FROM ANALOG TO DIGITAL AND BACK

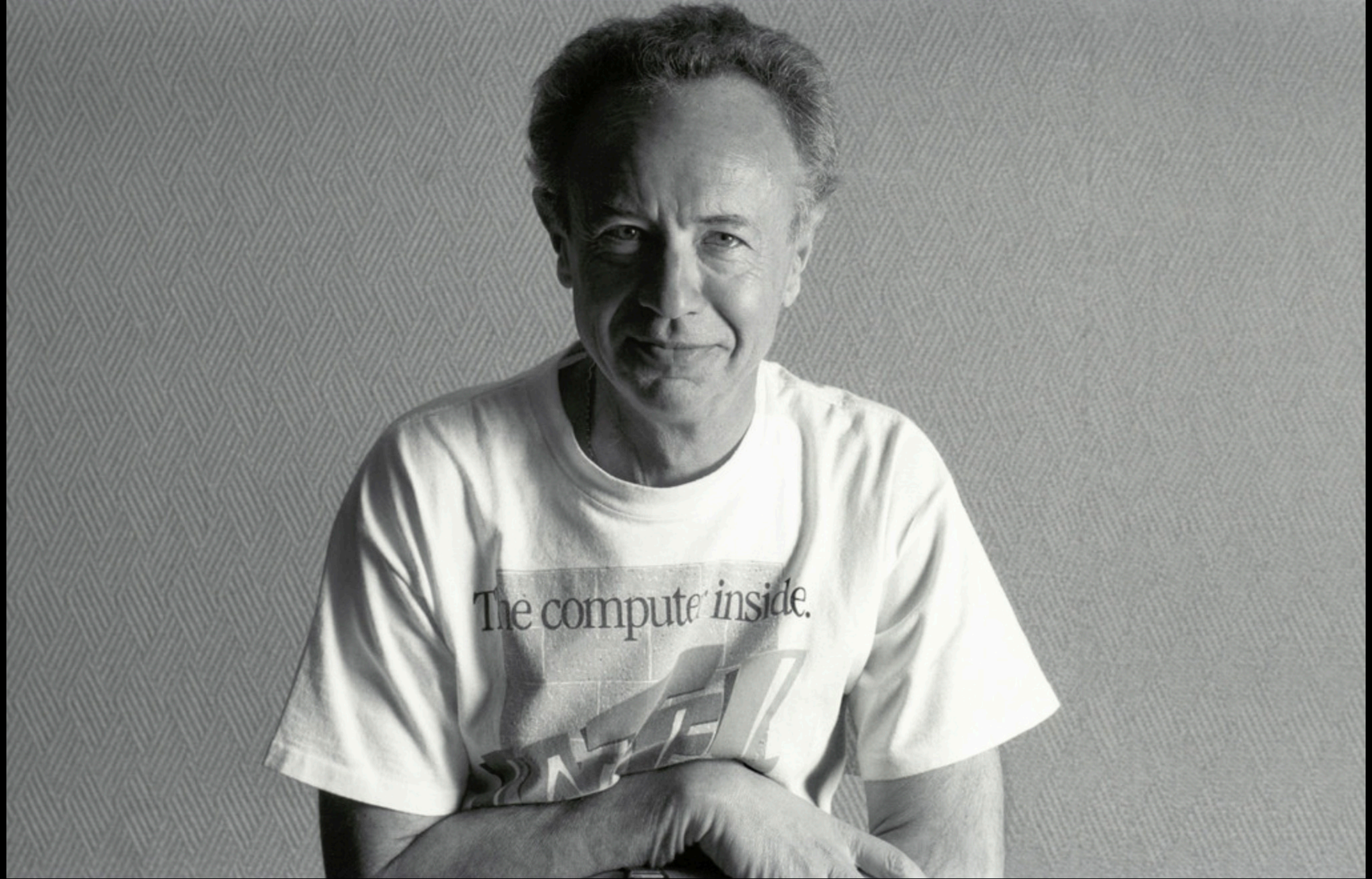
GEORGE DYSON

2018 NICE WORKSHOP

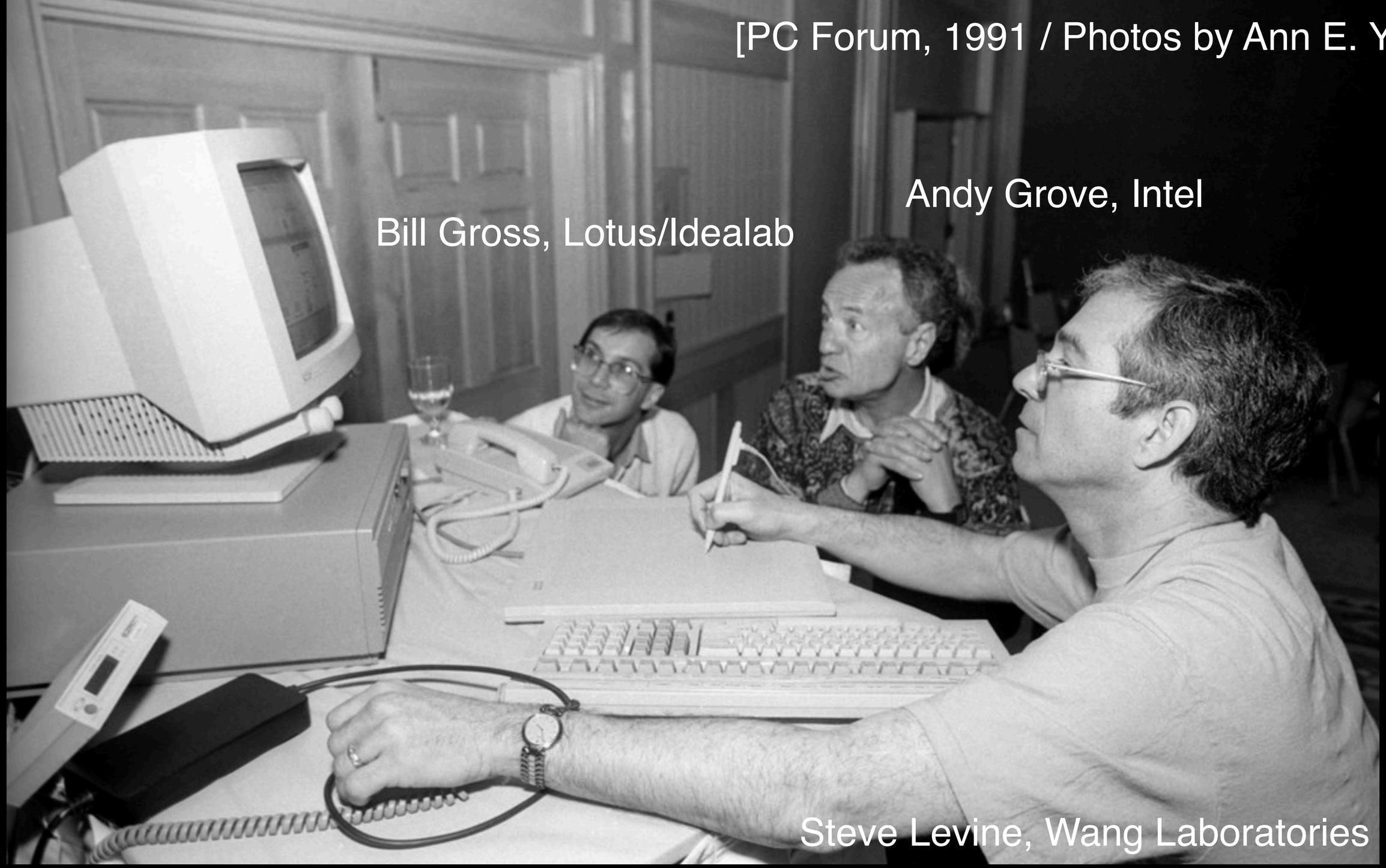
28 FEBUARY 2018

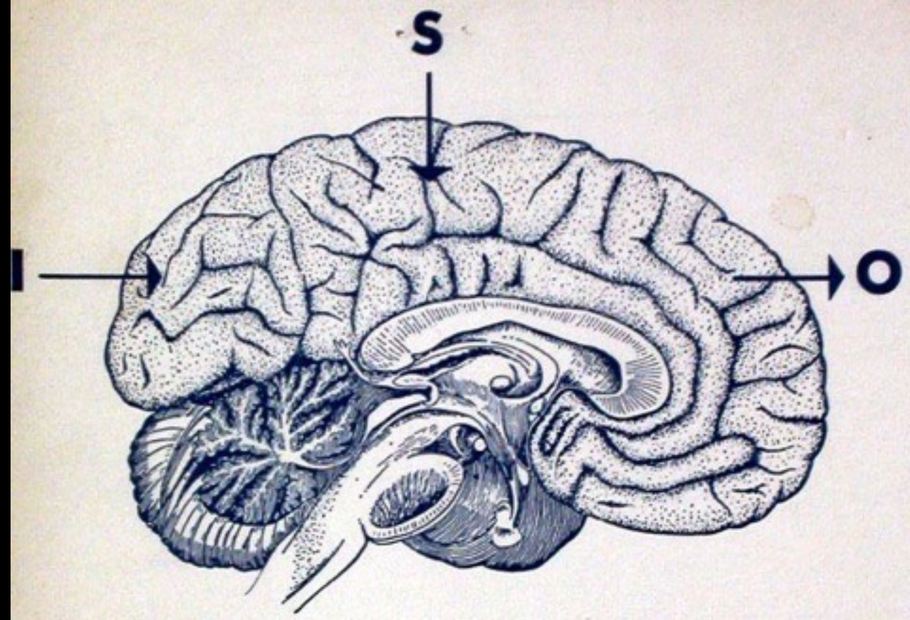
Logic will have to undergo a pseudomorphosis to neurology to a much greater extent than the reverse. . .

—John von Neumann, 1951


The computer inside.


Andy
FORUM
John
FORUM


[PC Forum, 1991 / Photos by Ann E. Yow]
Andy Grove, Intel
Bill Gross, Lotus/Idealab
Steve Levine, Wang Laboratories

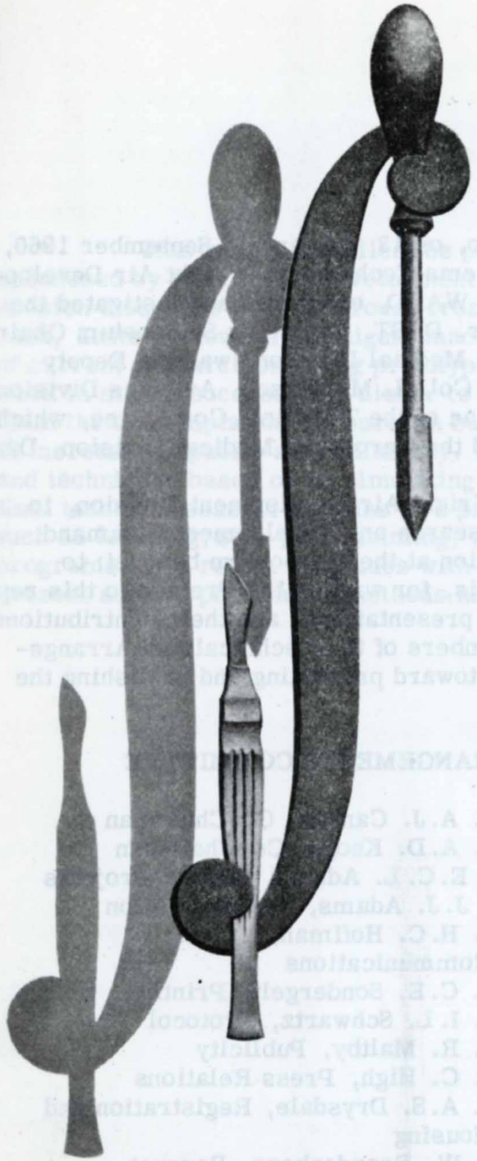


Descriptive Specification for the development of an Adaptive Memory Component

Presented to: Aeronautical Research Laboratory
Wright Air Development Center
Wright-Patterson Air Force Base
Ohio

Presented by: Development Engineering
Defense Electronic Products
Radio Corporation of America
Camden, New Jersey

[1959]



BIONICS SYMPOSIUM

LIVING PROTOTYPES— THE KEY TO NEW TECHNOLOGY

13-14-15 September 1960

December 1960

DIRECTORATE OF ADVANCED SYSTEMS TECHNOLOGY
WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

If your friends in AI persist in ignoring their past, they will be condemned to repeat it, at a high cost that will be borne by the taxpayers.

—Stanislaw Ulam, 1985

Stanislaw Ulam
(1909-1984)

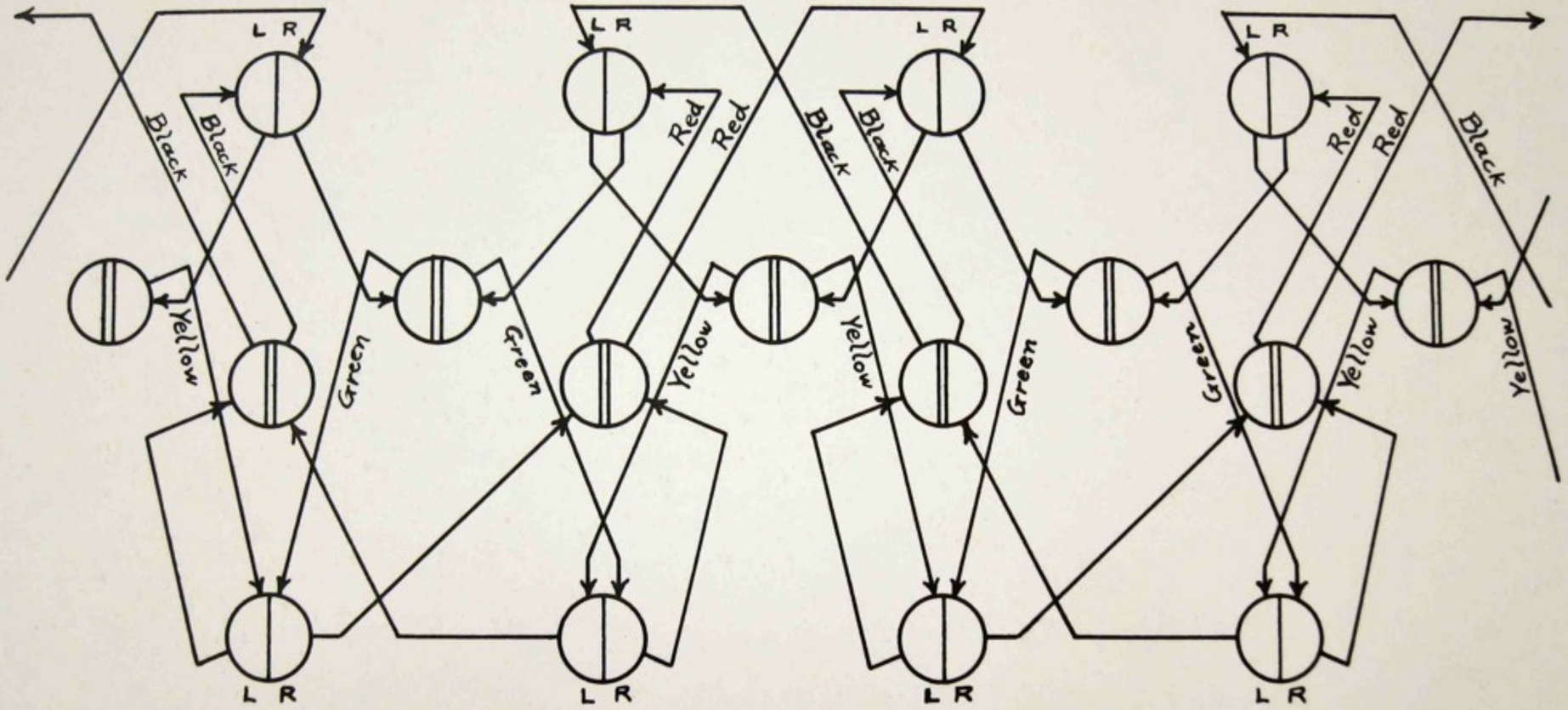
Francoise Ulam
(1918-2011)

Gottfried W. Leibniz
(1646—1716)

[1697]

This [binary] calculus could be implemented by a machine (without wheels) . . . provided with holes in such a way that they can be opened at those places that correspond to a 1 and remain closed at those that correspond to a 0. Through the opened gates small cubes or marbles are to fall into tracks, through the others nothing. It [the gate array] is to be shifted from column to column as required . . .

—G. W. Leibniz, 16 March 1679



ELECTRONIC COMPUTER PROJECT Institute for Advanced Study Princeton, N.J.		
SHIFTING REGISTER No. 7 FUNCTIONAL DIAGRAM C-3-1063		
DATE: March 3, 1948	DRAWN BY: Peter Panagos	CHECKED BY:

We enjoyed some interesting speculative discussions with von Neumann at this time about information propagation and switching among hypothetical arrays of cells, and I believe that some germs of his later cellular automata studies may have originated here.

— Julian Bigelow (1980)

John von Neumann (1903—1957)

United States Patent

2,815,488

NON-LINEAR CAPACITANCE OR INDUCTANCE SWITCHING, AMPLIFYING, AND MEMORY ORGANS

John Von Neumann, Princeton, N. J., assignor to International Business Machines Corporation, New York, N. Y.

Application April 28, 1954, Serial No. 426,149

10 Claims. (Cl. 332—52)

(0.1) Logical machines, so called, which perform complicated control, switching, and information and data handling functions, are at present mainly based on the vacuum tube as a basic component. High speed, long life, and great reliability are their most important and desirable traits.

(0.2) In view of the great complexity of such machines, their vacuum tube components cannot be driven at the highest speeds at which vacuum tubes might be individually operable.

Dec. 3, 1957 J. VON NEUMANN 2,815,488

NON-LINEAR CAPACITANCE OR INDUCTANCE SWITCHING, AMPLIFYING AND MEMORY ORGANS

Filed April 28, 1954 7 Sheets-Sheet 1

Fig. 1

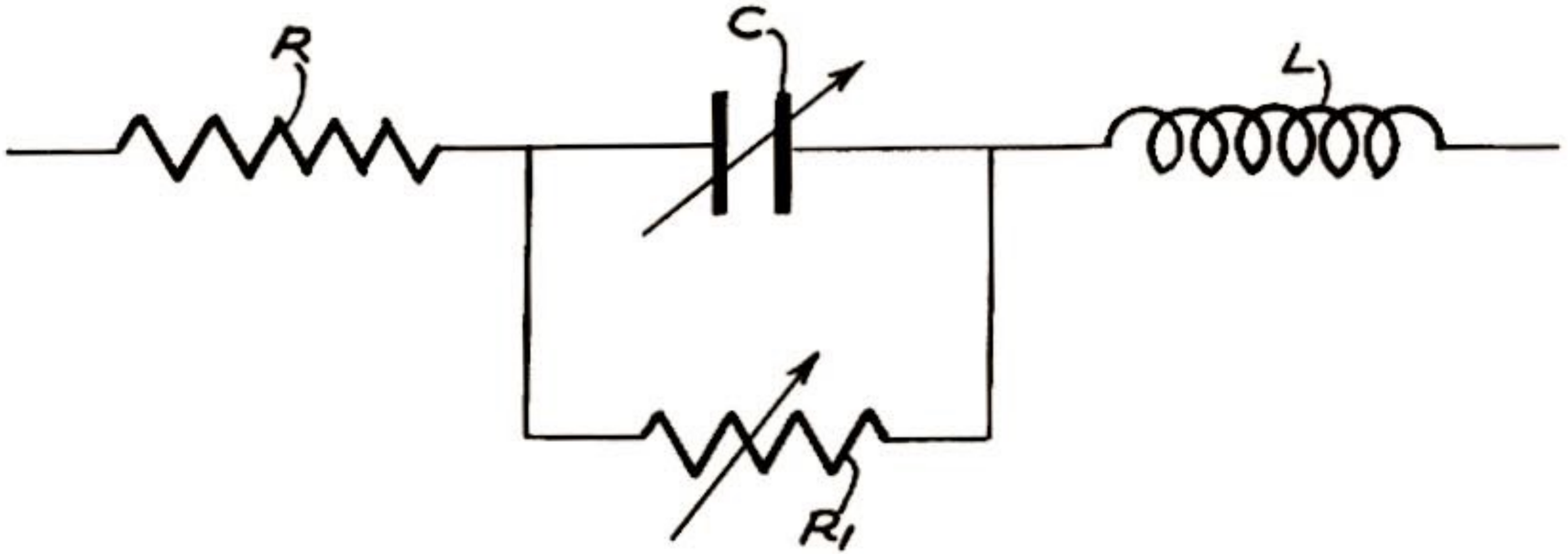


Fig. 2.

Fig. 2.

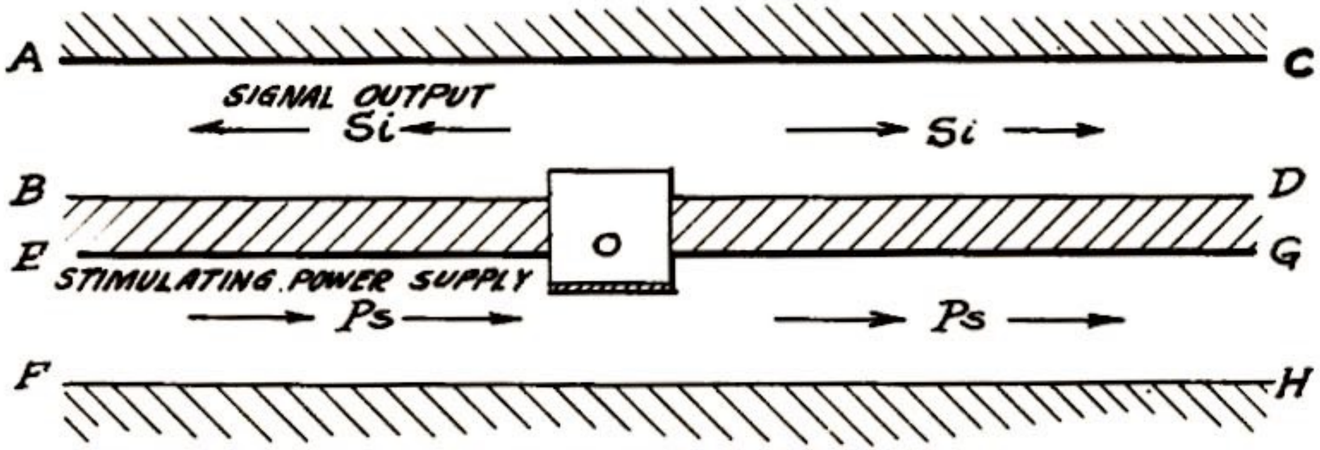
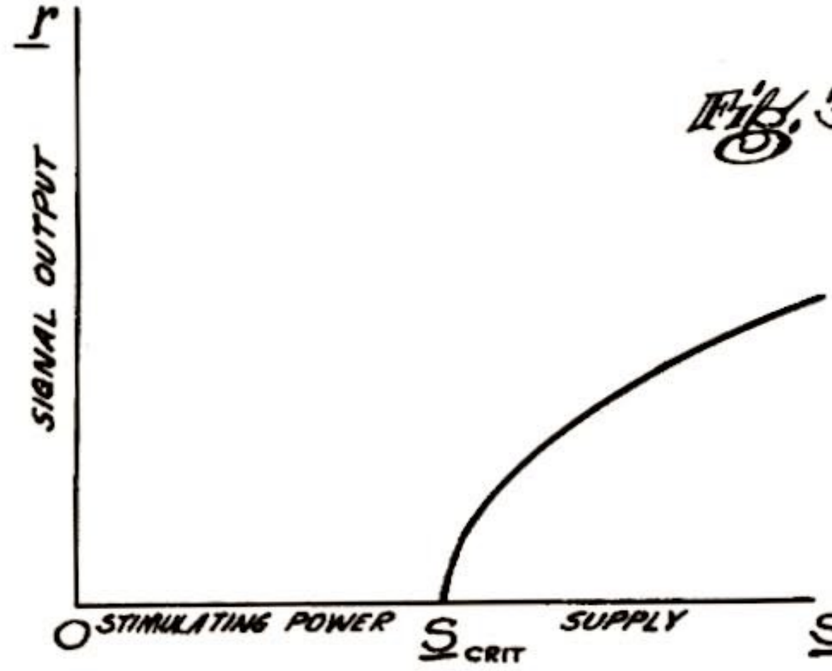
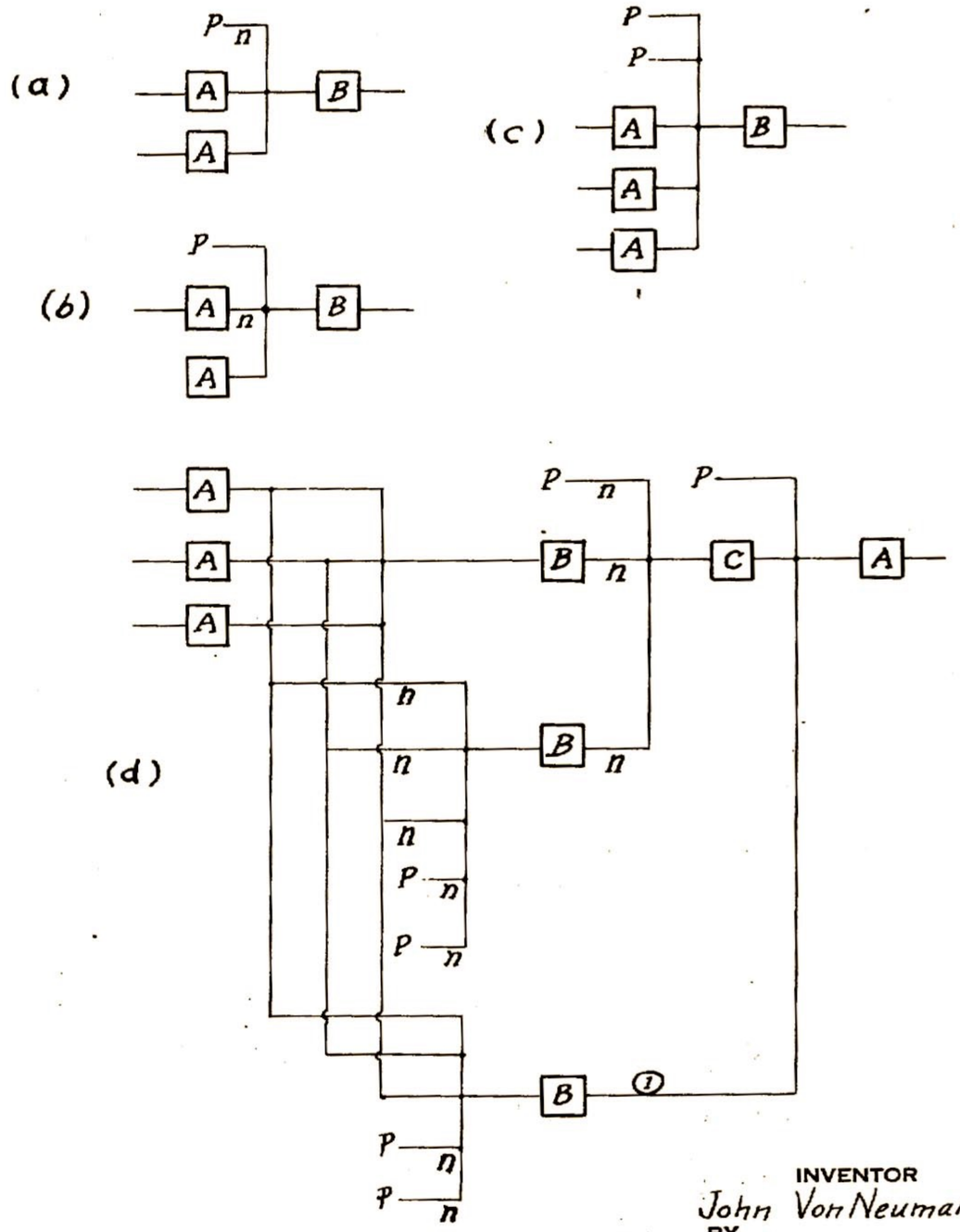


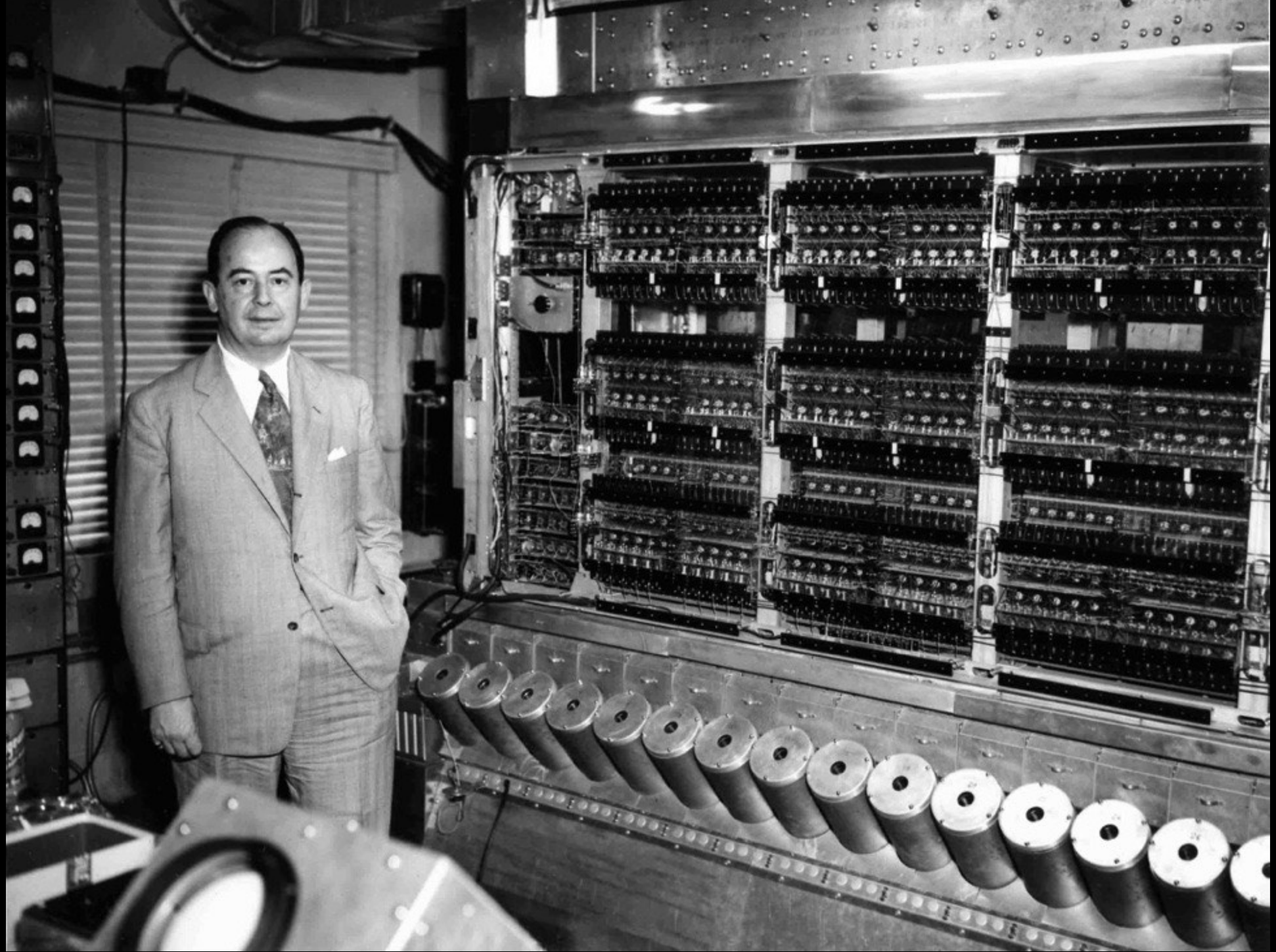
Fig. 3.



INVENTOR
John Von Neumann
BY
Davis Hoxie & Faithfull
ATTORNEYS



INVENTOR
John Von Neumann
BY
Davis Hoxie & Faithfull
ATTORNEYS




1915
Aug 22.

von Neumann

von Braun


(?)
John von Neumann
Eugene Wigner
Mariette (Kövesi)
von Neumann
Mary (Wheeler) Wigner
Angela (Turinsky)
Robertson
H. P Robertson

DIED JUNE 8,1954

PRINCETON UNIVERSITY THE GRADUATE SCHOOL

TURING, ALAN MATHISON Enrolled 9/29/36 Department MATHEMATICS

Date and place of birth June 23, 1912 (Paddington, London) Single x Married

Bachelor and other degrees B.A. University of Cambridge, 1934; Ph.D. Princeton University, 1938

Previous graduate study 1934 (July) to August 1936 University of Cambridge

Teaching experience Jan. 1935 to June 1936 Supervisor of Undergraduates, University of Cambridge

Address: Princeton 183 G.C.; 182 G.C.

Parent or Guardian and address Mr. J. M. Turing, 8 Ennismore Ave., Guildford, England.

1936-37 Fellow from King's College

1937-38 Jane Eliza Procter Visiting Fellow in Mathematics

1938- Fellow at King's College, Cambridge

A. M. or M. F. A. Degree granted

[21-803]

Address

PH. D.

French Satisfactory May 20, 1937 German satisfactory May 20, 1937

General Examination Passed May 26, 1937

Dissertation Subject "Systems of Logic Based on Ordinals".

Dissertation accepted May 18, 1938 Published under

Published 1939. Printed by C.F.Hodgson and Son,Ltd.,2 Newton St., London,W.C.2,England. Copies sent University Library 1939.

Final Examination Passed May 27, 1938 Degree granted June 21, 1938

Diploma address

SYSTEMS OF LOGIC BASED ON ORDINALS†

By A. M. TURING.

[Received 31 May, 1938.—Read 16 June, 1938.]

We have been trying to see how far it is possible to eliminate intuition, and leave only ingenuity. We do not mind how much ingenuity is required, and therefore assume it to be available in unlimited supply . . .

—Alan Turing, 1939

HW 25/3

CCR 1
102(6)

TOP SECRET
ULTRA

65/4/7A

I. A description of the machine.

We begin by describing the 'unsteckered enigma'. The machine consists of a box with 26 keys labelled with the letters of the alphabet and 26 bulbs which shine through stencils on which letters are marked. It also contains wheelswhose function will be described later on. When a key is depressed the wheels are made to move in a certain way and a current flows through the wheels to one of the bulbs. The letter which appears over the bulb is the result of enciphering the letter on the depressed key with the wheels in the position they have when the bulb lights.

To understand the working of the machine it is best to seperate in our minds

The electric circuit of the machine without the wheels.

The circuit through the wheels.

The mechanism for turning the wheels and for describing the positions of the wheels.

The circuit of the machine without the wheels.

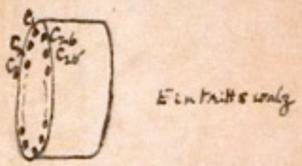


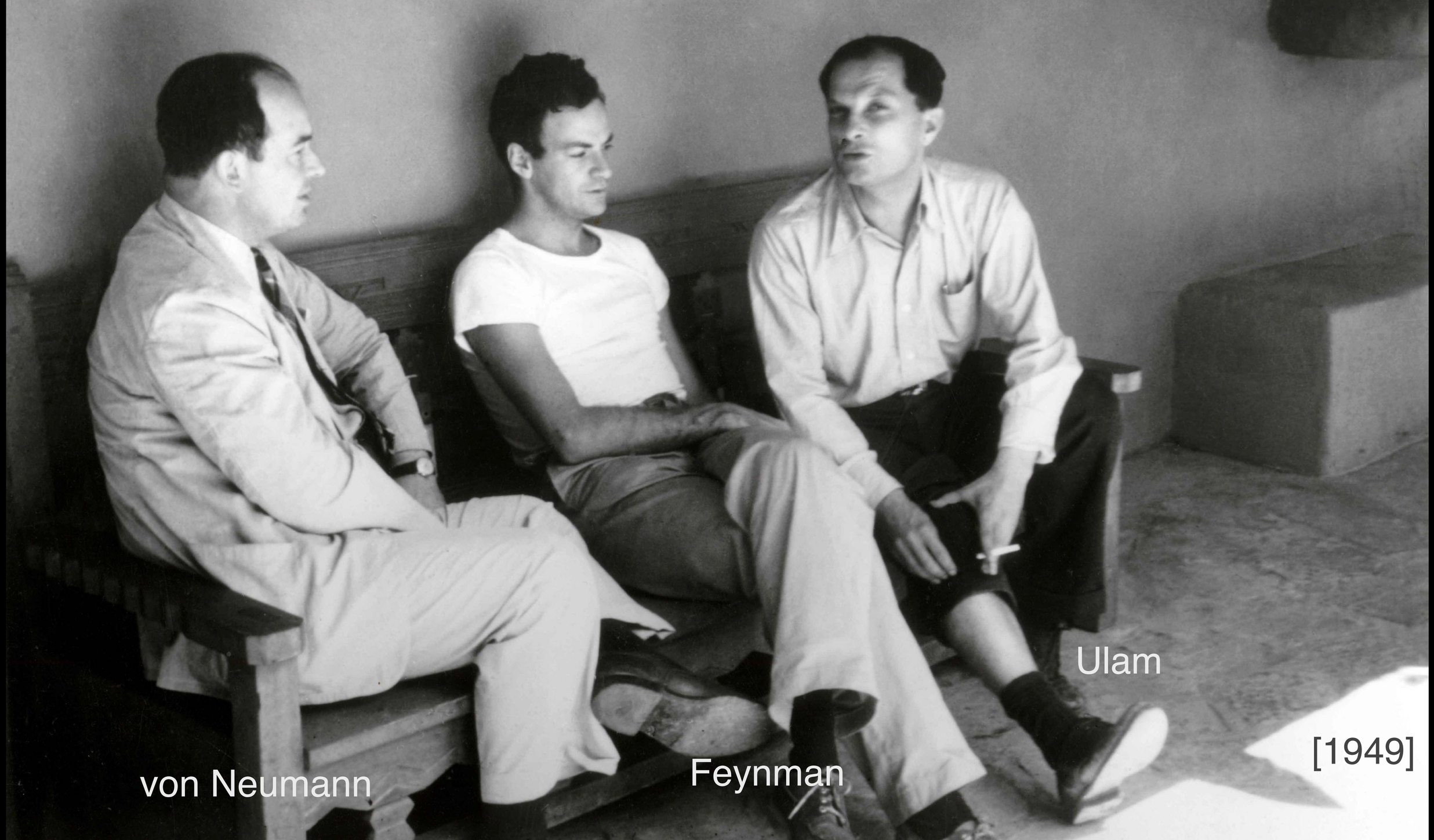
fig 1

Eintrittswalz

The machine contains a cylinder called the Eintrittswalz (E.W)on which are 26 contacts $C_1, C_2, \ldots, C_{26}$. The effect of the wheels is to connect these contacts up in pairs, the actual pairings of course depending on the positions of the wheels. On the other side the contacts $C_1, C_2, \ldots, C_{26}$ are connected each to one of the keys. For the moment we will suppose that the order is QWERTZUIOASDFGHJKPYXCVBNML , and we will say that Q is the letter associated with C_1, W that associated with C_2 etc. This series of letters associated with $C_1, C_2, \ldots, C_{26}$ is called the diagonal, for reasons which will appear in Chap

[1940]


LOS ALAMOS
PROJECT
MAIN GATE
PASSES MUST BE
PRESENTED TO
GUARDS


von Neumann
Feynman
Ulam
[1949]

Nicholas Metropolis (1915-1999)

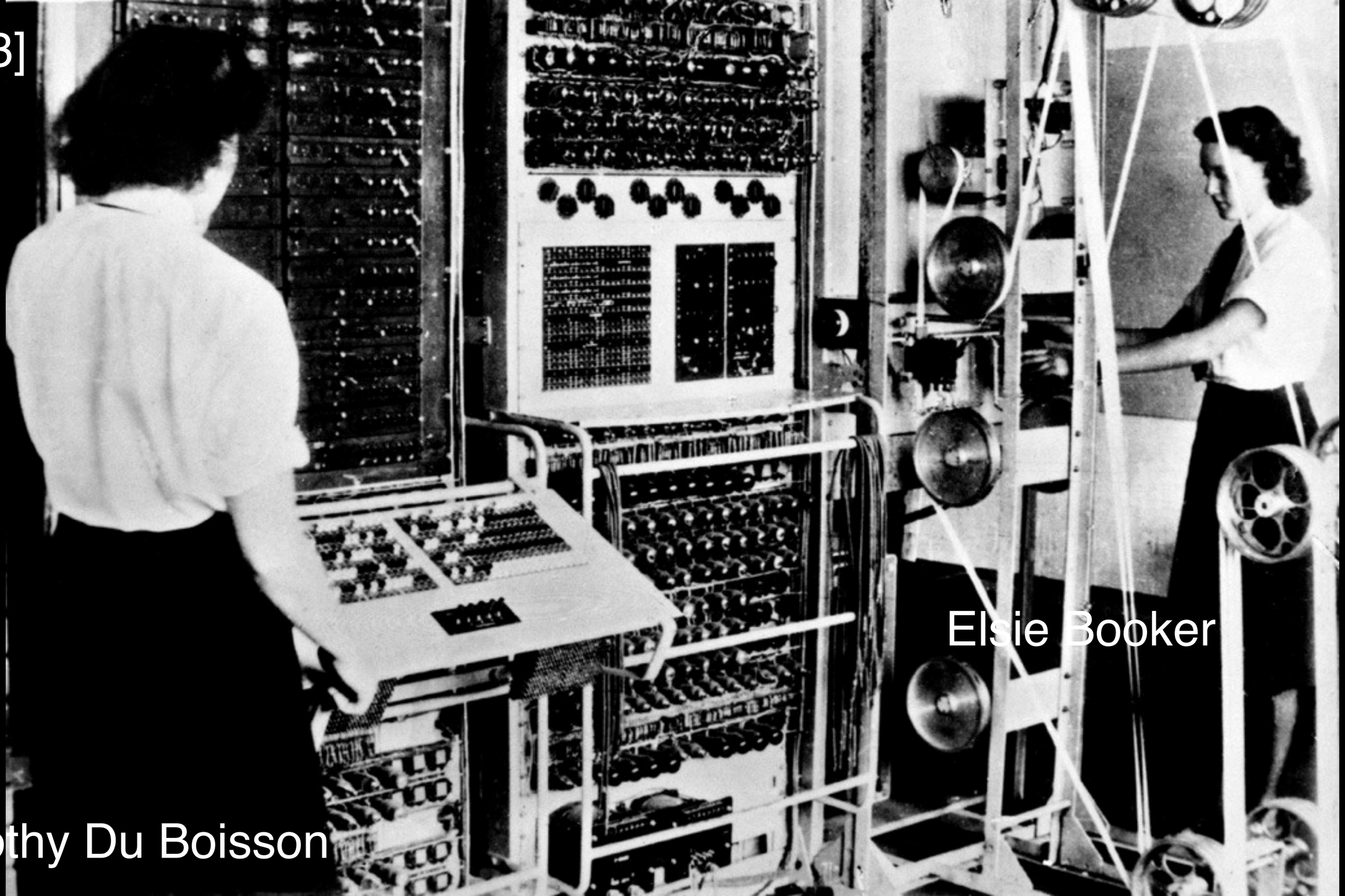
I am thinking about something

much more important than bombs.

I am thinking about computers.

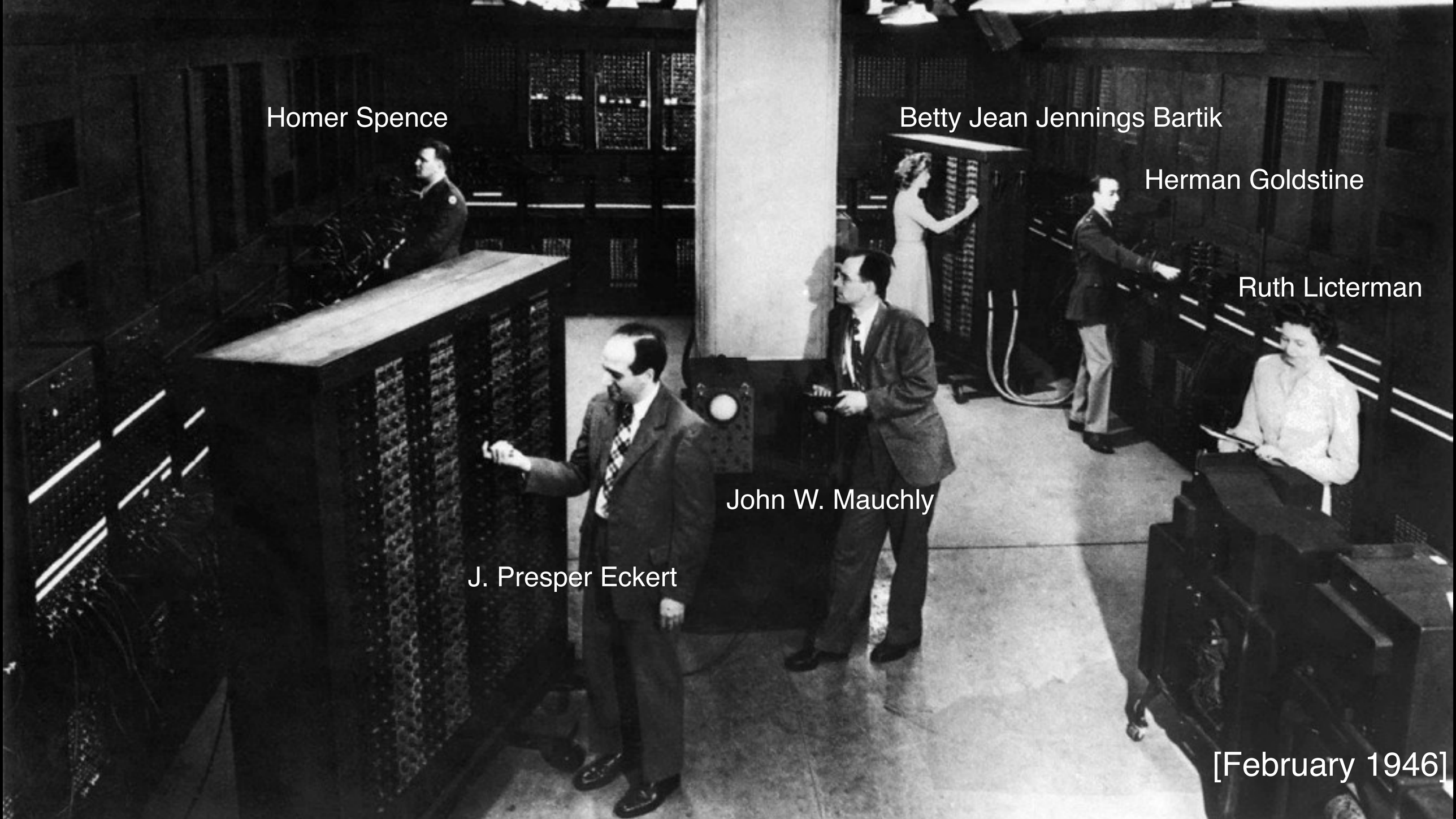
— John von Neumann, 1946

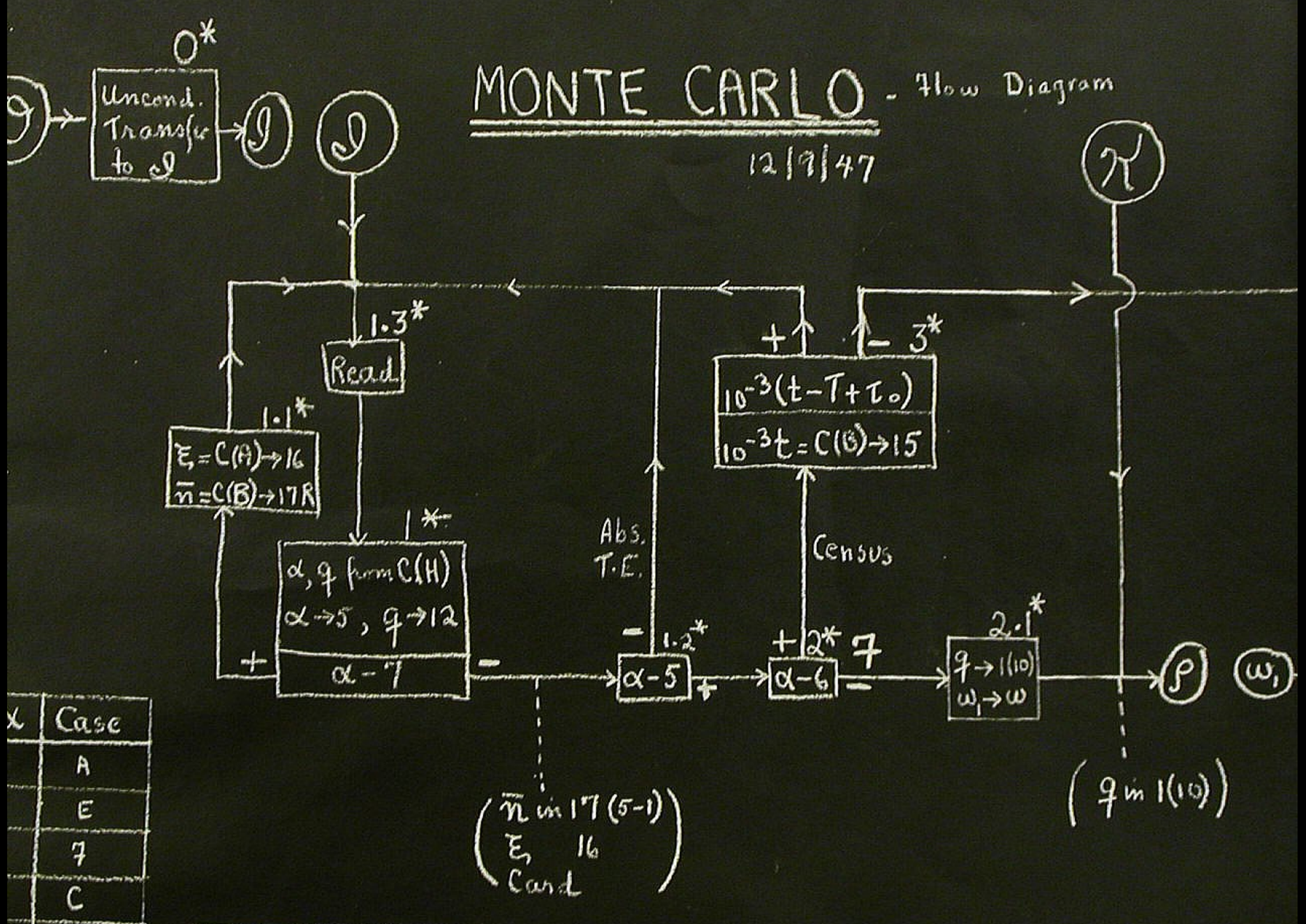
[1943]



Dorothy Du Boisson

Elsie Booker


Homer Spence
Betty Jean Jennings Bartik
Herman Goldstine
Ruth Licterman
John W. Mauchly
J. Presper Eckert
[February 1946]


MONTE CARLO - Flow Diagram
12/9/47
0*
Uncond. Transfer to 9
9
1.3*
Read
1.1*
ξ = C(A) → 16
n̄ = C(B) → 17R
1*
α, q from C(H)
α → 5 , q → 12
α - 7
Abs. T.E.
1.2*
α - 5
+
2*
α - 6
7
Census
+
- 3*
10^-3 (t - T + τ0)
10^-3 t = C(B) → 15
2.1*
q → 1(10)
ω1 → ω
π
ρ
ω1
(n̄ in 17 (5-1)
ξ 16
Card
(q in 1(10)
Case
A
E
7
C

INDICATIONS RELATIVES AU CONDUCTEUR.

Klári (Dan) von Neumann (1911-1963)

4-001789

ABERDEEN PROVING GROUND
MARYLAND
TO BRL

EXPIRES
20 Jan 51
DATE

SPECIAL IDENTIFICATION CARD

AEC

INDUSTRIAL AREA

NAME	VON NEUMANNN, KLARA	HAIR	BROWN
SIGNATURE	Klara v. Neumann	EYES	GREY
ISSUED BY		DATE	18 Dec 50

ORDBG-36

ARMY---OS---ABERDEEN PROVING GROUND, MD---387

[1945]

First Draft of a Report on the EDVAC

by

John von Neumann

Contract No. W-670-ORD-4926

Between the

United States Army Ordnance Department

and the

University of Pennsylvania

Moore School of Electrical Engineering
University of Pennsylvania

June 30, 1945

4.0 Elements, Synchronism Neuron Analogy

4.1 We begin the discussion with some general remarks:

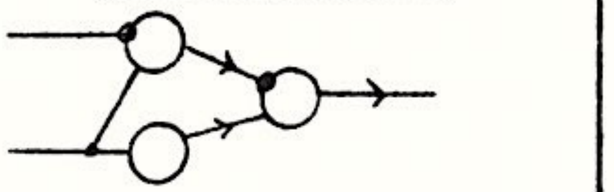
Every digital computing device contains certain relay like elements, with discrete equilibria. Such an element has two or more distinct states in which it can exist indefinitely. These may be perfect equilibria, in each of which the element will remain without any outside support, while appropriate outside stimuli will transfer it from one equilibrium into another. Or, alternatively, there may be two states, one of which is an equilibrium which exists when there is no outside

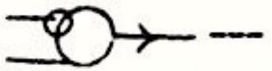
4.2 It is worth mentioning, that the neurons of the higher animals are definitely elements in the above sense. They have all-or-none character, that is two states: Quiescent and excited. They fulfill the requirements of 4.1 with an interesting variant: An excited neuron emits the standard stimulus along many lines (axons). Such a line can, however, be connected in two different ways to the next neuron: First: In an excitatory synapsis, so that the stimulus causes the excitation of that neuron. Second: In an inhibitory synapsis, so that the stimulus absolutely prevents the excitation of that neuron by any stimulus on any other (excitatory) synapsis. The neuron also has a definite reaction time, between the reception of a stimulus and the emission of the stimuli caused by it, the synaptic delay.

Following W. Pitts and W. S. MacCulloch ("A logical calculus of the ideas immanent in nervous activity", Bull. Math. Biophysics, Vol. 5 (1943), pp 115-133) we ignore the more complicated aspects

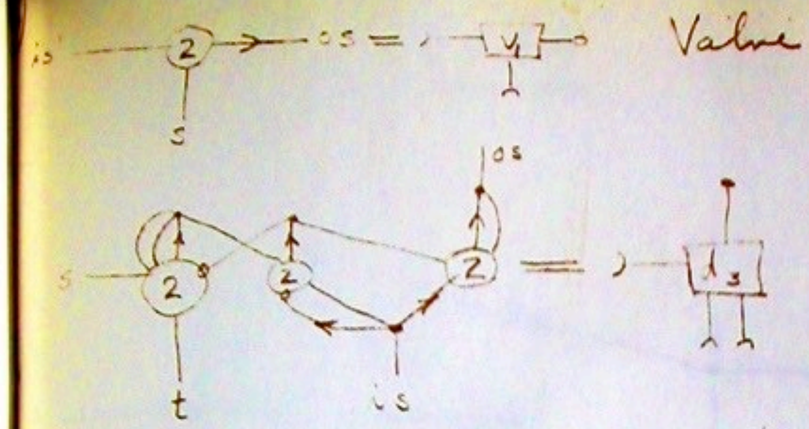
It should be observed, that the authors quoted above have shown, that most of these elements can be built up from each other. Thus $0 \rightarrow\!\!\!\!\!\rightarrow$ is clearly equivalent to $0 \rightarrow 0 \rightarrow$, and in the case of $\textcircled{2} \rightarrow$ at least $= \textcircled{2} \rightarrow\!\!\!\!\!\rightarrow$ is equivalent to the network of Figure 2, However, it would seem to be misleading in our application, to represent these functions as if they required 2 or 3 E-elements, since their complexity in a vacuum tube realization is not essentially greater than that of the simplest E-element $0 \rightarrow$, cf.

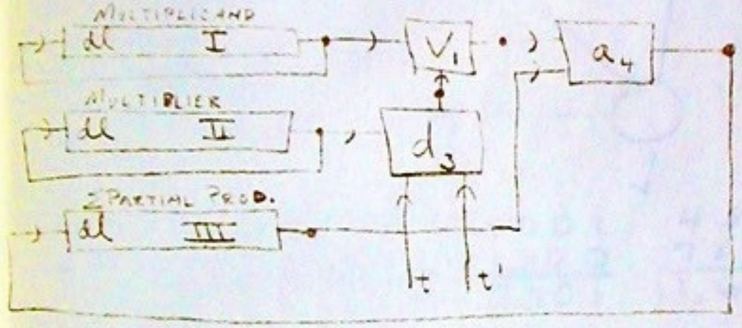
FIGURE 2



We conclude by observing that in planning networks of E-elements, all backtracks of stimuli along the connecting lines must be avoided. Specifically: The excitatory and the inhibitory synapses and the emission points—that is the three connections on  will be treated as one-way valves for stimuli---from left to right in the above picture. But everywhere else the lines and their connections  will be assumed to pass stimuli in all directions. For the delays  either assumption can be made, this last point does not happen to matter in our networks.

[June 1945]





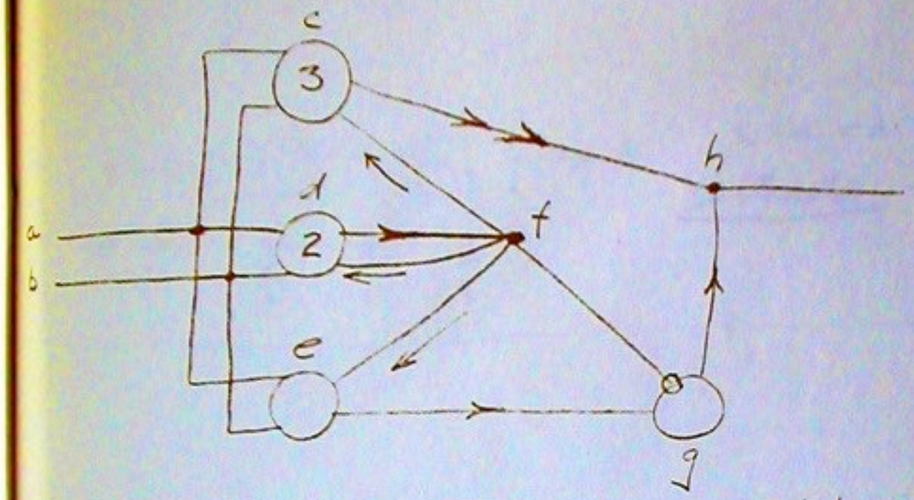

```
361 ← MULTIPLICAND → 101101001
557 ← MULTIPLIER   → 1000101101
                     9 8 7 6 5 4 3 2 1 0

  2527                  101101001                    1
 1805                  10110100100                   4
1805                  1110000011101                 16
201077               101101001000                   32
                    1001001010101                   64
                   10110100100000                  256
                  1111111011010101                4096
               1011010010000000000               65536
              1100010001011101101               131072
                                                201077
```

Left digit designates sign: 0 +
1 −

P28 ? 29?

ADDER



a	1000100001001	4361
b	1110001001000	7240
	10110101010001	11,601

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
a	✓	–	–	✓	–	–	–	–	✓	–	–	–	✓	–							
b	–	–	–	✓	–	–	✓	–	–	–	✓	✓	✓	–							
c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–					
d	✓	–	–	✓	–	–	–	–	–	–	–	–	✓	–	–	–					
e	✓	✓	–	✓	✓	–	✓	–	✓	–	✓	✓	✓	✓	–	–					
f	–	–	–	–	✓	–	–	–	–	–	–	–	–	✓	–	–					
g	–	✓	–	–	–	✓	–	✓	–	✓	–	✓	✓	–	✓	–					
h	–	–	✓	–	–	–	✓	–	✓	–	✓	–	✓	✓	–	✓					

1 0 0 0 1 0 1 0 1 0 1 1 0 1

[June 1945]

CA Central Arithmetical Part ($+, -, \times, \div, \sqrt{\ }, \sqrt[3]{\ }$, ln ...

CC Central control (coded general control)

M Memory (intermediate steps of CA, instructions from CC, specific functions, boundary values, steps for successive approx.)

R Recording medium (cards, tapes)

I Input (usually from R to M)

O Output (" " M to R)

E  delay t seconds ($\approx 10^{-6}$ sec) ; clock pulses $\frac{1}{5t}$ to $\frac{1}{2t}$, every $\frac{1}{t}$

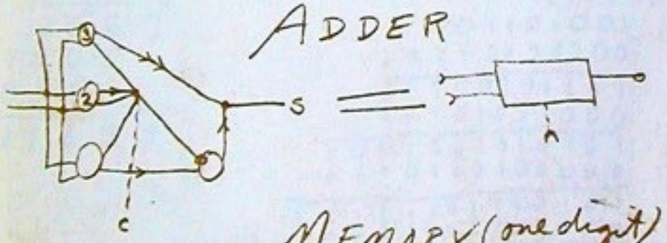
 Excited by pulse from a (Threshold 1, 2, 3)

 Inhibited " " " a (Absolute inhibition)

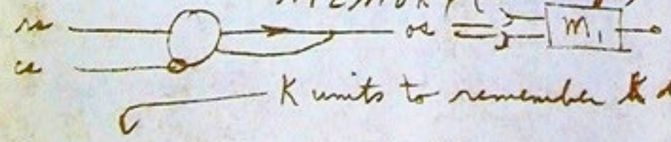
 left to right only

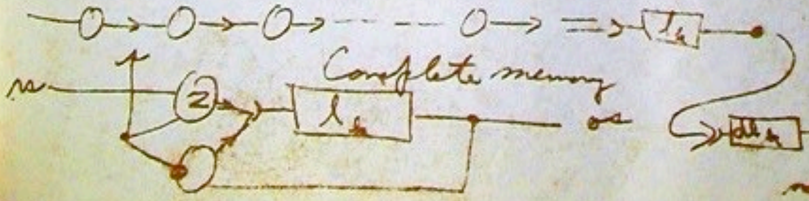
"Standard number" 30 binary digits

ADDER



MEMORY (one digit)





[June 1945]

CCM { CA Central Arithmetical Part (+, −, ×, ÷, $\sqrt{}$, $\sqrt[3]{}$, ln
CC Central control (coded general control)
M Memory (intermediate steps of CA, instructions from CC, specific functions, boundary values, steps of processing of proc.

R Recording medium (cards, tape
I Input (usually from R to M)
O Output (" " M to R)

E ○→ delay t seconds ($\approx 10^{-6}$ sec) ; clock pulses $\frac{1}{5t}$ to $\frac{1}{2t}$, every $\frac{1}{t}$

a —○ Excited by pulse from a (T thresholds 1, 2, 3)

a —○ Inhibited " " " a (Absolute inhibition)

═○→ left to right only

"Standard number" 30 binary digits

[1945]

RETAINER AGREEMENT

Von Neuman and IBM

This agreement made at New York City as of May 1, 1945, between Professor John von Neuman of Princeton ~~University at Princeton~~, New Jersey, and International Business Machines Corporation, a corporation of New York State, having principal offices at 590 Madison Avenue, New York City, hereinafter referred to as IBM, as follows: -

1) IBM agrees to retain von Neuman for a period of one year from May 1, 1945 at a retainer compensation of

Dollars ($) per month.

Oswald Veblen (1880-1960)

[1939]

THE USEFULNESS OF USELESS KNOWLEDGE

BY ABRAHAM FLEXNER

Meeting #1

MINUTES OF E.C. MEETING

Date - November 12, 1945

Time - 12:45 P.M.

Place - Office of V. K. Zworykin

Present:
G. W. Brown - RCA Laboratories
H. H. Goldstine - Army Ordnance Department
J. von Neumann - Institute for Advanced Study
J. A. Rajchman - RCA Laboratories
J. W. Tukey - Princeton University
A. W. Vance - RCA Laboratories
V. K. Zworykin - RCA Laboratories

I. Organization Discussion

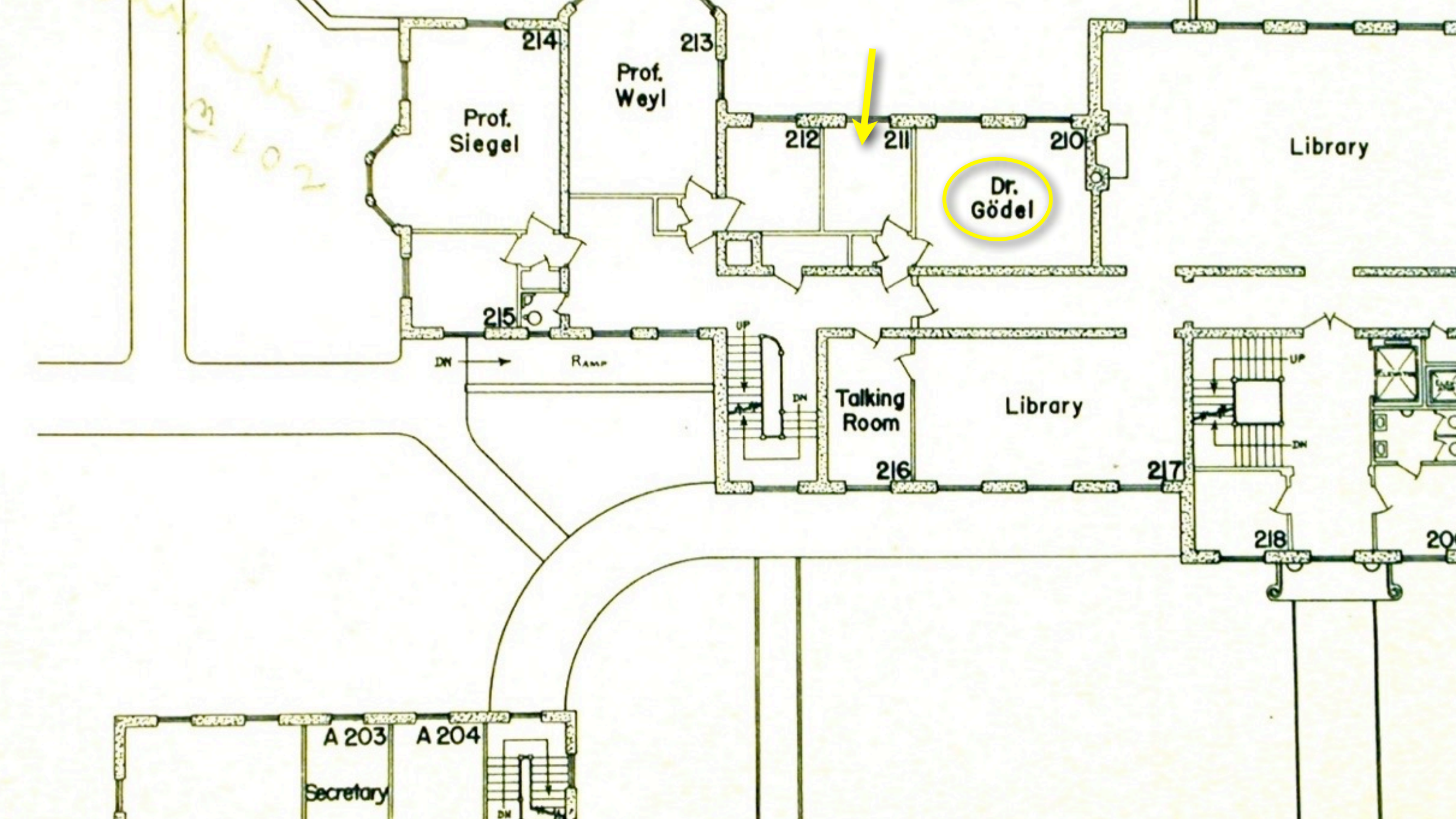
J.W.T. will continue, for the present, at least, to contribute 2 days per week to the Bell Laboratories, with the expectation that no conflict with RCA will result. J.W.T. will

‘Words’ coding the orders are handled in the memory just like numbers.

— 12 November 1945

11. The question of office space was discussed and it was agreed that the room connected with Dr. Gödel's office might be used for people working on the computing machine. Professor Pauli offered to make his room available while he is away. Reference was made to the need for more suitable rooms for Professors Siegel and Pauli, and Professor Morse called attention to a room on the fourth floor which he thought would make a desirable office.

[15 February 1946]


214
213
Prof.
Weyl
Prof.
Siegel
212
211
210
Dr.
Gödel
Library
215
DN
RAMP
UP
DN
Talking
Room
216
Library
217
UP
DN
218
A 203
A 204
Secretary
DN


Akrevoe Kondopria Emmanouilides

[28 June 1946]

PRELIMINARY DISCUSSION OF THE LOGICAL DESIGN OF AN ELECTRONIC COMPUTING INSTRUMENT

BY

Arthur W. Burks

Herman H. Goldstine

John von Neumann

Bernetta Miller (1884-1972)

ELECTRONIC COMPUTER PROJECT

STATEMENT OF EXPENDITURES FROM BEGINNING NOVEMBER 1945. to MAY 31, 1946.

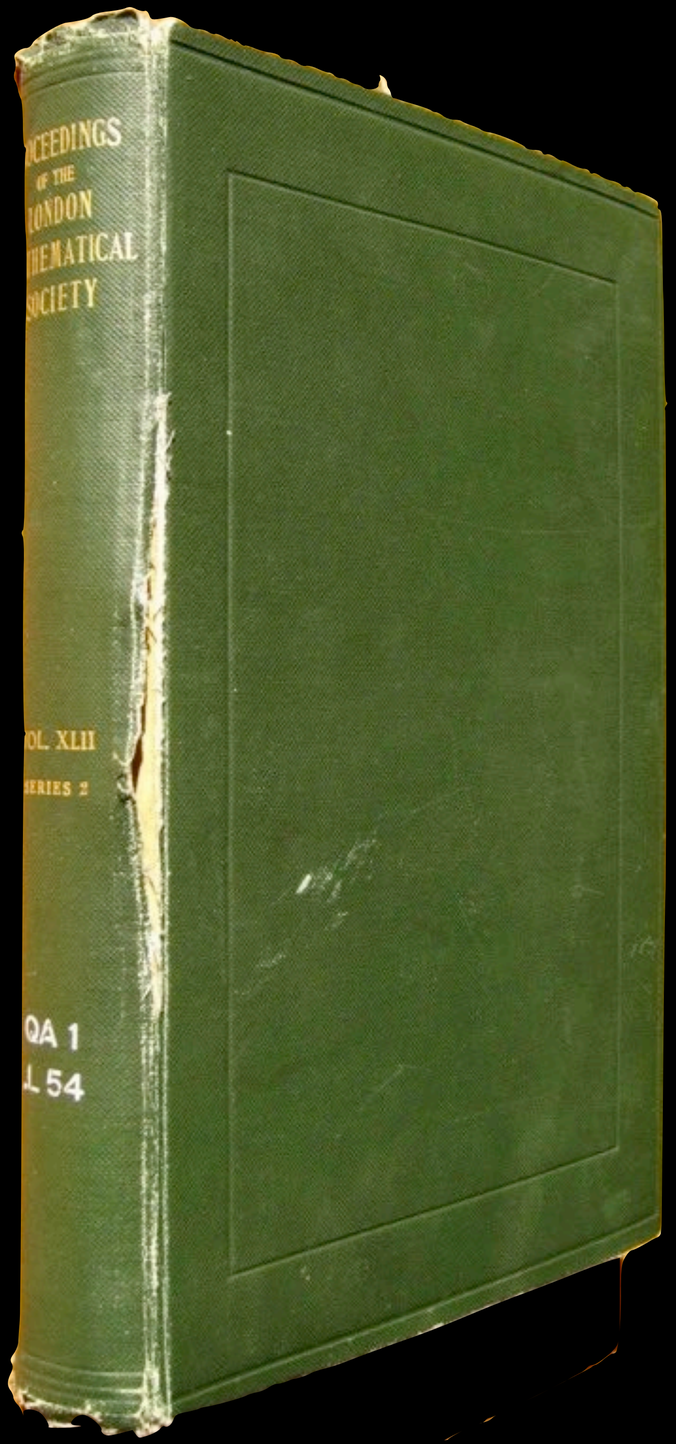
DISBURSED:

Salaries	$ 5,336.16
Communications	130.59
Supplies & Books	1,531.19
Travel	543.89
Entertainment & Conferences	33.10
Legal Services	591.87
Equipment	1,177.66
Electrical Work	4.00
TOTAL to 5/31/46 (Actual Expenditures)	$ 9,348.46

Julian Bigelow
(1913—2003)

Let the whole outside world consist of a long paper tape. . .

— John von Neumann, 1948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SECOND SERIES

[1936]

ON COMPUTABLE NUMBERS, WITH AN APPLICATION TO THE ENTSCHEIDUNGSPROBLEM

By A. M. TURING.

[Received 28 May, 1936.—Read 12 November, 1936.]

The "computable" numbers may be described briefly as the real numbers whose expressions as a decimal are calculable by finite means. Although the subject of this paper is ostensibly the computable *numbers*, it is almost equally easy to define and investigate computable functions of an integral variable or a real or computable variable, computable predicates, and so forth. The fundamental problems involved are, however, the same in each case, and I have chosen the computable numbers

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In §§ 9, 10 I give some arguments with the intention of showing that the computable numbers include all numbers which could naturally be regarded as computable. In particular, I show that certain large classes of numbers are computable. They include, for instance, the real parts of all algebraic numbers, the real parts of the zeros of the Bessel functions, the numbers π, e, etc. The computable numbers do not, however, include all definable numbers, and an example is given of a definable number which is not computable.

Although the class of computable numbers is so great, and in many ways similar to the class of real numbers, it is nevertheless enumerable. In § 8 I examine certain arguments which would seem to prove the contrary. By the correct application of one of these arguments, conclusions are reached which are superficially similar to those of Gödel†. These results

† Gödel, "Über formal unentscheidbare Sätze der Principia Mathematica und verwandter Systeme, I", *Monatshefte Math. Phys.*, 38 (1931), 173–198.

have valuable applications. In particular, it is shown (§ 11) that the Hilbertian Entscheidungsproblem can have no solution.

In a recent paper Alonzo Church† has introduced an idea of "effective calculability", which is equivalent to my "computability", but is very differently defined. Church also reaches similar conclusions about the Entscheidungsproblem‡. The proof of equivalence between "computability" and "effective calculability" is outlined in an appendix to the present paper.

1. *Computing machines.*

We have said that the computable numbers are those whose decimals are calculable by finite means. This requires rather more explicit definition. No real attempt will be made to justify the definitions given until we reach § 9. For the present I shall only say that the justification lies in the fact that the human memory is necessarily limited.

We may compare a man in the process of computing a real number to a machine which is only capable of a finite number of conditions $q_1, q_2, \ldots, q_R$ which will be called "*m*-configurations". The machine is supplied with a "tape" (the analogue of paper) running through it, and divided into sections (called "squares") each capable of bearing a "symbol". At any moment there is just one square, say the r-th, bearing the symbol $\mathfrak{S}(r)$ which is "in the machine". We may call this square the "scanned square". The symbol on the scanned square may be called the "scanned symbol". The "scanned symbol" is the only one of which the machine is, so to speak, "directly aware". However, by altering its *m*-configuration the machine can effectively remember some of the symbols which it has "seen" (scanned) previously. The possible behaviour of the machine at any moment is determined by the *m*-configuration q_n and the scanned symbol $\mathfrak{S}(r)$. This pair $q_n, \mathfrak{S}(r)$ will be called the "configuration": thus the configuration determines the possible behaviour of the machine. In some of the configurations in which the scanned square is blank (*i.e.* bears no symbol) the machine writes down a new symbol on the scanned square: in other configurations it erases the scanned symbol. The machine may also change the square which is being scanned, but only by shifting it one place to right or left. In addition to any of these operations the *m*-configuration may be changed. Some of the symbols written down

† Alonzo Church, "An unsolvable problem of elementary number theory", *American J. of Math.*, 58 (1936), 345–363.

‡ Alonzo Church, "A note on the Entscheidungsproblem", *J. of Symbolic Logic*, 1 (1936), 40–41.

The MANIAC machine didn't have anything like a pulser in it — no clocks, no pulsers, no nothing. It was all of it a large system of on-and-off, binary gates. No clocks.

You don’t need clocks. You only need counters.

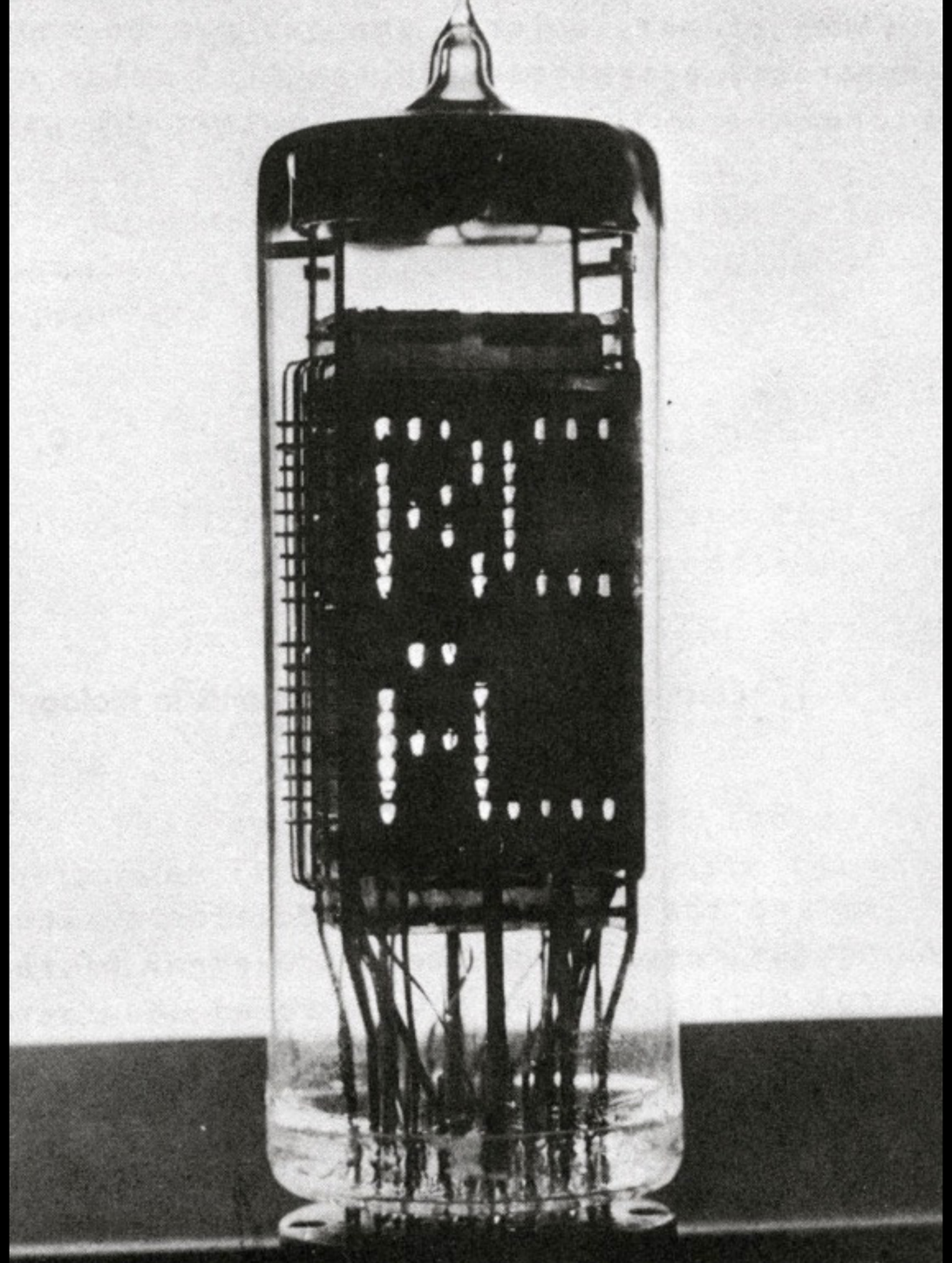
There’s a difference between a counter and a clock. A clock keeps track of time — and a modern general purpose computer keeps track of events.

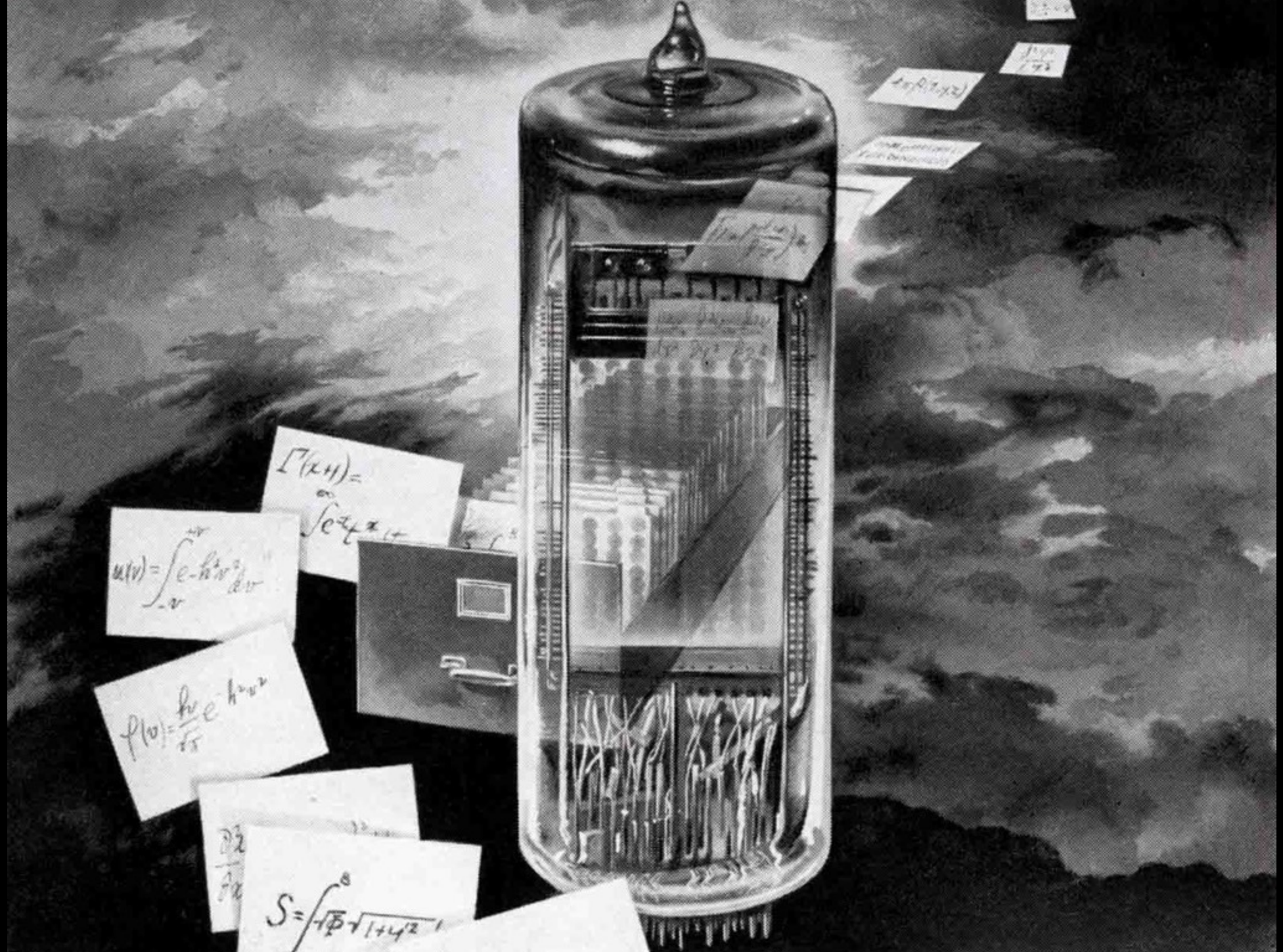
Sequence is different from time.

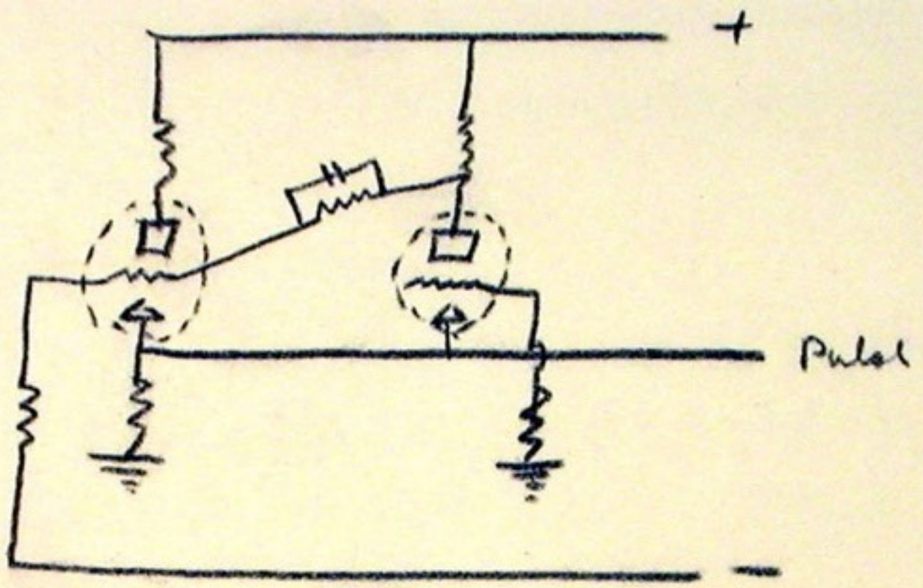
No time is there.

—Julian Bigelow, 1999

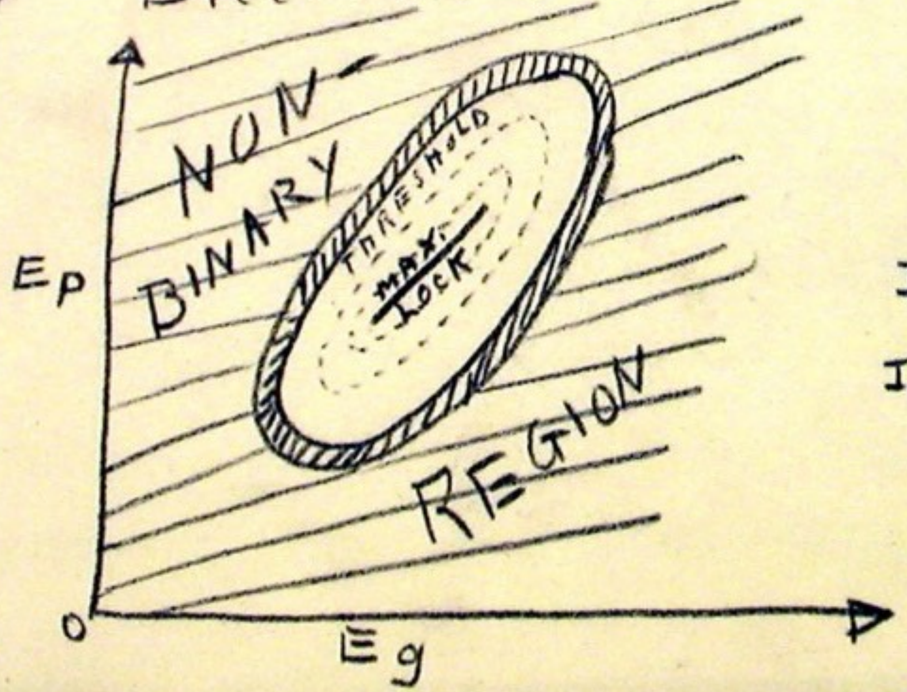
Vladimir Kosma Zworykin (1889-1982)

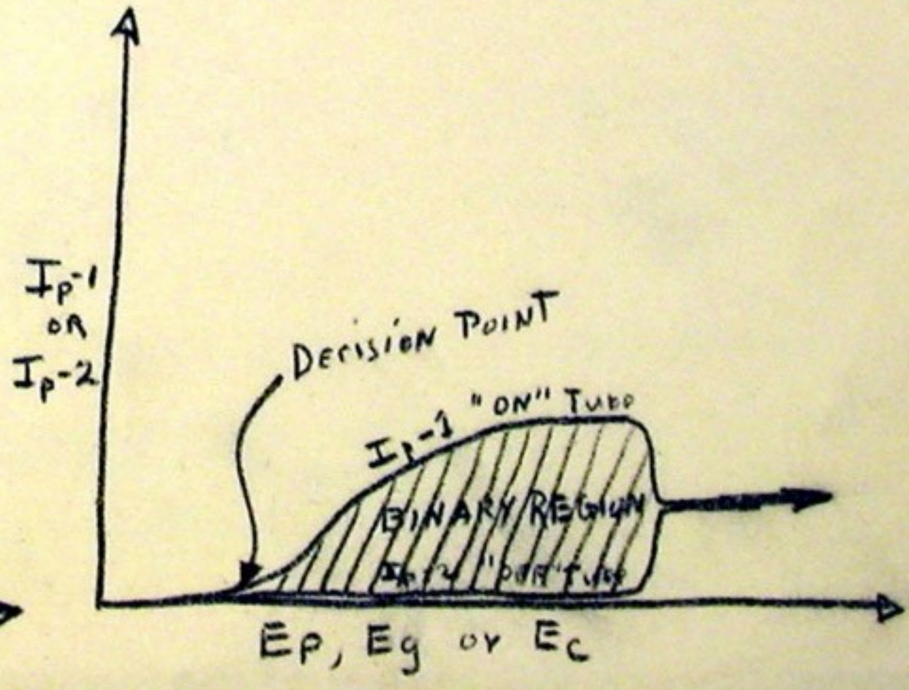


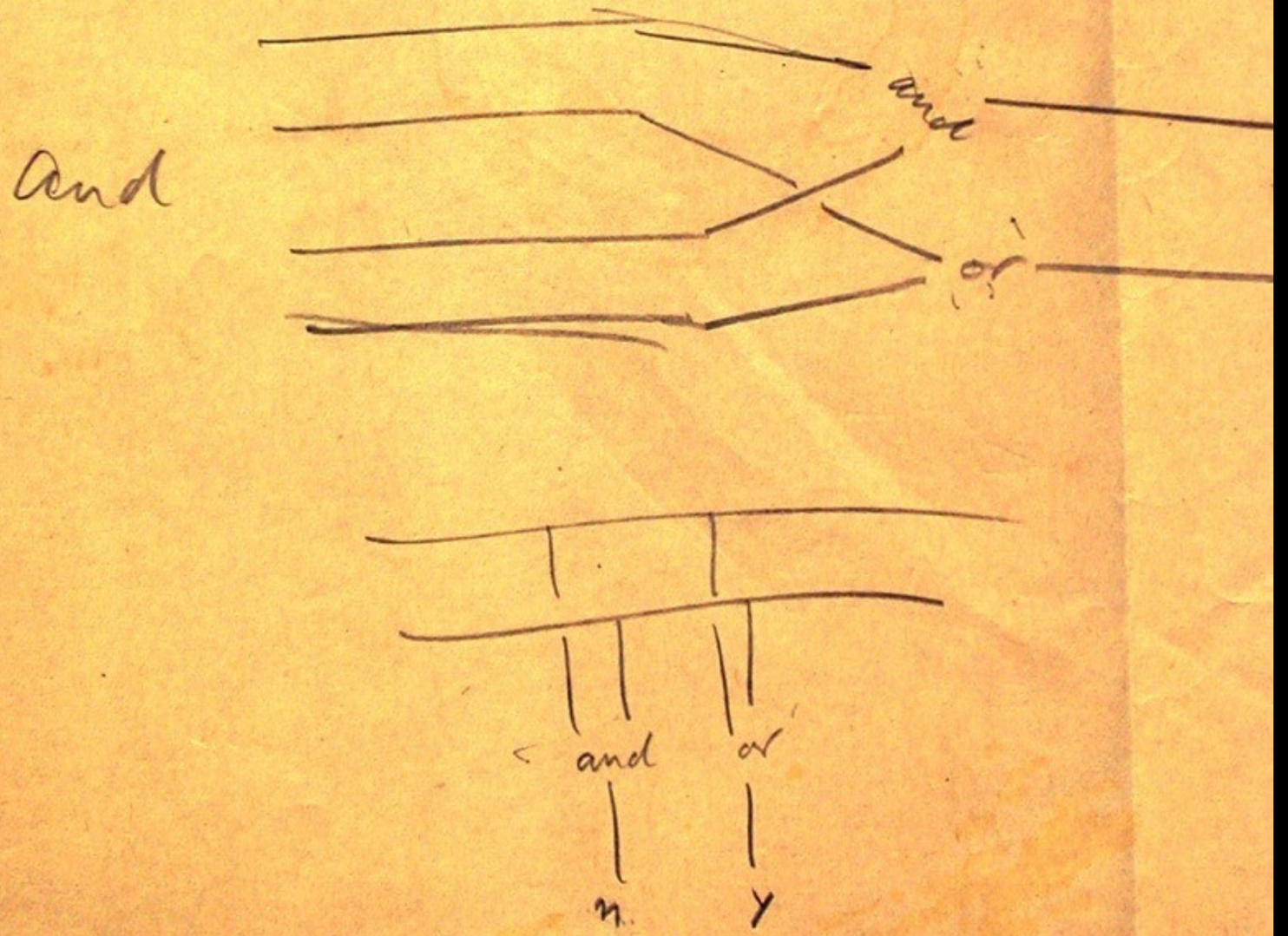

$\Gamma(x+1) = \int_0^\infty e^{-t} t^x \, dt$
$u(v) = \int_{-v}^{v} e^{-h^2 v^2} \, dv$
$p(v) = \frac{hv}{\sqrt{\pi}} e^{-h^2 v^2}$
$S = \int_0^\theta \sqrt{1+y'^2} \, dx$



(3) Electron-Tube Binary Cell Stability



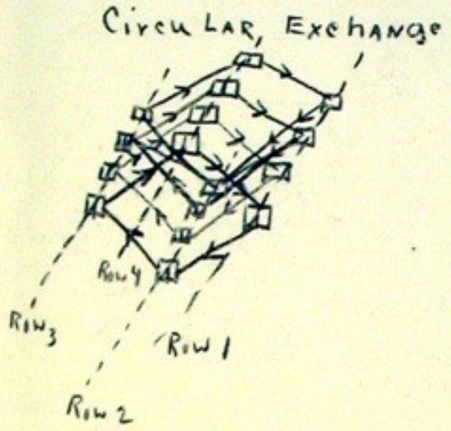


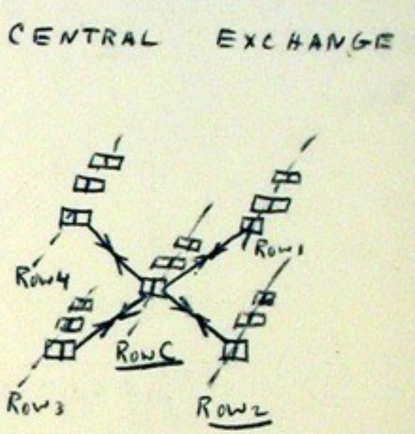

and
and
or
and
or
x
y

SKETCHES

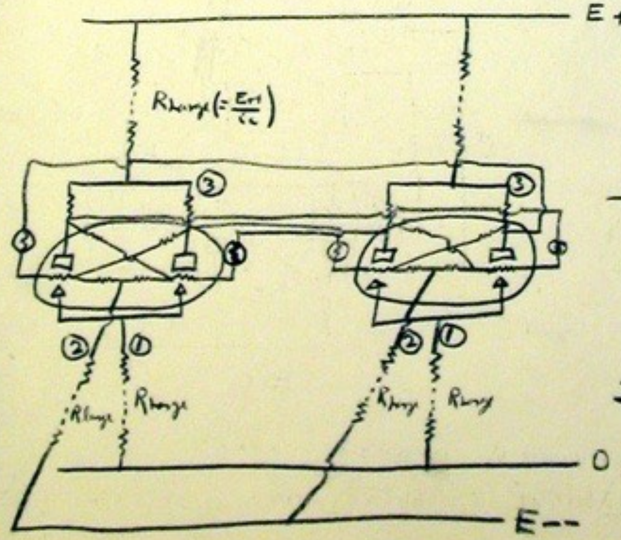
SKETCH 7 CONTINUED

D. Typical Combinations of Communicative Banks of Cells



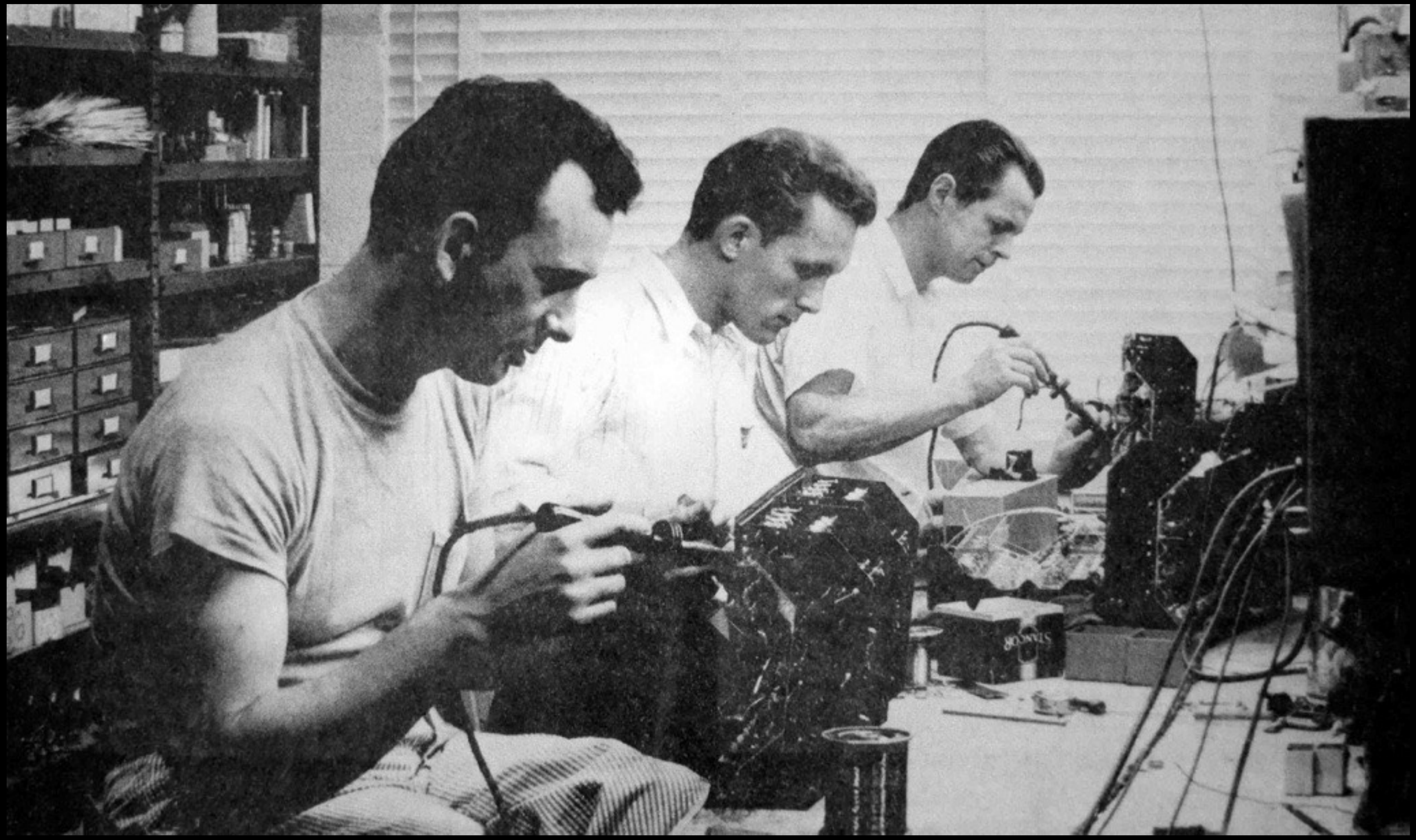


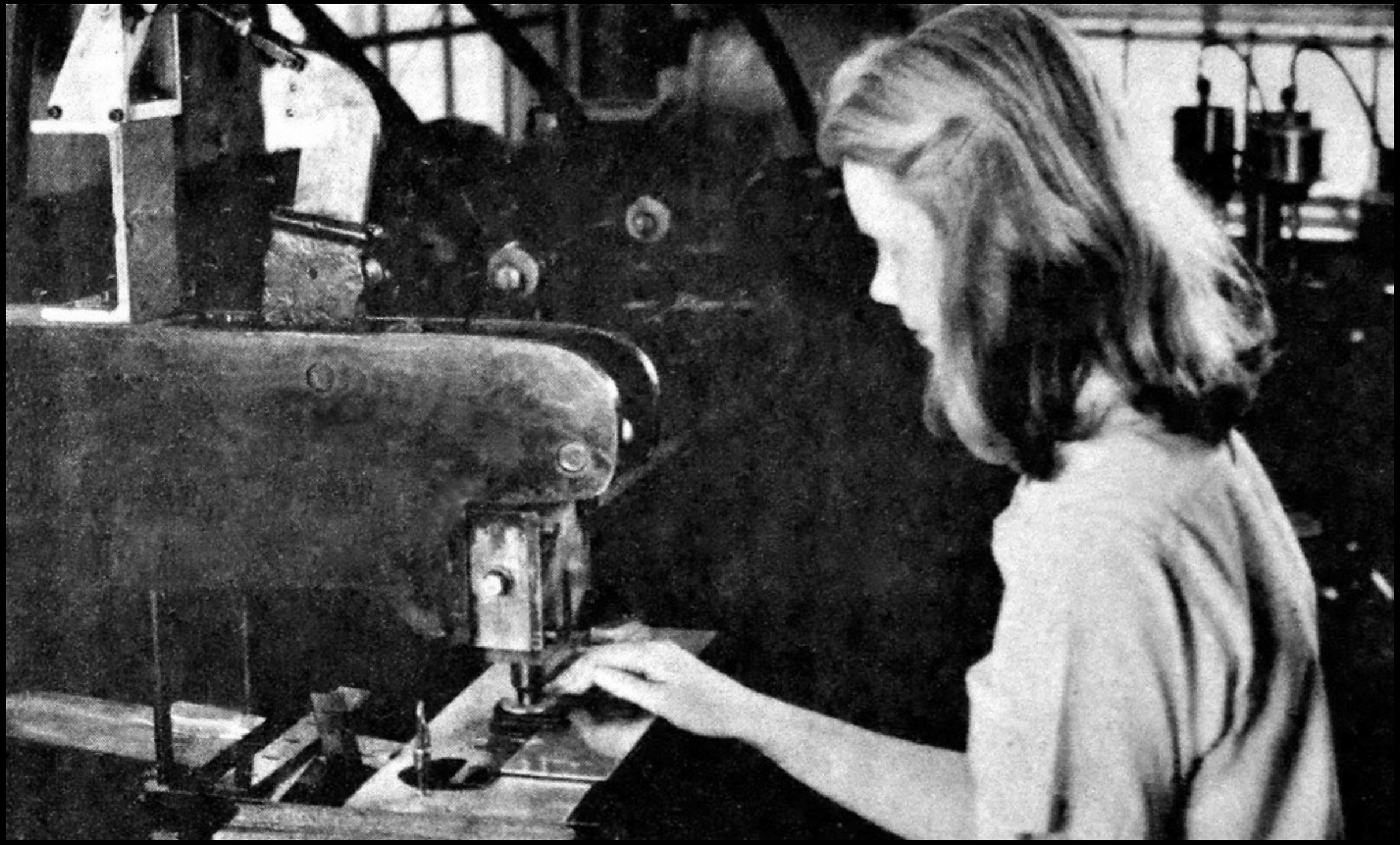
E.

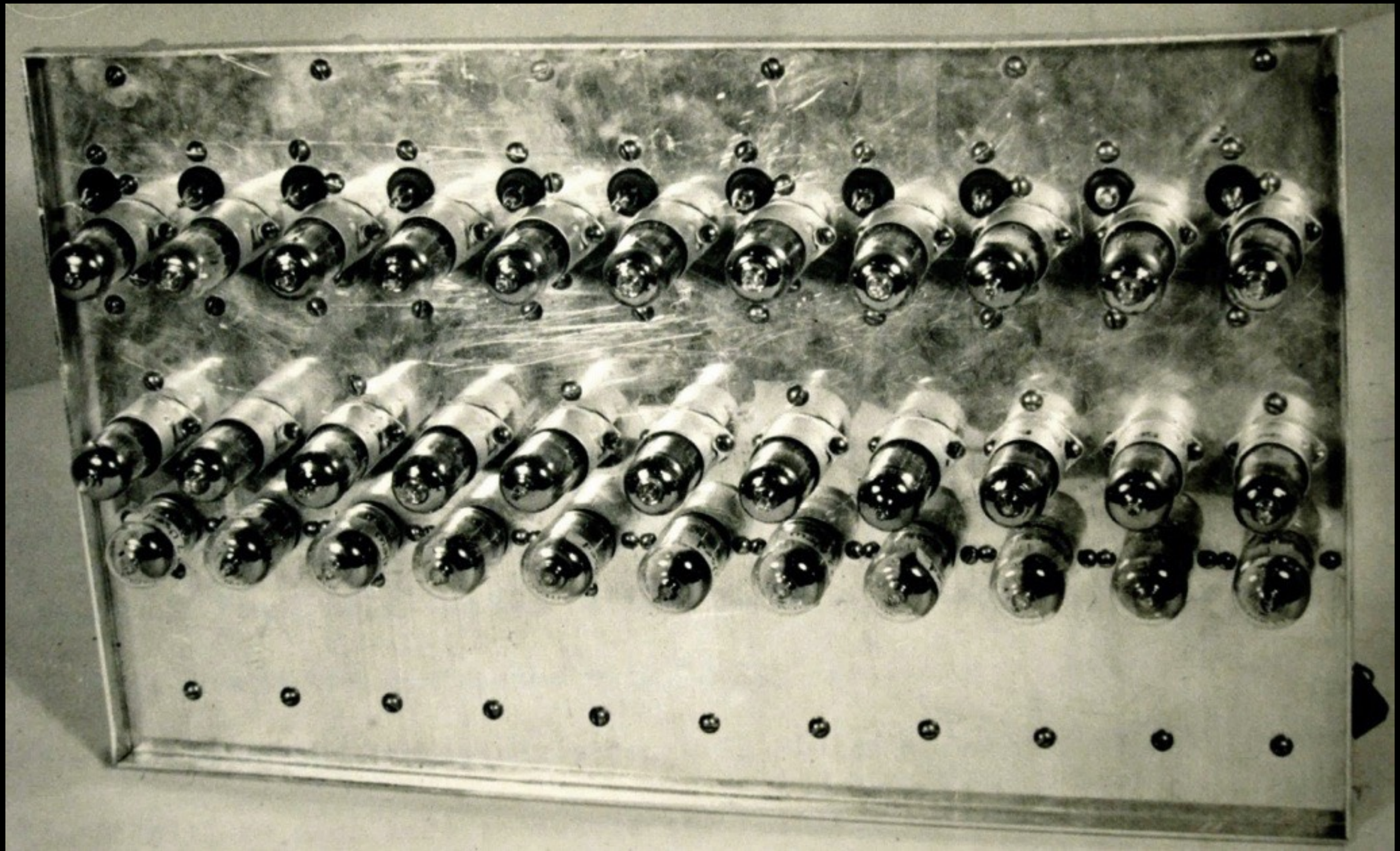


Circuit To Illustrate Effects of swinging locked Binary Cells

- Translation by swinging points ①, ②, ③ simultaneously DOES NOT TEND to unLock Toggle.
- RELATIVE SHIFT OF points ① and ② and ③ DOES AFFECT lock Threshold of Toggle








SYLVANIA
6J6
6J6
RCA
6J6
RADIOTRON
ITT
6J6A
Tube
6J6A
ELECTRON TUBE
RCA
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RADIOTRON
RCA
6J6
RADIOTRON
ELECTRON TUBE
World's Best-Known
ELECTRON TUBES
SYLVANIA
6J6
RADIO TUBE
SYLVANIA
RADIO TUBE
MADE IN U. S. A.
TUNG-SOL
6J6
ELECTRON TUBE
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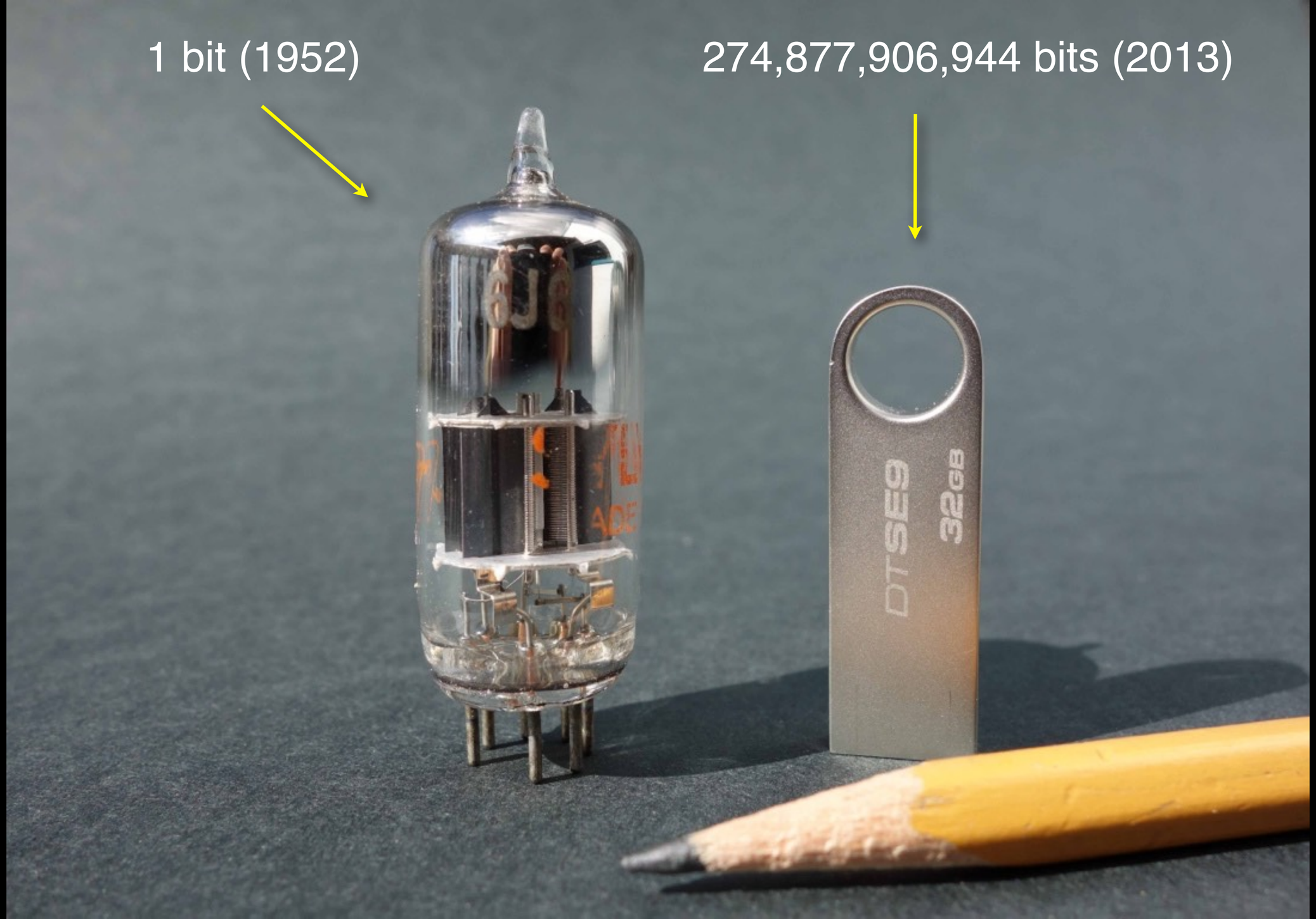
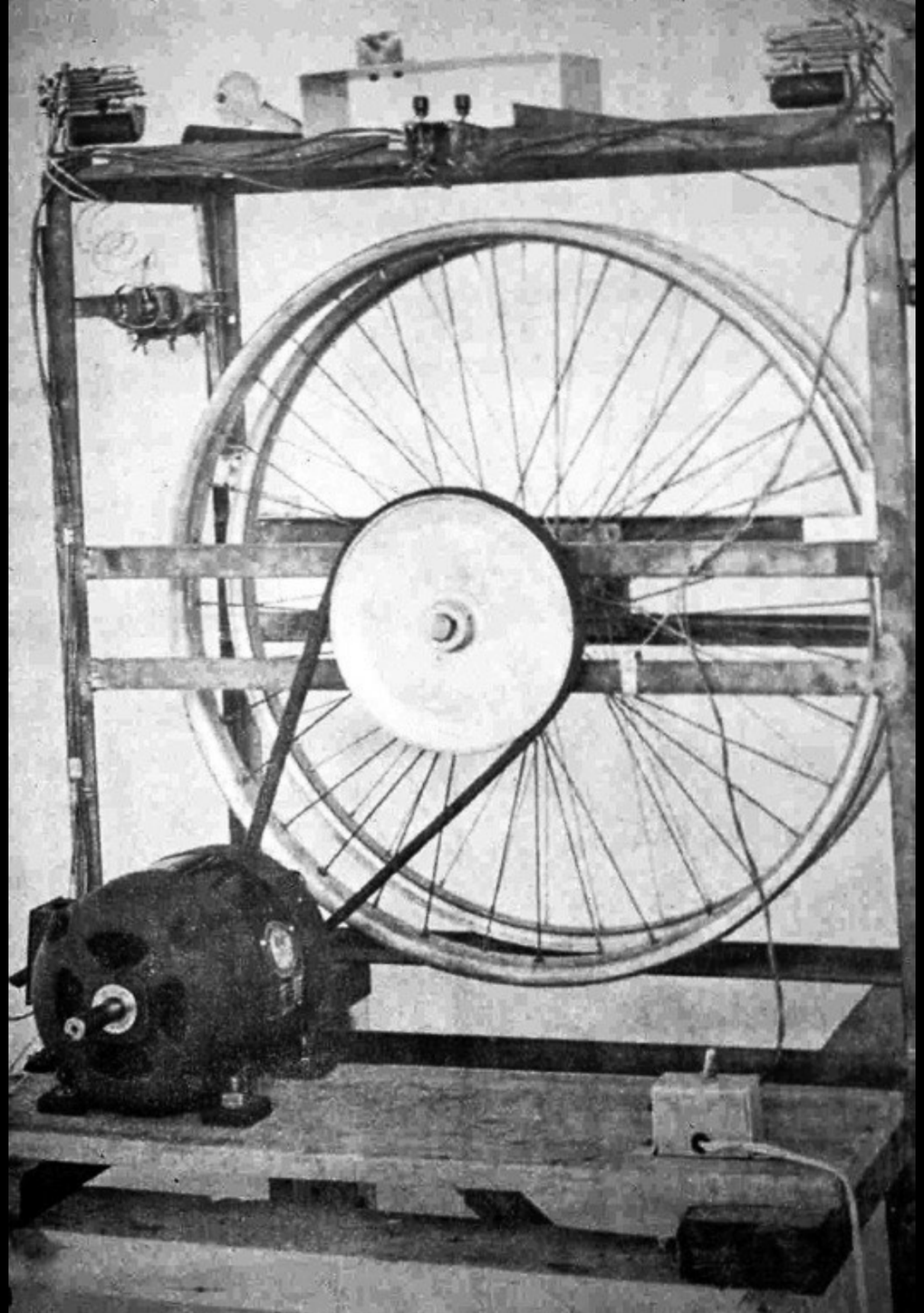
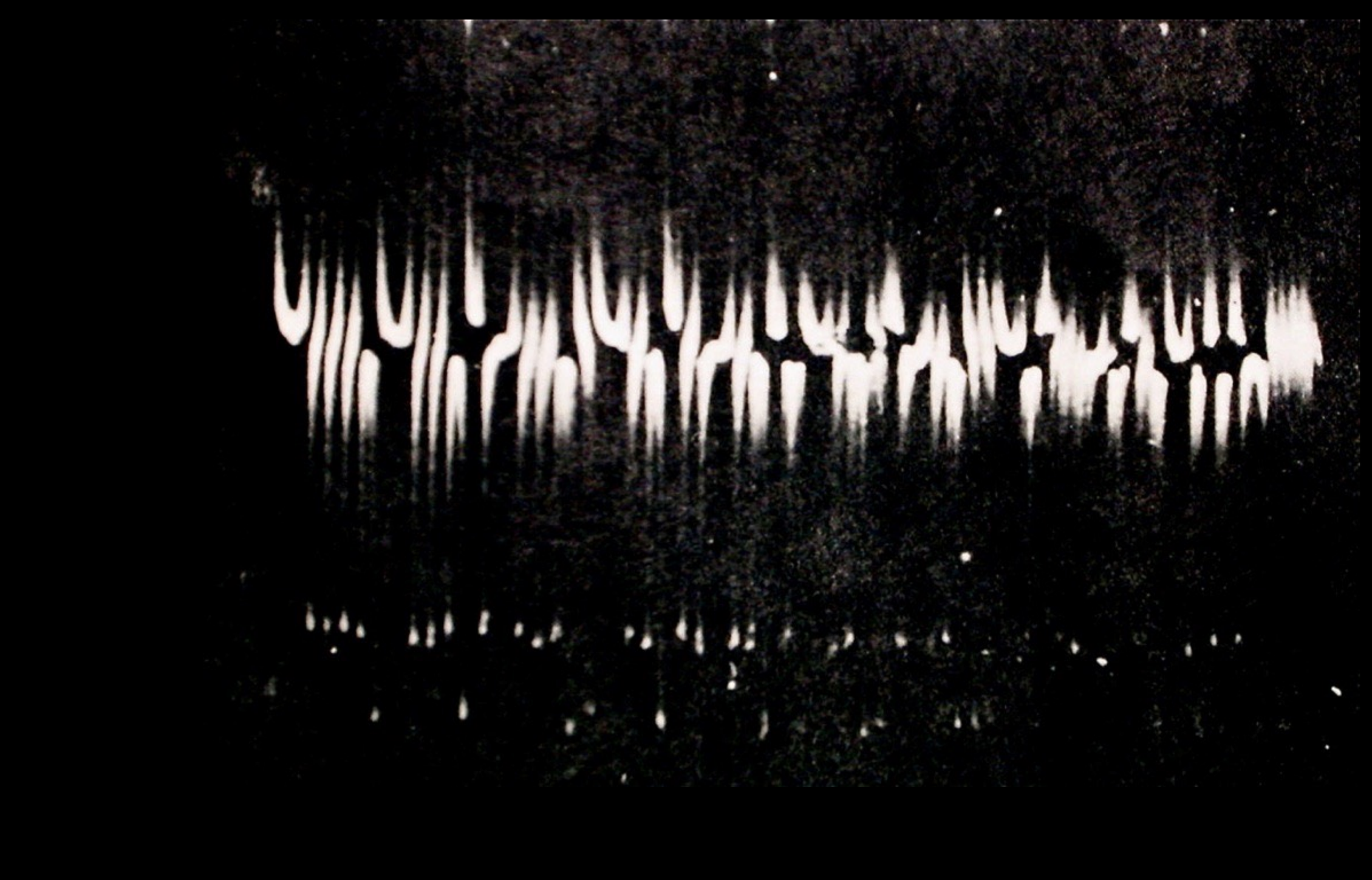
SYLVANIA ELECTRIC
Acceptance Date 6-52

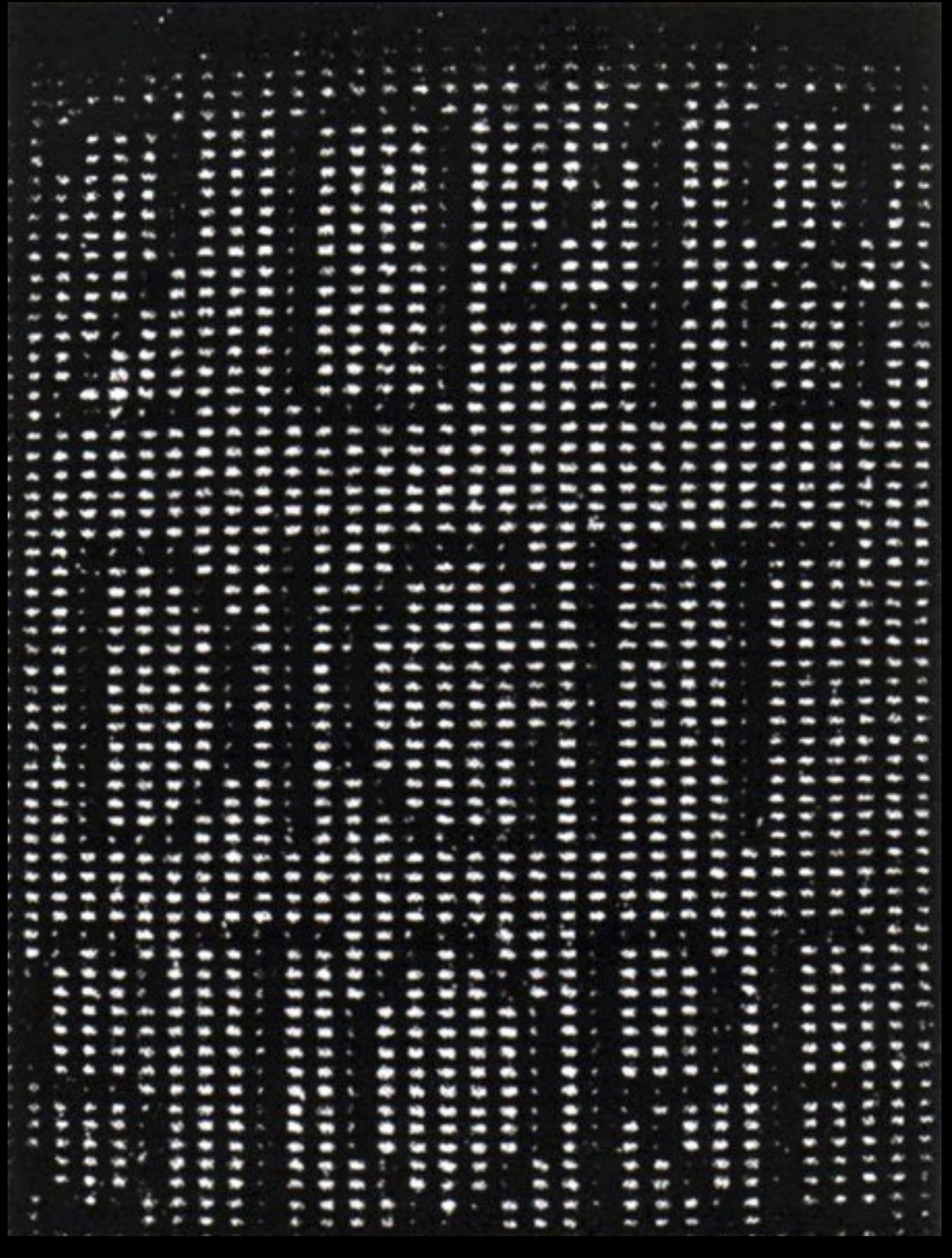

1 bit (1952)
274,877,906,944 bits (2013)
DTSE9
32GB





Thomas Kilburn

Frederic C. Williams



5CP1-A, 5CP7-A, 5CP11-A

OSCILLOGRAPH TUBES

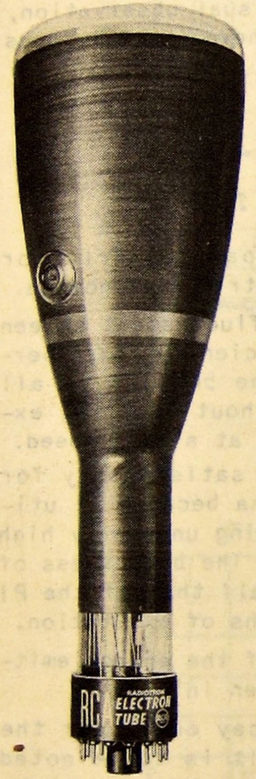
Electrostatic Deflection
Electrostatic Focus

HV Accelerator Electrode
"Zero First-Anode-Current" Gun

Maximum Diameter, 5-11/32"
Maximum Length, 17-1/8"

TENTATIVE DATA

The 5C-series of cathode-ray tubes consists of three, five-inch types--5CP1-A, 5CP7-A, and 5CP11-A--utilizing electrostatic deflection and electrostatic focus. They differ one from the other only in the spectral-energy emission and persistence characteristics of their respective phosphors P1, P7, and P11.



The types in this series are designed with a high-voltage accelerator electrode (anode No.3). This electrode permits the use of a high-intensity, fluorescent spot with minimum sacrifice in deflection sensitivity, and with slight increase in spot size.

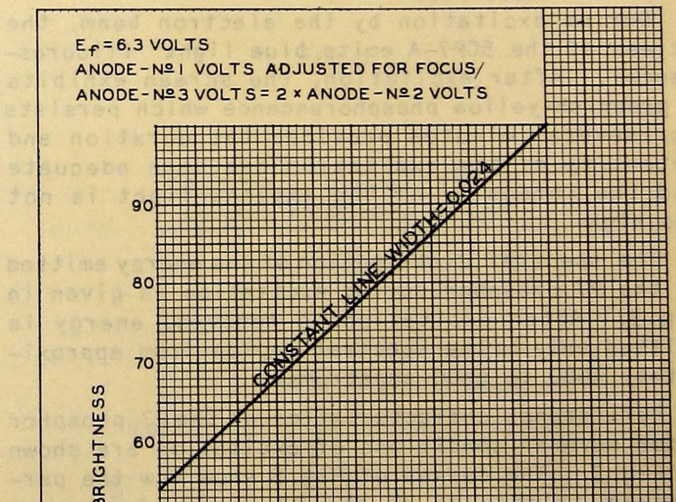
The electron gun employed in these types has a grid No.2 operated at constant high voltage so that the beam current will not be affected by changes in anode-No.1 voltage. It also has an anode No.1 which takes negligible current. As a result of these features, the spot can be sharply focused on the screen and remains sharp when beam current is varied over a wide range. balanced deflection because of design features which minimize spot and pattern distortion usually characteristic of such operation.

• RCA-5CP1-A •

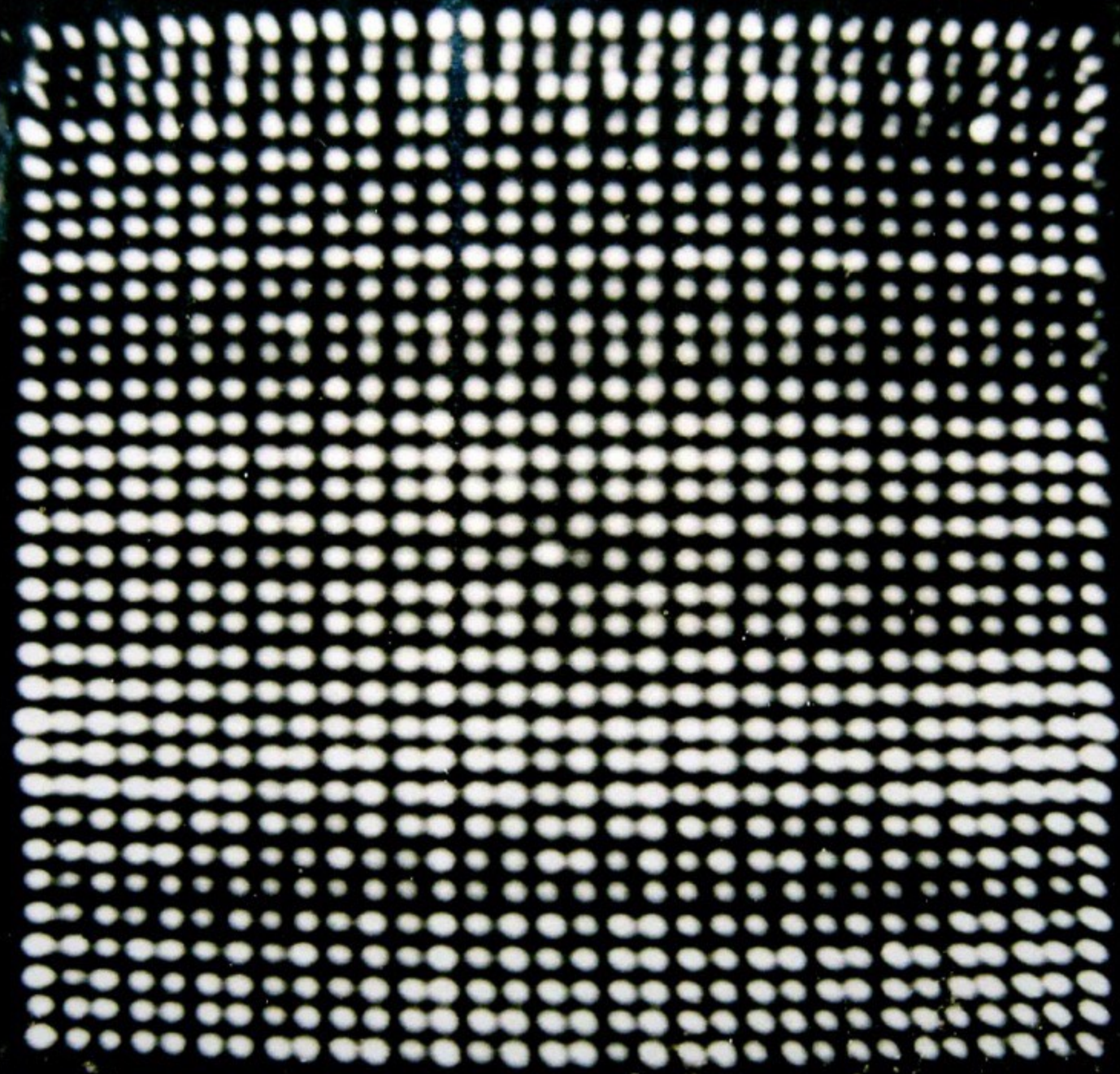
Medium-Persistence Type

The 5CP1-A is designed particularly for general oscillographic applications in which a high-intensity trace is needed.

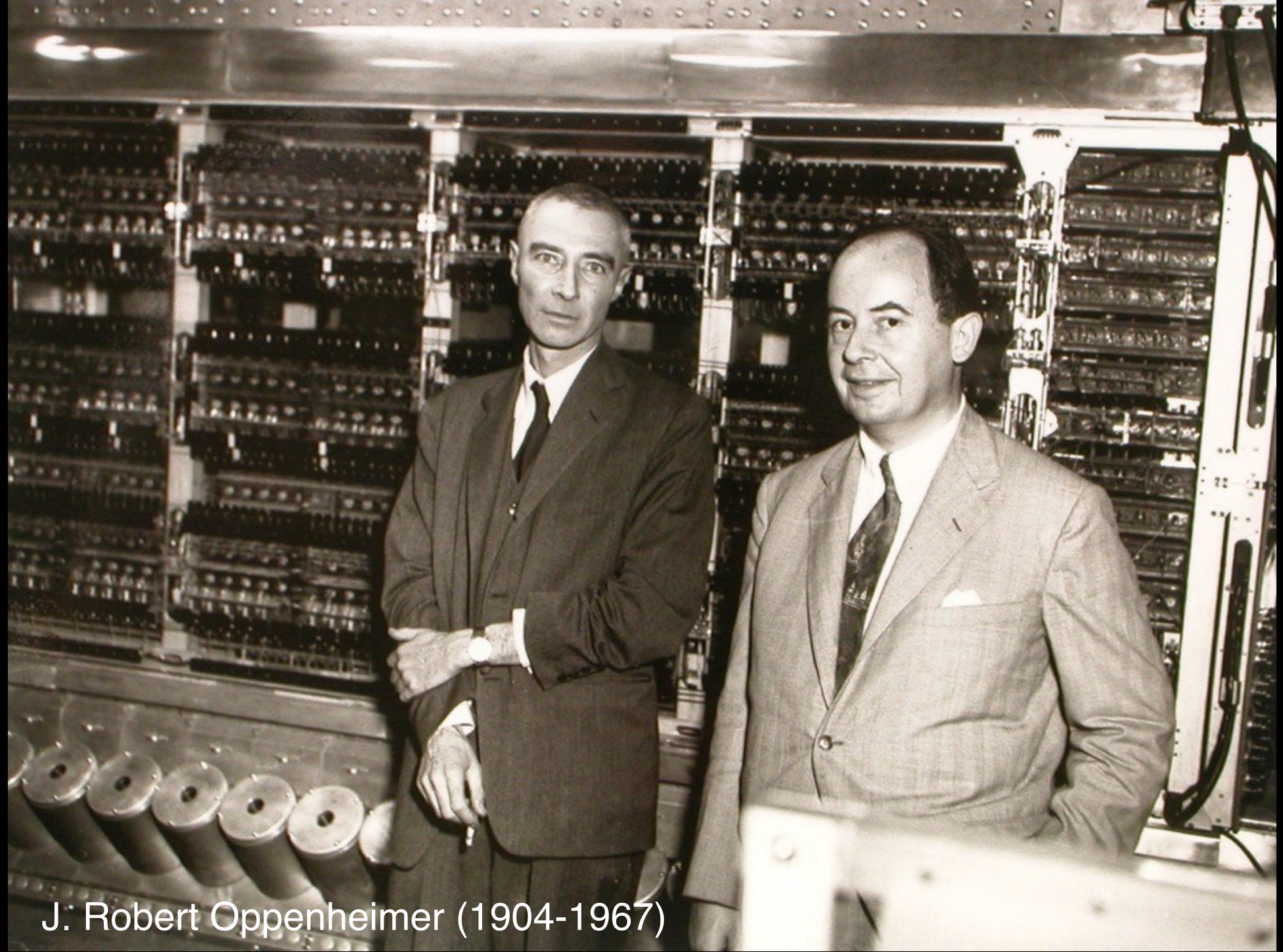
It has a green-fluorescence, medium-persistence screen which has high visual efficiency, and exceptionally good brightness contrast between the scanned line and the background. Under



James Pomerene (1920-2008)



[11 February 1953]



J. Robert Oppenheimer (1904-1967)

stop at (18, 8)

over to

[3-4 March 1953]

EXPERIMENTS IN BIONUMERIC EVOLUTION

EXECUTED BY THE ELECTRONIC COMPUTER AT PRINCETON, N. J.*

by

Nils Aall Barricelli

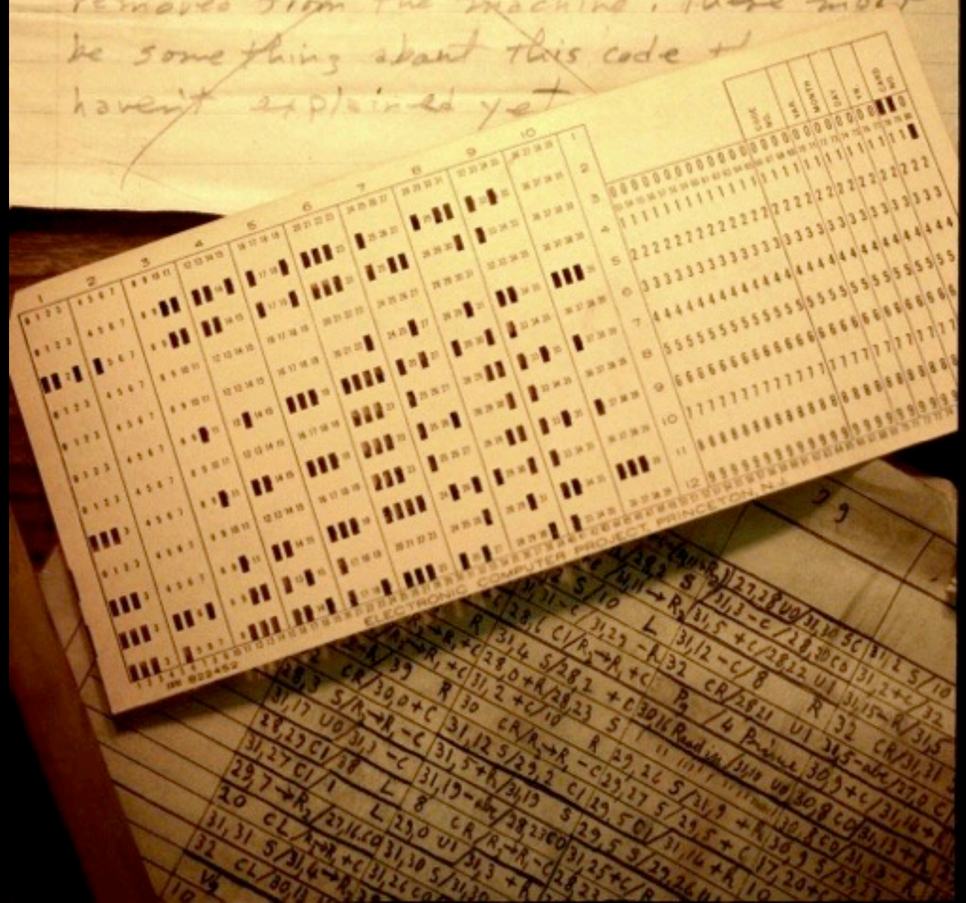
August 1953

Nils Barricelli was the only person who really understood the path toward genuine artificial intelligence at that time.

— Julian Bigelow, 1997

Mr. Barricelli

For some reason or other your code has continued to duplicate the 1000-1004 run. Unfortunately, this was not discovered until 1200-1204 had presumeably been run and duplicated. A second run starting from 1000 was run and the same thing occured. At this point the code was removed from the machine. There must be something about this code I haven't explained yet.



Mr. Barricelli

For some reason or other your code has continued to duplicate the 1000-1004 run. Unfortunately, this was not discovered until 1200-1204 had presumeably been run and duplicated. A second run starting from 1000 was run and the same thing occured. At this point the code was removed from the machine. there must be something about this code that you haven't explained yet.

TWL.

Alan Turing (1912—1954)

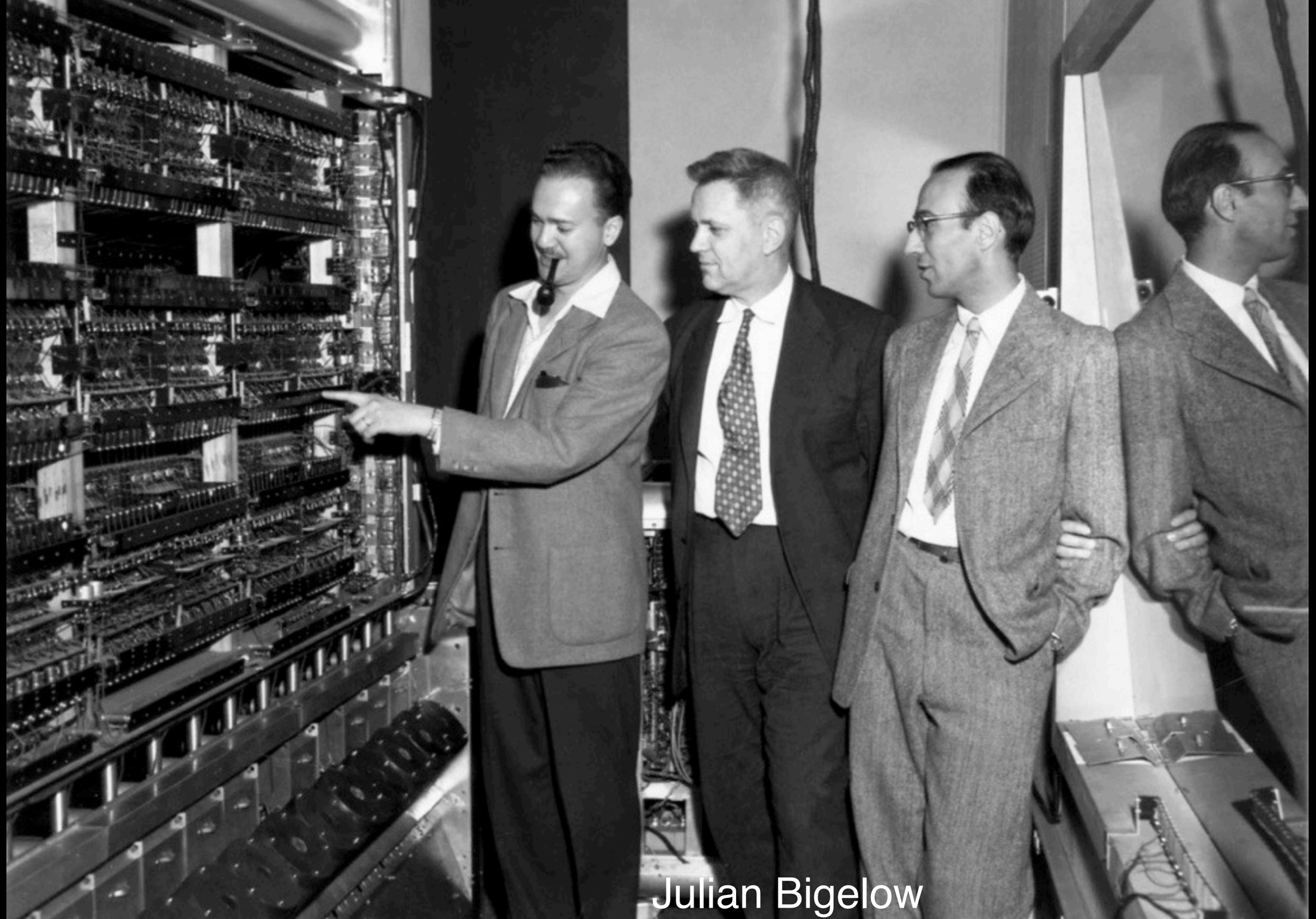
MACHINE LOG BOOK

DATE: July 15, 1958

TIME	RESPONSIBLE FOR MACHINE	NAME & NUMBER OF PROBLEM	MACHINE PERFORMANCE
	Bizmuth	start ϕE = 15,24 = 13,0 = 28,00 = 13,25	
		$\delta \phi E$ =	
	off		12:00 Midnight

J H B

11 P.M.


Julian Bigelow

The design of an electronic calculating machine turns out to be a frustrating wrestling-match with problems of interconnectability and proximity in three dimensions of space and one dimension of time . . .

Thousands of very refined logical elements are built . . .

and then they are interconnected in such a way that on the average almost all of them are waiting for one (or a very few of their number) to act .

Serial order along the time axis is the customary method of carrying out computations today . . . but in forming any model of real world processes for study in a computer, there seems no reason why this must be initiated by pairing computer-time-sequences with physical time parameters of the real-world model.

Electronic computers "eat up" instructions very rapidly, and therefore some way must be found of forming batches of instructions very efficiently, and of "tagging" them efficiently, so that the computer is kept effectively busier than the programmer . . .

Highly recursive, conditional and repetitive routines are used because they are notationally efficient (but not necessarily unique) as descriptions of underlying processes.

—Julian Bigelow, 1965

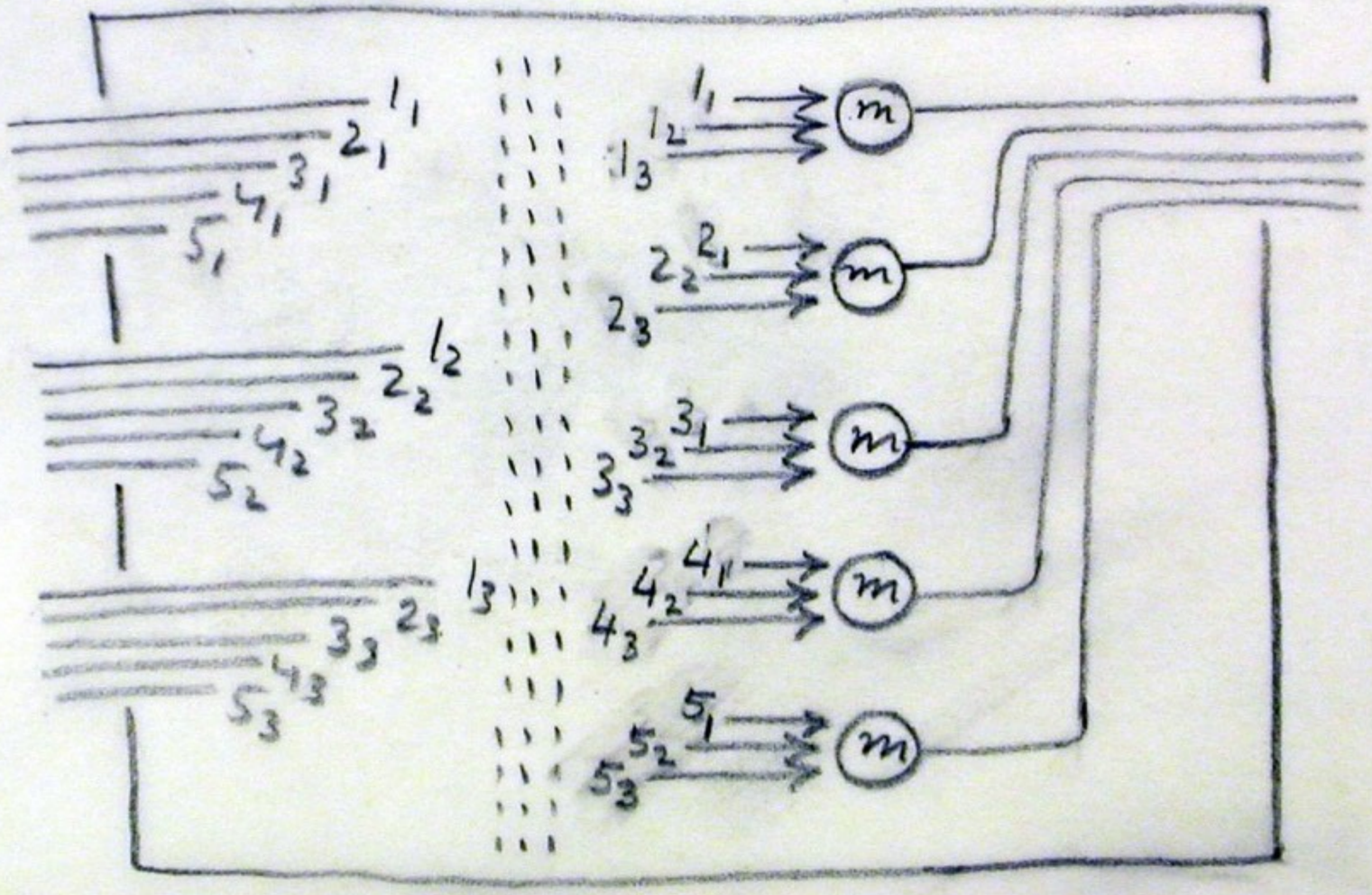
THE COMPUTER AND THE BRAIN

John von Neumann

If the only demerit of the digital expansion system were its greater logical complexity, nature would not, for this reason alone, have rejected it . . .

[1951]

Figure 30.



The simplest and only practical way to actually say what constitutes a visual analogy consists in giving a description of the connections of the visual brain.

—John von Neumann, 1951

PRINCIPLES

OF

THE HUMAN MIND,

DEDUCED FROM PHYSICAL LAWS;

TOGETHER WITH A LECTURE ON

ELECTRO-BIOLOGY,

OR

THE VOLTAIC MECHANISM OF MAN.

BY ALFRED SMEE, F.R.S.,

SURGEON TO THE ROYAL GENERAL DISPENSARY OF LONDON, AND LECTURER ON SURGERY, ETC., ETC.

[1849]

22. When an image is produced by an action upon the external senses, the actions on the organs of sense concur with the actions in the brain; and the image is then a *Reality.*

23. When an image occurs to the mind without a corresponding simultaneous action of the body, it is called a *Thought.*

24. The power to distinguish between a thought and a reality, is called *Consciousness.*

[1849]

INSTINCT AND REASON:

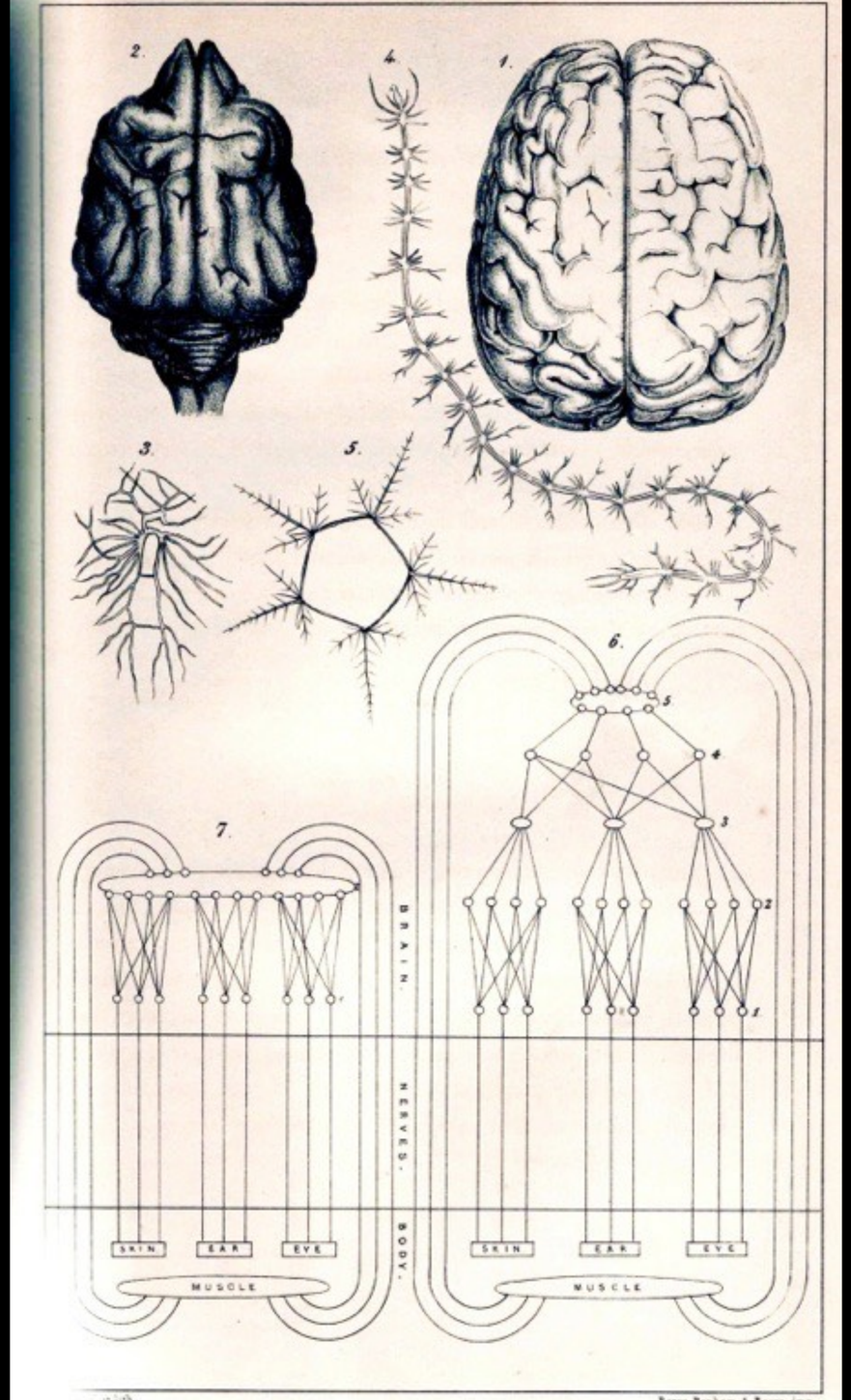
DEDUCED FROM

ELECTRO-BIOLOGY.

BY

ALFRED SMEE, F.R.S.

[1850]



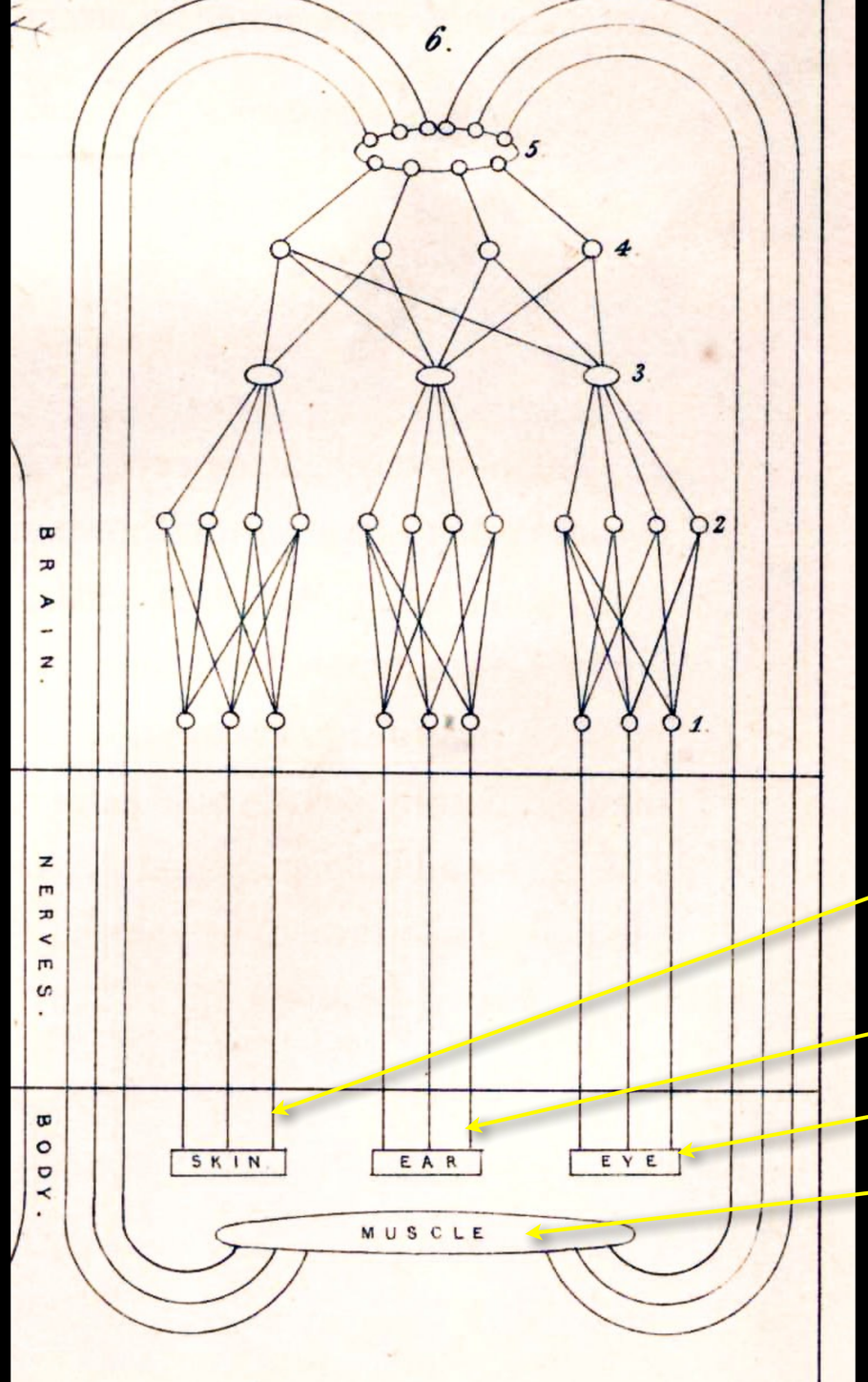
[1850]

[1850]

BRAIN

NERVES

BODY



SKIN

EAR

EYE

MUSCLE

THE

PROCESS OF THOUGHT

ADAPTED TO

WORDS AND LANGUAGE.

TOGETHER WITH A DESCRIPTION OF

THE RELATIONAL AND DIFFERENTIAL MACHINES.

BY

ALFRED SMEE, F.R.S.

[1851]

Royal Institution of Great Britain.

WEEKLY EVENING MEETING,

Friday, February 14, 1890.

WILLIAM CROOKES, Esq. F.R.S. Vice-President, in the Chair.

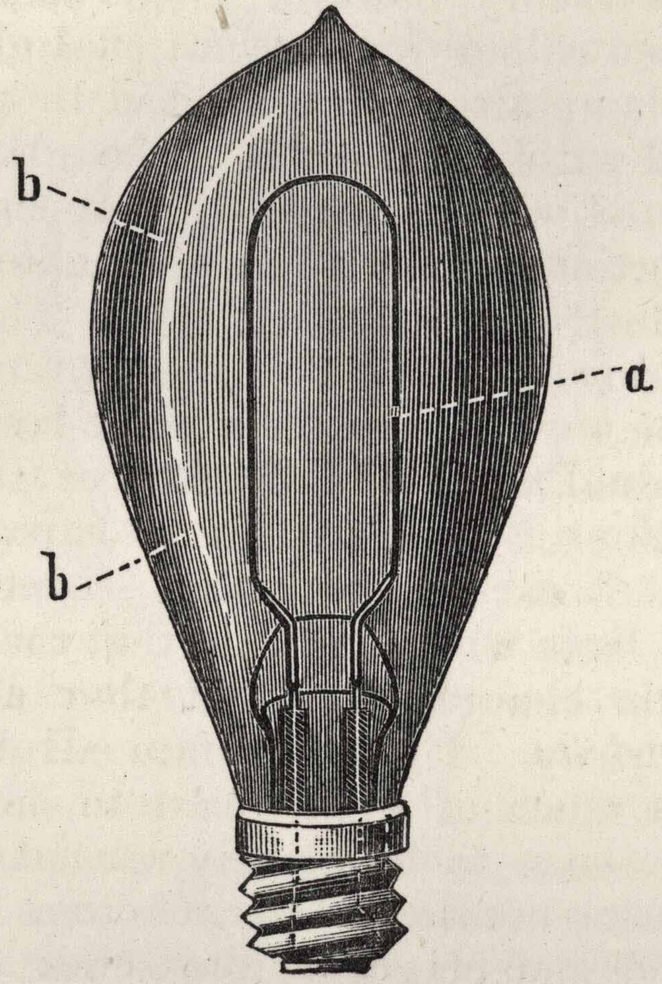
Professor J. A. FLEMING, M.A. D.Sc. *M.R.I.*

Problems in the Physics of an Electric Lamp.

MORE than eighty years ago Sir Humphry Davy provided the terminal wires of his great battery of 2000 pairs of plates with rods of carbon, and, bringing their extremities in contact, obtained for the first time a brilliant display of the electric arc.* The years that have fled away since that time have seen all the marvellous developments of electro-magnetic engineering, have placed in our possession the electric glow-lamp, and brought the art of electrical illumination to a condition in which it progresses each year with giant strides.

[John Ambrose Fleming]

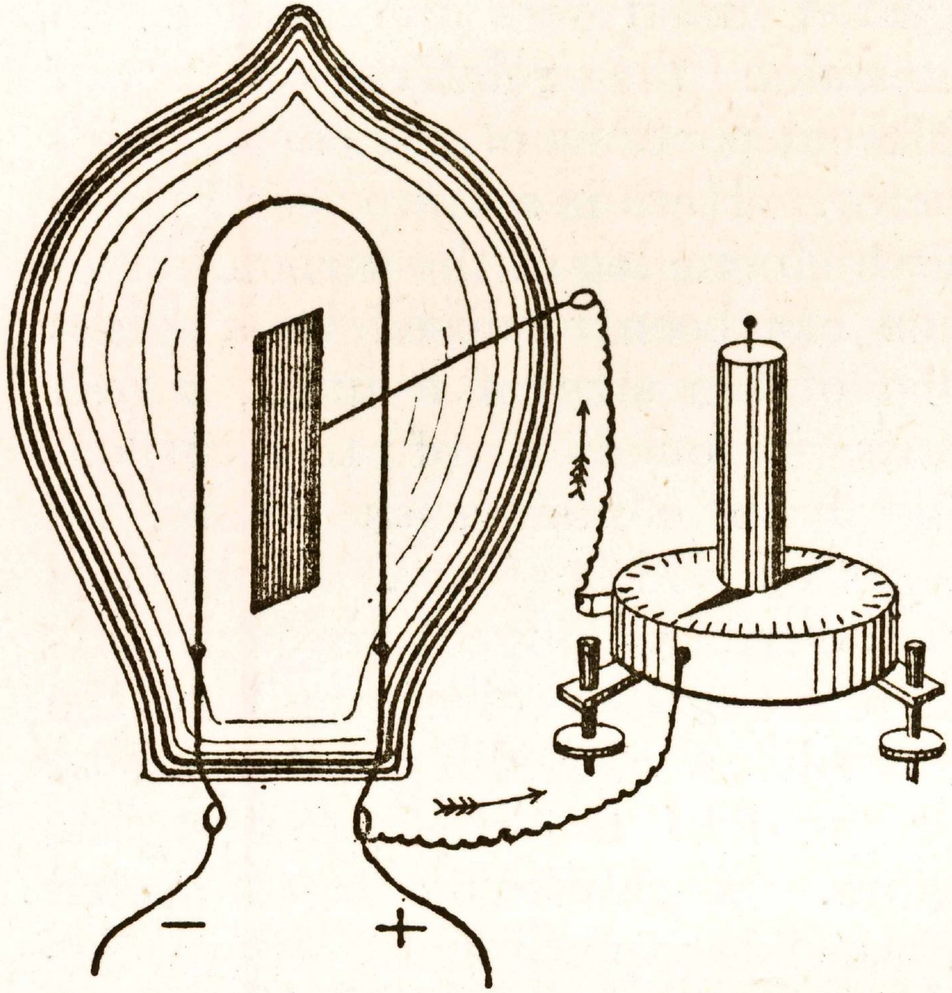
FIG. 1.



Glow lamp, having the glass bulb blackened by deposit of carbon, showing the molecular scattering which has taken place from the point *a* on the filament, and the shadow or line of no deposit produced at *b*.

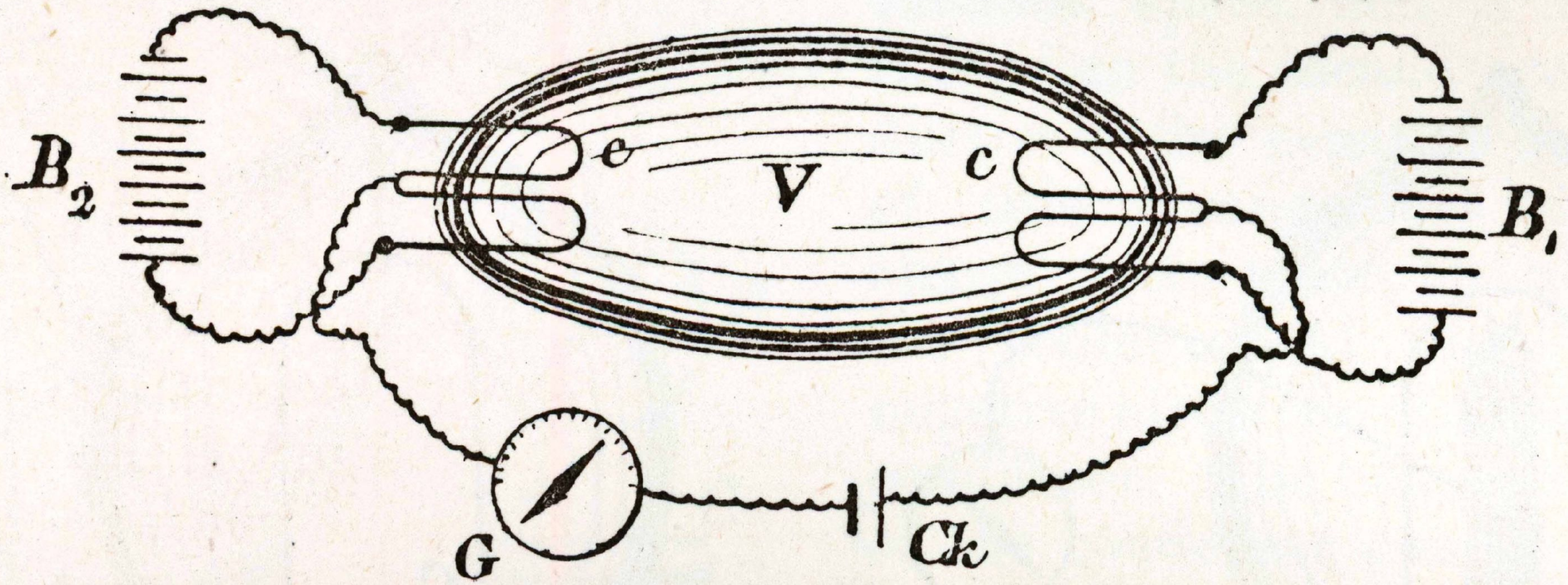
[14 February 1900]

FIG. 4.



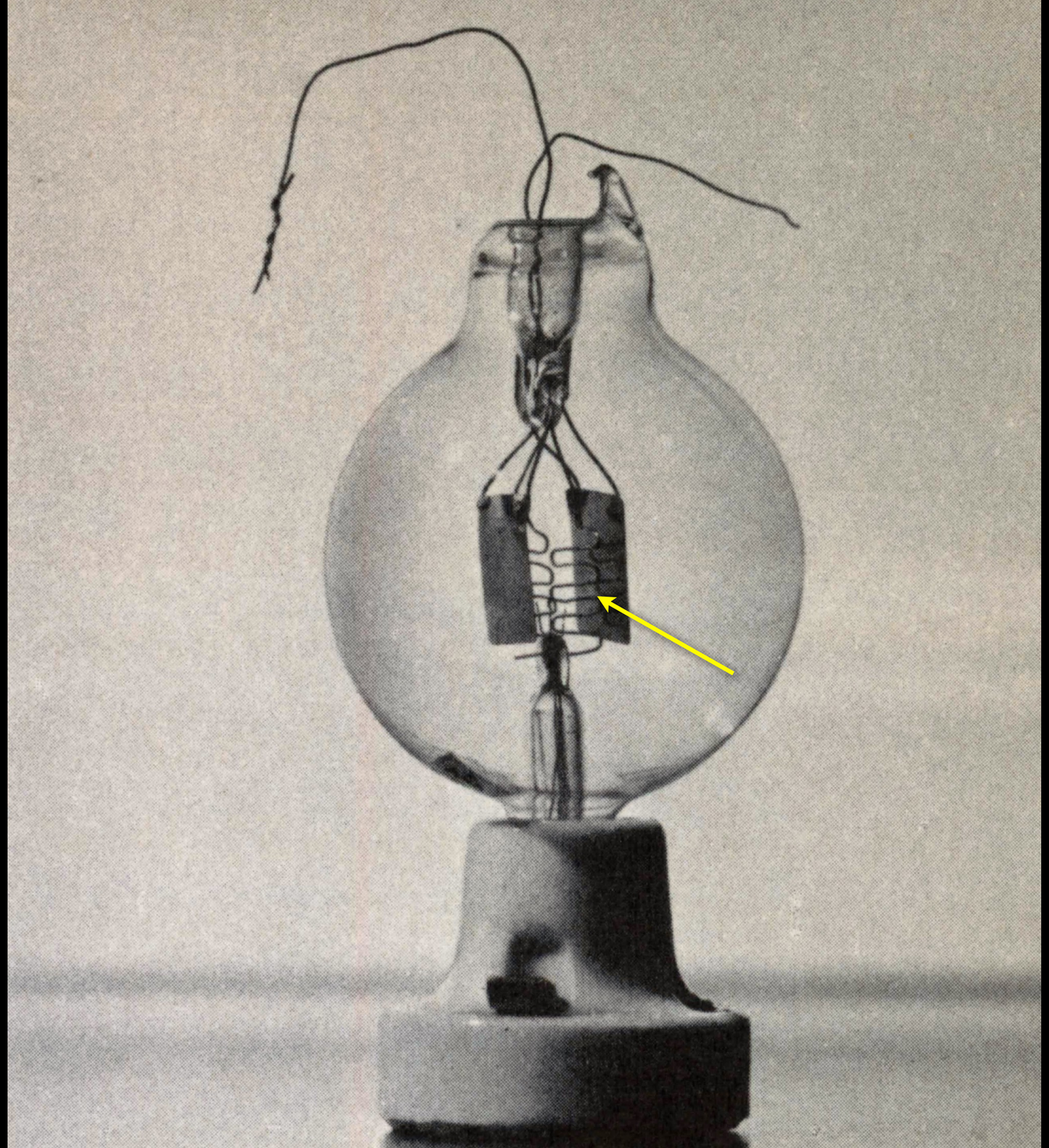
Sensitive galvanometer connected between the middle plate and positive electrode of a glow lamp, showing current flowing through it when the lamp is in action ("Edison effect").

FIG. 13.



Vacuum tube having carbon loop electrodes, *c c*, at each end rendered incandescent by insulated batteries B_1 B_2, showing current from Clark cell, *Ck*, passing through the high vacuum when the electrodes are incandescent.

[Lee De Forest]



[1907]

We have to regard the Universe . . . not as a collection of Things or Events existing apart from any awareness of them by observers, but as manifested Thoughts in a Universal Mind.

— John Ambrose Fleming, 1935

[Lewis Fry Richardson, 1930]

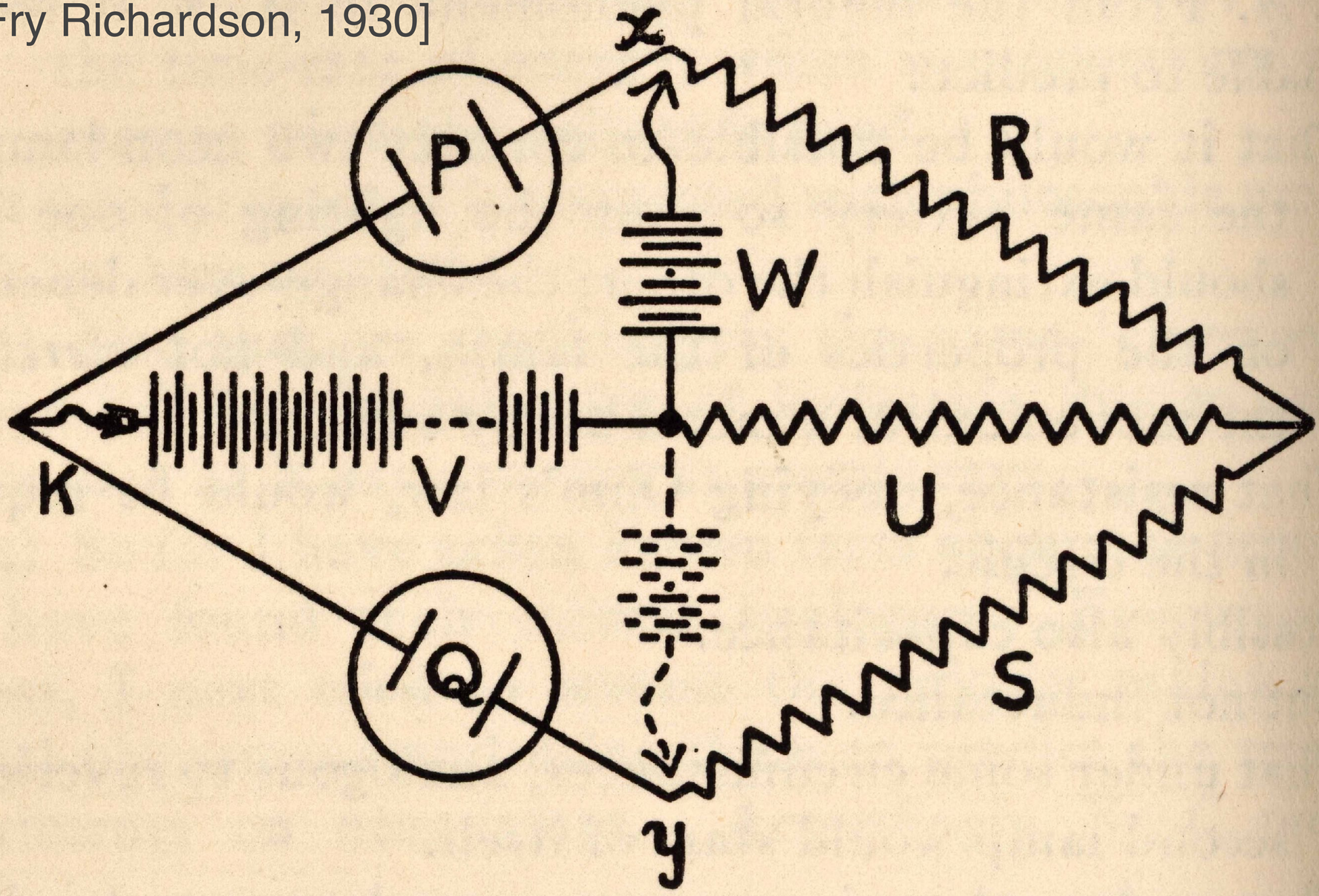
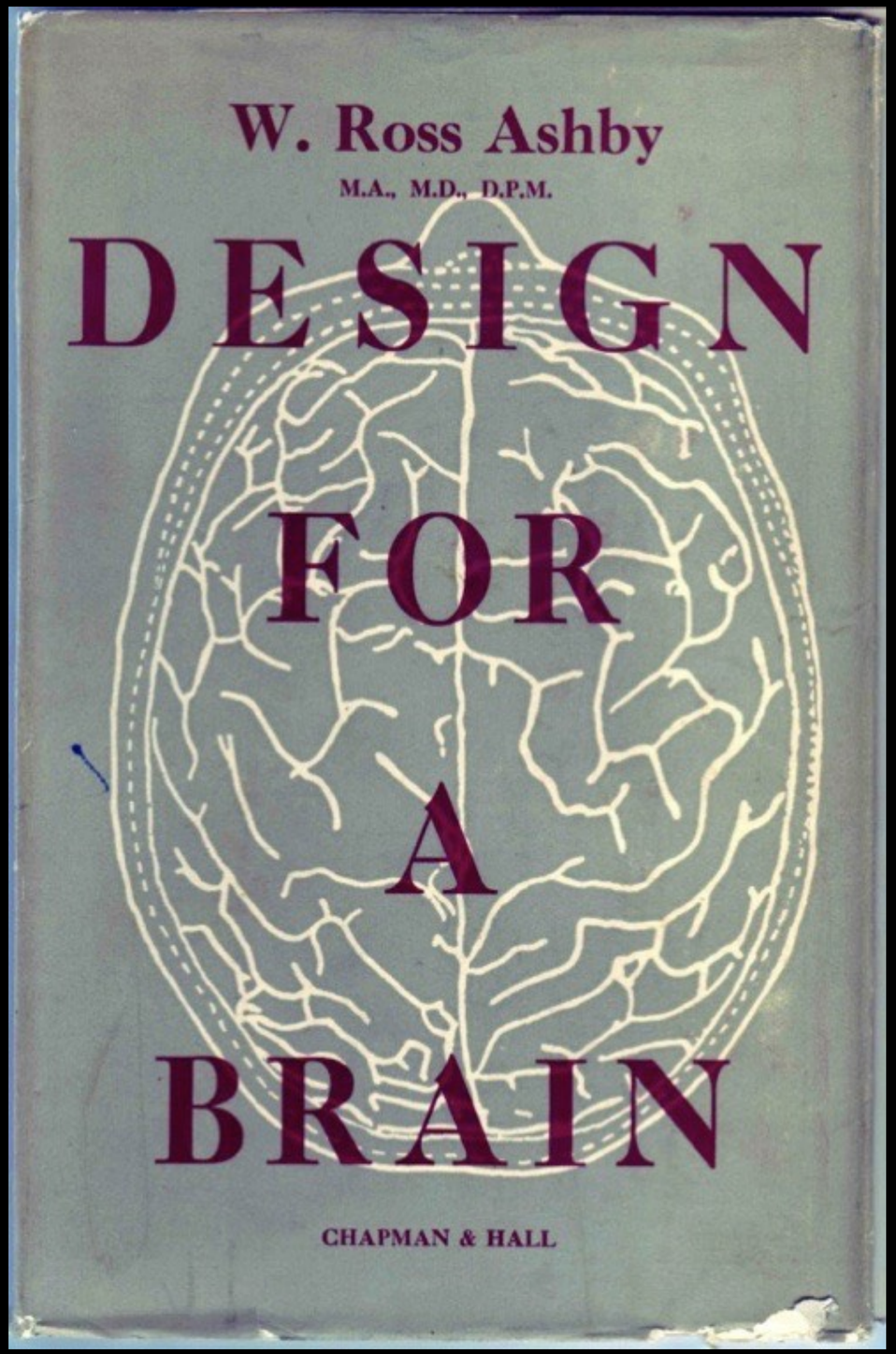


FIG. 1. Electrical Model illustrating a Mind having a Will but capable of only Two Ideas. See Analogies X., XI., XII., XIII.



[1952]

Ashby's Law of Requisite Variety

Any effective control system must be as complex as the system it controls.

Von Neumann's Law of Sufficient Complexity

A complex system constitutes its own simplest behavioral description.

The Third Law

Any system complicated enough to behave intelligently will be too complicated to understand.

NATIONAL PHYSICAL LABORATORY

SYMPOSIUM No. 10

Mechanisation of Thought Processes

VOLUME I

LONDON: HER MAJESTY'S STATIONERY OFFICE

Price £2. 10s. 0d. net for two volumes
(not to be sold separately)

[1958]

PANDEMONIUM: A PARADIGM FOR LEARNING

by

DR. O. G. SELFRIDGE

INTRODUCTION

WE are proposing here a model of a process which we claim can adaptively improve itself to handle certain pattern recognition problems which cannot be adequately specified in advance. Such problems are usual when trying to build a machine to imitate any one of a very large class of human data processing techniques. A speech typewriter is a good example of something that very many people have been trying unsuccessfully to build for some time.

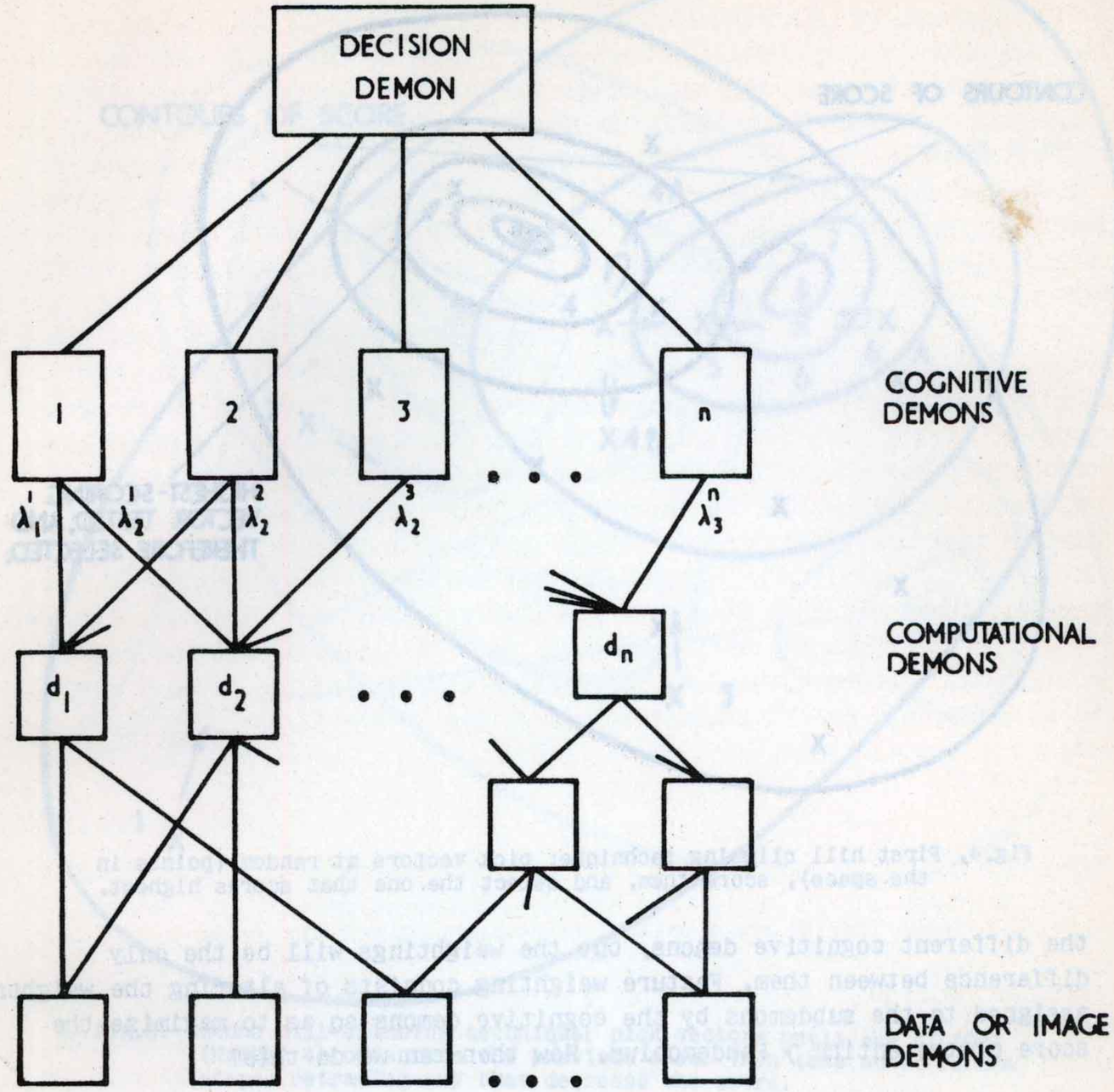


Fig. 3. Amended Pandemonium

[1958]

The Evolutionary Process

The adaptive changes mentioned above will tend, we hope, to promote a kind of evolution in our Pandemonium. The scheme sketched is really a natural selection on the processing demons. If they serve a useful function they survive, and perhaps are even the source for other subdemons who are themselves judged on their merits.

It is perfectly reasonable to conceive of this taking place on a broader scale - and in fact it takes place almost inevitably. Therefore, instead of having but one Pandemonium we might have some crowd of them, all fairly similarly constructed, and employ natural selection on the crowd of them. Eliminate the relatively poor and encourage the rest to generate new machines in their own images.

PROBABILITY AND THE WEIGHING OF EVIDENCE

By

I. J. GOOD, M.A., PH.D.

FORMER LECTURER IN MATHEMATICS
AT THE UNIVERSITY OF MANCHESTER

[1950]

An argument in favor of building a machine with initial randomness is that, if it is large enough, it will contain every network that will ever be required.

— Jack Good, 1958

REPRINTED FROM

ADVANCES IN COMPUTERS, VOLUME 6

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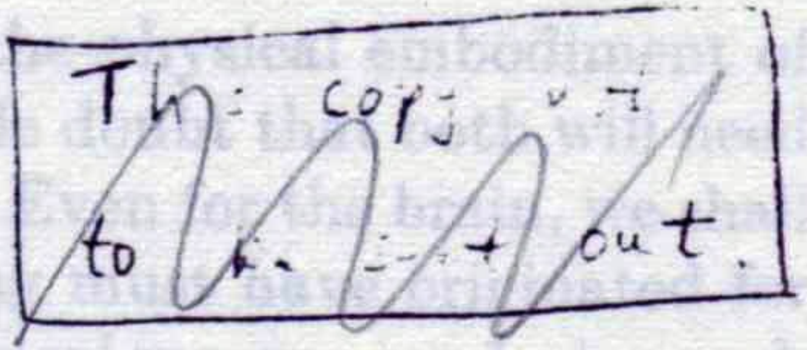
Speculations Concerning the First Ultraintelligent Machine*



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GTSD

1980 October 7

1350(i)

(This is the original longer version.)

(The version for publication is number 1350A.)

ETHICAL MACHINES

By I.J. Good
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Prepared for the Tenth Machine Intelligence Workshop, Case Western Reserve University, 1981 April 20-25.

Abstract

The notion of an ethical machine can be interpreted in more than one way. Perhaps the most important interpretation is a machine that can generalize from existing literature to infer one or more consistent ethical systems and can work out their consequences. An ultraintelligent machine should be able to do this, and that is one reason for not fearing it although this reason is by no means conclusive.

I once asked Turing whether he thought a machine could be conscious. He replied that he would say so if he would otherwise be punished.

— Irving J. (Jack) Good, 1962

Ch. I

P1 1) Wiener!

2) Hixon lecture. Pasadena '52 lecture.

P3 3) Turing!

4) Hixon lecture.

P4 5) Not Turing!

6) Boolean algebra.

7) Pitts-McCulloch!

8) Pasadena '52 lecture.

P5 9) Ref. 7), 8).

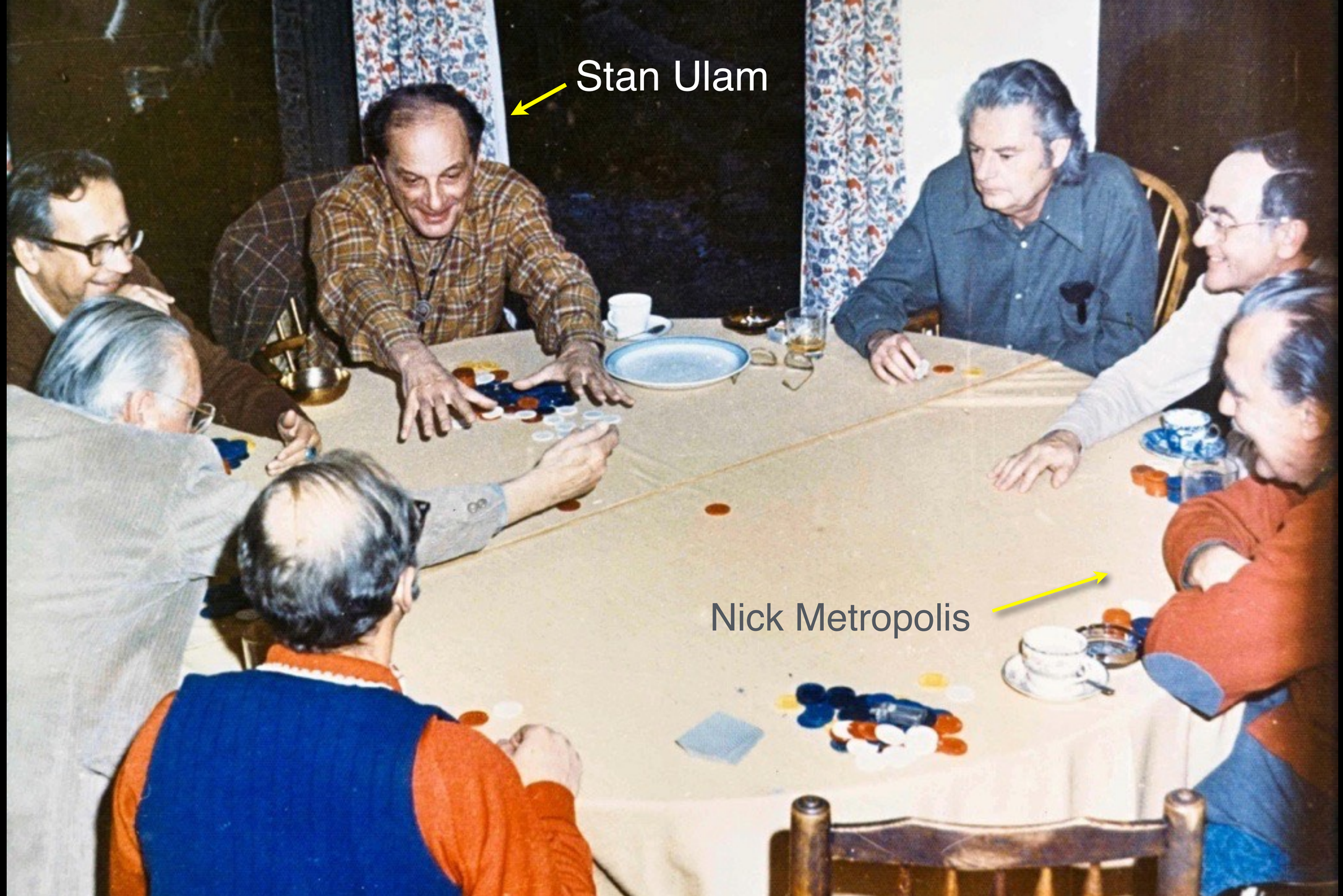
10) Ref. 7), 8).

11) Ref. 7), 8). Kleene!

P6 12) Hixon lecture.

P7 13) Ulam!

P8 14) Calling for stronger results.


Stan Ulam
Nick Metropolis

What makes you so sure that mathematical logic corresponds to the way we think?

—Stan Ulam


6J6

The difficulty is that most people who have been active in this field seem to believe that it is easier to write a new code than to understand an old one. . .

—John von Neumann, 23 April 1952

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THE END