Ada Lovelace and The Very First Computer Program

ffconf
10^{th} November 2023

by Steven Goodwin

@marquis de geek

www.MarquisdeGeek.com

@marquis de geek

Introduction

- What was the first program?
- How does it work?
- Transform the original into JavaScript
- Was Ada *really* the first programmer?

Who am I?

The Ego Slide

Who am I?

- Game developer (C/C++/Assembler/JavaScript/AS)
  - PC, Xbox, Playstation, Gamecube,Wii
  - Online, mobile
- EdTech Entrepreneur and CTO
  - JavaScript
  - Serverless
- Emerging Technology Specialist
  - AR/VR/Alexa/Leap Motion
- Open source advocate
  - FOSDEM
  - Keynote speaker

Who am I?

- Game developer (C/C++/Assembler/JavaScript/AS)
  - PC, Xbox, Playstation, Gamecube, Wii
  - Online, mobile
- EdTech Entrepreneur and CTO
  - JavaScript
  - Serverless
- Emerging Technology Specialist
  - AR/VR/Alexa/Leap Motion
- Open source advocate
  - FOSDEM
  - Keynote speaker

@marquis de geek

What was the first program?

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]	$^1V_2$ [2]	$^1V_3$ [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 in a decimal fraction. [B_1]	$^1V_{22}$ B_3 in a decimal fraction. [B_3]	$^1V_{23}$ B_5 in a decimal fraction. [B_5]	$^0V_{24}$ [B_7]
1	$\times$	$^1V_2 \times {}^1V_3$	$^1V_4, {}^1V_5, {}^1V_6$	$\left\{\begin{matrix} ^1V_2 = {}^1V_2 \\ ^1V_3 = {}^1V_3 \end{matrix}\right\}$	$= 2n$	...	2	n	2n	2n	2n											
2	$-$	$^1V_4 - {}^1V_1$	$^2V_4$	$\left\{\begin{matrix} ^1V_4 = {}^2V_4 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 2n - 1$	1	...	...	2n − 1													
3	$+$	$^1V_5 + {}^1V_1$	$^2V_5$	$\left\{\begin{matrix} ^1V_5 = {}^2V_5 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 2n + 1$	1	...	...	...	2n + 1												
4	$\div$	$^2V_5 \div {}^2V_4$	$^1V_{11}$	$\left\{\begin{matrix} ^2V_5 = {}^0V_5 \\ ^2V_4 = {}^0V_4 \end{matrix}\right\}$	$= \frac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\frac{2n-1}{2n+1}$						
5	$\div$	$^1V_{11} \div {}^1V_2$	$^2V_{11}$	$\left\{\begin{matrix} ^1V_{11} = {}^2V_{11} \\ ^1V_2 = {}^1V_2 \end{matrix}\right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\frac{1}{2} \cdot \frac{2n-1}{2n+1}$						
6	$-$	$^0V_{13} - {}^2V_{11}$	$^1V_{13}$	$\left\{\begin{matrix} ^2V_{11} = {}^0V_{11} \\ ^0V_{13} = {}^1V_{13} \end{matrix}\right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	....	$-\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$				
7	$-$	$^1V_3 - {}^1V_1$	$^1V_{10}$	$\left\{\begin{matrix} ^1V_3 = {}^1V_3 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= n - 1\ (= 3)$	1	...	n	...	...	...	...	...	...	n − 1							
8	$+$	$^1V_2 + {}^0V_7$	$^1V_7$	$\left\{\begin{matrix} ^1V_2 = {}^1V_2 \\ ^0V_7 = {}^1V_7 \end{matrix}\right\}$	$= 2 + 0 = 2$	...	2	...	...	...	...	2										
9	$\div$	$^1V_6 \div {}^1V_7$	$^3V_{11}$	$\left\{\begin{matrix} ^1V_6 = {}^1V_6 \\ ^0V_{11} = {}^3V_{11} \end{matrix}\right\}$	$= \frac{2n}{2} = A_1$	...	...	...	...	...	2n	2	...	...	...	$\frac{2n}{2} = A_1$						
10	$\times$	$^1V_{21} \times {}^3V_{11}$	$^1V_{12}$	$\left\{\begin{matrix} ^1V_{21} = {}^1V_{21} \\ ^3V_{11} = {}^3V_{11} \end{matrix}\right\}$	$= B_1 \cdot \frac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\frac{2n}{2} = A_1$	$B_1 \cdot \frac{2n}{2} = B_1 A_1$	....	B_1			
11	$+$	$^1V_{12} + {}^1V_{13}$	$^2V_{13}$	$\left\{\begin{matrix} ^1V_{12} = {}^0V_{12} \\ ^1V_{13} = {}^2V_{13} \end{matrix}\right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{-\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}\right\}$				
12	$-$	$^1V_{10} - {}^1V_1$	$^2V_{10}$	$\left\{\begin{matrix} ^1V_{10} = {}^2V_{10} \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= n - 2\ (= 2)$	1	...	...	...	...	...	...	...	...	n − 2							
13	$-$	$^1V_6 - {}^1V_1$	$^2V_6$	$\left\{\begin{matrix} ^1V_6 = {}^2V_6 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 2n - 1$	1	...	...	...	...	2n − 1											
14	$+$	$^1V_1 + {}^1V_7$	$^2V_7$	$\left\{\begin{matrix} ^1V_1 = {}^1V_1 \\ ^1V_7 = {}^2V_7 \end{matrix}\right\}$	$= 2 + 1 = 3$	1	...	...	...	...	...	3										
15	$\div$	$^2V_6 \div {}^2V_7$	$^1V_8$	$\left\{\begin{matrix} ^2V_6 = {}^2V_6 \\ ^2V_7 = {}^2V_7 \end{matrix}\right\}$	$= \frac{2n-1}{3}$	...	...	...	...	...	2n − 1	3	$\frac{2n-1}{3}$									
16	$\times$	$^1V_8 \times {}^3V_{11}$	$^4V_{11}$	$\left\{\begin{matrix} ^1V_8 = {}^0V_8 \\ ^3V_{11} = {}^4V_{11} \end{matrix}\right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\frac{2n}{2} \cdot \frac{2n-1}{3}$						
17	$-$	$^2V_6 - {}^1V_1$	$^3V_6$	$\left\{\begin{matrix} ^2V_6 = {}^3V_6 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 2n - 2$	1	...	...	...	...	2n − 2											
18	$+$	$^1V_1 + {}^2V_7$	$^3V_7$	$\left\{\begin{matrix} ^2V_7 = {}^3V_7 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 3 + 1 = 4$	1	...	...	...	...	...	4										
19	$\div$	$^3V_6 \div {}^3V_7$	$^1V_9$	$\left\{\begin{matrix} ^3V_6 = {}^3V_6 \\ ^3V_7 = {}^3V_7 \end{matrix}\right\}$	$= \frac{2n-2}{4}$	...	...	...	...	...	2n − 2	4	...	$\frac{2n-2}{4}$	...	$\left\{\frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = A_3\right\}$						
20	$\times$	$^1V_9 \times {}^4V_{11}$	$^5V_{11}$	$\left\{\begin{matrix} ^1V_9 = {}^0V_9 \\ ^4V_{11} = {}^5V_{11} \end{matrix}\right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0	...							
21	$\times$	$^1V_{22} \times {}^5V_{11}$	$^0V_{12}$	$\left\{\begin{matrix} ^1V_{22} = {}^1V_{22} \\ ^0V_{12} = {}^2V_{12} \end{matrix}\right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	....	......	B_3		
22	$+$	$^2V_{12} + {}^2V_{13}$	$^3V_{13}$	$\left\{\begin{matrix} ^2V_{12} = {}^0V_{12} \\ ^2V_{13} = {}^3V_{13} \end{matrix}\right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....	0	$\{A_0 + B_1 A_1 + B_3 A_3\}$				
23	$-$	$^2V_{10} - {}^1V_1$	$^3V_{10}$	$\left\{\begin{matrix} ^2V_{10} = {}^3V_{10} \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= n - 3\ (= 1)$	1	...	...	...	...	...	...	...	...	n − 3							
					Here follows a repetition of Operations thirteen to twenty-three.																	
24	$+$	$^4V_{13} + {}^0V_{24}$	$^1V_{24}$	$\left\{\begin{matrix} ^4V_{13} = {}^0V_{13} \\ ^0V_{24} = {}^1V_{24} \end{matrix}\right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....	....	....	......	......	......	B_7
25	$+$	$^1V_1 + {}^1V_3$	$^1V_3$	$\left\{\begin{matrix} ^1V_1 = {}^1V_1 \\ ^1V_3 = {}^1V_3 \\ ^5V_6 = {}^0V_6 \\ ^5V_7 = {}^0V_7 \end{matrix}\right\}$	$= n + 1 = 4 + 1 = 5$ by a Variable-card. by a Variable-card.	1	...	n + 1	...	...	0	0										

What does it do?

- Calculates Bernoulli numbers

n	0	1	2	4	6	8	10	12	14	16	18	20
B_n	1	$-\frac{1}{2}$	$\frac{1}{6}$	$-\frac{1}{30}$	$\frac{1}{42}$	$-\frac{1}{30}$	$\frac{5}{66}$	$-\frac{691}{2730}$	$\frac{7}{6}$	$-\frac{3617}{510}$	$\frac{43867}{798}$	$-\frac{174611}{330}$
$\frac{B_n}{n}$			$\frac{1}{12}$	$-\frac{1}{120}$	$\frac{1}{252}$	$-\frac{1}{240}$	$\frac{1}{132}$	$-\frac{691}{32760}$	$\frac{1}{12}$	$-\frac{3617}{8160}$	$\frac{43867}{14364}$	$-\frac{174611}{6600}$

What does it do?

- ...but in decimals!

1: -0.5
2: 0.16666666666666666
4: -0.033333333333333326
6: 0.023809523809523778
8: -0.03333333333333313
10: 0.07575757575757391
12: -0.2531135531135289
14: 1.1666666666662246
16: -7.092156862734392
18: 54.97117794453055

How are the numbers calculated?

- Stuff with fractions

How are the numbers calculated?

- Stuff with fractions

$$0 = -\frac{1}{2}\cdot\frac{2n-1}{2n+1} + B_1\left(\frac{2n}{2}\right) + B_3\left(\frac{2n\cdot(2n-1)\cdot(2n-2)}{2\cdot 3\cdot 4}\right)$$
$$+B_5\left(\frac{2n\cdot(2n-1)\cdot(2n-2)\cdot(2n-3)\cdot(2n-4)}{2\cdot 3\cdot 4\cdot 5\cdot 6}\right) + \ldots + B_{2n-1}$$

How are the numbers calculated?

- Stuff with fractions

$$0 = A_0(n) + A_1(n) \cdot B_1 + A_3(n) \cdot B_3 + \ldots + A_{2n-3}(n) \cdot B_{2n-3} + B_{2n-1}$$

$$A_0(n) = -\frac{1}{2} \cdot \frac{2n-1}{2n+1}$$

$$A_1(n) = \frac{2n}{2}$$

$$A_3(n) = A_1(n) \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4}$$

$$A_5(n) = A_3(n) \cdot \frac{2n-3}{5} \cdot \frac{2n-4}{6}$$

How are the numbers calculated?

- Stuff with fractions

$$-B_{2n-1} = A_0(n) + A_1(n) \cdot B_1 + A_3(n) \cdot B_3 + \ldots + A_{2n-3}(n) \cdot B_{2n-3}$$

$$-B_5 = A_0(3) + A_1(3) \cdot B_1 + A_3(3) \cdot B_3$$

$$-B_7 = A_0(4) + A_1(4) \cdot B_1 + A_3(4) \cdot B_3 + A_5(4) \cdot B_5$$

So how does the program do it?

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.			Working Variables.										Result Variables.			
						${}^{1}V_{1}$ ○ 0 0 0 1 [1]	${}^{1}V_{2}$ ○ 0 0 0 2 [2]	${}^{1}V_{3}$ ○ 0 0 0 4 [n]	${}^{0}V_{4}$ ○ 0 0 0 0 [ ]	${}^{0}V_{5}$ ○ 0 0 0 0 [ ]	${}^{0}V_{6}$ ○ 0 0 0 0 [ ]	${}^{0}V_{7}$ ○ 0 0 0 0 [ ]	${}^{0}V_{8}$ ○ 0 0 0 0 [ ]	${}^{0}V_{9}$ ○ 0 0 0 0 [ ]	${}^{0}V_{10}$ ○ 0 0 0 0 [ ]	${}^{0}V_{11}$ ○ 0 0 0 0 [ ]	${}^{0}V_{12}$ ○ 0 0 0 0 [ ]	${}^{0}V_{13}$ ○ 0 0 0 0 [ ]	${}^{1}V_{21}$ B_1 in a decimal ○ fraction. [B_1]	${}^{1}V_{22}$ B_3 in a decimal ○ fraction. [B_3]	${}^{1}V_{23}$ B_5 in a decimal ○ fraction. [B_5]	${}^{0}V_{24}$ ○ 0 0 0 0 [B_7]
1	×	${}^{1}V_{2} \times {}^{1}V_{3}$	${}^{1}V_{4}, {}^{1}V_{5}, {}^{1}V_{6}$	$\left\{ {}^{1}V_{2} = {}^{1}V_{2} \atop {}^{1}V_{3} = {}^{1}V_{3} \right\}$	$= 2n$	...	2	n	2n	2n	2n											
2	−	${}^{1}V_{4} - {}^{1}V_{1}$	${}^{2}V_{4}$	$\left\{ {}^{1}V_{4} = {}^{2}V_{4} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= 2n - 1$	1	...	...	2n − 1													
3	+	${}^{1}V_{5} + {}^{1}V_{1}$	${}^{2}V_{5}$	$\left\{ {}^{1}V_{5} = {}^{2}V_{5} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= 2n + 1$	1	...	...	...	2n + 1												
4	÷	${}^{2}V_{5} \div {}^{2}V_{4}$	${}^{1}V_{11}$	$\left\{ {}^{2}V_{5} = {}^{0}V_{5} \atop {}^{2}V_{4} = {}^{0}V_{4} \right\}$	$= \frac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\frac{2n-1}{2n+1}$						
5	÷	${}^{1}V_{11} \div {}^{1}V_{2}$	${}^{2}V_{11}$	$\left\{ {}^{1}V_{11} = {}^{2}V_{11} \atop {}^{1}V_{2} = {}^{1}V_{2} \right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\frac{1}{2} \cdot \frac{2n-1}{2n+1}$						
6	−	${}^{0}V_{13} - {}^{2}V_{11}$	${}^{1}V_{13}$	$\left\{ {}^{2}V_{11} = {}^{0}V_{11} \atop {}^{0}V_{13} = {}^{1}V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	....	$-\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$				
7	−	${}^{1}V_{3} - {}^{1}V_{1}$	${}^{1}V_{10}$	$\left\{ {}^{1}V_{3} = {}^{1}V_{3} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= n - 1\ (= 3)$	1	...	n	...	...	...	...	...	...	n − 1							
8	+	${}^{1}V_{2} + {}^{0}V_{7}$	${}^{1}V_{7}$	$\left\{ {}^{1}V_{2} = {}^{1}V_{2} \atop {}^{0}V_{7} = {}^{1}V_{7} \right\}$	$= 2 + 0 = 2$	...	2	...	...	...	...	2										
9	÷	${}^{1}V_{6} \div {}^{1}V_{7}$	${}^{3}V_{11}$	$\left\{ {}^{1}V_{6} = {}^{1}V_{6} \atop {}^{0}V_{11} = {}^{3}V_{11} \right\}$	$= \frac{2n}{2} = A_1$	...	...	...	...	...	2n	2	...	...	...	$\frac{2n}{2} = A_1$						
10	×	${}^{1}V_{21} \times {}^{3}V_{11}$	${}^{1}V_{12}$	$\left\{ {}^{1}V_{21} = {}^{1}V_{21} \atop {}^{3}V_{11} = {}^{3}V_{11} \right\}$	$= B_1 \cdot \frac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\frac{2n}{2} = A_1$	$B_1 \cdot \frac{2n}{2} = B_1 A_1$	....	B_1			
11	+	${}^{1}V_{12} + {}^{1}V_{13}$	${}^{2}V_{13}$	$\left\{ {}^{1}V_{12} = {}^{0}V_{12} \atop {}^{1}V_{13} = {}^{2}V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2} \right\}$				
12	−	${}^{1}V_{10} - {}^{1}V_{1}$	${}^{2}V_{10}$	$\left\{ {}^{1}V_{10} = {}^{2}V_{10} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= n - 2\ (= 2)$	1	...	...	...	...	...	...	...	...	n − 2							
13	−	${}^{1}V_{6} - {}^{1}V_{1}$	${}^{2}V_{6}$	$\left\{ {}^{1}V_{6} = {}^{2}V_{6} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= 2n - 1$	1	...	...	...	...	2n − 1											
14	+	${}^{1}V_{1} + {}^{1}V_{7}$	${}^{2}V_{7}$	$\left\{ {}^{1}V_{1} = {}^{1}V_{1} \atop {}^{1}V_{7} = {}^{2}V_{7} \right\}$	$= 2 + 1 = 3$	1	...	...	...	...	...	3										
15	÷	${}^{2}V_{6} \div {}^{2}V_{7}$	${}^{1}V_{8}$	$\left\{ {}^{2}V_{6} = {}^{2}V_{6} \atop {}^{2}V_{7} = {}^{2}V_{7} \right\}$	$= \frac{2n-1}{3}$	...	...	...	...	...	2n − 1	3	$\frac{2n-1}{3}$									
16	×	${}^{1}V_{8} \times {}^{3}V_{11}$	${}^{4}V_{11}$	$\left\{ {}^{1}V_{8} = {}^{0}V_{8} \atop {}^{3}V_{11} = {}^{4}V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\frac{2n}{2} \cdot \frac{2n-1}{3}$						
17	−	${}^{2}V_{6} - {}^{1}V_{1}$	${}^{3}V_{6}$	$\left\{ {}^{2}V_{6} = {}^{3}V_{6} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= 2n - 2$	1	...	...	...	...	2n − 2											
18	+	${}^{1}V_{1} + {}^{2}V_{7}$	${}^{3}V_{7}$	$\left\{ {}^{2}V_{7} = {}^{3}V_{7} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= 3 + 1 = 4$	1	...	...	...	...	...	4										
19	÷	${}^{3}V_{6} \div {}^{3}V_{7}$	${}^{1}V_{9}$	$\left\{ {}^{3}V_{6} = {}^{3}V_{6} \atop {}^{3}V_{7} = {}^{3}V_{7} \right\}$	$= \frac{2n-2}{4}$	...	...	...	...	...	2n − 2	4	...	$\frac{2n-2}{4}$	...	$\left\{ \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = A_3 \right\}$						
20	×	${}^{1}V_{9} \times {}^{4}V_{11}$	${}^{5}V_{11}$	$\left\{ {}^{1}V_{9} = {}^{0}V_{9} \atop {}^{4}V_{11} = {}^{5}V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0	...							
21	×	${}^{1}V_{22} \times {}^{5}V_{11}$	${}^{0}V_{12}$	$\left\{ {}^{1}V_{22} = {}^{1}V_{22} \atop {}^{0}V_{12} = {}^{2}V_{12} \right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	....	......	B_3		
22	+	${}^{2}V_{12} + {}^{2}V_{13}$	${}^{3}V_{13}$	$\left\{ {}^{2}V_{12} = {}^{0}V_{12} \atop {}^{2}V_{13} = {}^{3}V_{13} \right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ A_0 + B_1 A_1 + B_3 A_3 \right\}$				
23	−	${}^{2}V_{10} - {}^{1}V_{1}$	${}^{3}V_{10}$	$\left\{ {}^{2}V_{10} = {}^{3}V_{10} \atop {}^{1}V_{1} = {}^{1}V_{1} \right\}$	$= n - 3\ (= 1)$	1	...	...	...	...	...	...	...	...	n − 3							
Here follows a repetition of Operations thirteen to twenty-three.																						
24	+	${}^{4}V_{13} + {}^{0}V_{24}$	${}^{1}V_{24}$	$\left\{ {}^{4}V_{13} = {}^{0}V_{13} \atop {}^{0}V_{24} = {}^{1}V_{24} \right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....	....	....	......	......	......	B_7
25	+	${}^{1}V_{1} + {}^{1}V_{3}$	${}^{1}V_{3}$	$\left\{ {}^{1}V_{1} = {}^{1}V_{1} \atop {}^{1}V_{3} = {}^{1}V_{3} \right\}$ $\left\{ {}^{5}V_{6} = {}^{0}V_{6} \atop {}^{5}V_{7} = {}^{0}V_{7} \right\}$	$= n + 1 = 4 + 1 = 5$ by a Variable-card. by a Variable card.	1	...	n + 1	...	...	0	0										

So how does the program do it?

- Number of operation
- Nature of operation
- Variables acted upon
- Variables receiving results
- Indication of change in the value on any variable
- Statement of results

1	×	$^1V_2 \times {}^1V_3$	$^1V_4, {}^1V_5, {}^1V_6$	$\left\{\begin{matrix} ^1V_2 = {}^1V_2 \\ ^1V_3 = {}^1V_3 \end{matrix}\right\}$	$= 2n$ ....
2	−	$^1V_4 - {}^1V_1$	$^2V_4$	$\left\{\begin{matrix} ^1V_4 = {}^2V_4 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 2n - 1$ ....
3	+	$^1V_5 + {}^1V_1$	$^2V_5$	$\left\{\begin{matrix} ^1V_5 = {}^2V_5 \\ ^1V_1 = {}^1V_1 \end{matrix}\right\}$	$= 2n + 1$ ....

@marquis de geek

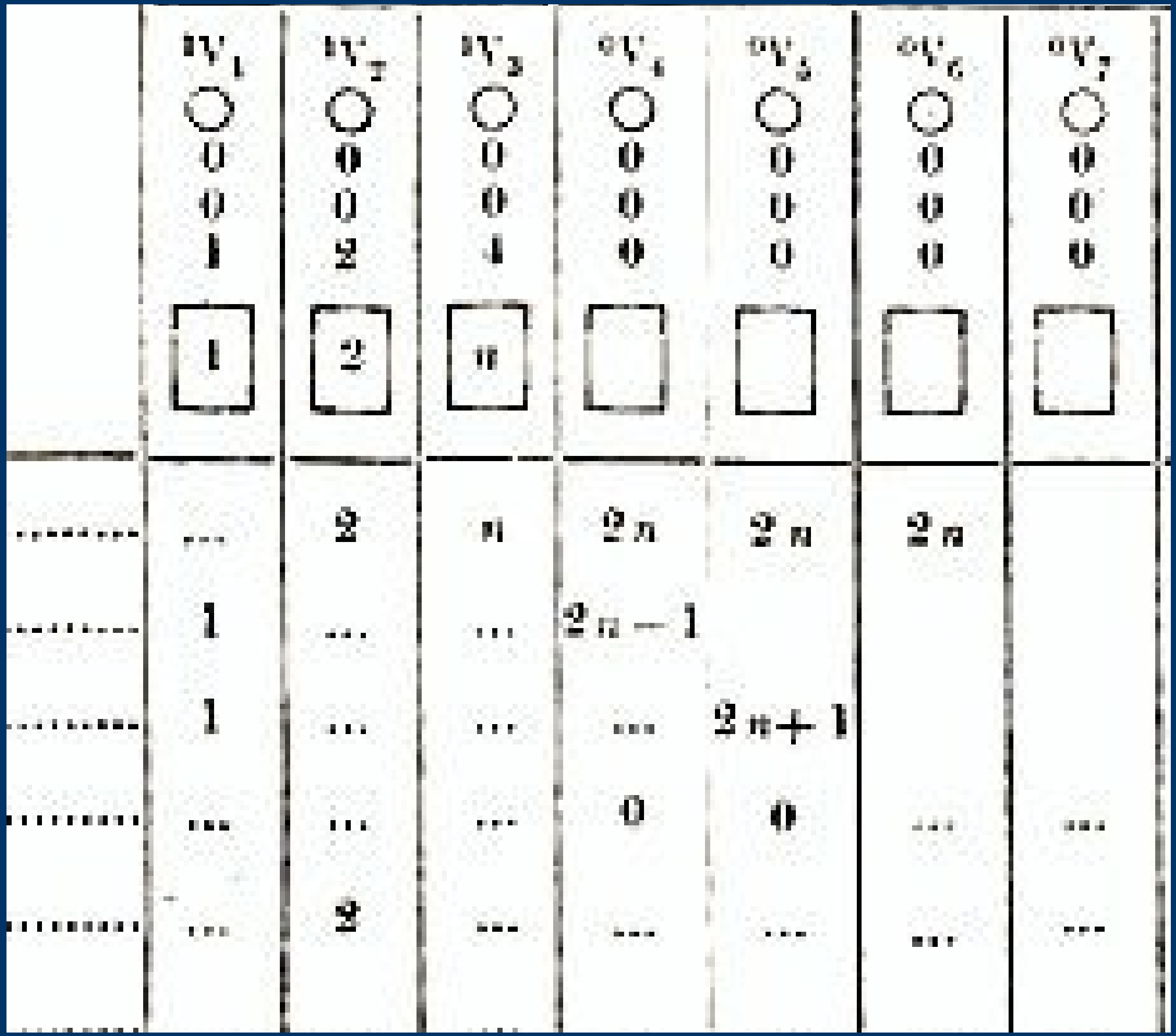
Initialisation?

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. ${}^{1}V_{1}$ ○ 0 0 0 1 [1]	Data. ${}^{1}V_{2}$ ○ 0 0 0 2 [2]	Data. ${}^{1}V_{3}$ ○ 0 0 0 4 [n]	Working Variables. ${}^{0}V_{4}$ ○ 0 0 0 0	${}^{0}V_{5}$ ○ 0 0 0 0	${}^{0}V_{6}$ ○ 0 0 0 0	${}^{0}V_{7}$ ○ 0 0 0 0	${}^{0}V_{8}$ ○ 0 0 0 0	${}^{0}V_{9}$ ○ 0 0 0 0	${}^{0}V_{10}$ ○ 0 0 0 0	${}^{0}V_{11}$ ○ 0 0 0 0	${}^{0}V_{12}$ ○ 0 0 0 0	${}^{0}V_{13}$ ○ 0 0 0 0	Result Variables. ${}^{1}V_{21}$ B_1 in a decimal fraction. ○ [B_1]	${}^{1}V_{22}$ B_3 in a decimal fraction. ○ [B_3]	${}^{1}V_{23}$ B_5 in a decimal fraction. ○ [B_5]	${}^{0}V_{24}$ ○ 0 0 0 0 [B_7]
1	×	${}^{1}V_2 \times {}^{1}V_3$	${}^{1}V_4, {}^{1}V_5, {}^{1}V_6$	$\left\{ {}^{1}V_2 = {}^{1}V_2 \atop {}^{1}V_3 = {}^{1}V_3 \right\}$	$= 2n$	...	2	n	2n	2n	2n											
2	−	${}^{1}V_4 - {}^{1}V_1$	${}^{2}V_4$	$\left\{ {}^{1}V_4 = {}^{2}V_4 \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= 2n - 1$	1	...	...	2n − 1													
3	+	${}^{1}V_5 + {}^{1}V_1$	${}^{2}V_5$	$\left\{ {}^{1}V_5 = {}^{2}V_5 \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= 2n + 1$	1	...	...	...	2n + 1												
4	÷	${}^{2}V_5 \div {}^{2}V_4$	${}^{1}V_{11}$	$\left\{ {}^{2}V_5 = {}^{0}V_5 \atop {}^{2}V_4 = {}^{0}V_4 \right\}$	$= \frac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\frac{2n-1}{2n+1}$						
5	÷	${}^{1}V_{11} \div {}^{1}V_2$	${}^{2}V_{11}$	$\left\{ {}^{1}V_{11} = {}^{2}V_{11} \atop {}^{1}V_2 = {}^{1}V_2 \right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\frac{1}{2} \cdot \frac{2n-1}{2n+1}$						
6	−	${}^{0}V_{13} - {}^{2}V_{11}$	${}^{1}V_{13}$	$\left\{ {}^{2}V_{11} = {}^{0}V_{11} \atop {}^{0}V_{13} = {}^{1}V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	....	$-\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$				
7	−	${}^{1}V_3 - {}^{1}V_1$	${}^{1}V_{10}$	$\left\{ {}^{1}V_3 = {}^{1}V_3 \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= n - 1 \; (= 3)$	1	...	n	...	...	...	...	...	...	n − 1							
8	+	${}^{1}V_2 + {}^{0}V_7$	${}^{1}V_7$	$\left\{ {}^{1}V_2 = {}^{1}V_2 \atop {}^{0}V_7 = {}^{1}V_7 \right\}$	$= 2 + 0 = 2$	...	2	...	...	...	...	2										
9	÷	${}^{1}V_6 \div {}^{1}V_7$	${}^{3}V_{11}$	$\left\{ {}^{1}V_6 = {}^{1}V_6 \atop {}^{0}V_{11} = {}^{3}V_{11} \right\}$	$= \frac{2n}{2} = A_1$	...	...	...	...	...	2n	2	...	...	...	$\frac{2n}{2} = A_1$						
10	×	${}^{1}V_{21} \times {}^{3}V_{11}$	${}^{1}V_{12}$	$\left\{ {}^{1}V_{21} = {}^{1}V_{21} \atop {}^{3}V_{11} = {}^{3}V_{11} \right\}$	$= B_1 \cdot \frac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\frac{2n}{2} = A_1$	$B_1 \cdot \frac{2n}{2} = B_1 A_1$	....	B_1			
11	+	${}^{1}V_{12} + {}^{1}V_{13}$	${}^{2}V_{13}$	$\left\{ {}^{1}V_{12} = {}^{0}V_{12} \atop {}^{1}V_{13} = {}^{2}V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2} \right\}$				
12	−	${}^{1}V_{10} - {}^{1}V_1$	${}^{2}V_{10}$	$\left\{ {}^{1}V_{10} = {}^{2}V_{10} \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= n - 2 \; (= 2)$	1	...	...	...	...	...	...	...	...	n − 2							
13	−	${}^{1}V_6 - {}^{1}V_1$	${}^{2}V_6$	$\left\{ {}^{1}V_6 = {}^{2}V_6 \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= 2n - 1$	1	...	...	...	...	2n − 1											
14	+	${}^{1}V_1 + {}^{1}V_7$	${}^{2}V_7$	$\left\{ {}^{1}V_1 = {}^{1}V_1 \atop {}^{1}V_7 = {}^{2}V_7 \right\}$	$= 2 + 1 = 3$	1	...	...	...	...	...	3										
15	÷	${}^{2}V_6 \div {}^{2}V_7$	${}^{1}V_8$	$\left\{ {}^{2}V_6 = {}^{2}V_6 \atop {}^{2}V_7 = {}^{2}V_7 \right\}$	$= \frac{2n-1}{3}$	...	...	...	...	...	2n − 1	3	$\frac{2n-1}{3}$									
16	×	${}^{1}V_8 \times {}^{3}V_{11}$	${}^{4}V_{11}$	$\left\{ {}^{1}V_8 = {}^{0}V_8 \atop {}^{3}V_{11} = {}^{4}V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\frac{2n}{2} \cdot \frac{2n-1}{3}$						
17	−	${}^{2}V_6 - {}^{1}V_1$	${}^{3}V_6$	$\left\{ {}^{2}V_6 = {}^{3}V_6 \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= 2n - 2$	1	...	...	...	...	2n − 2											
18	+	${}^{1}V_1 + {}^{2}V_7$	${}^{3}V_7$	$\left\{ {}^{2}V_7 = {}^{3}V_7 \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= 3 + 1 = 4$	1	...	...	...	...	...	4										
19	÷	${}^{3}V_6 \div {}^{3}V_7$	${}^{1}V_9$	$\left\{ {}^{3}V_6 = {}^{3}V_6 \atop {}^{3}V_7 = {}^{3}V_7 \right\}$	$= \frac{2n-2}{4}$	...	...	...	...	...	2n − 2	4	...	$\frac{2n-2}{4}$	...	$\left\{ \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = A_3 \right\}$						
20	×	${}^{1}V_9 \times {}^{4}V_{11}$	${}^{5}V_{11}$	$\left\{ {}^{1}V_9 = {}^{0}V_9 \atop {}^{4}V_{11} = {}^{5}V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0								
21	×	${}^{1}V_{22} \times {}^{5}V_{11}$	${}^{0}V_{12}$	$\left\{ {}^{1}V_{22} = {}^{1}V_{22} \atop {}^{0}V_{12} = {}^{2}V_{12} \right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	....	....	B_3		
22	+	${}^{2}V_{12} + {}^{2}V_{13}$	${}^{3}V_{13}$	$\left\{ {}^{2}V_{12} = {}^{0}V_{12} \atop {}^{2}V_{13} = {}^{3}V_{13} \right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ A_0 + B_1 A_1 + B_3 A_3 \right\}$				
23	−	${}^{2}V_{10} - {}^{1}V_1$	${}^{3}V_{10}$	$\left\{ {}^{2}V_{10} = {}^{3}V_{10} \atop {}^{1}V_1 = {}^{1}V_1 \right\}$	$= n - 3 \; (= 1)$	1	...	...	...	...	...	...	...	...	n − 3							
					Here follows a repetition of Operations thirteen to twenty-three.																	
24	+	${}^{4}V_{13} + {}^{0}V_{24}$	${}^{1}V_{24}$	$\left\{ {}^{4}V_{13} = {}^{0}V_{13} \atop {}^{0}V_{24} = {}^{1}V_{24} \right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....	....	....	....	....	....	B_7
25	+	${}^{1}V_1 + {}^{1}V_3$	${}^{1}V_3$	$\left\{ {}^{1}V_1 = {}^{1}V_1 \atop {}^{1}V_3 = {}^{1}V_3 \right\}$; ${}^{5}V_6 = {}^{0}V_6$; ${}^{5}V_7 = {}^{0}V_7$	$= n + 1 = 4 + 1 = 5$; by a Variable-card.; by a Variable-card.	1	...	n + 1	...	...	0	0										

Initialisation?

- V1 = 1
- V2 = 2
- V3 = n = 4



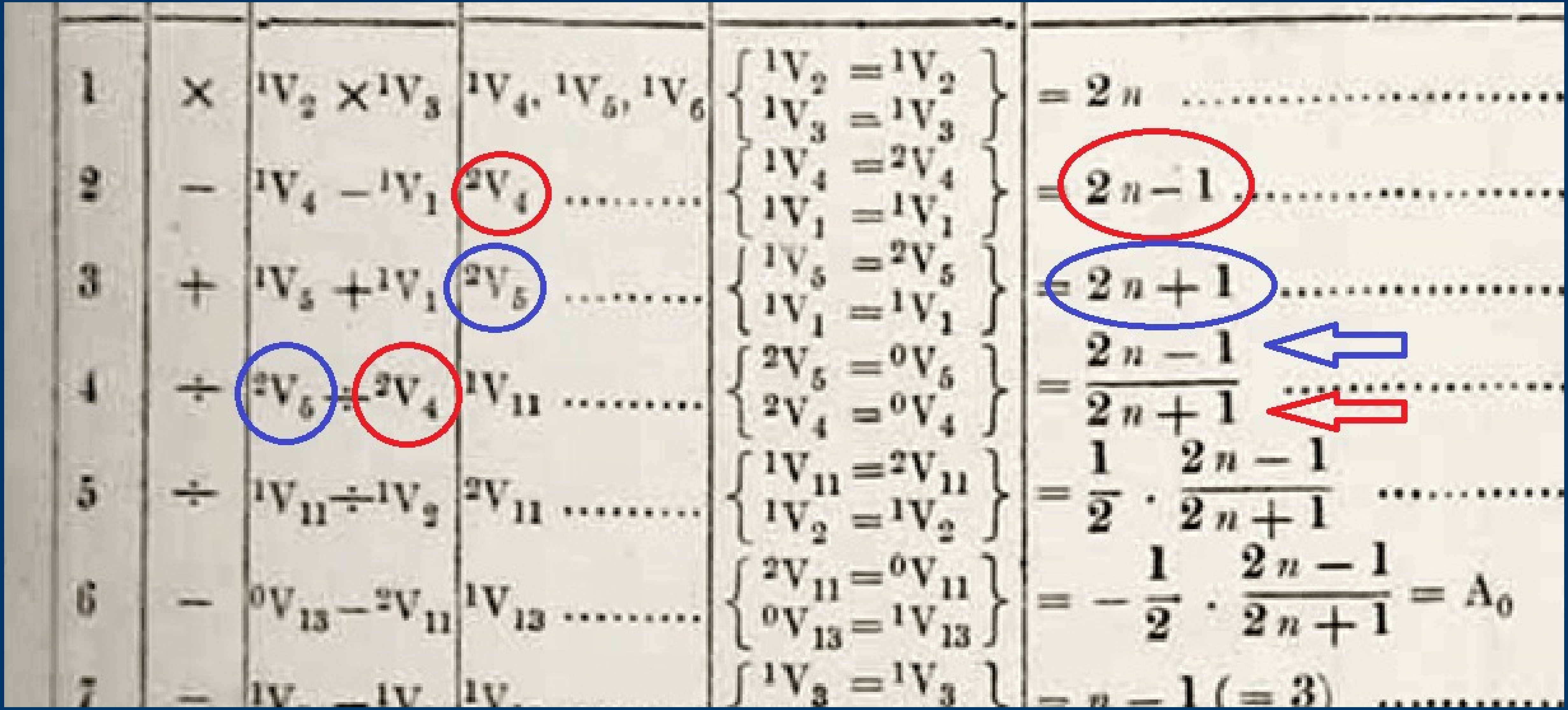
	$^1V_1$	$^1V_2$	$^1V_3$	$^0V_4$	$^0V_5$	$^0V_6$	$^0V_7$
	0 0 0 1 [1]	0 0 0 2 [2]	0 0 0 4 [n]	0 0 0 0 [ ]	0 0 0 0 [ ]	0 0 0 0 [ ]	0 0 0 0 [ ]
....	...	2	n	2n	2n	2n	
....	1	...	...	2n − 1			
....	1	...	...	...	2n + 1		
....	...	...	...	0	0	...	...
....	...	2	...	...	...	...	...

The very first computer program

1	×	$^1V_2 \times {}^1V_3$	$^1V_4, {}^1V_5, {}^1V_6$	$\left\{ \begin{matrix} ^1V_2 = {}^1V_2 \\ ^1V_3 = {}^1V_3 \end{matrix} \right\}$	$= 2n$ ....
2	−	$^1V_4 - {}^1V_1$	$^2V_4$	$\left\{ \begin{matrix} ^1V_4 = {}^2V_4 \\ ^1V_1 = {}^1V_1 \end{matrix} \right\}$	$= 2n - 1$ ....
3	+	$^1V_5 + {}^1V_1$	$^2V_5$	$\left\{ \begin{matrix} ^1V_5 = {}^2V_5 \\ ^1V_1 = {}^1V_1 \end{matrix} \right\}$	$= 2n + 1$ ....
4	÷	$^2V_5 \div {}^2V_4$	$^1V_{11}$	$\left\{ \begin{matrix} ^2V_5 = {}^0V_5 \\ ^2V_4 = {}^0V_4 \end{matrix} \right\}$	$= \frac{2n - 1}{2n + 1}$ ....
5	÷	$^1V_{11} \div {}^1V_2$	$^2V_{11}$	$\left\{ \begin{matrix} ^1V_{11} = {}^2V_{11} \\ ^1V_2 = {}^1V_2 \end{matrix} \right\}$	$= \frac{1}{2} \cdot \frac{2n - 1}{2n + 1}$ ....
6	−	$^0V_{13} - {}^2V_{11}$	$^1V_{13}$	$\left\{ \begin{matrix} ^2V_{11} = {}^0V_{11} \\ ^0V_{13} = {}^1V_{13} \end{matrix} \right\}$	$= -\frac{1}{2} \cdot \frac{2n - 1}{2n + 1} = A_0$ ....

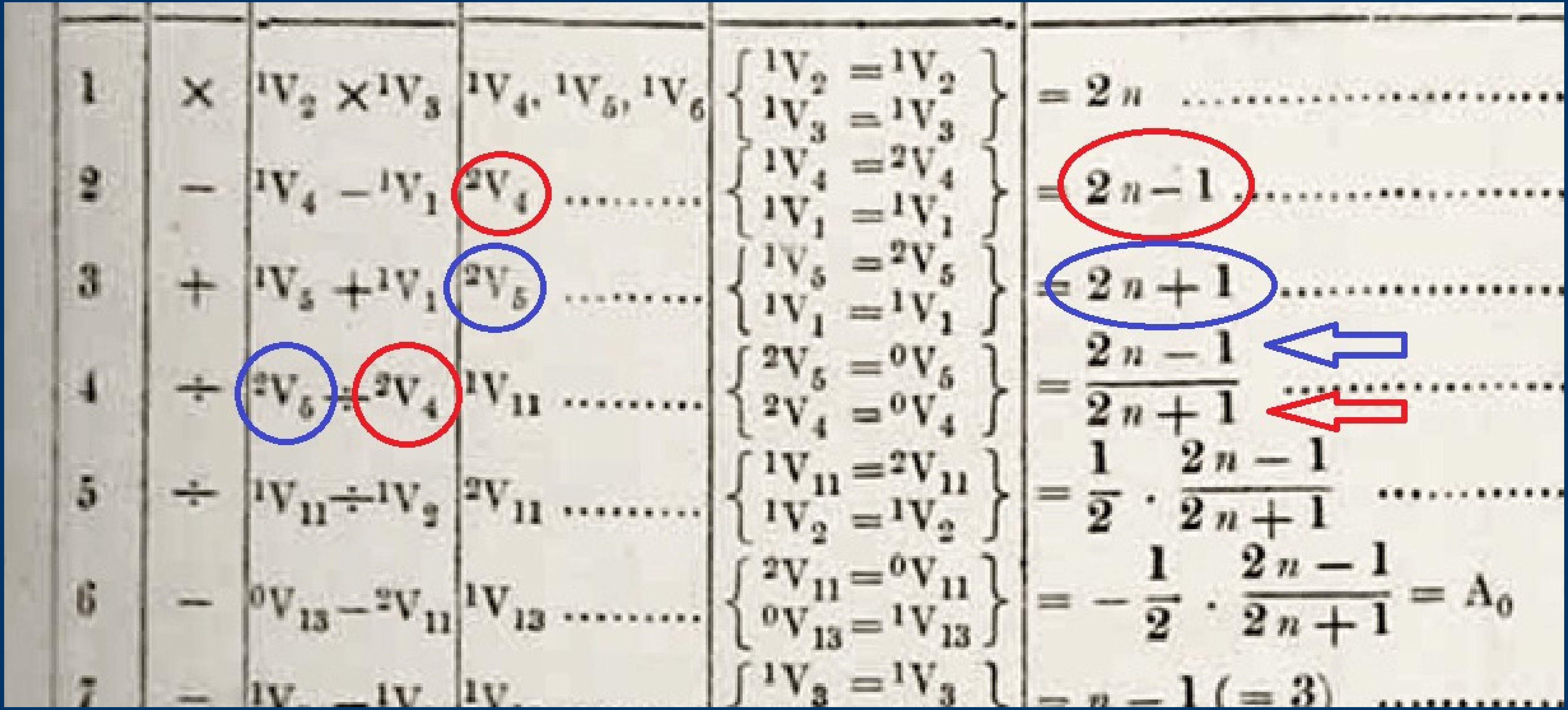
@marquis de geek

The very first computer program



1	$\times$	${}^1V_2 \times {}^1V_3$	${}^1V_4, {}^1V_5, {}^1V_6$	$\left\{ {}^1V_2 = {}^1V_2 \atop {}^1V_3 = {}^1V_3 \right\}$	$= 2n$
2	$-$	${}^1V_4 - {}^1V_1$	${}^2V_4$	$\left\{ {}^1V_4 = {}^2V_4 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 1$
3	$+$	${}^1V_5 + {}^1V_1$	${}^2V_5$	$\left\{ {}^1V_5 = {}^2V_5 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 2n + 1$
4	$\div$	${}^2V_5 \div {}^2V_4$	${}^1V_{11}$	$\left\{ {}^2V_5 = {}^0V_5 \atop {}^2V_4 = {}^0V_4 \right\}$	$= \frac{2n-1}{2n+1}$
5	$\div$	${}^1V_{11} \div {}^1V_2$	${}^2V_{11}$	$\left\{ {}^1V_{11} = {}^2V_{11} \atop {}^1V_2 = {}^1V_2 \right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$
6	$-$	${}^0V_{13} - {}^2V_{11}$	${}^1V_{13}$	$\left\{ {}^2V_{11} = {}^0V_{11} \atop {}^0V_{13} = {}^1V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$
7	$-$	[illegible]	[illegible]	$\{ {}^1V_3 = {}^1V_3$ …	$= n - 1 (= 3)$

The very first computer bug



1	×	$^1V_2 \times {}^1V_3$	$^1V_4, {}^1V_5, {}^1V_6$	$\left\{ \begin{matrix} ^1V_2 = {}^1V_2 \\ ^1V_3 = {}^1V_3 \end{matrix} \right\}$	$= 2n$
2	−	$^1V_4 - {}^1V_1$	$^2V_4$	$\left\{ \begin{matrix} ^1V_4 = {}^2V_4 \\ ^1V_1 = {}^1V_1 \end{matrix} \right\}$	$= 2n - 1$
3	+	$^1V_5 + {}^1V_1$	$^2V_5$	$\left\{ \begin{matrix} ^1V_5 = {}^2V_5 \\ ^1V_1 = {}^1V_1 \end{matrix} \right\}$	$= 2n + 1$
4	÷	$^2V_5 \div {}^2V_4$	$^1V_{11}$	$\left\{ \begin{matrix} ^2V_5 = {}^0V_5 \\ ^2V_4 = {}^0V_4 \end{matrix} \right\}$	$= \frac{2n-1}{2n+1}$
5	÷	$^1V_{11} \div {}^1V_2$	$^2V_{11}$	$\left\{ \begin{matrix} ^1V_{11} = {}^2V_{11} \\ ^1V_2 = {}^1V_2 \end{matrix} \right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$
6	−	$^0V_{13} - {}^2V_{11}$	$^1V_{13}$	$\left\{ \begin{matrix} ^2V_{11} = {}^0V_{11} \\ ^0V_{13} = {}^1V_{13} \end{matrix} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$
7	−	[illegible]	[illegible]	$^1V_3 = {}^1V_3$	$= n - 1 \ (= 3)$

@marquis de geek

A basic simulator

```
/*  1 */  { op:'x', a:2,  b:3,  d:[4,5,6] }, // 2n
/*  2 */  { op:'-', a:4,  b:1,  d:[4] },     // 2n-1
/*  3 */  { op:'+', a:5,  b:1,  d:[5] },     // 2n+1
/*  4 */  { op:'/', a:4,  b:5,  d:[11] },    // (2n-1)/(2n+1)
/*  5 */  { op:'/', a:11, b:2,  d:[11] },    // (2n-1)/(2n+1)/2
```

A basic simulator

```
let a = code[pc].a;
let b = code[pc].b;

switch(code[pc].op) {
  case 'x':
  mill = state.v[a] * state.v[b];
  break;
  case '+':
  mill = state.v[a] + state.v[b];
  break;
  case '-':
  mill = state.v[a] - state.v[b];
  break;
  case '/':
  mill = state.v[a] / state.v[b];
  break;
```

@marquis de geek

A basic simulator

```
code[pc].d.forEach(function(dest) {
  state.v[dest] = mill;
});

pc = pc + 1;
```

Going around?

- Remember this?

$$-B_5 = A_0(3) + A_1(3) \cdot B_1 + A_3(3) \cdot B_3$$
$$-B_7 = A_0(4) + A_1(4) \cdot B_1 + A_3(4) \cdot B_3 + A_5(4) \cdot B_5$$

Going around?

- The first loop!

21	×	${}^1V_{22} \times {}^5V_{11}$	${}^0V_{12}$	$\left\{ \begin{matrix} {}^1V_{22} = {}^1V_{22} \\ {}^0V_{12} = {}^2V_{12} \end{matrix} \right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0
22	+	${}^2V_{12} + {}^2V_{13}$	${}^3V_{13}$	$\left\{ \begin{matrix} {}^2V_{12} = {}^0V_{12} \\ {}^2V_{13} = {}^3V_{13} \end{matrix} \right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....
23	−	${}^2V_{10} - {}^1V_1$	${}^3V_{10}$	$\left\{ \begin{matrix} {}^2V_{10} = {}^3V_{10} \\ {}^1V_1 = {}^1V_1 \end{matrix} \right\}$	$= n - 3\ (= 1)$	1	...	...	...	...	...	...	...	...	$n - 3$	
									Here follows a repetition of Operations thirteen to twenty-three.							
24	+	${}^4V_{13} + {}^0V_{24}$	${}^1V_{24}$	$\left\{ \begin{matrix} {}^4V_{13} = {}^0V_{13} \\ {}^0V_{24} = {}^1V_{24} \end{matrix} \right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....

@marquis de geek

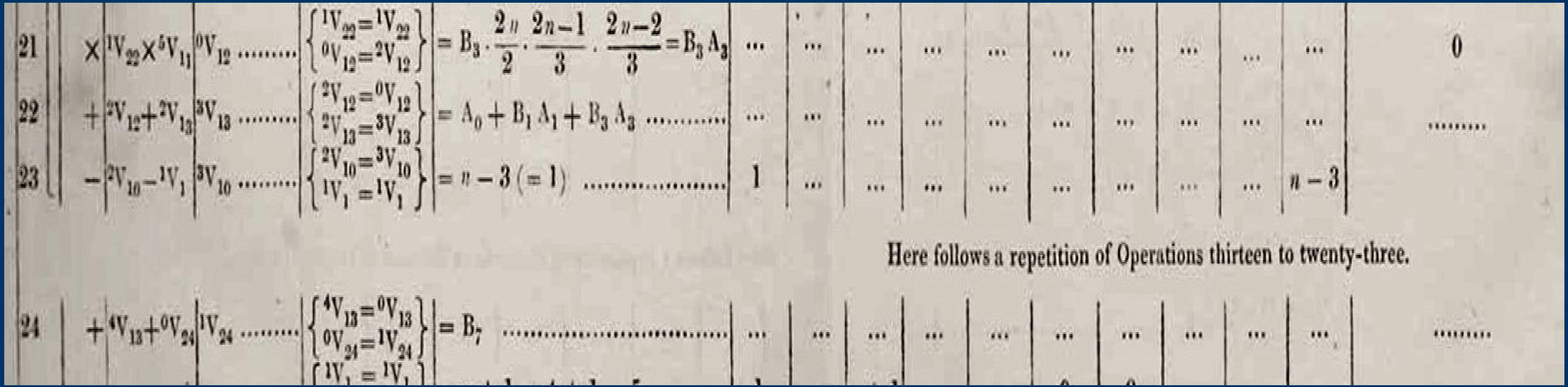
But...

But...

- The variables are constant!

The variables are constant!

- Always a given number!
- No way of saying v[idx]



21	$\times$	$^1V_{22} \times {}^5V_{11}$	$^0V_{12}$	$\left\{\begin{array}{l} ^1V_{22} = {}^1V_{22} \\ ^0V_{12} = {}^2V_{12} \end{array}\right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0
22	$+$	$^2V_{12} + {}^2V_{13}$	$^3V_{13}$	$\left\{\begin{array}{l} ^2V_{12} = {}^0V_{12} \\ ^2V_{13} = {}^3V_{13} \end{array}\right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....
23	$-$	$^2V_{10} - {}^1V_1$	$^3V_{10}$	$\left\{\begin{array}{l} ^2V_{10} = {}^3V_{10} \\ ^1V_1 = {}^1V_1 \end{array}\right\}$	$= n - 3 \; (= 1)$	1	...	...	...	...	...	...	...	...	$n-3$	
							Here follows a repetition of Operations thirteen to twenty-three.									
24	$+$	$^4V_{13} + {}^0V_{24}$	$^1V_{24}$	$\left\{\begin{array}{l} ^4V_{13} = {}^0V_{13} \\ ^0V_{24} = {}^1V_{24} \end{array}\right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....

The transformation process

- `{ op:'x', a:2,  b:3,  d:[4,5,6] }, // 2n`
- `state.v[4] = state.v[5] = state.v[6] = state.v[2] * state.v[3];`
- `state.v[N2M1] = state.v[N2P1] = state.v[6] = 2 * state.v[N];`

- `{ op:'-', a:4,  b:1,  d:[4] },     // 2n-1`
- `state.v[4] -= 1;`
- `state.v[N2M1] -= 1;`

- `accumulatingTotal = (2*n - 1)`

https://github.com/MarquisdeGeek/Ada-Origins

The transformation process

```
  let indexToResult = 1;
  do {
    accumulatingFraction *= (numerator - 1) / (denom + 1); // first terms
of A : (2n-1)/3
    accumulatingFraction *= (numerator - 2) / (denom + 2); // #19  second
2n+1/4

    accumulatingTotal += accumulatingFraction *
state.results[indexToResult];  // #21 A3 * B3

    numerator -= 2;
    denom += 2;

    ++indexToResult;

  } while(--k > 0);

  state.results[indexToResult] = -accumulatingTotal;
```

@marquis de geek

Was Ada really the first programmer?

- The code has a bug
- The notation is problematic
- The loop didn't work
- She was translating someone else's work
- Babbage had already written programs for his own machine

Was Ada really the first programmer?

- I have only one more argument...

Was Ada really the first programmer?

- I have only one more argument...
- ...why *should* she be the first?

Was Ada really the first programmer?

- If this work had been done by a man, would he be considered the first ever programmer?

Was Ada really the first programmer?

- If this work had been done by a man, would he be considered the first ever programmer?
- YES!

Was Ada really the first programmer?

- If this work had been done by a man, would he be considered the first ever programmer?
- YES!
- Therefore, Ada was the first programmer!

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.			Working Variables.										Result Variables.			
						$^1V_1$ 0001 [1]	$^1V_2$ 0002 [2]	$^1V_3$ 0004 [n]	$^0V_4$ 0000	$^0V_5$ 0000	$^0V_6$ 0000	$^0V_7$ 0000	$^0V_8$ 0000	$^0V_9$ 0000	$^0V_{10}$ 0000	$^0V_{11}$ 0000	$^0V_{12}$ 0000	$^0V_{13}$ 0000	$^1V_{21}$ B_1 in a decimal fraction. [B_1]	$^1V_{22}$ B_3 in a decimal fraction. [B_3]	$^1V_{23}$ B_5 in a decimal fraction. [B_5]	$^0V_{24}$ 0000 [B_7]
1	×	$^1V_2 \times {}^1V_3$	$^1V_4, {}^1V_5, {}^1V_6$	$\left\{ {}^1V_2 = {}^1V_2 \atop {}^1V_3 = {}^1V_3 \right\}$	$= 2n$	...	2	n	2n	2n	2n											
2	−	$^1V_4 - {}^1V_1$	$^2V_4$	$\left\{ {}^1V_4 = {}^2V_4 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 1$	1	...	...	2n − 1													
3	+	$^1V_5 + {}^1V_1$	$^2V_5$	$\left\{ {}^1V_5 = {}^2V_5 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 2n + 1$	1	...	...	...	2n + 1												
4	÷	$^2V_5 \div {}^2V_4$	$^1V_{11}$	$\left\{ {}^2V_5 = {}^0V_5 \atop {}^2V_4 = {}^0V_4 \right\}$	$= \frac{2n-1}{2n+1}$	...	...	...	0	0	...	...	...	...	...	$\frac{2n-1}{2n+1}$						
5	÷	$^1V_{11} \div {}^1V_2$	$^2V_{11}$	$\left\{ {}^1V_{11} = {}^2V_{11} \atop {}^1V_2 = {}^1V_2 \right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$	...	2	...	...	...	...	...	...	...	...	$\frac{1}{2} \cdot \frac{2n-1}{2n+1}$						
6	−	$^0V_{13} - {}^2V_{11}$	$^1V_{13}$	$\left\{ {}^2V_{11} = {}^0V_{11} \atop {}^0V_{13} = {}^1V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$	...	...	...	...	...	...	...	...	...	...	0	....	$-\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$				
7	−	$^1V_3 - {}^1V_1$	$^1V_{10}$	$\left\{ {}^1V_3 = {}^1V_3 \atop {}^1V_1 = {}^1V_1 \right\}$	$= n - 1 \ (= 3)$	1	...	n	...	...	...	...	...	...	n − 1							
8	+	$^1V_2 + {}^0V_7$	$^1V_7$	$\left\{ {}^1V_2 = {}^1V_2 \atop {}^0V_7 = {}^1V_7 \right\}$	$= 2 + 0 = 2$	...	2	...	...	...	...	2										
9	÷	$^1V_6 \div {}^1V_7$	$^3V_{11}$	$\left\{ {}^1V_6 = {}^1V_6 \atop {}^0V_{11} = {}^3V_{11} \right\}$	$= \frac{2n}{2} = A_1$	...	...	...	...	...	2n	2	...	...	...	$\frac{2n}{2} = A_1$						
10	×	$^1V_{21} \times {}^3V_{11}$	$^1V_{12}$	$\left\{ {}^1V_{21} = {}^1V_{21} \atop {}^3V_{11} = {}^3V_{11} \right\}$	$= B_1 \cdot \frac{2n}{2} = B_1 A_1$	...	...	...	...	...	...	...	...	...	...	$\frac{2n}{2} = A_1$	$B_1 \cdot \frac{2n}{2} = B_1 A_1$	....	B_1			
11	+	$^1V_{12} + {}^1V_{13}$	$^2V_{13}$	$\left\{ {}^1V_{12} = {}^0V_{12} \atop {}^1V_{13} = {}^2V_{13} \right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2}$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ -\frac{1}{2} \cdot \frac{2n-1}{2n+1} + B_1 \cdot \frac{2n}{2} \right\}$				
12	−	$^1V_{10} - {}^1V_1$	$^2V_{10}$	$\left\{ {}^1V_{10} = {}^2V_{10} \atop {}^1V_1 = {}^1V_1 \right\}$	$= n - 2 \ (= 2)$	1	...	...	...	...	...	...	...	...	n − 2							
13	−	$^1V_6 - {}^1V_1$	$^2V_6$	$\left\{ {}^1V_6 = {}^2V_6 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 1$	1	...	...	...	...	2n − 1											
14	+	$^1V_1 + {}^1V_7$	$^2V_7$	$\left\{ {}^1V_1 = {}^1V_1 \atop {}^1V_7 = {}^2V_7 \right\}$	$= 2 + 1 = 3$	1	...	...	...	...	...	3										
15	÷	$^2V_6 \div {}^2V_7$	$^1V_8$	$\left\{ {}^2V_6 = {}^2V_6 \atop {}^2V_7 = {}^2V_7 \right\}$	$= \frac{2n-1}{3}$	...	...	...	...	...	2n − 1	3	$\frac{2n-1}{3}$									
16	×	$^1V_8 \times {}^3V_{11}$	$^4V_{11}$	$\left\{ {}^1V_8 = {}^0V_8 \atop {}^3V_{11} = {}^4V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3}$	...	...	...	...	...	...	...	0	...	...	$\frac{2n}{2} \cdot \frac{2n-1}{3}$						
17	−	$^2V_6 - {}^1V_1$	$^3V_6$	$\left\{ {}^2V_6 = {}^3V_6 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 2n - 2$	1	...	...	...	...	2n − 2											
18	+	$^1V_1 + {}^2V_7$	$^3V_7$	$\left\{ {}^2V_7 = {}^3V_7 \atop {}^1V_1 = {}^1V_1 \right\}$	$= 3 + 1 = 4$	1	...	...	...	...	...	4										
19	÷	$^3V_6 \div {}^3V_7$	$^1V_9$	$\left\{ {}^3V_6 = {}^3V_6 \atop {}^3V_7 = {}^3V_7 \right\}$	$= \frac{2n-2}{4}$	...	...	...	...	...	2n − 2	4	...	$\frac{2n-2}{4}$	...	$\left\{ \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} \atop = A_3 \right\}$						
20	×	$^1V_9 \times {}^4V_{11}$	$^5V_{11}$	$\left\{ {}^1V_9 = {}^0V_9 \atop {}^4V_{11} = {}^5V_{11} \right\}$	$= \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{4} = A_3$	...	...	...	...	...	...	...	...	0	...							
21	×	$^1V_{22} \times {}^5V_{11}$	$^0V_{12}$	$\left\{ {}^1V_{22} = {}^1V_{22} \atop {}^0V_{12} = {}^2V_{12} \right\}$	$= B_3 \cdot \frac{2n}{2} \cdot \frac{2n-1}{3} \cdot \frac{2n-2}{3} = B_3 A_3$	...	...	...	...	...	...	...	...	...	...	0	$B_3 A_3$	....	......	B_3		
22	+	$^2V_{12} + {}^2V_{13}$	$^3V_{13}$	$\left\{ {}^2V_{12} = {}^0V_{12} \atop {}^2V_{13} = {}^3V_{13} \right\}$	$= A_0 + B_1 A_1 + B_3 A_3$	...	...	...	...	...	...	...	...	...	...	....	0	$\left\{ A_0 + B_1 A_1 + B_3 A_3 \right\}$				
23	−	$^2V_{10} - {}^1V_1$	$^3V_{10}$	$\left\{ {}^2V_{10} = {}^3V_{10} \atop {}^1V_1 = {}^1V_1 \right\}$	$= n - 3 \ (= 1)$	1	...	...	...	...	...	...	...	...	n − 3							
					Here follows a repetition of Operations thirteen to twenty-three.																	
24	+	$^4V_{13} + {}^0V_{24}$	$^1V_{24}$	$\left\{ {}^4V_{13} = {}^0V_{13} \atop {}^0V_{24} = {}^1V_{24} \right\}$	$= B_7$	...	...	...	...	...	...	...	...	...	...	....	....	....	......	......	......	B_7
25	+	$^1V_1 + {}^1V_3$	$^1V_3$	$\left\{ {}^1V_1 = {}^1V_1; \ {}^1V_3 = {}^1V_3; \ {}^5V_6 = {}^0V_6; \ {}^5V_7 = {}^0V_7 \right\}$	$= n + 1 = 4 + 1 = 5$ by a Variable-card. by a Variable card.	1	...	n + 1	...	...	0	0										

Conclusions

- The first program did decimal approximations of Bernoulli numbers
- The algorithm given described what to do, but not how
- Ada was that first programmer

Any Questions? Ask me later!

@marquis de geek

www.MarquisdeGeek.com

https://github.com/MarquisdeGeek/Ada-Origins

https://marquisdegeek.com/code_ada99