	...	...	...	...	...	$n-1$							
8	+	${}^1V_2 + {}^0V_7$	${}^1V_7$	${}^1V_2 = {}^1V_2$, ${}^0V_7 = {}^1V_7$	$= 2+0=2$	...	2	...	...	...	...	2										
9	÷	${}^1V_6 \div {}^1V_7$	${}^3V_{11}$	${}^1V_6 = {}^1V_6$, ${}^0V_{11} = {}^3V_{11}$	$= \frac{2n}{2} = A_1$	...	...	...	...	...	$2n$	2	...	...	...	$\frac{2n}{2} = A_1$						
10	×	${}^1V_{21} \times {}^3V_{11}$	${}^1V_{12}$	${}^1V_{21} = {}^1V_{21}$, ${}^3V_{11} = {}^3V_{11}$	$= B_1 \cdot \frac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\frac{2n}{2} = A_1$	$B_1 \cdot \frac{2n}{2} = B_1 A_1$	.....	B_1			
11	+	${}^1V_{12} + {}^1V_{13}$	${}^2V_{13}$	${}^1V_{12} = {}^0V_{12}$, ${}^1V_{13} = {}^2V_{13}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}$ ...	...	...	...	...	...	...	...	...	...	...	.....	0	$\left\{-\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}\right\}$				
12	−	${}^1V_{10} - {}^1V_1$	${}^2V_{10}$	${}^1V_{10} = {}^2V_{10}$, ${}^1V_1 = {}^1V_1$	$= n-2\ (=2)$	1	...	...	...	...	...	...	...	...	$n-2$							
13	−	${}^1V_6 - {}^1V_1$	${}^2V_6$	${}^1V_6 = {}^2V_6$, ${}^1V_1 = {}^1V_1$	$= 2n-1$	1	...	...	...	...	$2n-1$											
14	+	${}^1V_1 + {}^1V_7$	${}^2V_7$	${}^1V_1 = {}^1V_1$, ${}^1V_7 = {}^2V_7$	$= 2+1=3$	1	...	...	...	...	...	3										
15	÷	${}^2V_6 \div {}^2V_7$	${}^1V_8$	${}^2V_6 = {}^2V_6$, ${}^2V_7 = {}^2V_7$	$= \frac{2n-1}{3}$	...	...	...	...	...	$2n-1$	3	$\frac{2n-1}{3}$									
16	×	${}^1V_8 \times {}^3V_{11}$	${}^4V_{11}$	${}^1V_8 = {}^0V_8$, ${}^3V_{11} = {}^4V_{11}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\frac{2n}{2} \cdot \frac{2n-1}{3}$						
17	−	${}^2V_6 - {}^1V_1$	${}^3V_6$	${}^2V_6 = {}^3V_6$, ${}^1V_1 = {}^1V_1$	$= 2n-2$	1	...	...	...	...	$2n-2$											
18	+	${}^1V_1 + {}^2V_7$	${}^3V_7$	${}^2V_7 = {}^3V_7$, ${}^1V_1 = {}^1V_1$	$= 3+1=4$	1	...	...	...	...	...	4										
19	÷	${}^3V_6 \div {}^3V_7$	${}^1V_9$	${}^3V_6 = {}^3V_6$, ${}^3V_7 = {}^3V_7$	$= \frac{2n-2}{4}$	...	...	...	...	...	$2n-2$	4	...	$\frac{2n-2}{4}$	...	$\left\{\frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3}\right\} = A_3$							
20	×	${}^1V_9 \times {}^4V_{11}$	${}^5V_{11}$	${}^1V_9 = {}^0V_9$, ${}^4V_{11} = {}^5V_{11}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0								
21	×	${}^1V_{22} \times {}^5V_{11}$	${}^0V_{12}$	${}^1V_{22} = {}^1V_{22}$, ${}^0V_{12} = {}^2V_{12}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	.....	.....	B_3		
22	+	${}^2V_{12} + {}^2V_{13}$	${}^2V_{13}$	${}^2V_{12} = {}^0V_{12}$, ${}^2V_{13} = {}^3V_{13}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	.....	0	$\{A_3 + B_1 A_1 + B_2 A_2\}$				
23	−	${}^2V_{10} - {}^1V_1$	${}^3V_{10}$	${}^2V_{10} = {}^3V_{10}$, ${}^1V_1 = {}^1V_1$	$= n-3\ (=1)$	1	...	...	...	...	...	...	...	...	$n-3$							
Here follows a repetition of Operations thirteen to twenty-three.																						
24	+	${}^4V_{13} + {}^0V_{24}$	${}^1V_{24}$	${}^4V_{13} = {}^0V_{13}$, ${}^0V_{24} = {}^1V_{24}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	.....	.....	.....	.....	.....	.....	B_7
25	+	${}^1V_1 + {}^1V_3$	${}^1V_3$	${}^1V_1 = {}^1V_1$, ${}^1V_3 = {}^0V_3$, ${}^5V_6 = {}^0V_6$, ${}^5V_7 = {}^0V_7$	$= n+1 = 4+1=5$ by a Variable-card. by a Variable card.	1	...	$n+1$	...	...	0	0										

https://gist.github.com/sinclairtarget/ad18ac65d277e453da5f479d6ccfc20e

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