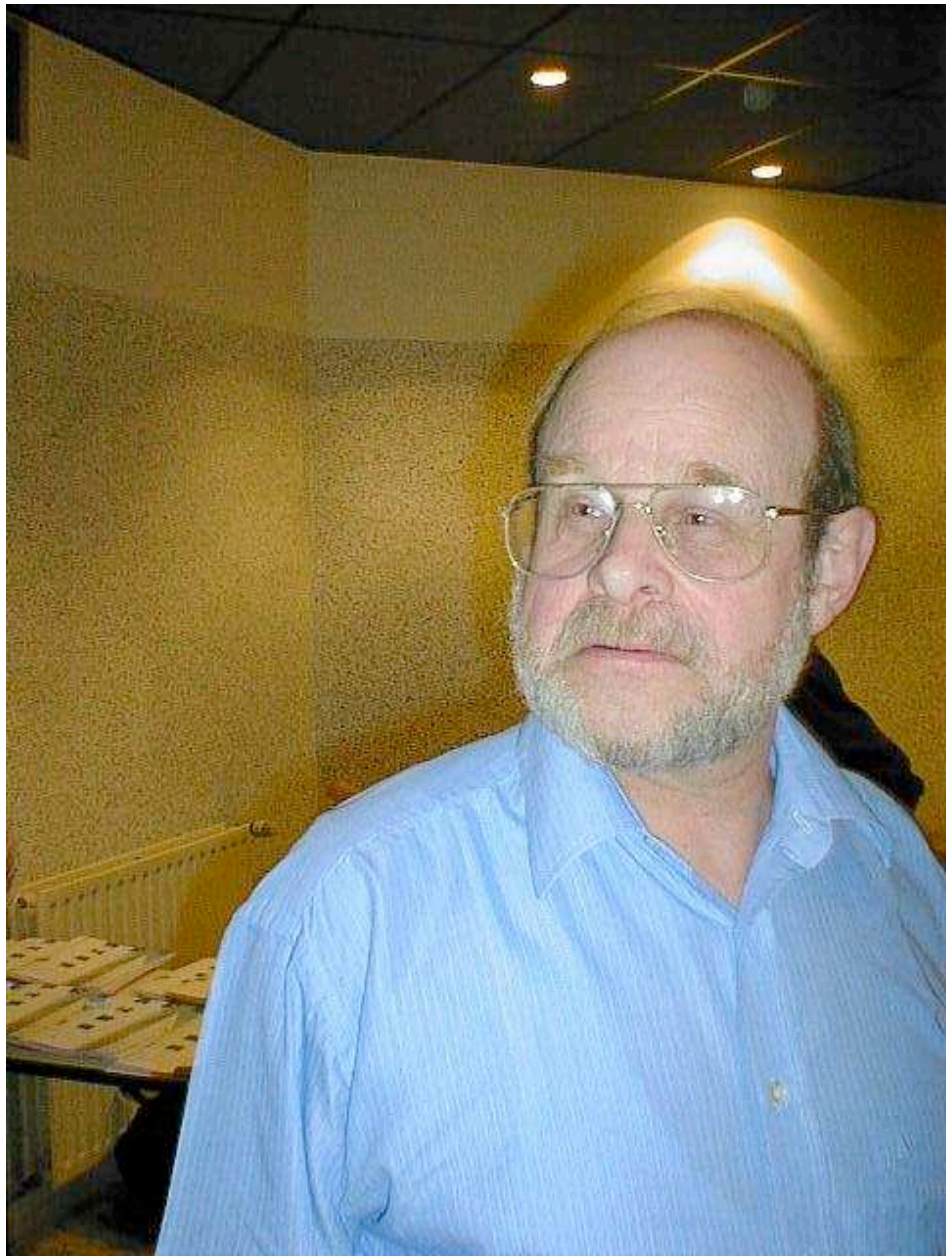
(pré)Histoire de l’informatique: quelques jalons…

Gilles Geeraerts

Guy Louchard 1936-2023



Informatique ?

- *Computer science is the study of **computation**, **information**, and **automation***

- L'informatique est un domaine d'activité scientifique, technique, et industriel concernant le **traitement automatique** de **l'information** numérique par l'exécution de programmes informatiques hébergés par des dispositifs électriques-électroniques

Wikipedia

Mécanisation du raisonnement

- *Ἀναλυτικὰ Πρότερα ~ 350 avant JC*
- *συλλογισμός:* syllogisme
  - Tous les humains sont mortels
  - Socrate est un humain
  - Donc, Socrate est mortel

Aristote 384–322 avant JC

Syllogisme

- Tous les Tugudus sont des Coin-Coin
- Tagadapouetpouet est un Tugudu
- Donc, Tagadapouetpouet est un Coin-Coin

Aristote après un TD CI

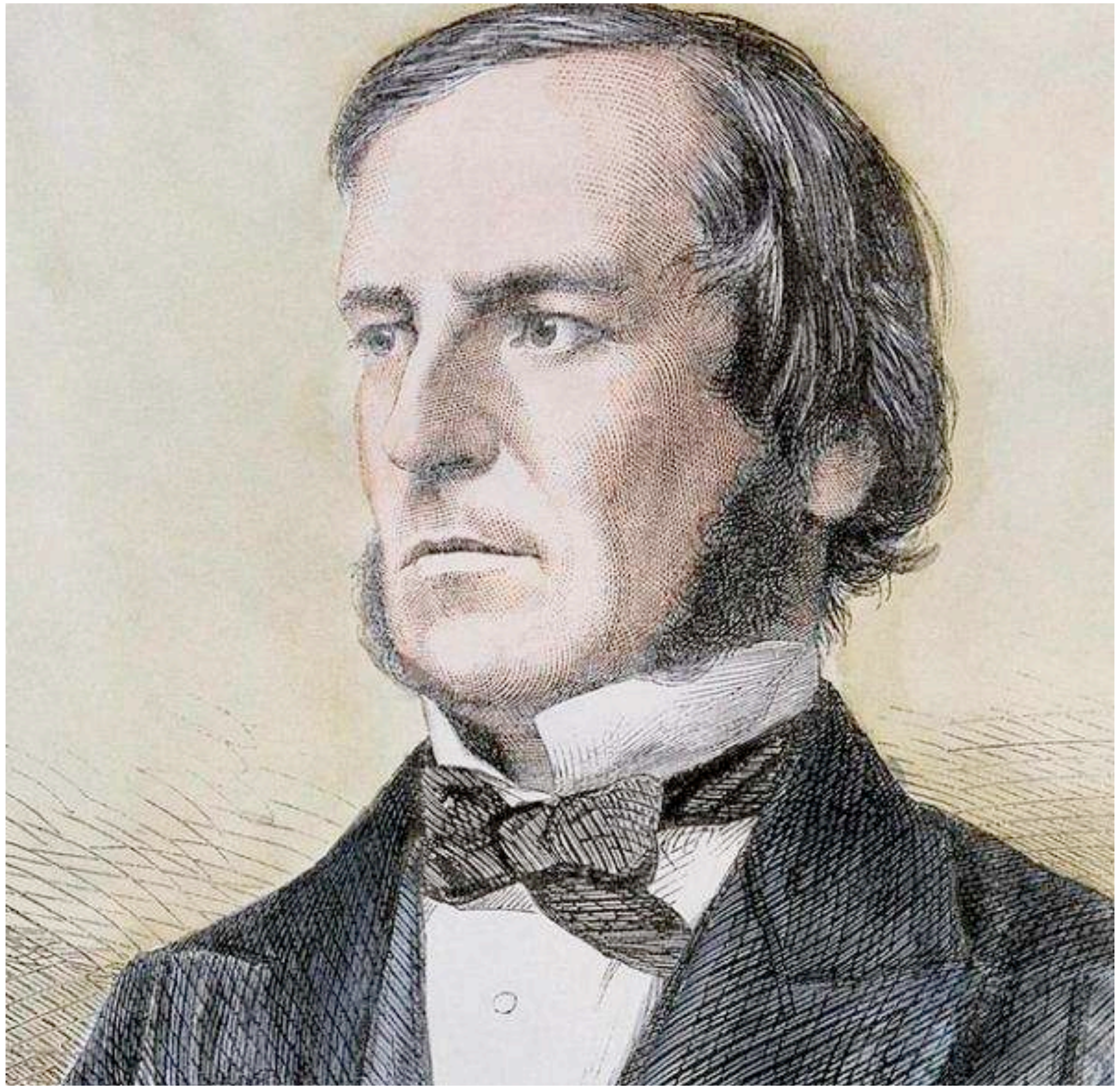
Logique et mathématique ?

- Jusqu’au XIX ème siècle, la logique était considérée comme une branche de la philosophie

- Les raisonnements logiques sont exprimés en langue naturelle

George Boole

- 1815 (UK) — 1864 (Irlande)
- Son père, cordonnier, fabriquait des télescopes et avait même essayé de fabriquer une machine à calculer…
- Il apprend les mathématiques en autodidacte dès l'âge de 16 ans…
- Devient professeur à l'University College à Dublin



An Investigation of the Laws of Thought

PROPOSITION III.

If x represent any class of objects, then will $1 - x$ represent the contrary or supplementary class of objects., i.e. the class including all objects which are not comprehended in the class x.

For greater distinctness of conception let x represent the class men, and let us express, according to the last Proposition, the Universe by 1; now if from the conception of the Universe, as consisting of "men" and "not-men," we exclude the conception of "men," the resulting conception is that of the contrary class, "not-men." Hence the class "not-men" will be represented by $1 - x$. And, in general, whatever class of objects is represented by the symbol x, the contrary class will be expressed by $1 - x$.

15. Although the following Proposition belongs in strictness to a future chapter of this work, devoted to the subject of *maxims* or *necessary truths*, yet, on account of the great importance of that law of thought to which it relates, it has been thought proper to introduce it here.

PROPOSITION IV.

That axiom of metaphysicians which is termed the principle of contradiction, and which affirms that it is impossible for any being to possess a quality, and at the same time not to possess it, is a consequence of the fundamental law of thought, whose expression is $x^2 = x$.

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Let us write this equation in the form

$$x - x^2 = 0,$$

whence we have

$$x\,(1 - x) = 0; \qquad (1)$$

both these transformations being justified by the axiomatic laws of combination and transposition (II. 13). Let us, for simplicity of conception, give to the symbol x the particular interpretation of *men*, then $1 - x$ will represent the class: of "not-men" (Prop. III.) Now the formal product of the expressions of two classes represents that class of individuals which is common to them both (II. 6). Hence $x\,(1 - x)$ will represent the class whose members are at once "men," and "not men," and the equation (1) thus express the principle, *that a class whose members are at the same time men and not men does not exist.* In other words, that *it is impossible for the same individual to be at the same time a man and not a man.* Now let the meaning of the symbol x be extended from the representing of "men," to that of any class of beings characterized by the possession of any quality whatever; and the equation (1) will then express that it is impossible for a being to possess a quality and not to possess that quality at the same time. But this is identically that "principle of contradiction" which Aristotle has described as the fundamental axiom of all philosophy. "It is impossible that the same quality should both belong and not belong to the same thing.... This is the most certain of all principles.... Wherefore they who demonstrate refer to this as an ultimate opinion. For it is by nature the source of all the other axioms."[1]

An Investigation of the Laws of Thought

An Investigation of the Laws of Thought

10. RULE.—*When both Subject and Predicate of a Proposition are universal, form the separate expressions for them, and connect them by the sign =.*

This case will usually present itself in the expression of the definitions of science, or of subjects treated after the manner of pure science. Mr. Senior's definition of wealth affords a good example of this kind, viz.:

"Wealth consists of things transferable, limited in supply, and either productive of pleasure or preventive of pain."

Before proceeding to express this definition symbolically, it must be remarked that the conjunction *and* is superfluous. Wealth is really defined by its possession of three properties or qualities, not by its composition out of three classes or collections of objects. Omitting then the conjunction *and*, let us make

w = wealth.

t = things transferable.

s = limited in supply.

p = productive of pleasure.

r = preventive of pain.

An Investigation of the Laws of Thought

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t =

s =

p =

r =

Now it is plain from the nature of the subject, that the expression, "Either productive of pleasure or preventive of pain," in the above definition, is meant to be equivalent to "Either productive of pleasure; or, if not productive of pleasure, preventive of pain." Thus the class of things which the above expression, taken alone, would define, would consist of all things productive of pleasure, together with all things not productive of pleasure, but preventive of pain, and its symbolical expression would be

$$p + (1 - p)r.$$

Algèbre Booléenne

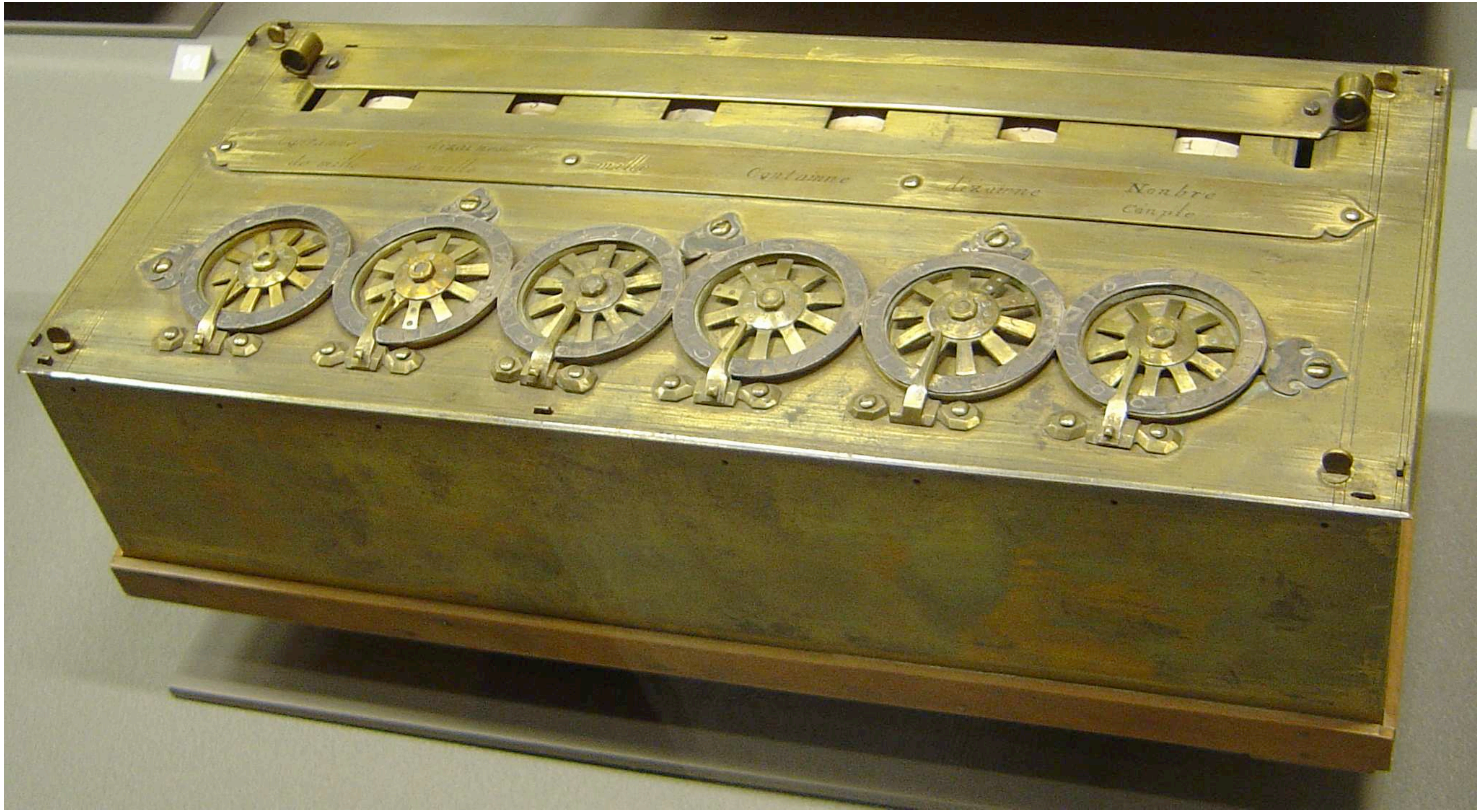
1.	$x + 0 = x$	(Additive Identity)
2.	$x + (y + z) = (x + y) + z$	(Associativity)
3.	$x + y = y + x$	(Commutativity)
4.	$x + (1 – x) = 1$	(Not operator)
5.	$x1 = x$	(Multiplicative Identity)
6.	$x0 = 0$	
7.	$x + 1 = 1$	
8.	$xy = yx$	(Commutativity)
9.	$x(yz) = (xy)z$	(Associativity)
10.	$x(y + z) = xy + xz$	(Distributive)
11.	$x(y – z) = xy – xz$	(Distributive)
12.	$x^2 = x$	(Idempotent)
13.	$x^n = x$	

Gerard O’Regan, *A brief history of Computing*, Springer, 2008

Blaise Pascal

- 1623-1662
- mathématicien, physicien, écrivain, philosophe…
- inventeur de la première machine à calculer

Pascaline



Brunsviga 13RM

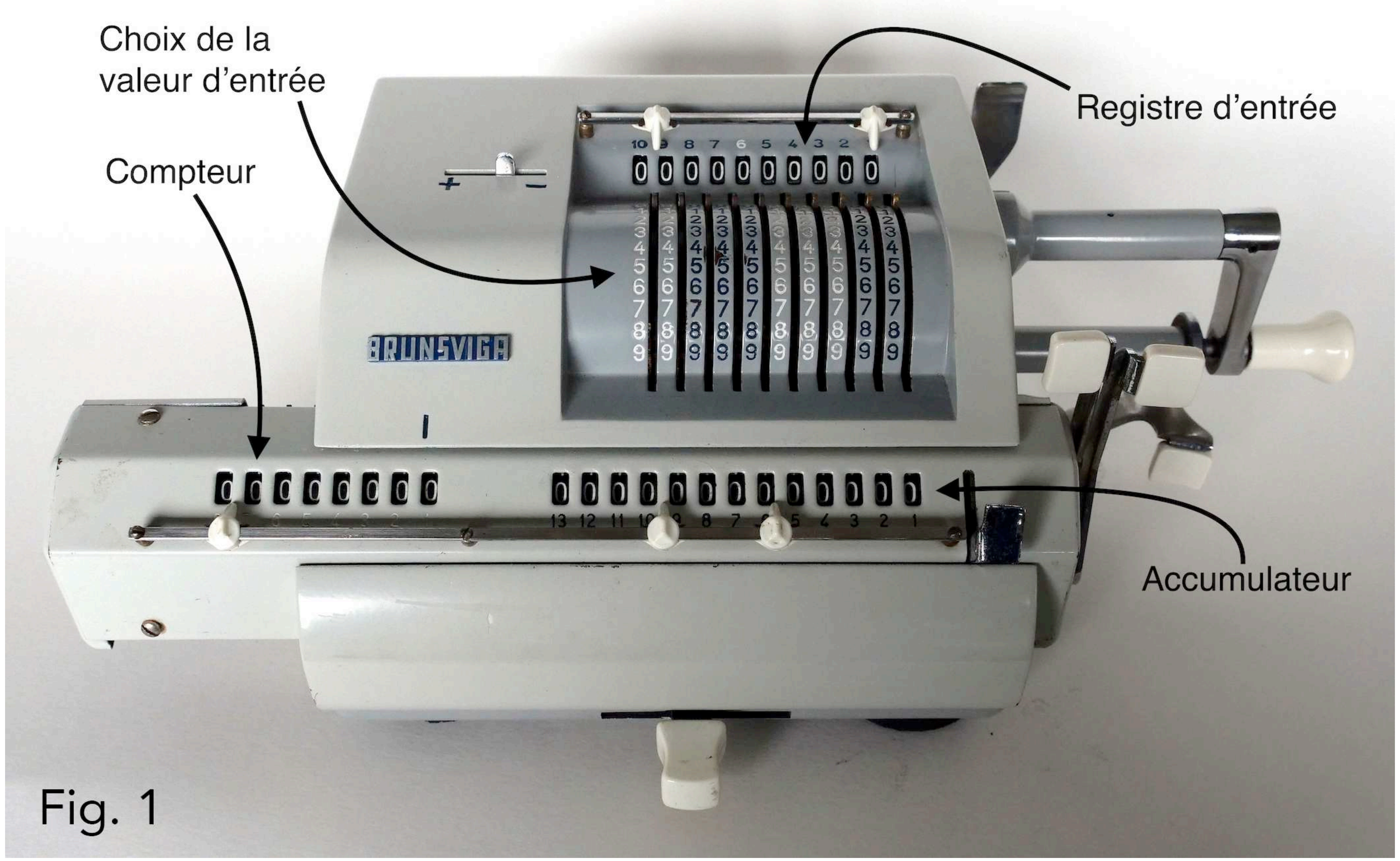


Fig. 1

https://musees.ulb.be/fr/objet-du-mois/09-2019-la-brunsviga-13rm

Brunsviga 13RM

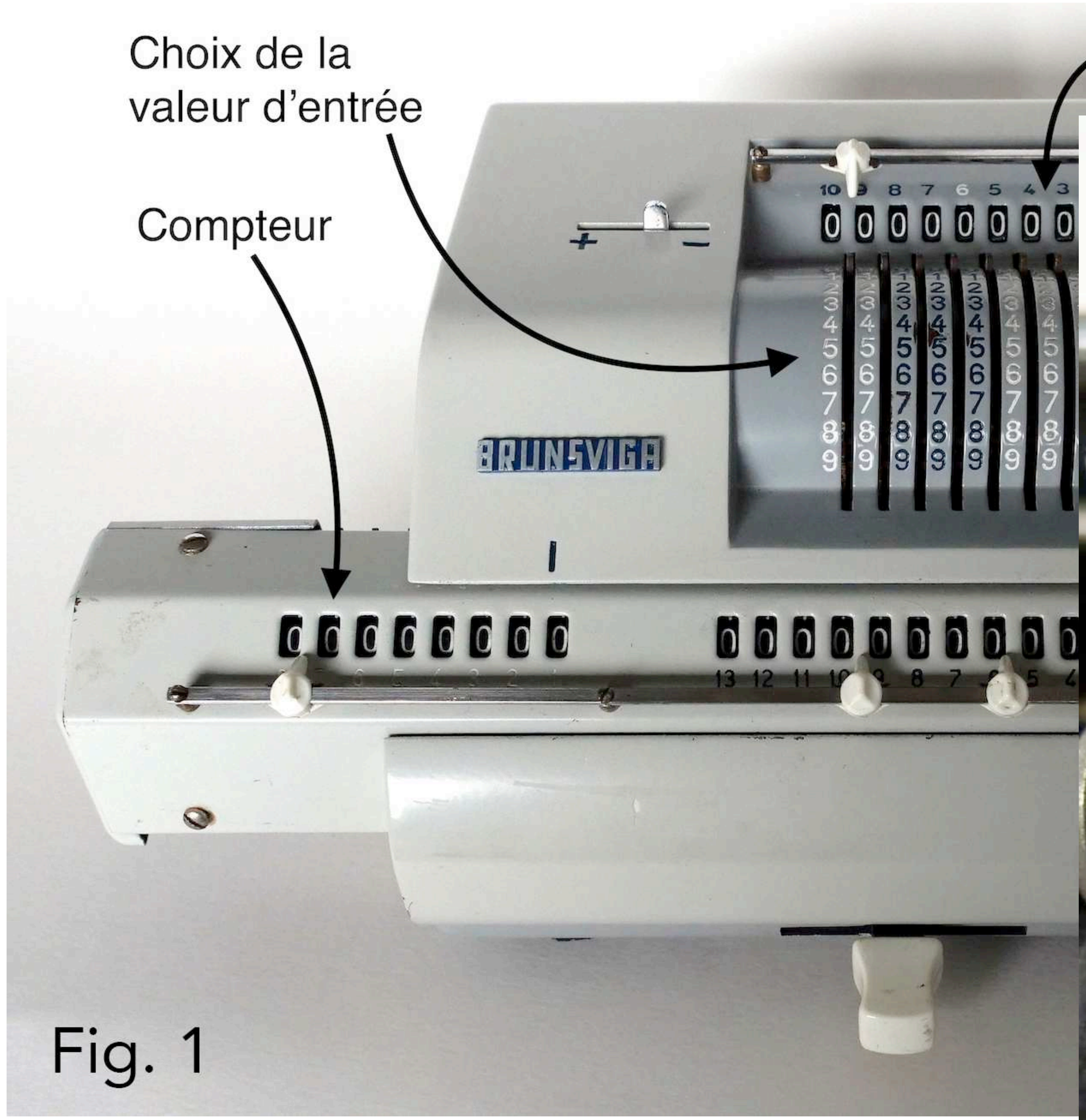


Fig. 1

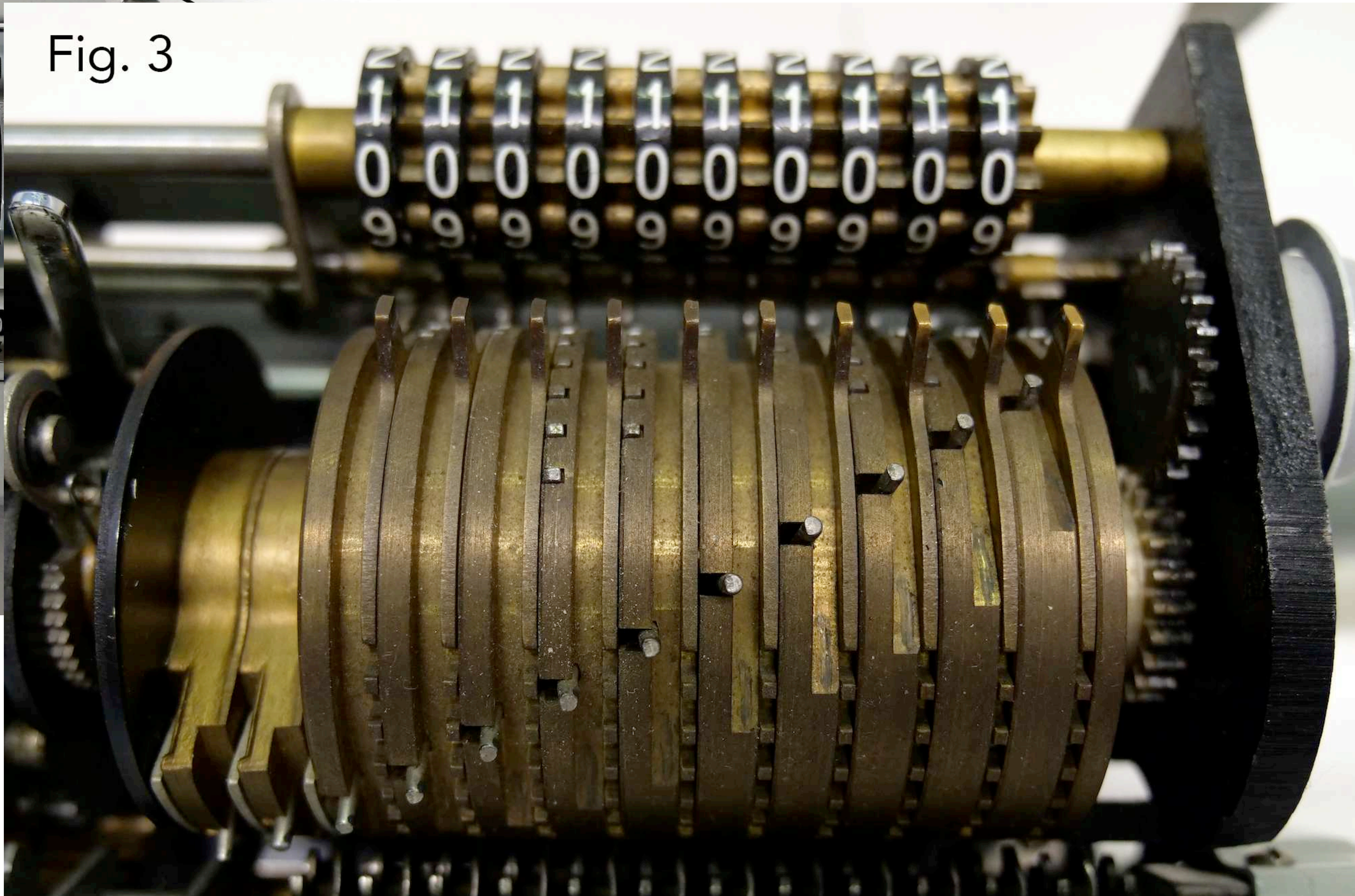


Fig. 3

https://musees.ulb.be/fr/objet-du-mois/09-2019-la-brunsviga-13rm

Friden ~ années 1950

Collection informatique ULB

Joseph Marie Jacquard

- 1752-1834, tisserand français
- Invente (1803) un métier à tisser automatique, dont les motifs sont stockés sur des cartes perforées

By Ephraïm Conquy/ After Jean-Claude Bonnefond - sil.si.edu, Public Domain, https://commons.wikimedia.org/w/index.php?curid=62538

Charles Babbage

- 1791-1871, Royaume-Uni
- Un des fondateurs de la *Royal Astronomical Society*
- Intéressé par le calcul des tables astronomiques et des tables de logarithmes

By Antoine Claudet - National Portrait Gallery, Public Domain, https://commons.wikimedia.org/w/index.php?curid=48042816

Tables de logarithmes

Table des logarithmes décimaux entre 1 et 100

N	ln(N)	N	ln(N)	N	ln(N)	N	ln(N)	N	ln(N)
1	0	21	1,322 22	41	1,612 78	61	1,785 33	81	1,908 49
2	0,301 03	22	1,342 42	42	1,623 25	62	1,792 39	82	1,913 81
3	0,477 12	23	1,361 73	43	1,633 47	63	1,799 34	83	1,919 08
4	0,602 06	24	1,380 21	44	1,643 45	64	1,806 18	84	1,924 28
5	0,698 97	25	1,397 94	45	1,653 21	65	1,812 91	85	1,929 42
6	0,778 15	26	1,414 97	46	1,662 76	66	1,819 54	86	1,934 5
7	0,845 1	27	1,431 36	47	1,672 1	67	1,826 07	87	1,939 52
8	0,903 09	28	1,447 16	48	1,681 24	68	1,832 51	88	1,944 48
9	0,954 24	29	1,462 4	49	1,690 2	69	1,838 85	89	1,949 39
10	1	**30**	1,477 12	**50**	1,698 97	**70**	1,845 1	**90**	1,954 24
11	1,041 39	31	1,491 36	51	1,707 57	71	1,851 26	91	1,959 04
12	1,079 18	32	1,505 15	52	1,716	72	1,857 33	92	1,963 79
13	1,113 94	33	1,518 51	53	1,724 28	73	1,863 32	93	1,968 48
14	1,146 13	34	1,531 48	54	1,732 39	74	1,869 23	94	1,973 13
15	1,176 09	35	1,544 07	55	1,740 36	75	1,875 06	95	1,977 72
16	1,204 12	36	1,556 3	56	1,748 19	76	1,880 81	96	1,982 27
17	1,230 45	37	1,568 2	57	1,755 87	77	1,886 49	97	1,986 77
18	1,255 27	38	1,579 78	58	1,763 43	78	1,892 09	98	1,991 23
19	1,278 75	39	1,591 06	59	1,770 85	79	1,897 63	99	1,995 64
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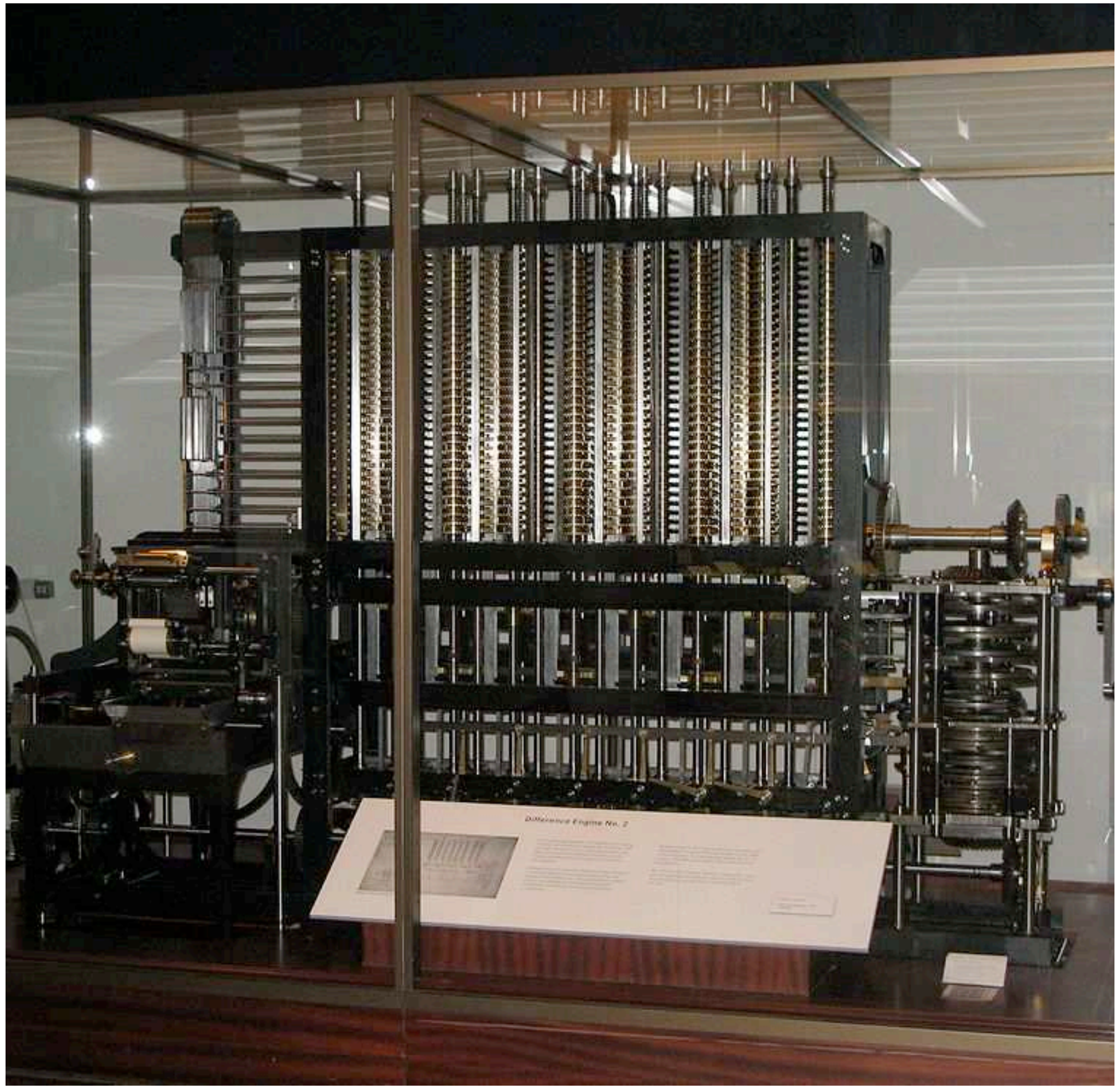
The difference engine

- Machine utilisée pour calculer des polynômes, utilisés pour approximer des logarithmes et d'autres fonctions

- Soutenue financièrement par le gouvernement britannique (jusqu'à 17 000£ en 1842)

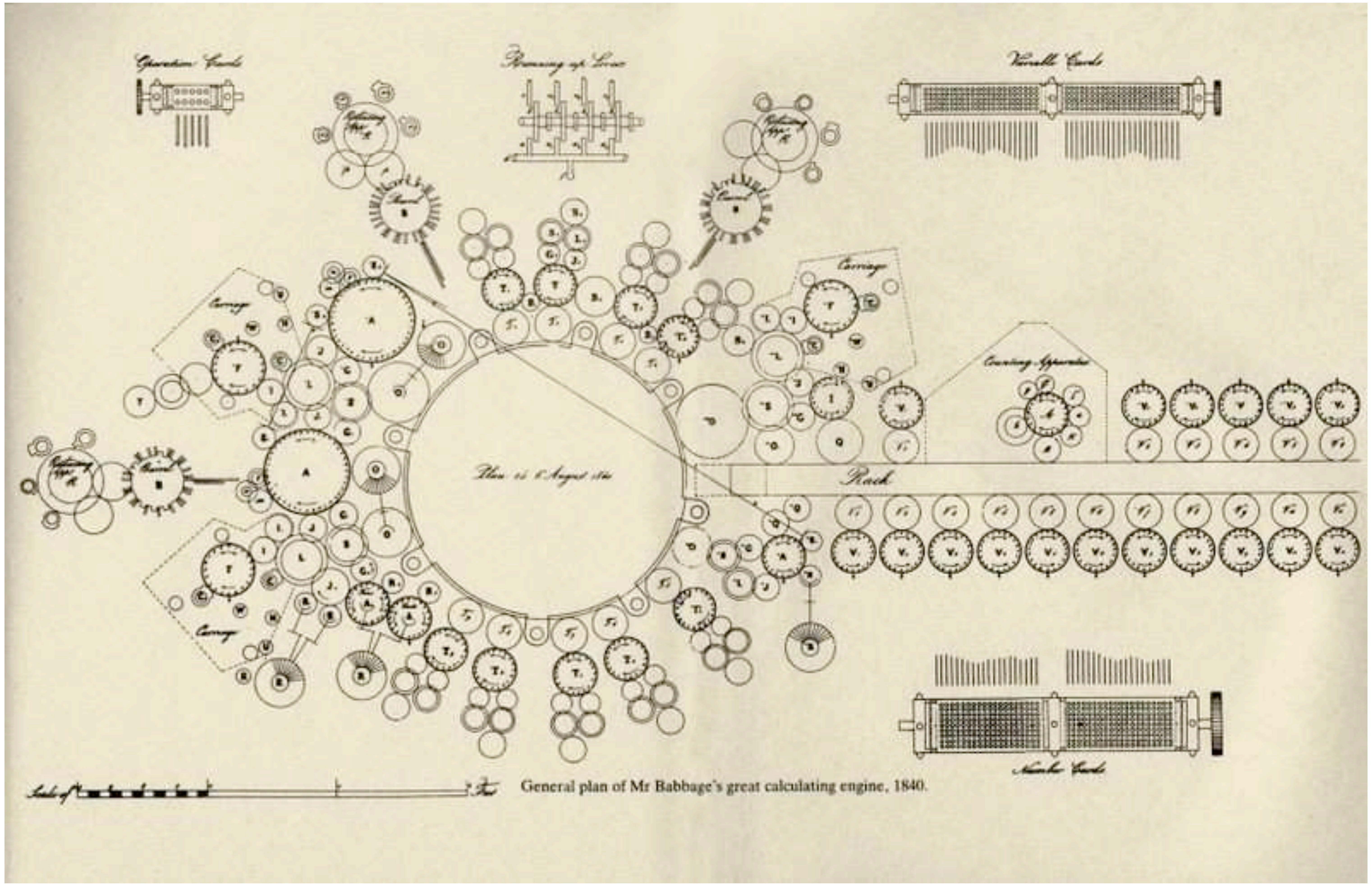
- Jamais terminé du temps de Babbage, construit plus tard sur base de ses plans

- Pas un ordinateur…



The analytical engine

- Premier ordinateur de l’histoire: conçu en 1840
- Programmable à l’aide de cartes perforées
- Entièrement mécanique
- Jamais construit



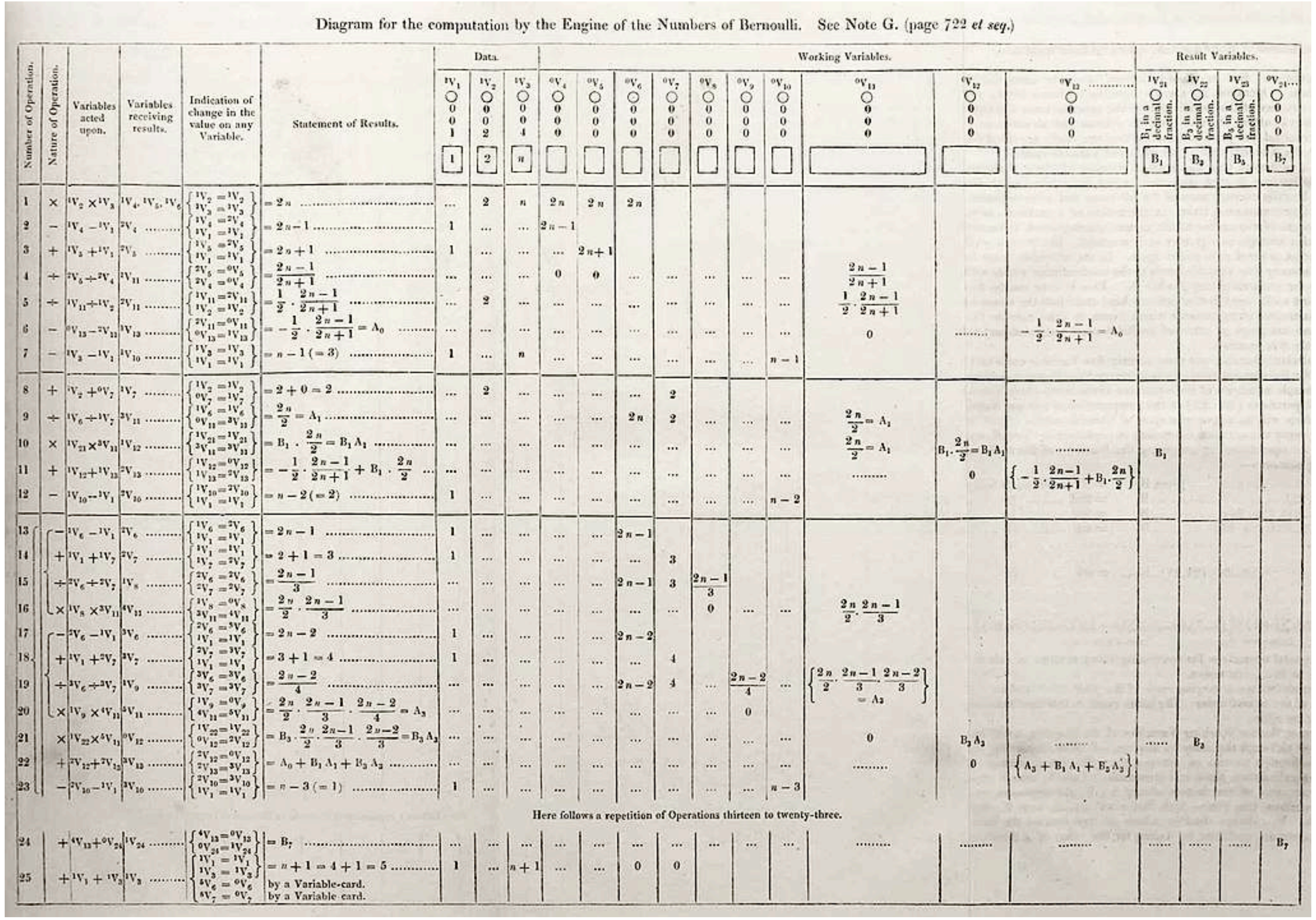
General plan of Mr Babbage's great calculating engine, 1840.

Ada Lovelace

- 1815-1852, Royaume-Uni
- Fille du poète Lord Byron
- Amie proche de Babbage
- « Première programmeuse de l'histoire »… pas vraiment…
- Première personne à avoir compris les applications possibles de l'ordinateur, au-delà du pur calcul

Ada première programmeuse ?

- En 1840, Ada Lovelace participe à la publication d'une traduction en français d'une conférence donnée par Babbage à Turin, transcrite par Menabrea
- Des notes sont ajoutées, dont le premier programme publié pour le calcul des nombres de Bernoulli
- Babbage avait déjà écrit d'autres programmes (non publiés) plusieurs années avant



By Ada Lovelace - http://www.sophiararebooks.com/pictures/3544a.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=37285970

Ada Lovelace la visionnaire

« [The Analytical Engine] might act upon other things besides *number*, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and which should be also susceptible of adaptations to the action of the operating notation and mechanism of the engine… Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent. »

Lovelace, Ada; Menabrea, Luigi (1842). "Sketch of the Analytical Engine invented by Charles Babbage Esq". Scientific Memoirs. Richard Taylor: 694.

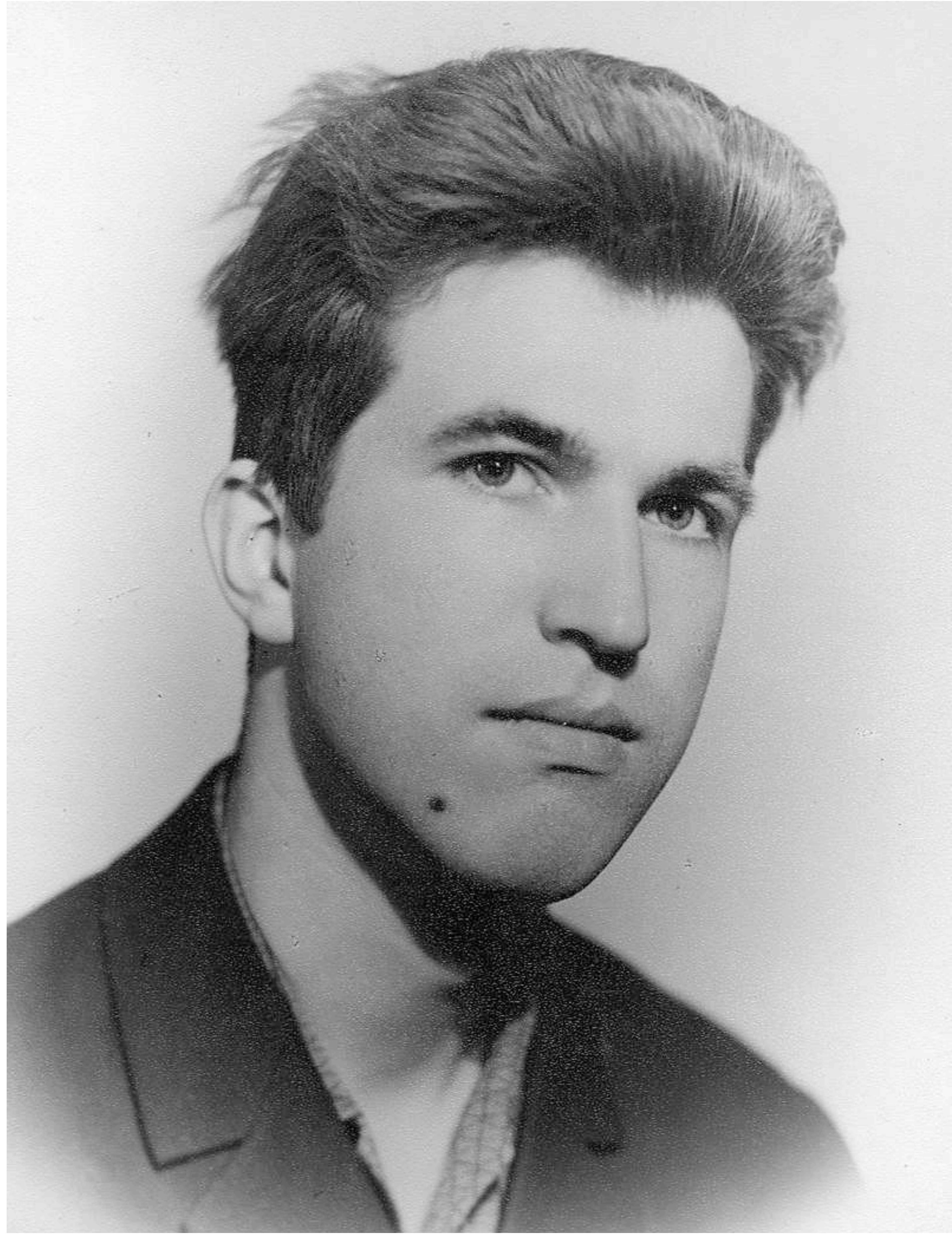
Hilbert et ses 23 problèmes

- 1862 - 1943, Allemagne
- Présente en 1900 23 problèmes à résoudre pour le vingtième siècle
- 10ème problème:
    - « *Trouver un algorithme déterminant si une équation diophantienne a des solutions.* »

Par Auteur inconnu — Possibly Reid, Constance (1970) Hilbert, Berlin, Heidelberg : Springer Berlin Heidelberg Imprint Springer, p. 230 ISBN : 978-3-662-27132-2., Domaine public, https://commons.wikimedia.org/w/index.php?curid=36302

Yuri Matiyasevich et le 10ème problème

- Né à Leningrad en 1947
- Prouve en 1970 que le dixième problème d’Hilbert n’a pas de solution car le problème est indécidable



Alan Turing

- 1912-1954, Royaume-Uni
- Étudiant d’Alonzo Church à Princeton, où il définit la notion de *machine de Turing*
- *On Computable Numbers, with an Application to the Entscheidungsproblem*

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On Computable Numbers, with an Application to the Entscheidungsproblem

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.

On Computable Numbers, with an Application to the Entscheidungsproblem

ON COMPUTABLE NUMBERS, WITH AN APPLICATION TO THE ENTS

By

[Received 28 May

The "computable" num
numbers whose expressions a

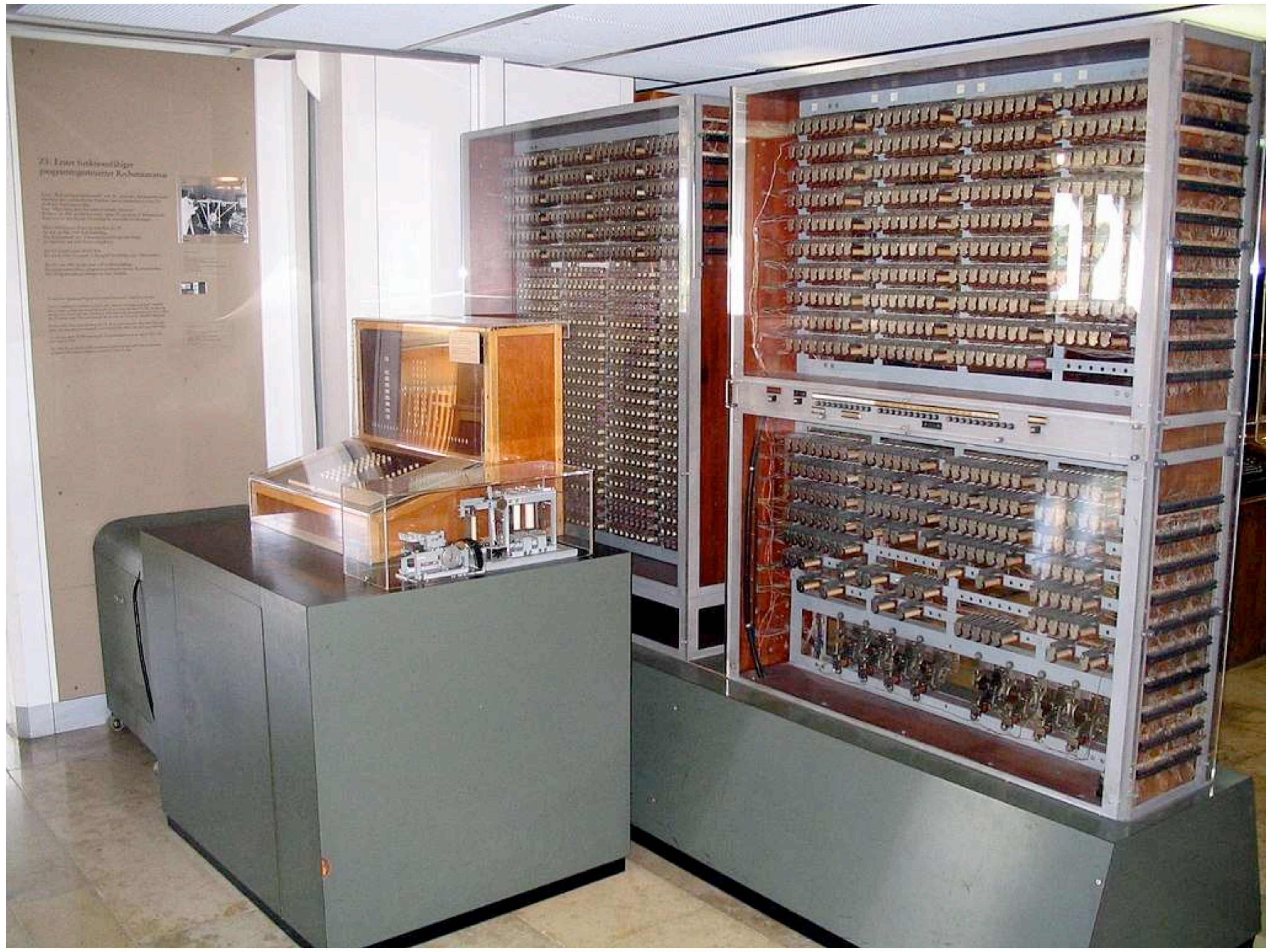
We may compare a man in the process of computing a real number to a machine which is only capable of a finite number of conditions $q_1, q_2, \ldots, q_R$ which will be called "m-configurations". The machine is supplied with a "tape" (the analogue of paper) running through it, and divided into sections (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.

Konrad Zuse et le Z3

- 1910-1995 Allemagne
- Considéré comme le premier à avoir réalisé un ordinateur (Turing complet) fonctionnel (électromécanique) en 1941

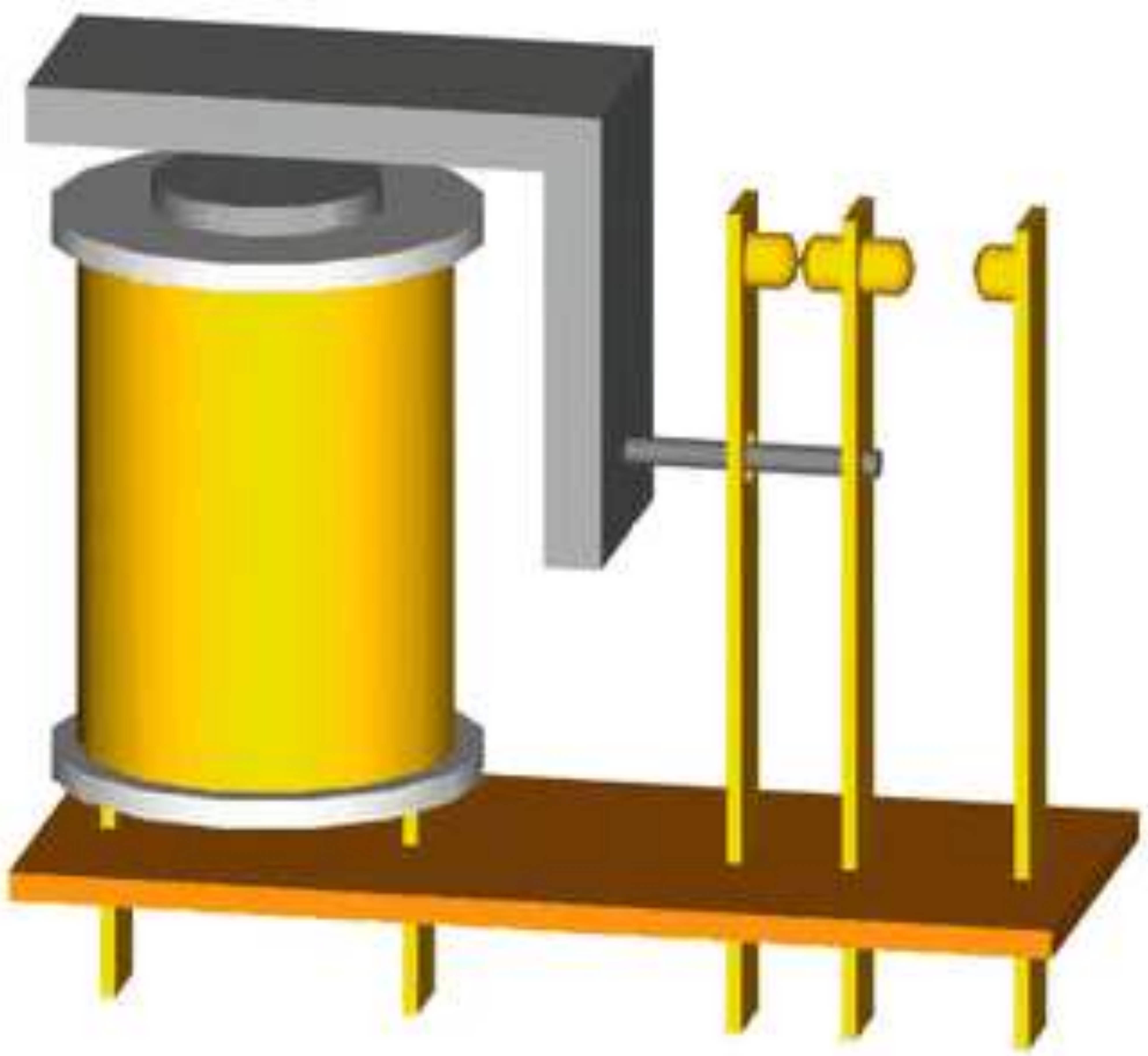
Le Z3

- Ordinateur électromécanique composé de 2000 relais
- Vitesse: entre 5,3 Hz
- Programmes sur rubans perforés
- 4000 Watts !

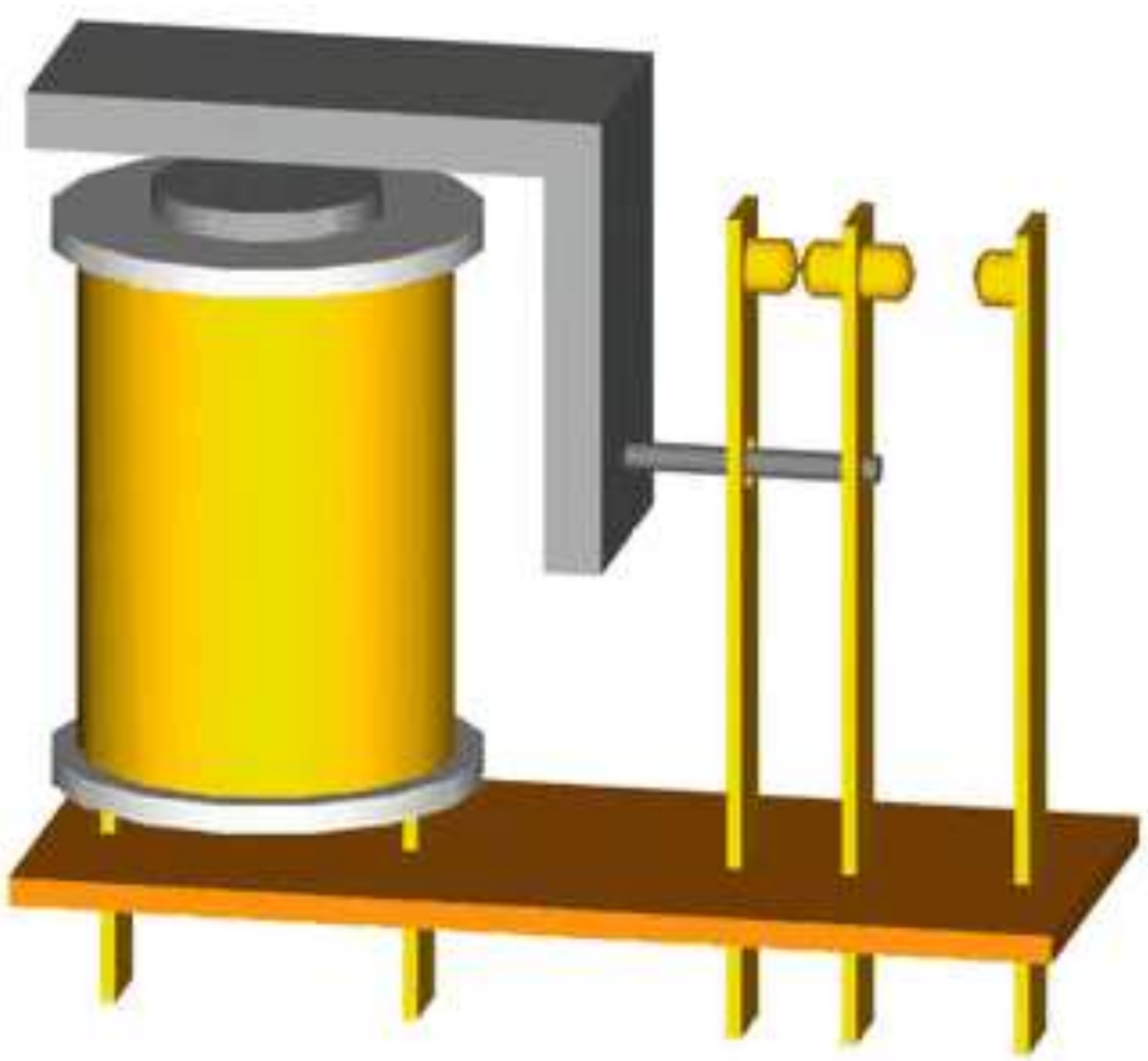


(replique au musée allemand de Munich)

Relais électromécanique

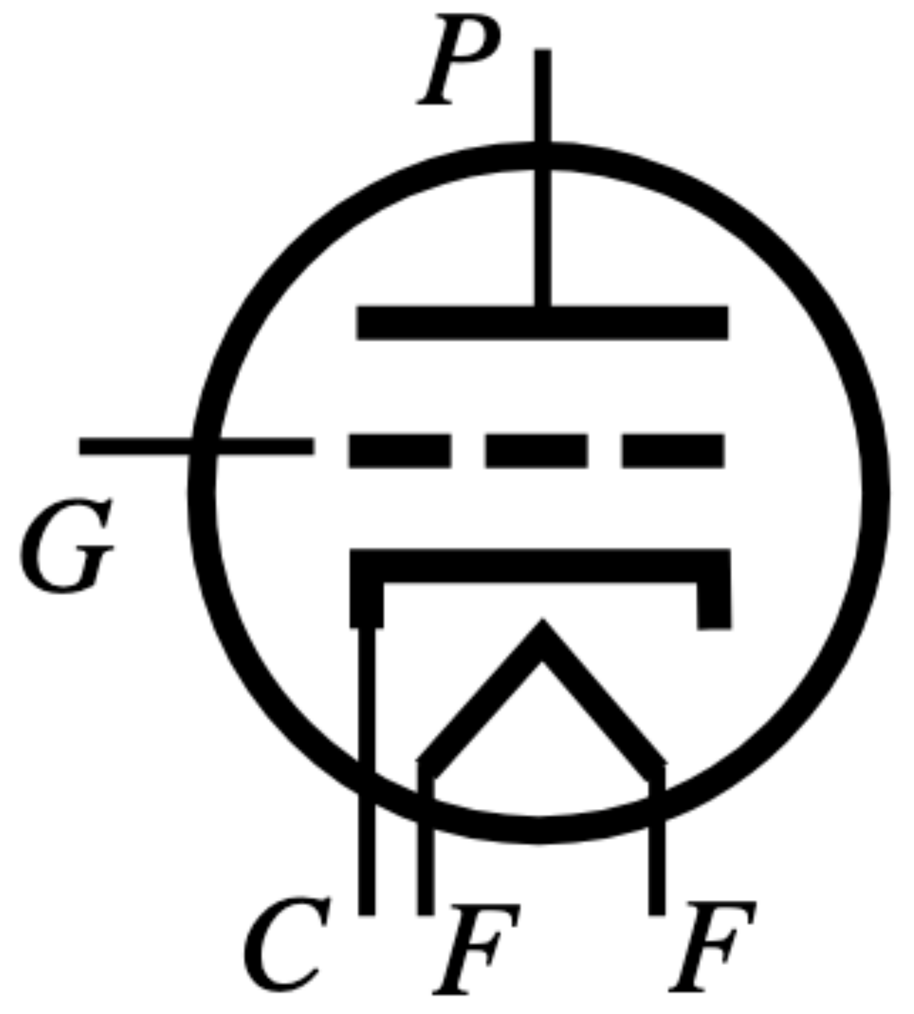


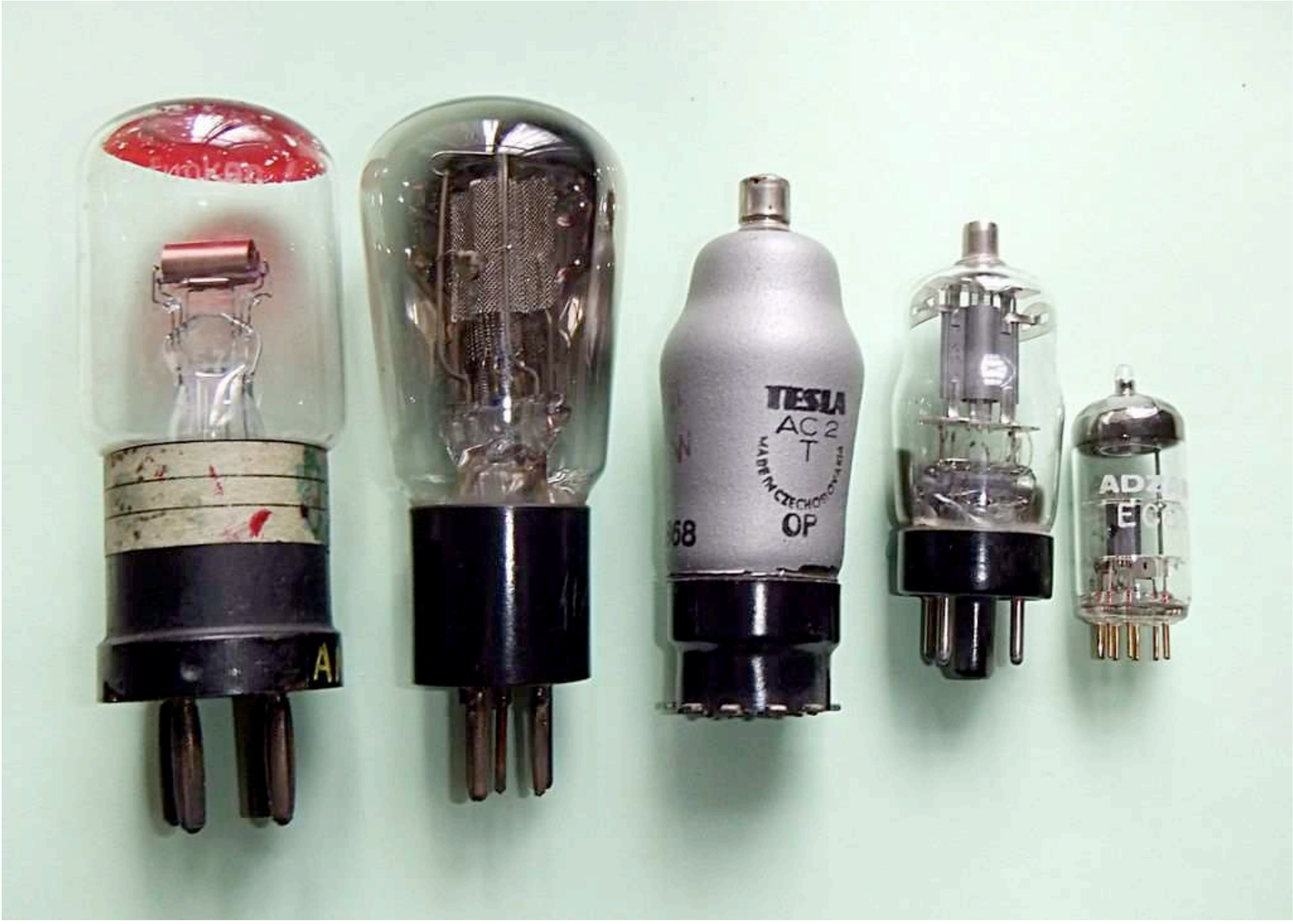
Relais électromécanique



Lampes à vide

- Composant électronique inventé vers 1906
- Permet d'amplifier un signal en entrée
- Peut être utilisé comme un relais





Claude Shannon

- 1916 - 2001, États-Unis
- Dans son mémoire de master (1937), il décrit la façon de calculer, de façon systématique, des opérations de logique booléenne à l'aide de relais
- Contributions importantes en intelligence artificielle, cryptographie,… considéré comme le père de la théorie de l'information…
- Rem: travaux inconnus de Zuse

A Symbolic Analysis of Relay and Switching Circuits

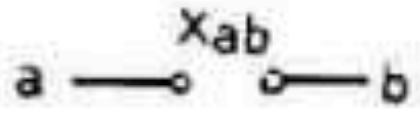


Figure 1 (left). Symbol for hindrance function

Figure 2 (right). Interpretation of addition

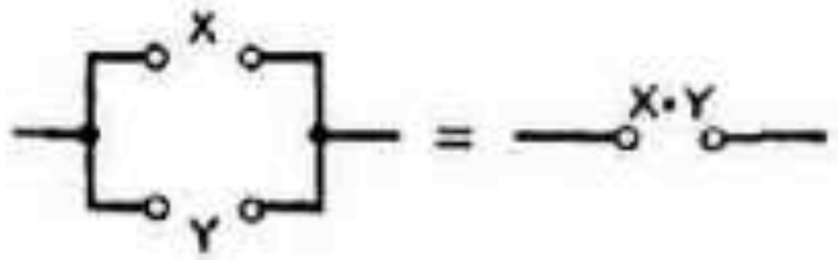


Figure 3 (middle). Interpretation of multiplication

It is evident that with the above definitions the following postulates will hold:

Postulates

1. *a.*	$0 \cdot 0 = 0$	A closed circuit in parallel with a closed circuit is a closed circuit.
b.	$1 + 1 = 1$	An open circuit in series with an open circuit is an open circuit.
2. *a.*	$1 + 0 = 0 + 1 = 1$	An open circuit in series with a closed circuit in either order (i.e., whether the open circuit is to the right or left of the closed circuit) is an open circuit.
b.	$0 \cdot 1 = 1 \cdot 0 = 0$	A closed circuit in parallel with an open circuit in either order is a closed circuit.
3. *a.*	$0 + 0 = 0$	A closed circuit in series with a closed circuit is a closed circuit.
b.	$1 \cdot 1 = 1$	An open circuit in parallel with an open circuit is an open circuit.

A Symbolic Analysis of Relay and Switching Circuits

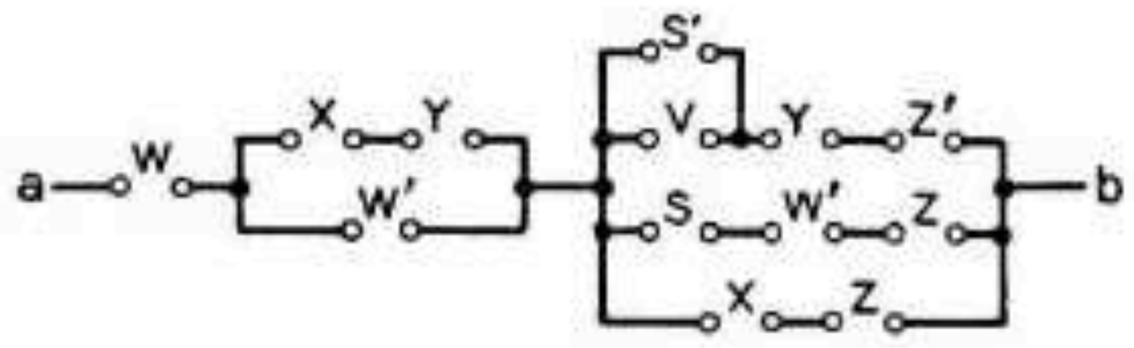


Figure 5. Circuit to be simplified

As an example of the simplification of expressions consider the circuit shown in Figure 5. The hindrance function X_{ab} for this circuit will be:

$$\begin{aligned} X_{ab} &= W + W'(X + Y) + (X + Z)(S + W' + Z)(Z' + Y + S'V) \\ &= W + X + Y + (X + Z)(S + 1 + Z)(Z' + Y + S'V) \\ &= W + X + Y + Z(Z' + S'V) \ . \end{aligned}$$

These reductions were made with 17b using first W, then X and Y as the "X" of 17b. Now multiplying out:

$$\begin{aligned} X_{ab} &= W + X + Y + ZZ' + ZS'V \\ &= W + X + Y + ZS'V \ . \end{aligned}$$

The circuit corresponding to this expression is shown in Figure 6. Note the large reduction in the number of elements.

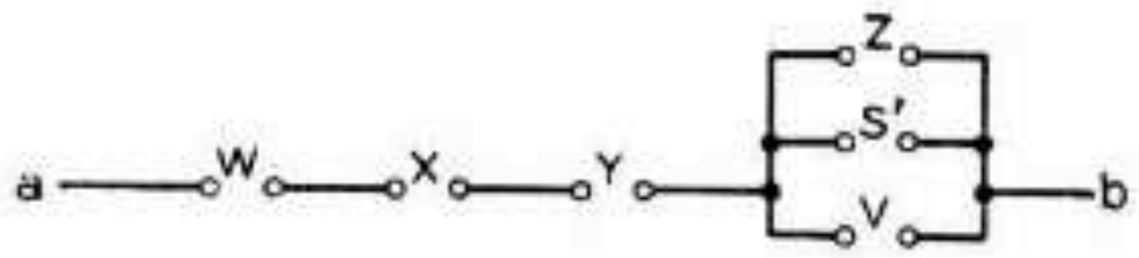


Figure 6. Simplification of figure 5

A Symbolic Analysis of Relay and Switching Circuits

c_{k+1}	$c_k \quad c_{j+1} c_j \quad c_2 c_1$	Carried numbers
	a_k---$a_{j+1} a_j$---$a_2 a_1 a_0$	First number
	$b_k \quad b_{j+1} b_j \quad b_2 b_1 b_0$	Second number
c_{k+1} or s_{k+1}	s_k---$s_{j+1} s_j$---$s_2, s_1 s_0$	Sum

Starting from the right, s_0 is one if a_0 is one and b_0 is zero or if a_0 is zero and b_0 one but not otherwise. Hence

$$s_0 = a_0 b_0' + a_0' b_0 = a_0 \oplus b_0 .$$

c_1 is one if both a_0 and b_0 are one but not otherwise:

$$c_1 = a_0 \cdot b_0 .$$

s_j is one if just one of a_j, b_j, c_j is one, or if all three are one:

$$s_j = S_{1,3}(a_j, b_j, c_j), \quad j = 1, 2, \ldots k .$$

c_{j+1} is one if two or if three of these variables are one:

$$c_{j+1} = S_{2,3}(a_j, b_j, c_j), \quad j = 1, 2, \ldots k .$$

Using the method of symmetric functions, and shifting down for s_j gives the circuits of Figure 35. Eliminating superfluous elements we arrive at Figure 36.

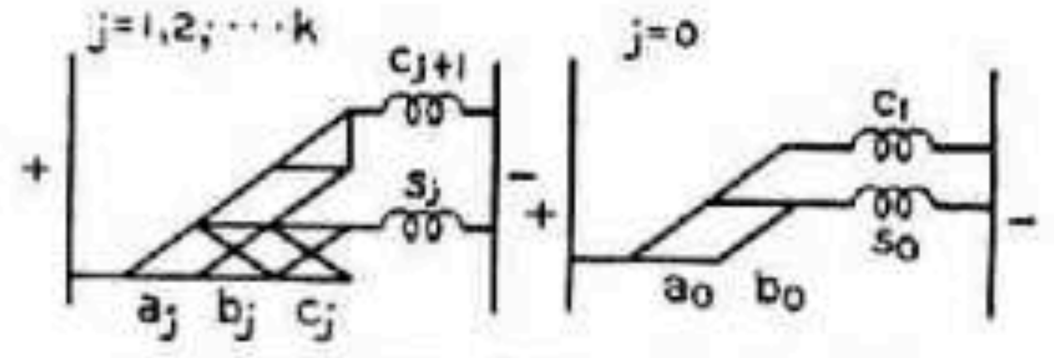


Figure 35. Circuits for electric adder

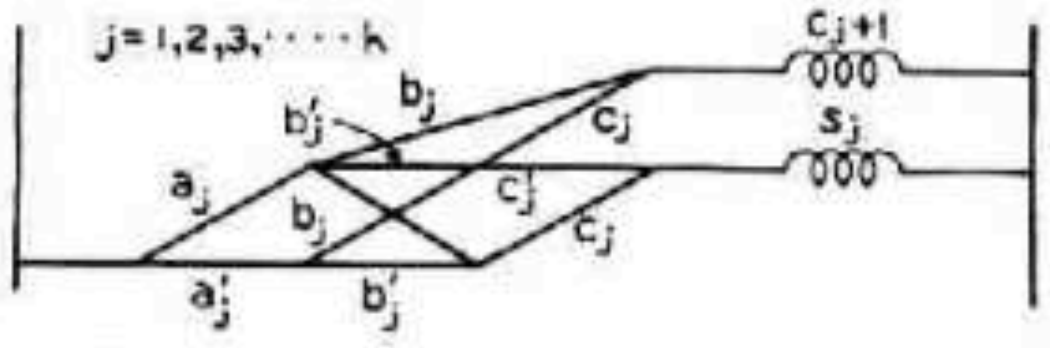
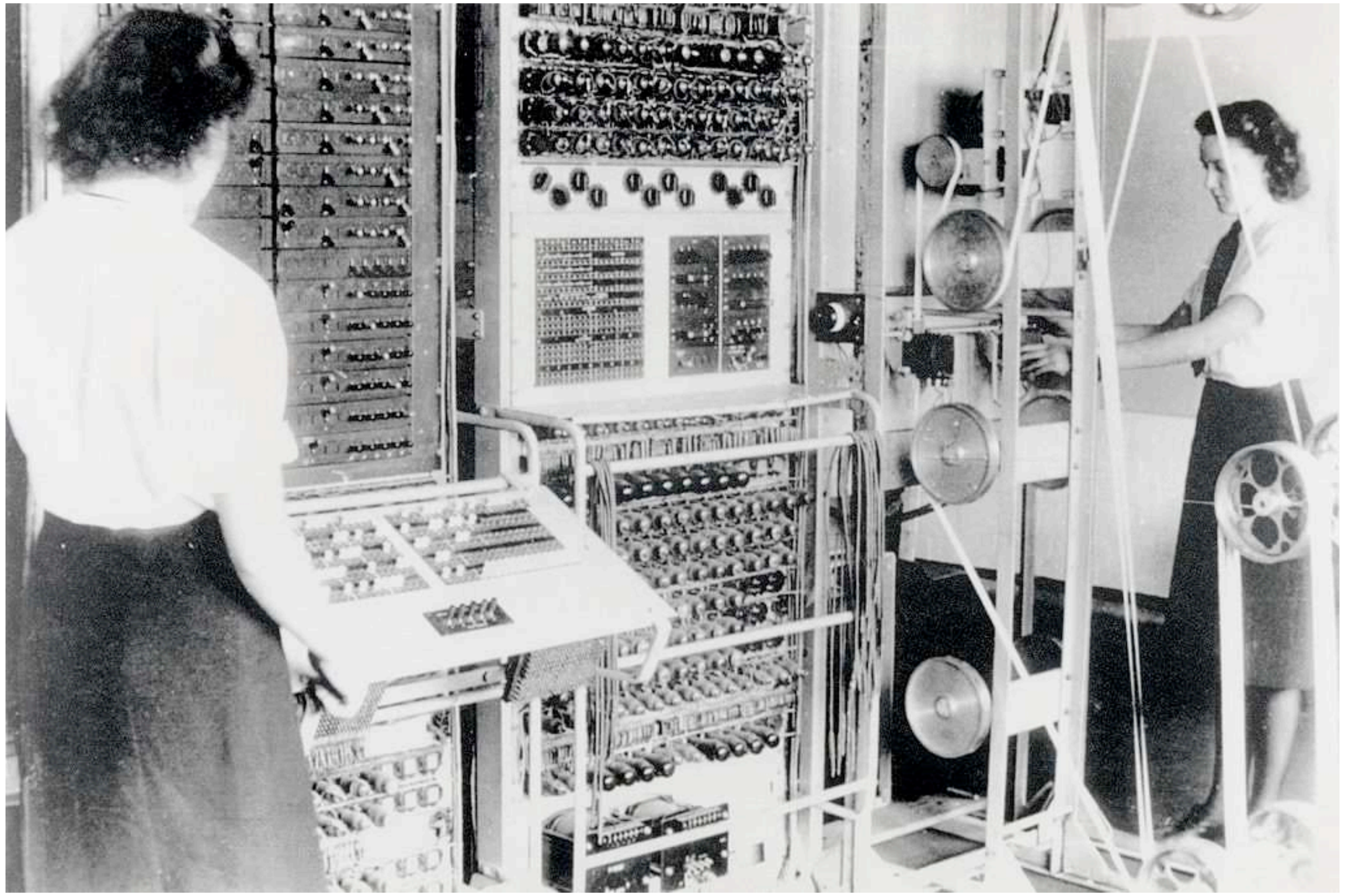


Figure 36. Simplification of figure 35

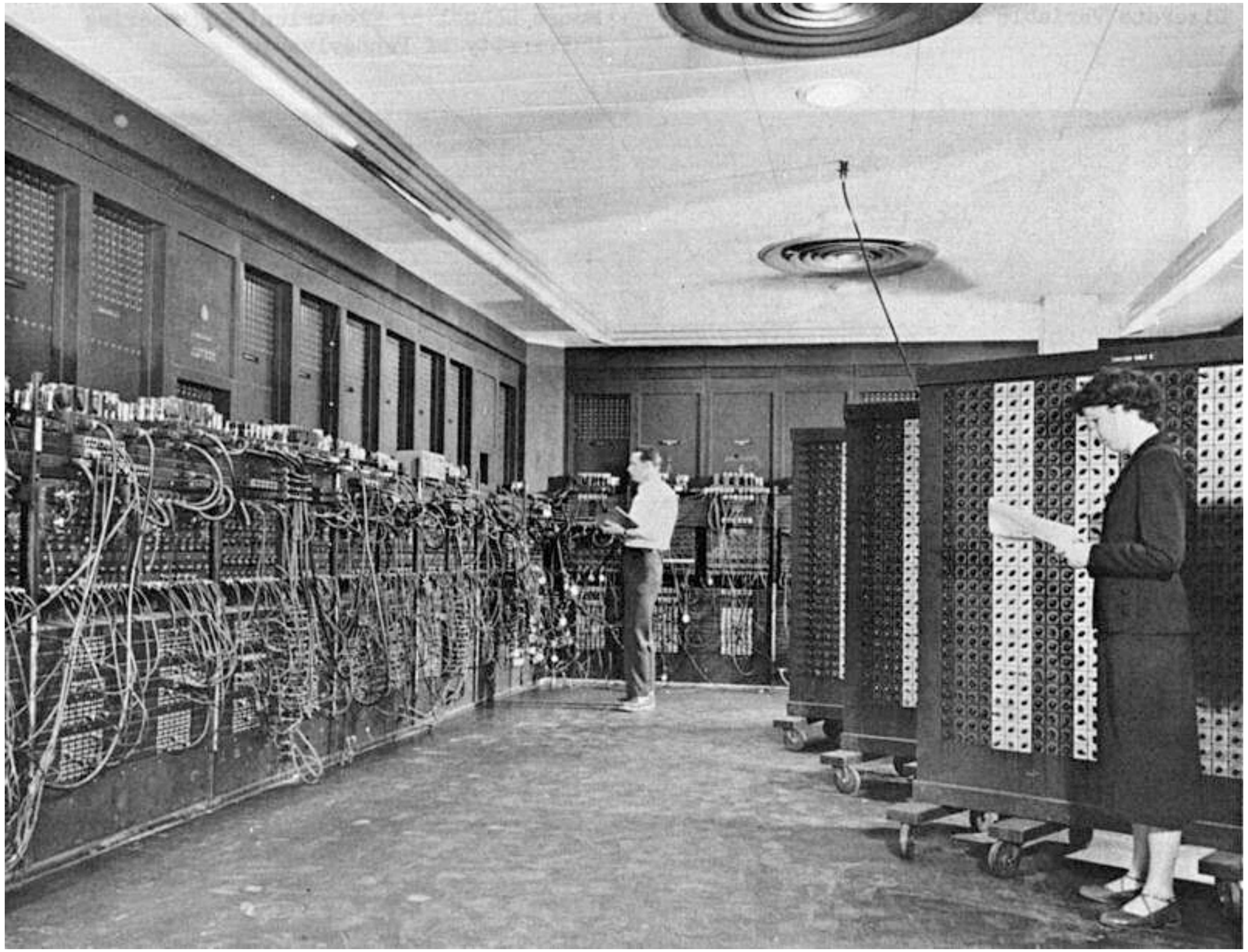
Colossus

- Plusieurs ordinateurs développé en 1943 et 1944
- Programmables pour résoudre certains problèmes de cryptanalyse, mais pas Turing-complets
- Entièrement électroniques (tubes à vide)
- Pas de programme stocké en mémoire: lu directement depuis le ruban perforé
- Bletchly Park, UK
- Détruits après la deuxième guerre mais reconstruits entre 1993 et 2008



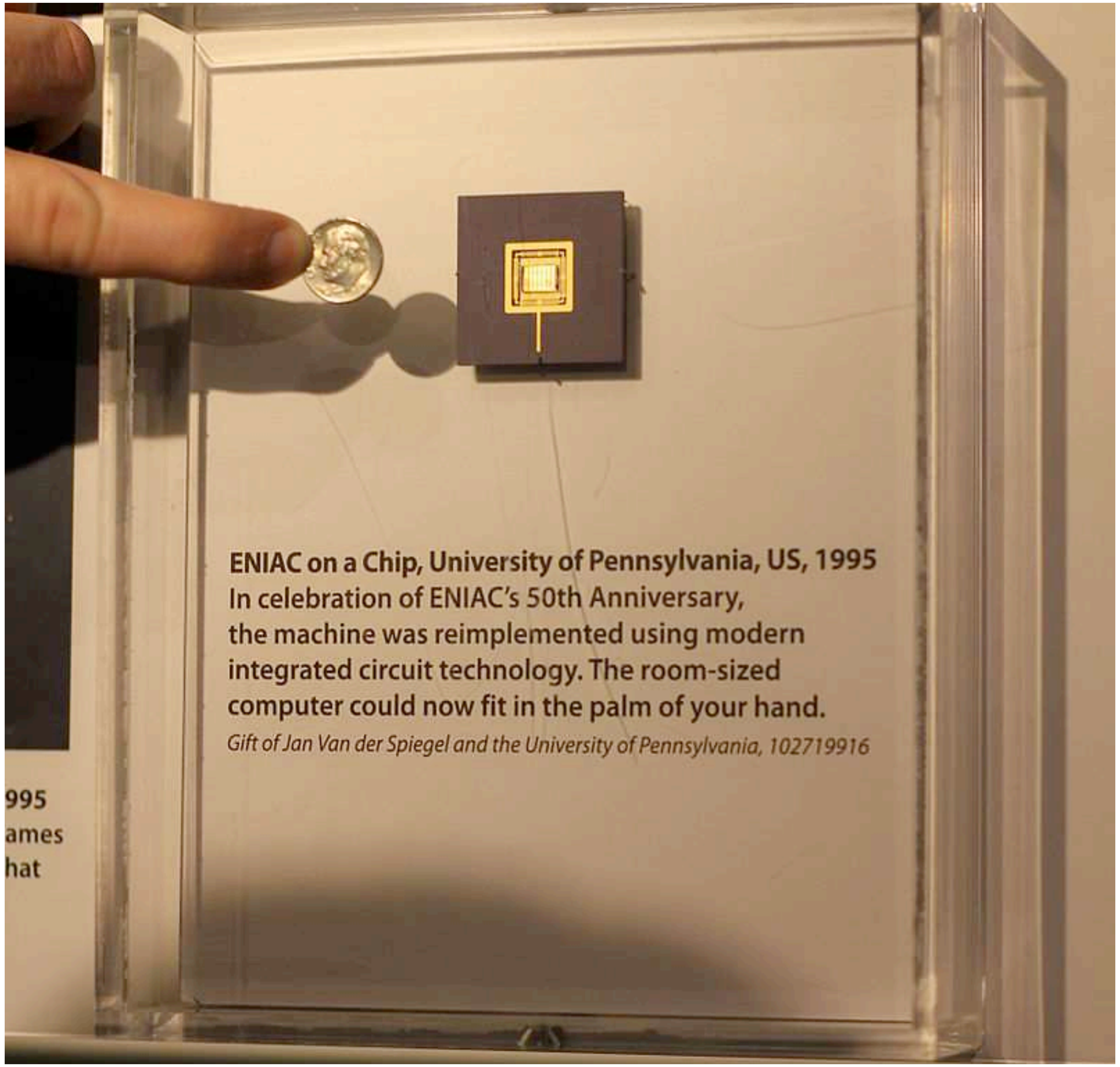
ENIAC: Electronic Numerical Integrator and Computer

- John Mauchly, J. Presper Eckert, Université de Pennsylvanie, 1945
- Premier ordinateur Turing-complet, programmable et électronique
- Programmé par: Jean Jennings, Marlyn Wescoff, Ruth Lichterman, Betty Snyder, Frances Bilas, and Kay McNulty
- 18 000 tubes, des millions de soudures faites à la main !
- 27 tonnes, 150 kW…
- Les chercheurs démissionnent pour aller fonder UNIVAC…



By Unknown author - U.S. Army Photo, Public Domain, https://commons.wikimedia.org/w/index.php?curid=55124

ENIAC-on-a-chip



By Michael Hicks from Saint Paul, MN, USA - img_7736, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=32789320

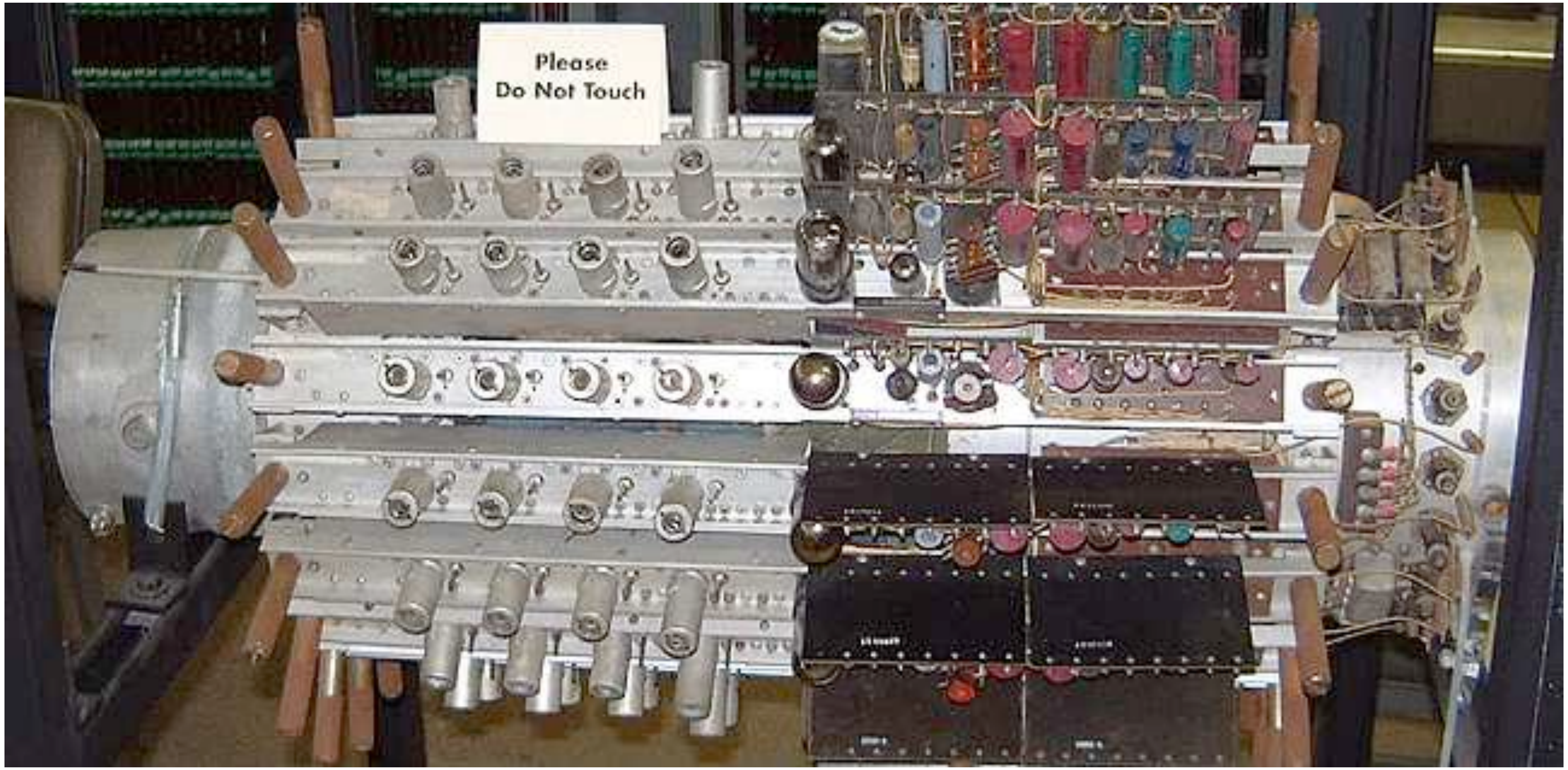
UNIVAC

- Premier ordinateur commercial pour le business produit aux États-Unis
- Produit par la Eckert-Mauchly Corporation, rachetée par Remington Rand (aujourd'hui Unisys)
- 6 103 tubes
- 125 kW
- 2,25 MHz
- Mémoire à ligne de mercure

By U.S. Census Bureau employees - https://www.census.gov/history/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=61118833

Mémoire à ligne de mercure

126 canaux de 10 mots de 12 caractères



Devinette…

Devinette…

Computing Tabulating Recording Company

- La CTR est née en 1911 de l'amalgamation de plusieurs companies vendant des balances commerciales, des tabulatrices et des horloges de bureau

- Devient IBM en 1933

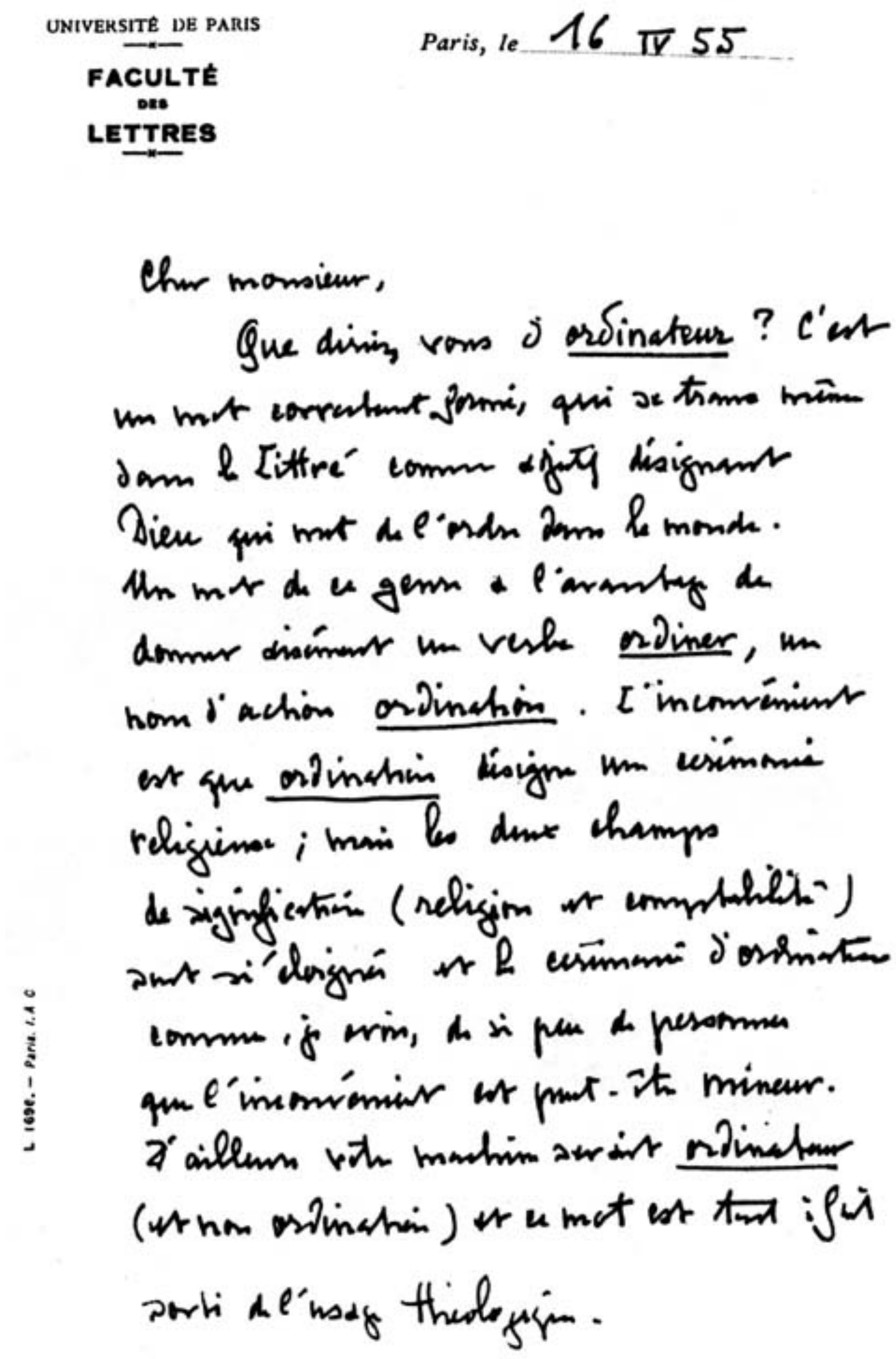
- Commercialise ses premiers ordinateurs en 1951

Introduction du terme « ordinateur » en français

- Quel est le rapport entre ce poète romain et l'informatique ?

Jacques Perret

- IBM consulte le philologue classique Jacques Perret pour trouver un nom français pour les « computers »



UNIVERSITÉ DE PARIS
FACULTÉ DES LETTRES

Paris, le 16 IV 55

Cher monsieur,

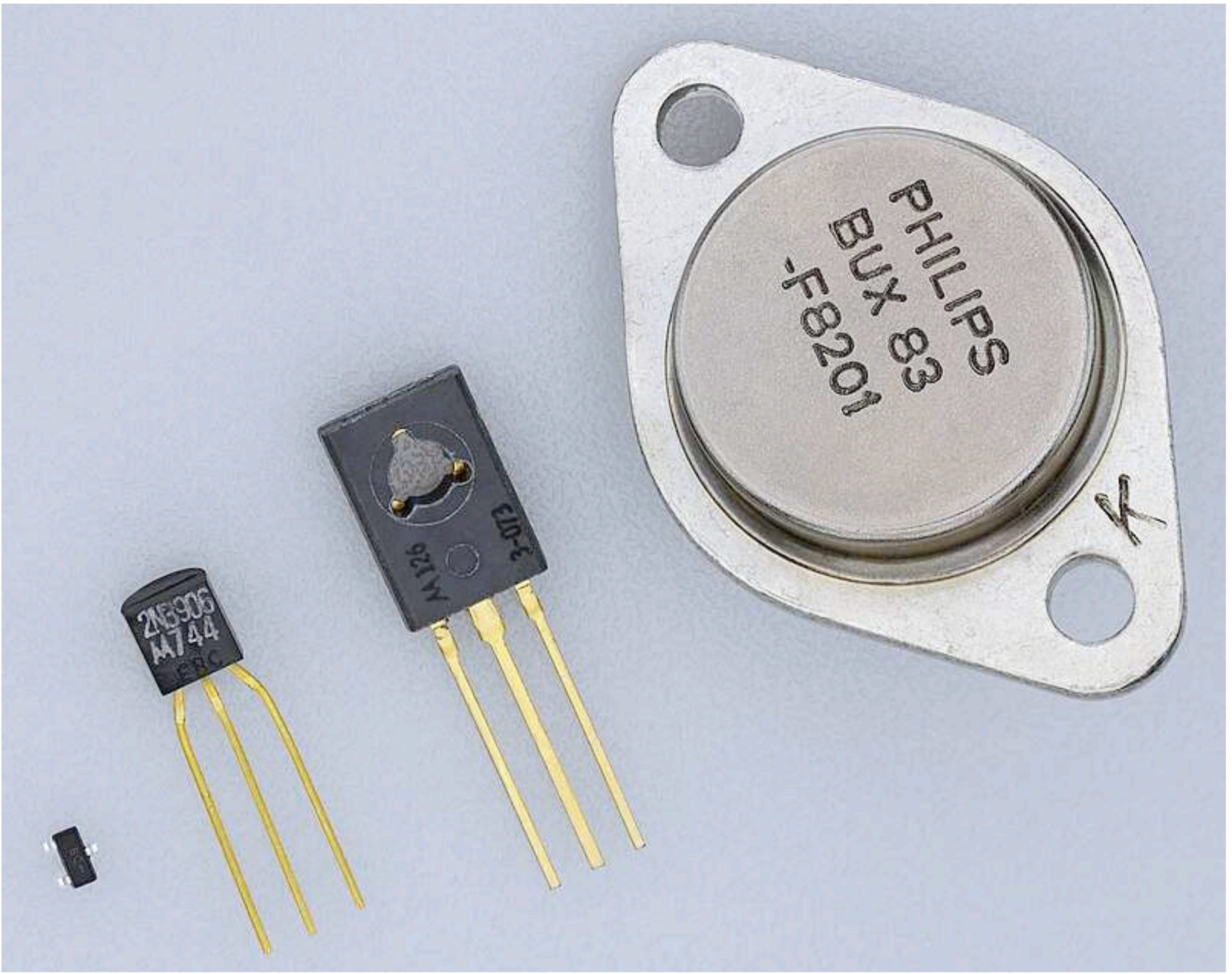
Que diriez vous d'ordinateur ? C'est un mot correctement formé, qui se trouve même dans le Littré comme adjectif désignant Dieu qui met de l'ordre dans le monde. Un mot de ce genre a l'avantage de donner aisément un verbe ordiner, un nom d'action ordination. L'inconvénient est que ordination désigne une cérémonie religieuse ; mais les deux champs de signification (religion et comptabilité) sont si éloignés et la cérémonie d'ordination connue, je crois, de si peu de personnes que l'inconvénient est peut-être mineur. D'ailleurs votre machine serait ordinateur (et non ordination) et ce mot est tout à fait sorti de l'usage théologique.

L 1696. — Paris. I.A.C.

Les transistors

- Révolution technologique: premier transistor en 1947 par Bardeen, Shockley et Brattain (Bell Labs, Nobel de physique en 1956)

- Remplacement plus efficace du tube à vide



Fonctions logiques et transistors

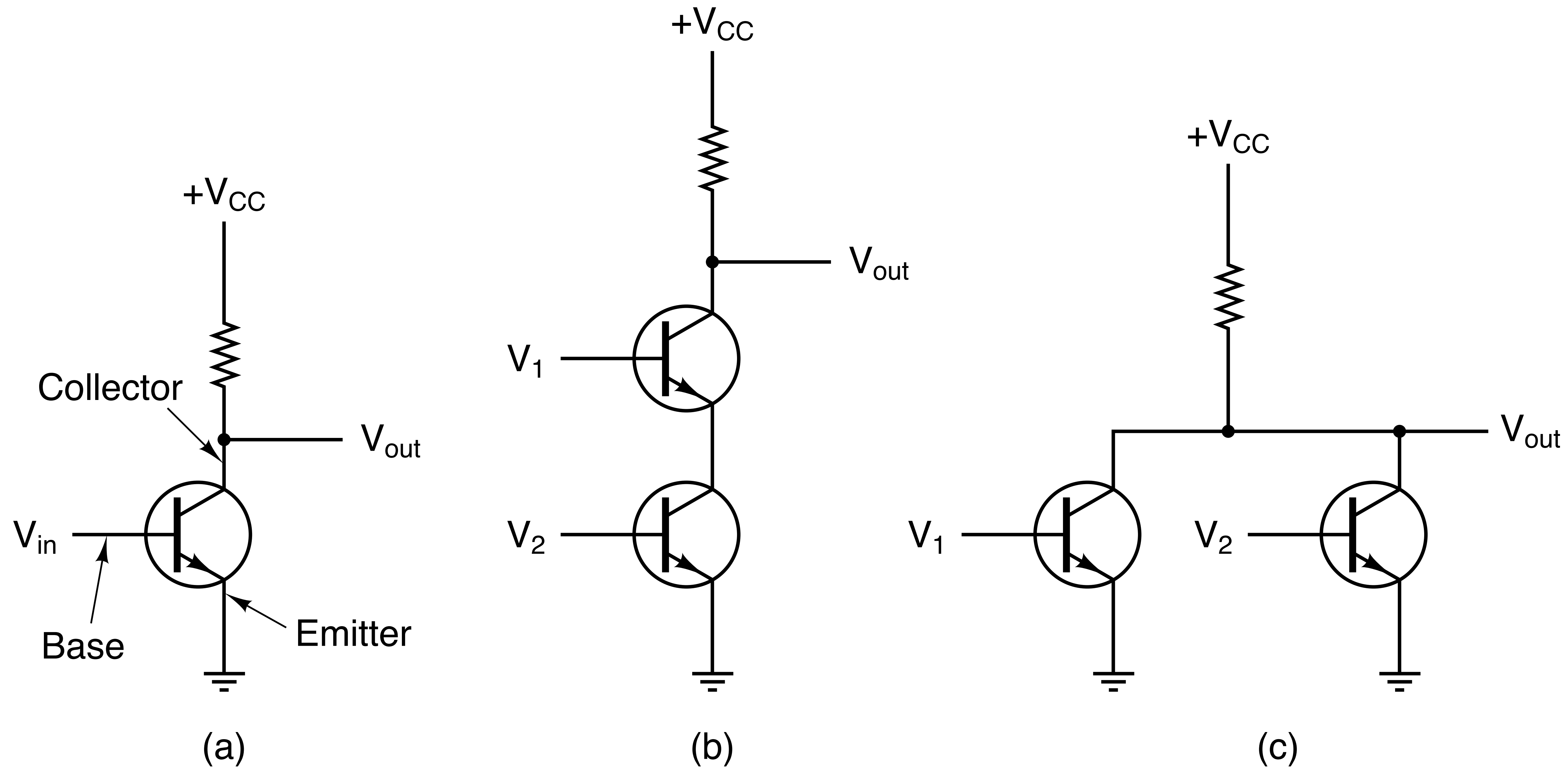
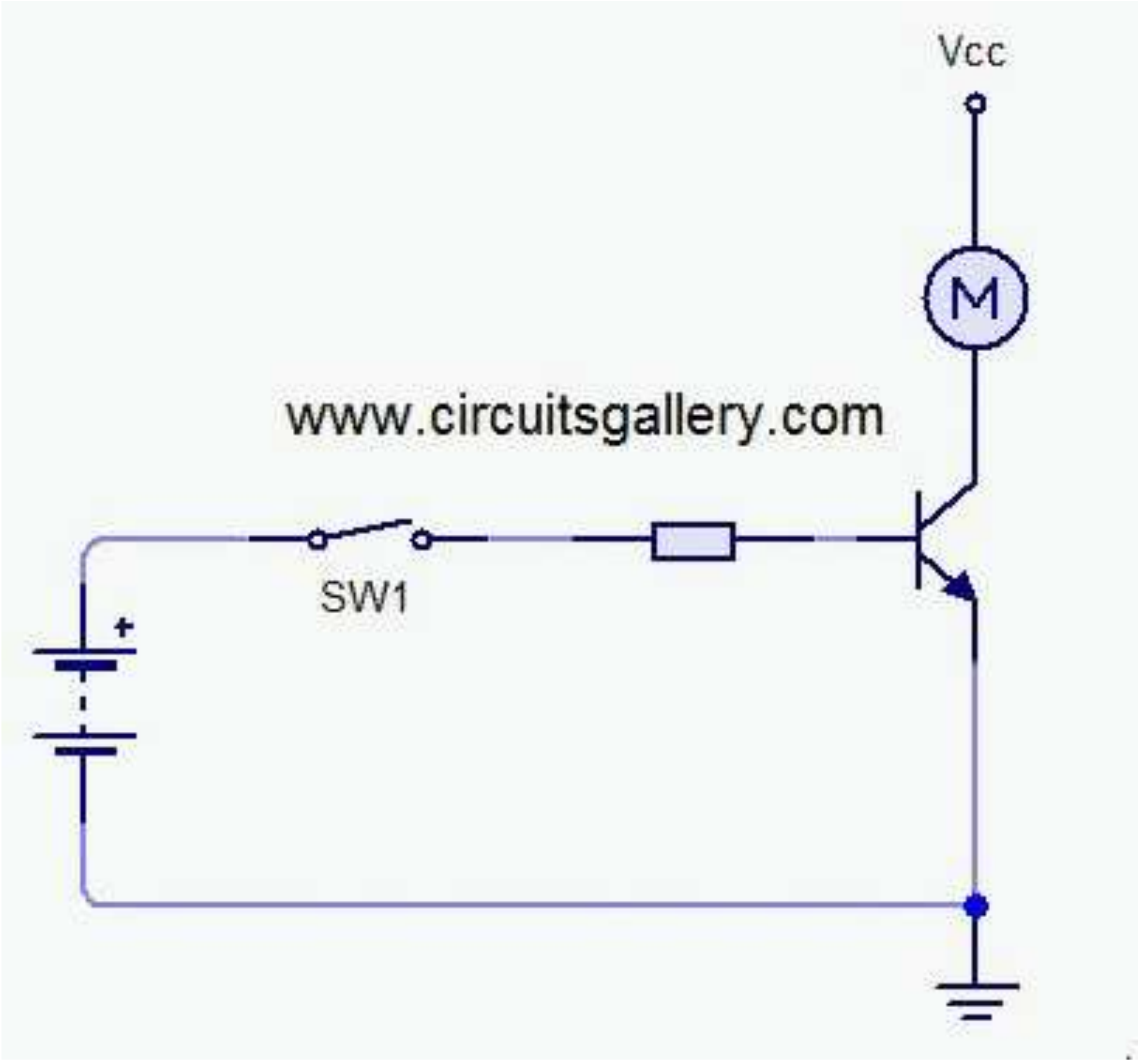
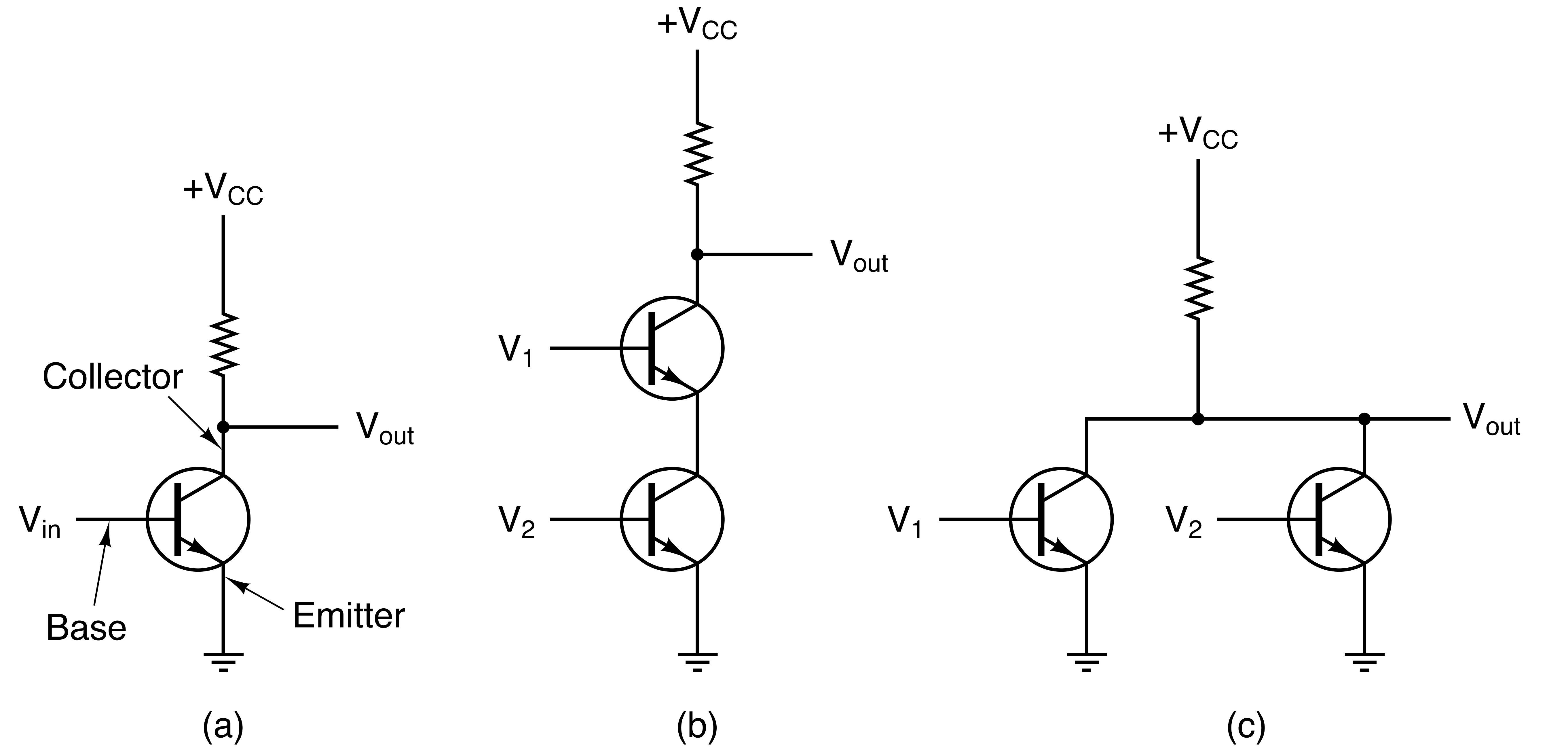


Figure 3-1. (a) A transistor inverter. (b) A NAND gate. (c) A NOR gate.

A. Tanenbaum, *Modern Operating Systems*, 4th ed (2015)



Fonctions logiques et transistors



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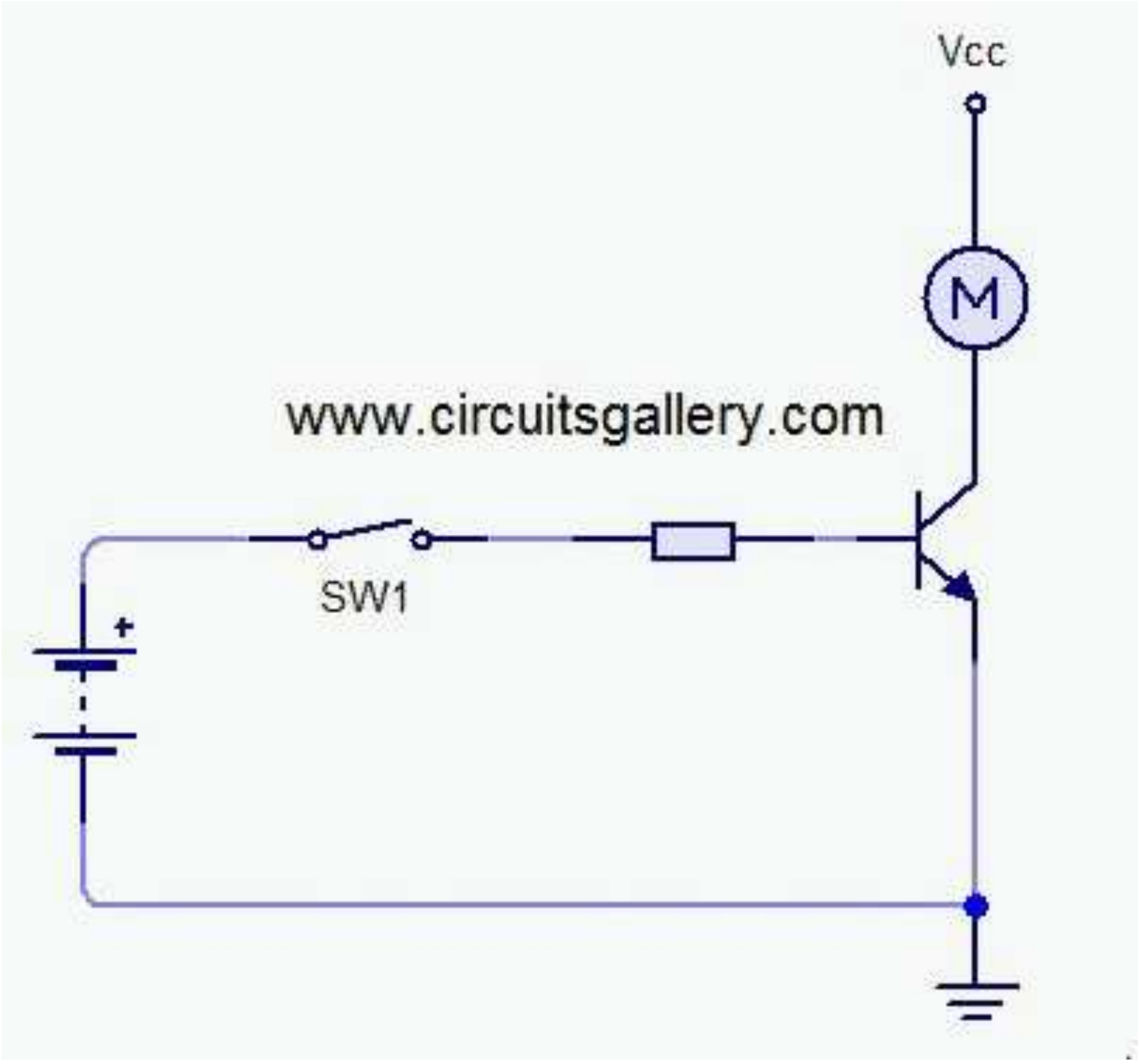


A. Tanenbaum, *Modern Operating Systems*, 4th ed (2015)

IBM 650

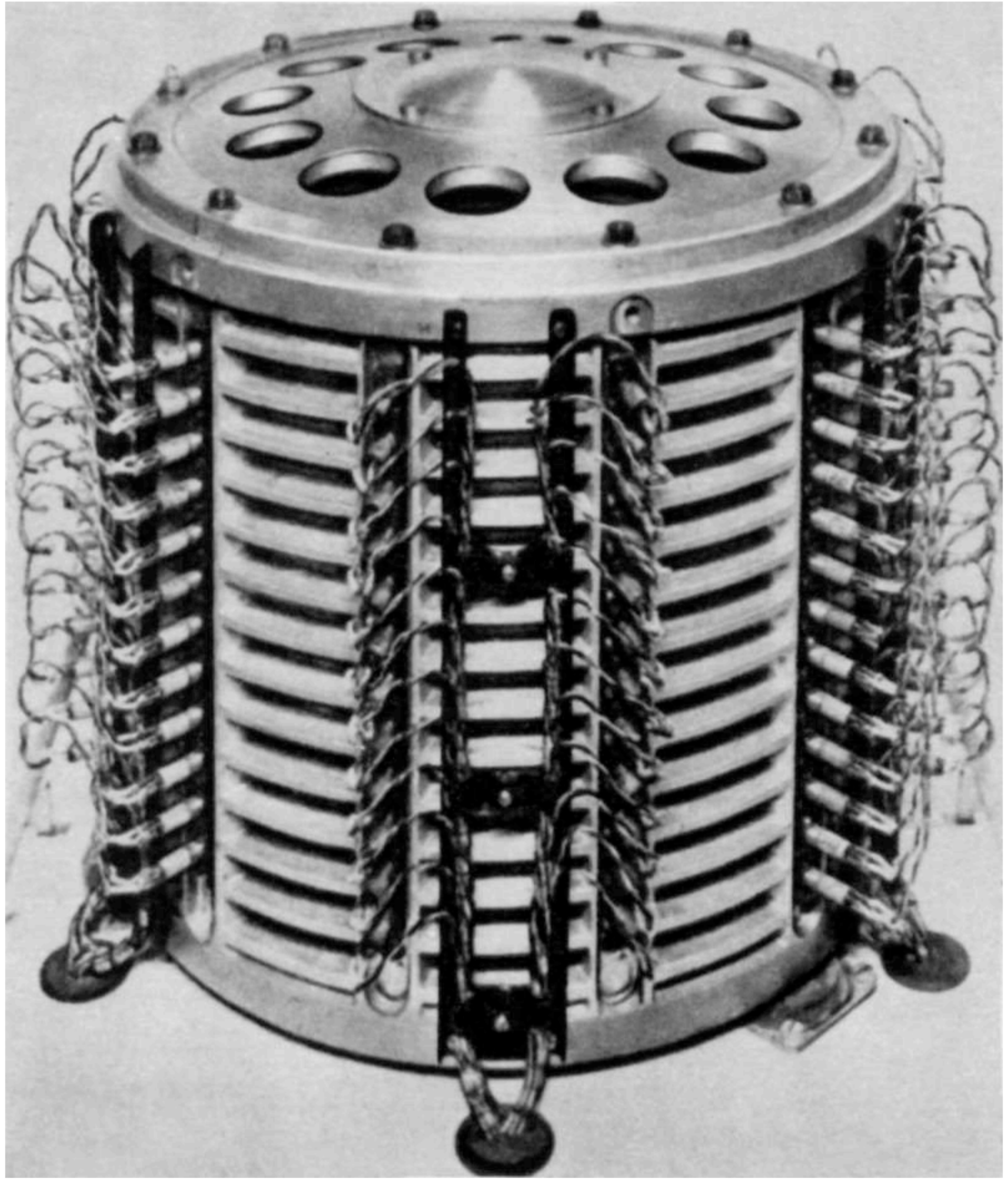
- 1954
- Premier ordinateur produit en masse (2 000 exemplaires)
- Stocke les nombres en décimal
- Utilise de la mémoire sous forme d’un tambour magnétique

By Cushing Memorial Library and Archives, Texas A&M - Flickr: IBM Processing Machine, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=17397582

IBM 650

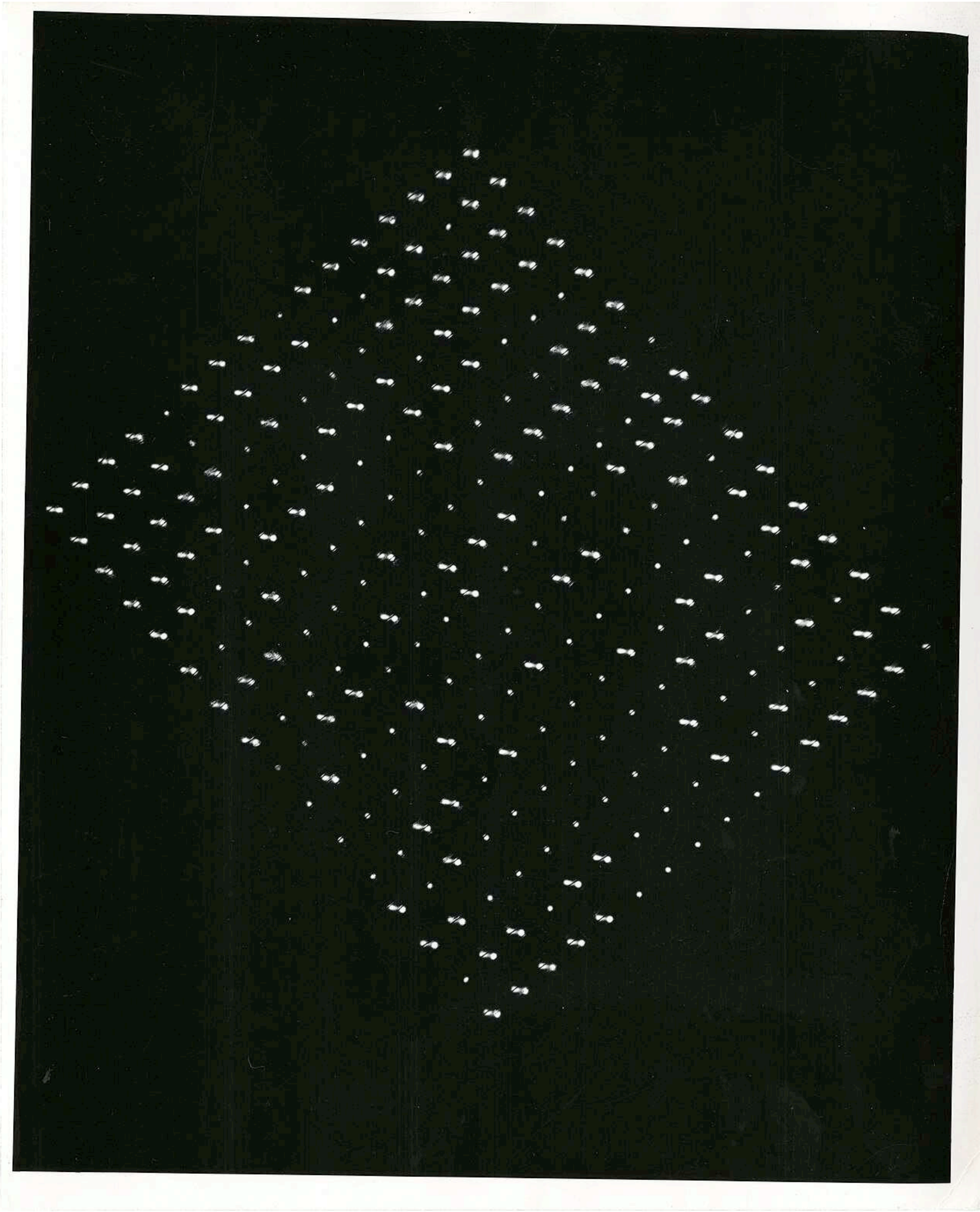

IBM
DISPLAY
SIGN
STORAGE — ENTRY
SIGN
OPERATION
ADDRESS
OPERATING
CHECKING
PROGRAMMED
HALF CYCLE
ADDRESS SELECTION
OVERFLOW
ERROR
TRANSFER
PROGRAM START
COMPUTER RESET
ERROR RESET
ERROR SENSE RESET

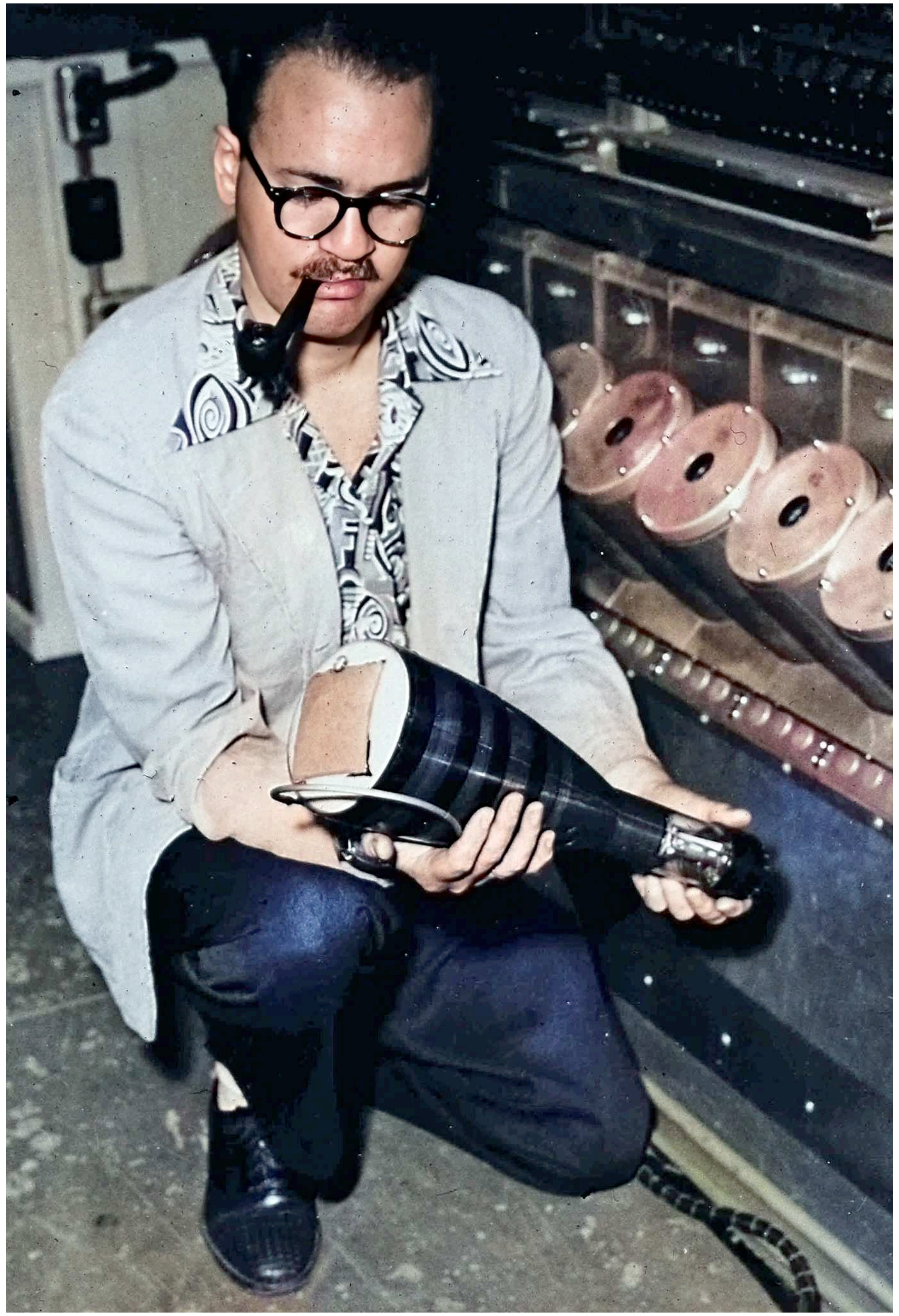
Mémoire à tambour d’un ZAM-41



Digression: la mémoire primaire

- Tubes de Williams
- Utilisent l'effet photoélectrique pour stocker des données
- Quelques bits dans un tube CRT de 40cm de longueur

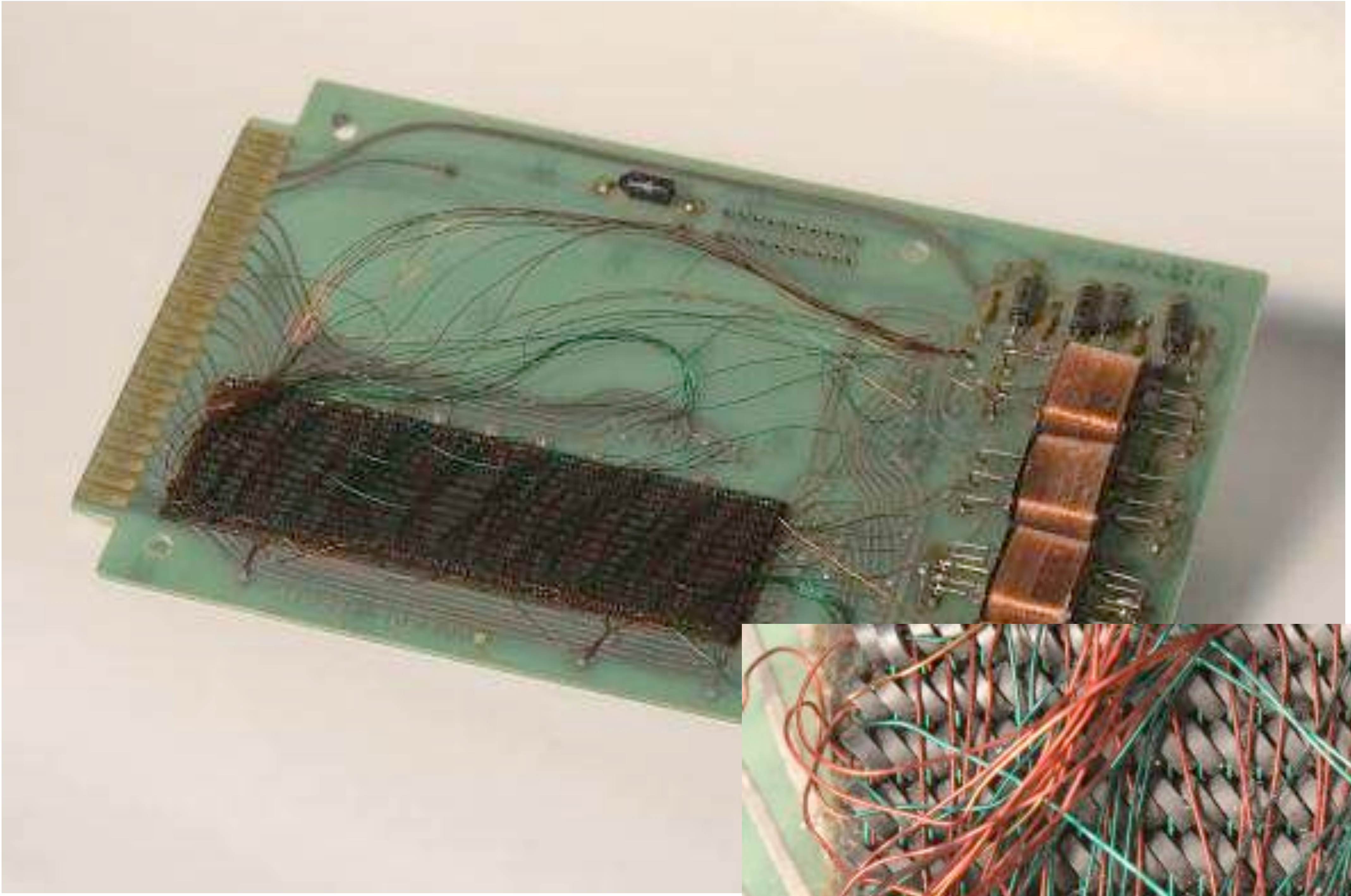


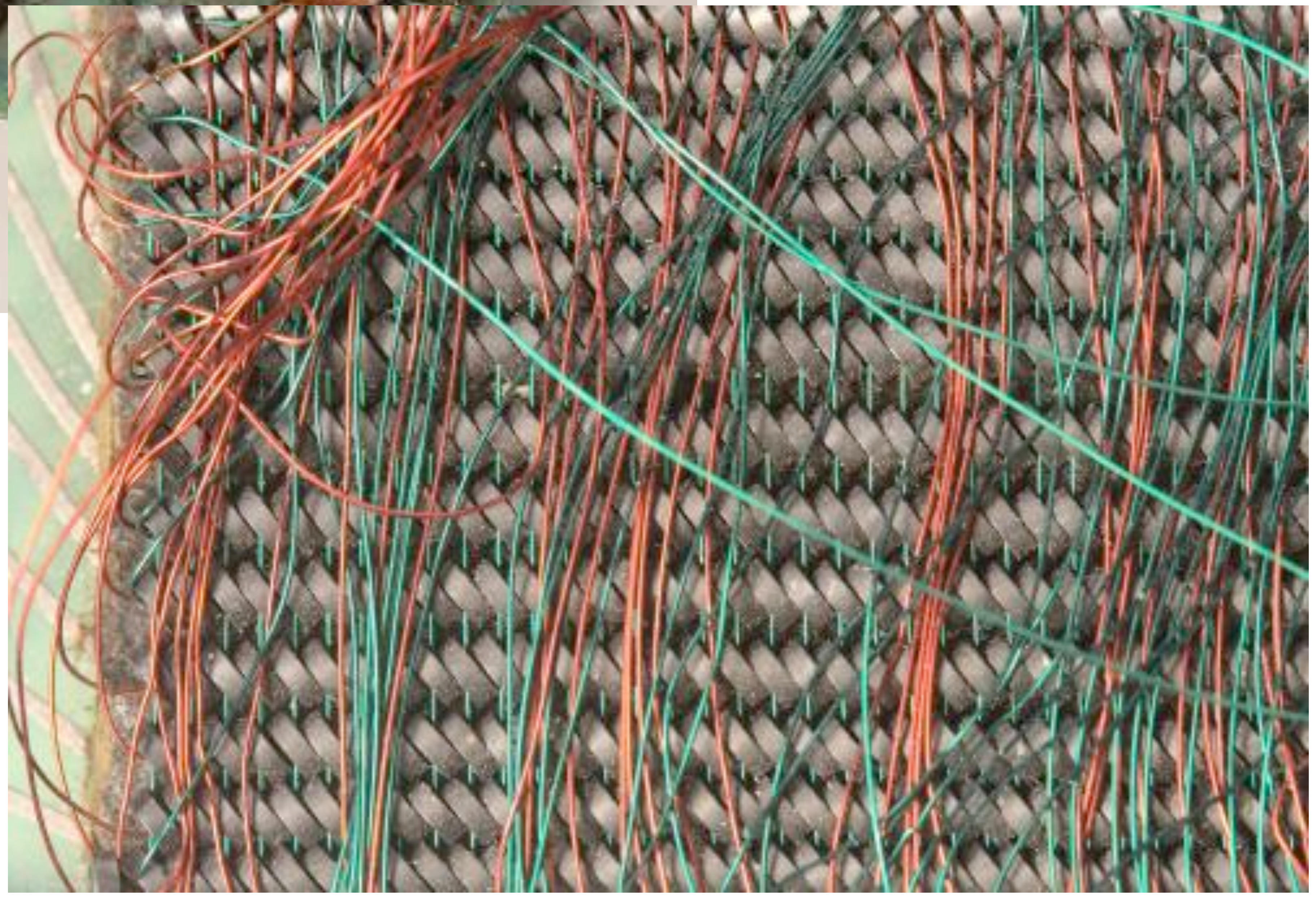


By National Institute of Standards and Technology
National Institute of Standards and Technology, Public Domain, https://commons.wikimedia.org/w/index.php?curid=31539966

Digression: la mémoire primaire

- « Core memory »
- Utilise des tores de ferrite pour stocker les bits individuels à travers le sens du champ magnétique





IBM 1401

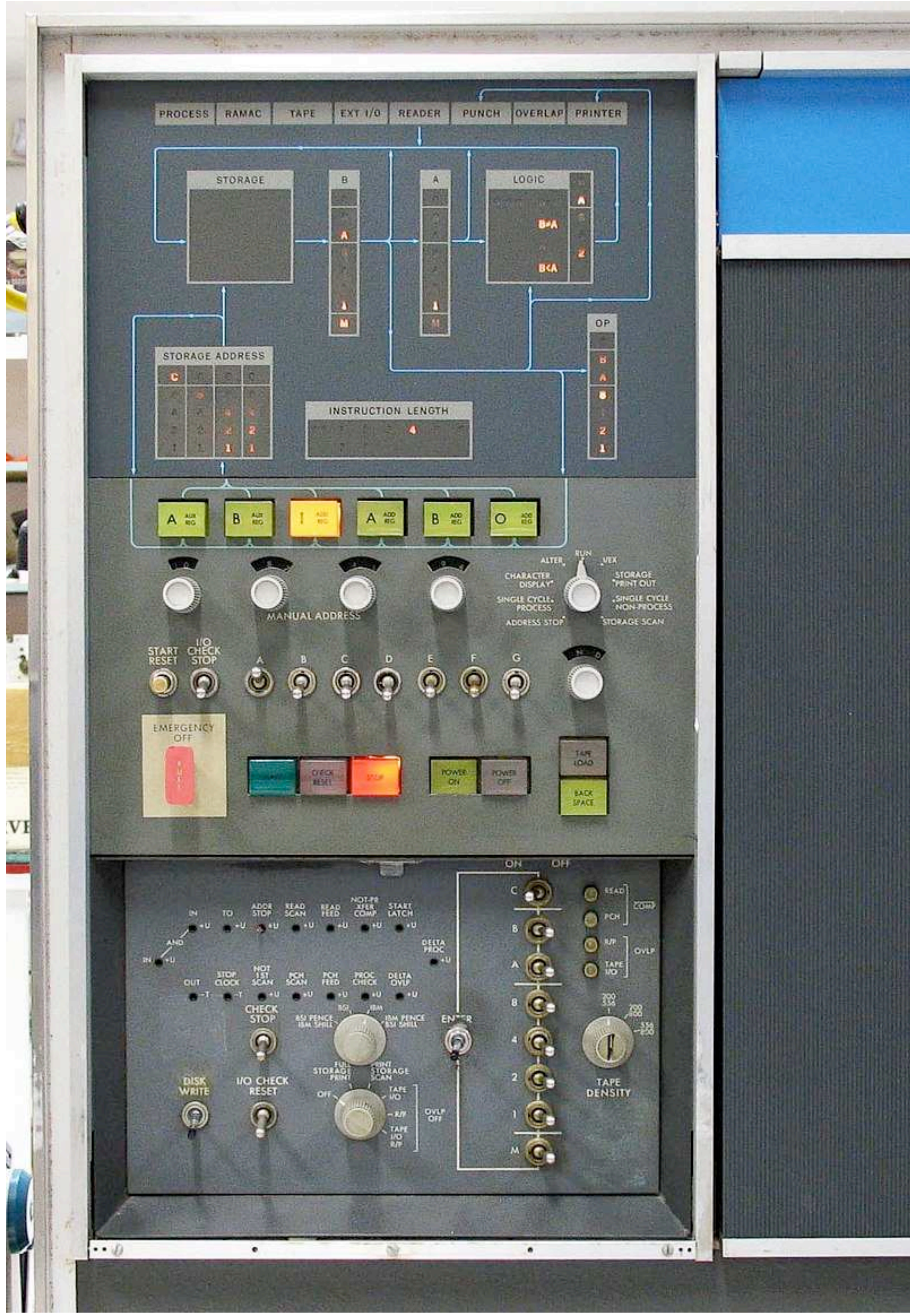
- Ordinateur le plus vendu de la série à transistors (avant les circuits intégrés)

- 1959 - 1965

- $78 000 de l'époque (environ $500 000 actuels)

- « Le 1401 réalisait 193 000 additions de 8 chiffres par minute. Son lecteur de cartes, le 1402, lisait 800 cartes à la minute. Il pouvait être équipé de bandes magnétiques lisant en moyenne 15 000 caractères par seconde. L'imprimante lancée avec la série, nommée 1403, imprimait 600 lignes de 132 caractères par minute. » (Wikipedia)

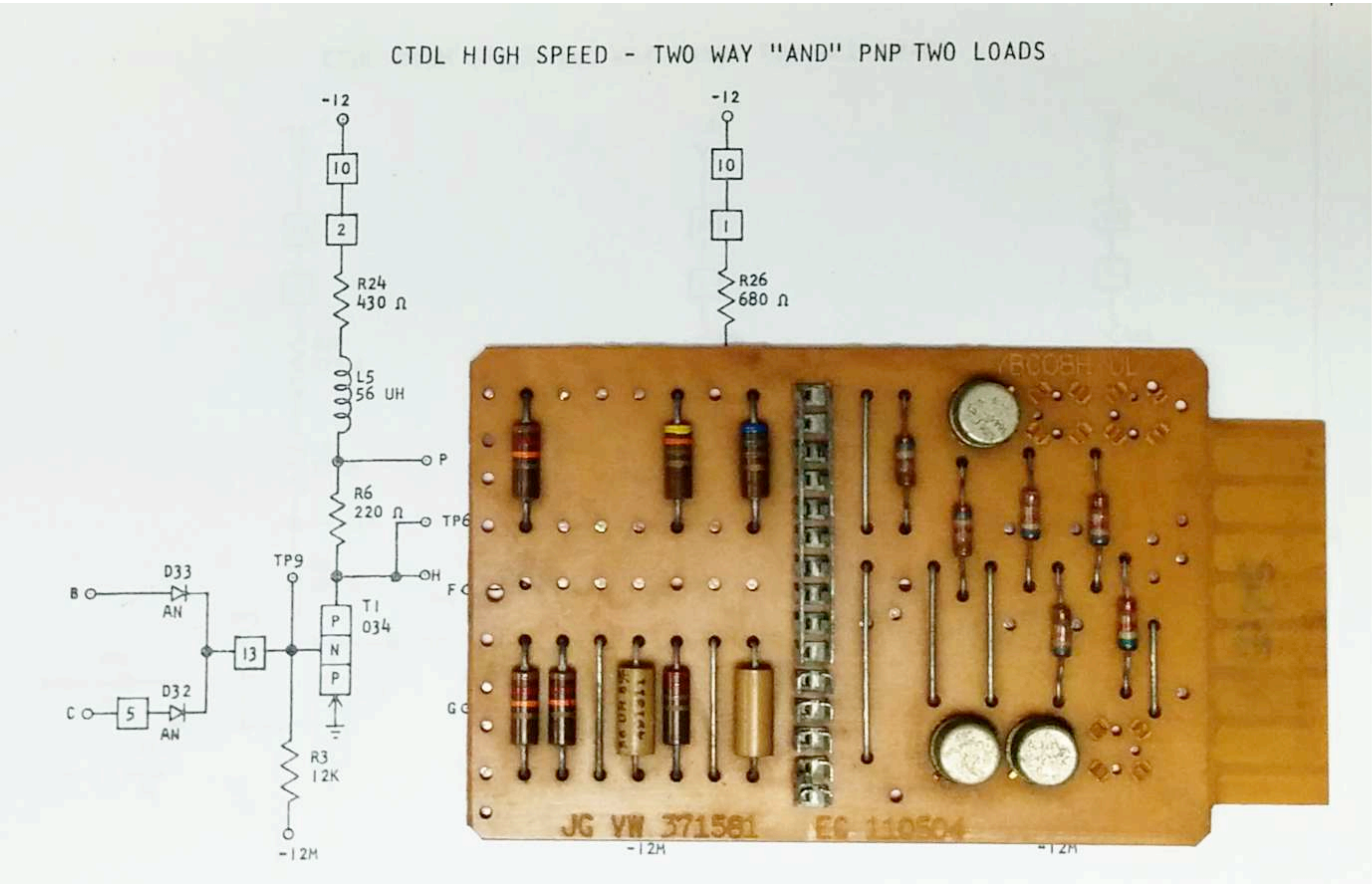
- COBOL, FORTRAN, RPG…



Par Swtpc6800 en:User:Swtpc6800 Michael Holley — Travail personnel, Domaine public, https://commons.wikimedia.org/w/index.php?curid=3932223

IBM 1401

- Cartes SMS (Standard Modular System)



Ken Shiriff's blog: http://www.righto.com/2015/03/a-database-of-sms-cards-technology.html

DEC PDP-1

- 1959 — 1969
- « mini-ordinateur » de… 730 kg
- mémoire (core memory): 4096 mots de 18 bits
- Ici avec Steve Russel, créateur du premier jeu vidéo sur cette machine: Space Wars !

… en 1970, sur un PDP-11

- C’est sur un PDP-11 que Ken Thompson et Denis Ritchie développeront le système d’exploitation Unix aux Bell Lab vers 1970…

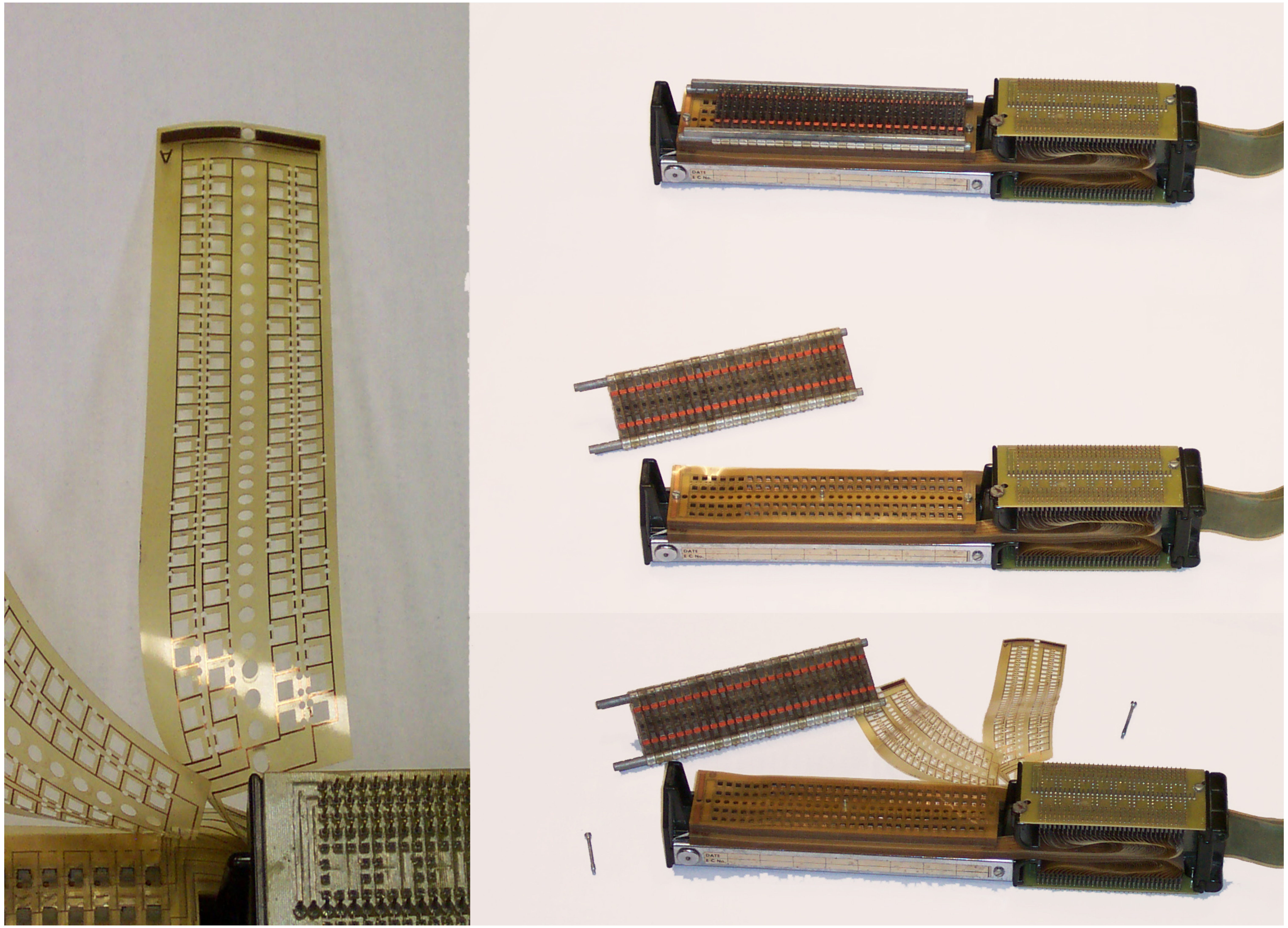
- … Ses lointains descendants incluent Linux, Android, MacOs…

IBM System/360

- Plus qu’un ordinateur unique, c’est une famille d’ordinateurs qui sont compatibles entre eux à travers la notion d’architecture

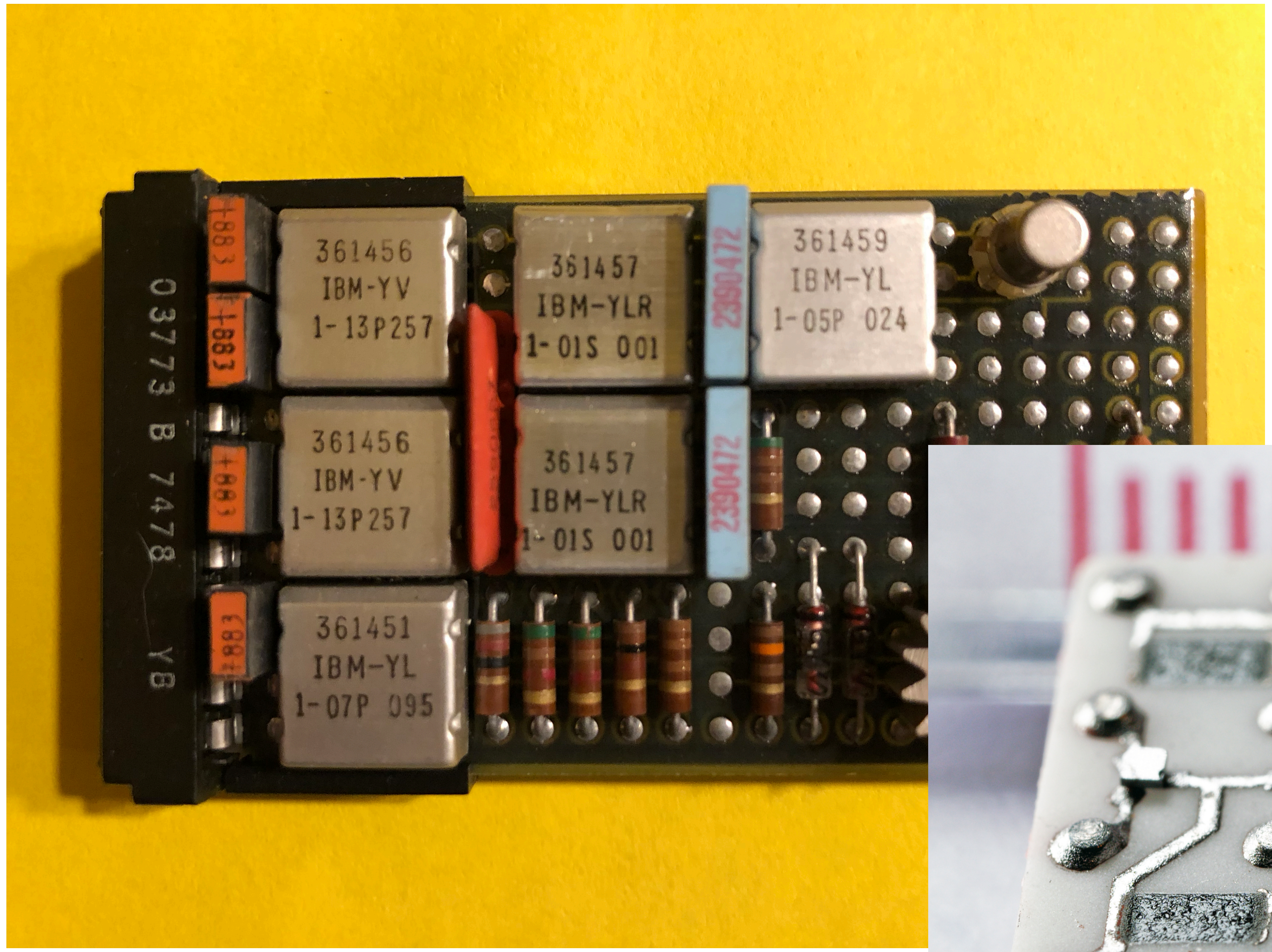
IBM System/360

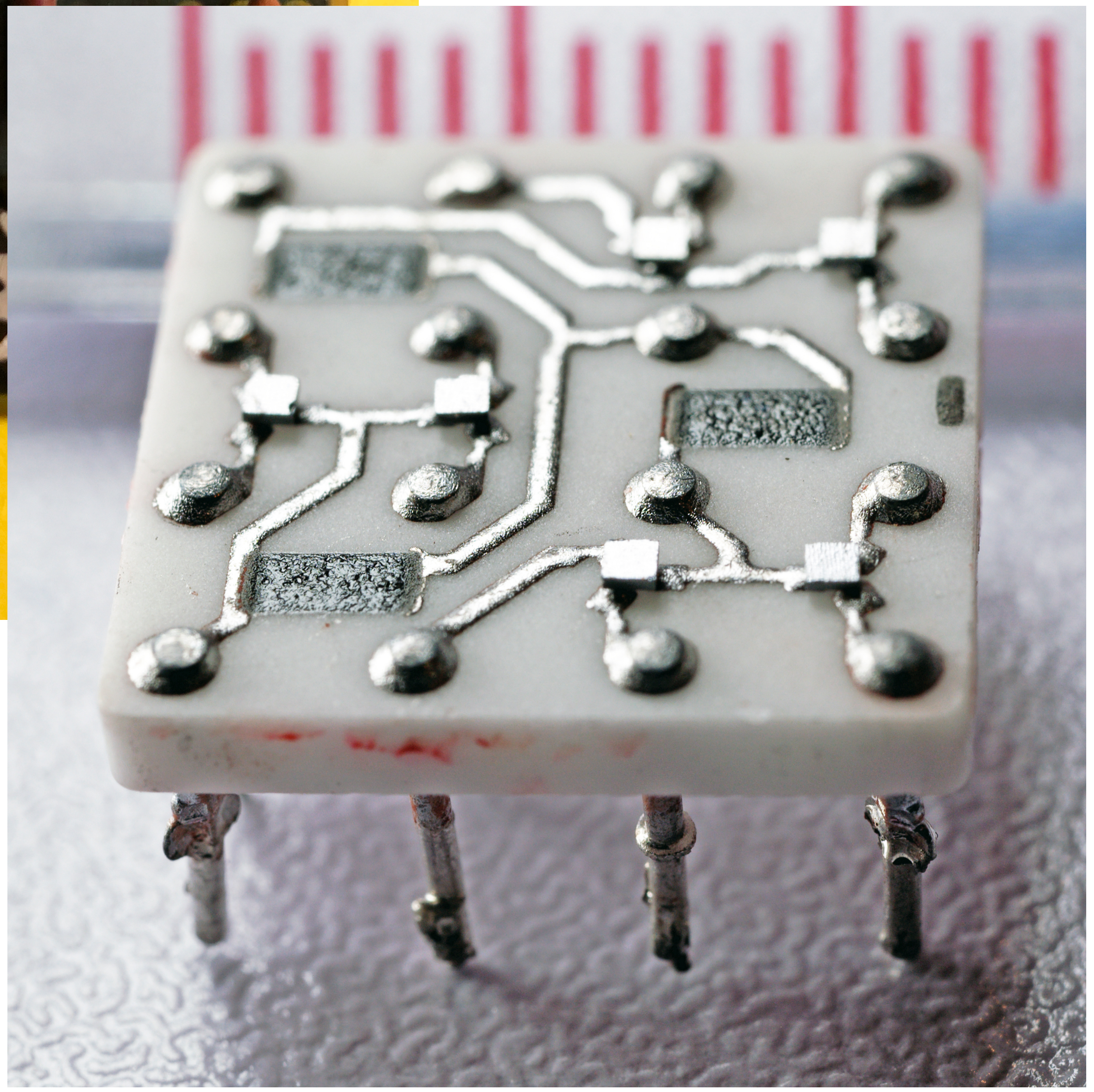
- Les processeurs utilisaient du microcode, pour traduire les instructions machines (communes à tous les modèles) vers le matériel disponible



IBM System/360

- Circuits « hybrides »
  - Presque des circuits intégrés, mais pas tout à fait…

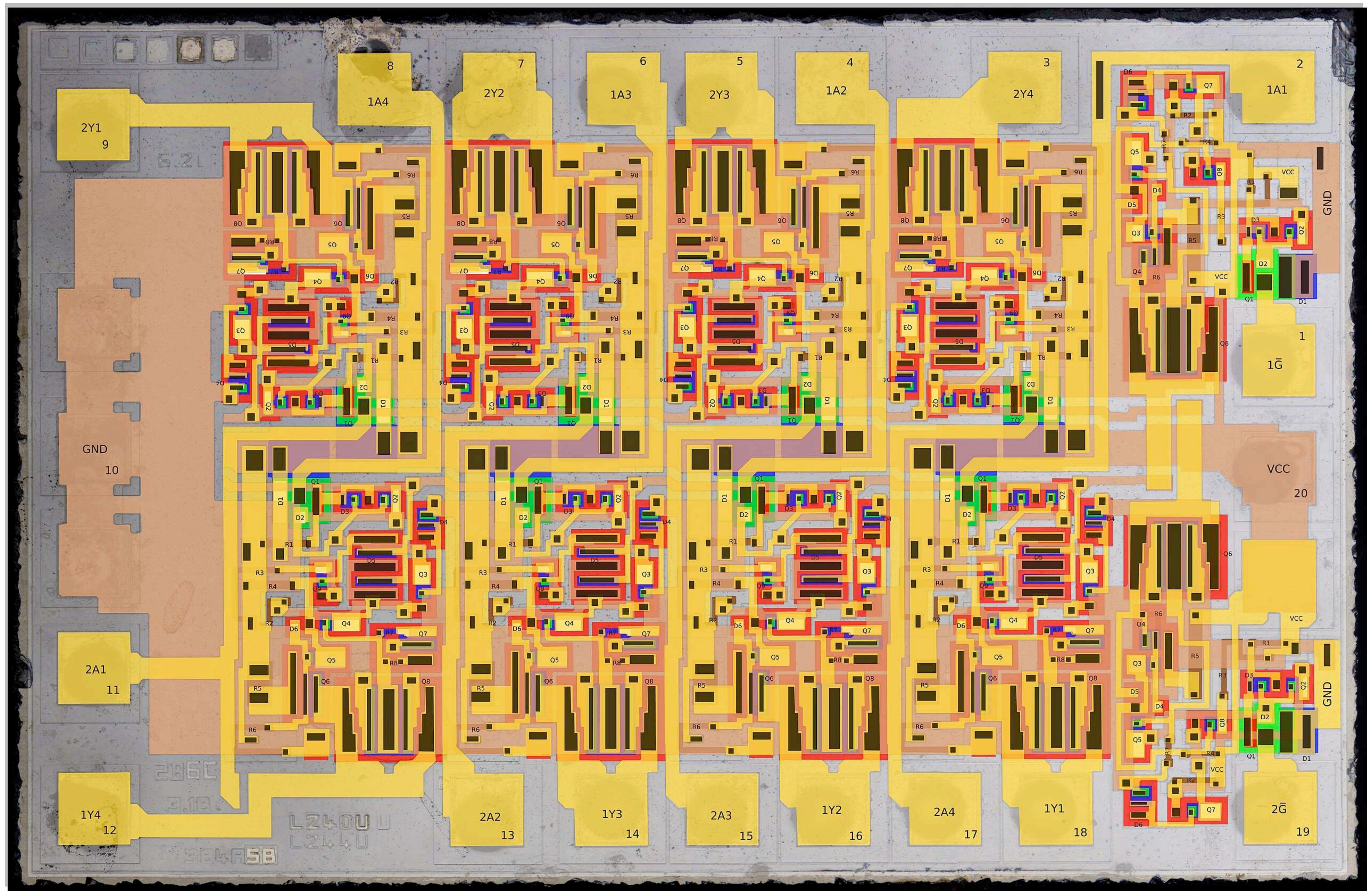




Circuits intégrés

- Procédé permettant d'intégrer et de miniaturiser fortement de nombreux composants électroniques de base (exemple: des transistors) dans un seul composant

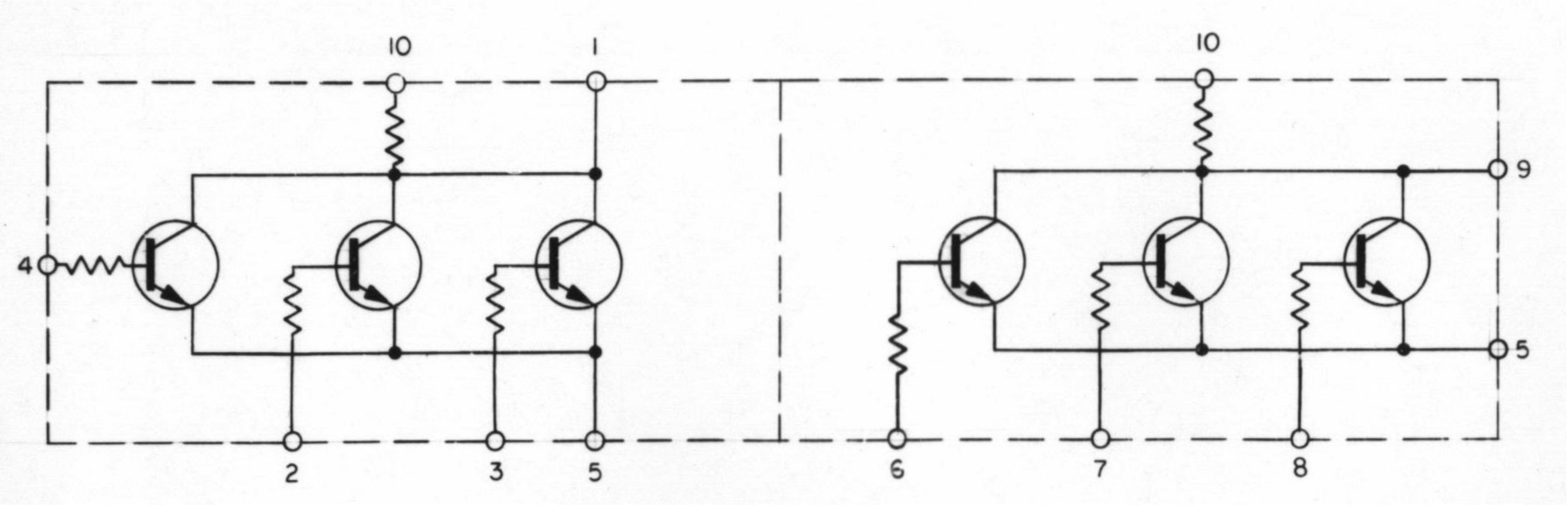
- Inventé en 1958 par des chercheurs de Texas Instruments et Fairchilds: Jack Kilby (prix Nobel), Robert Noyce, Jean Hoerni…

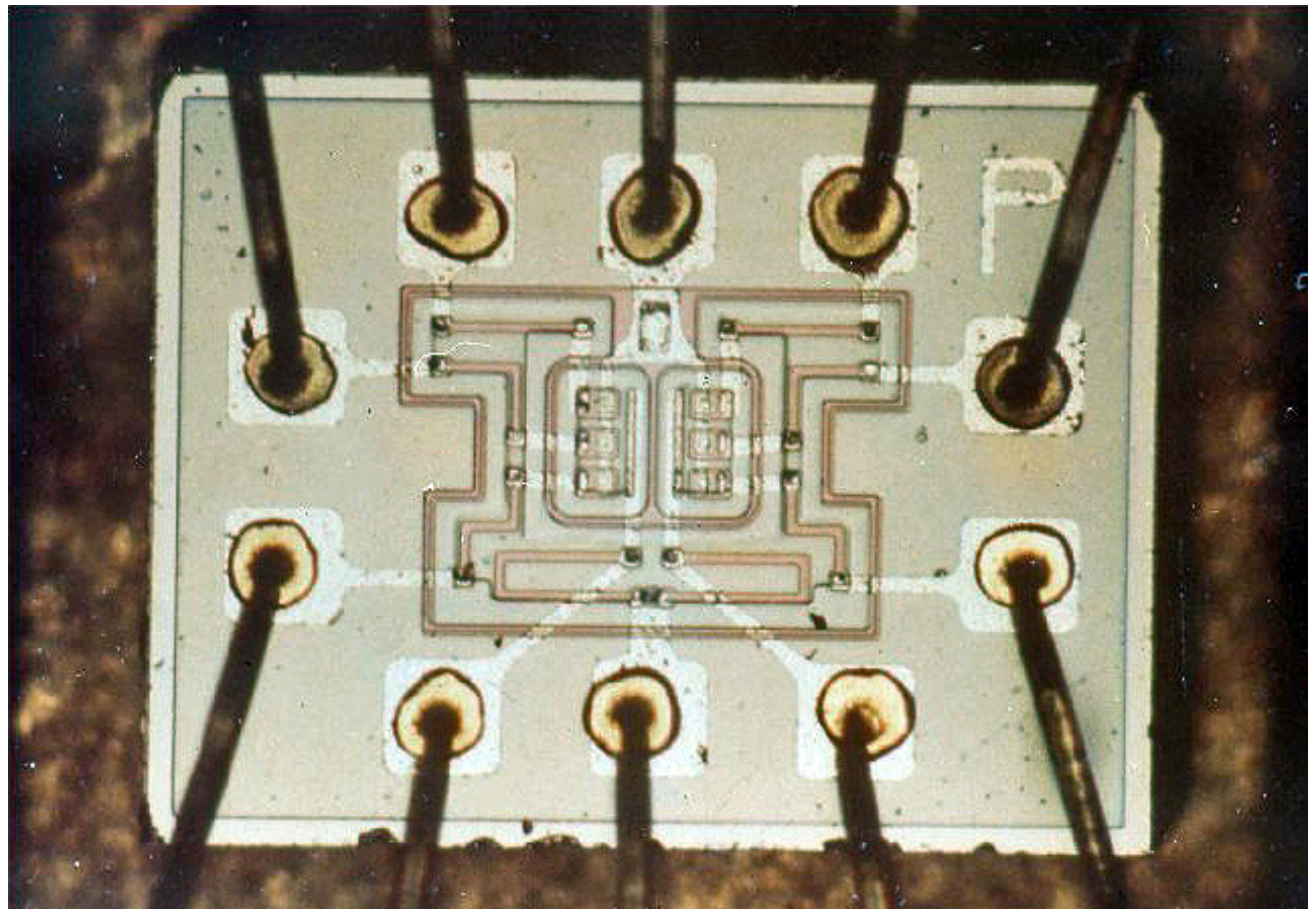


Circuits intégrés de l’AGC

- l’AGC était l’ordinateur embarqué dans le module Apollo du programme spatial américain: Apollo Guidance Computer

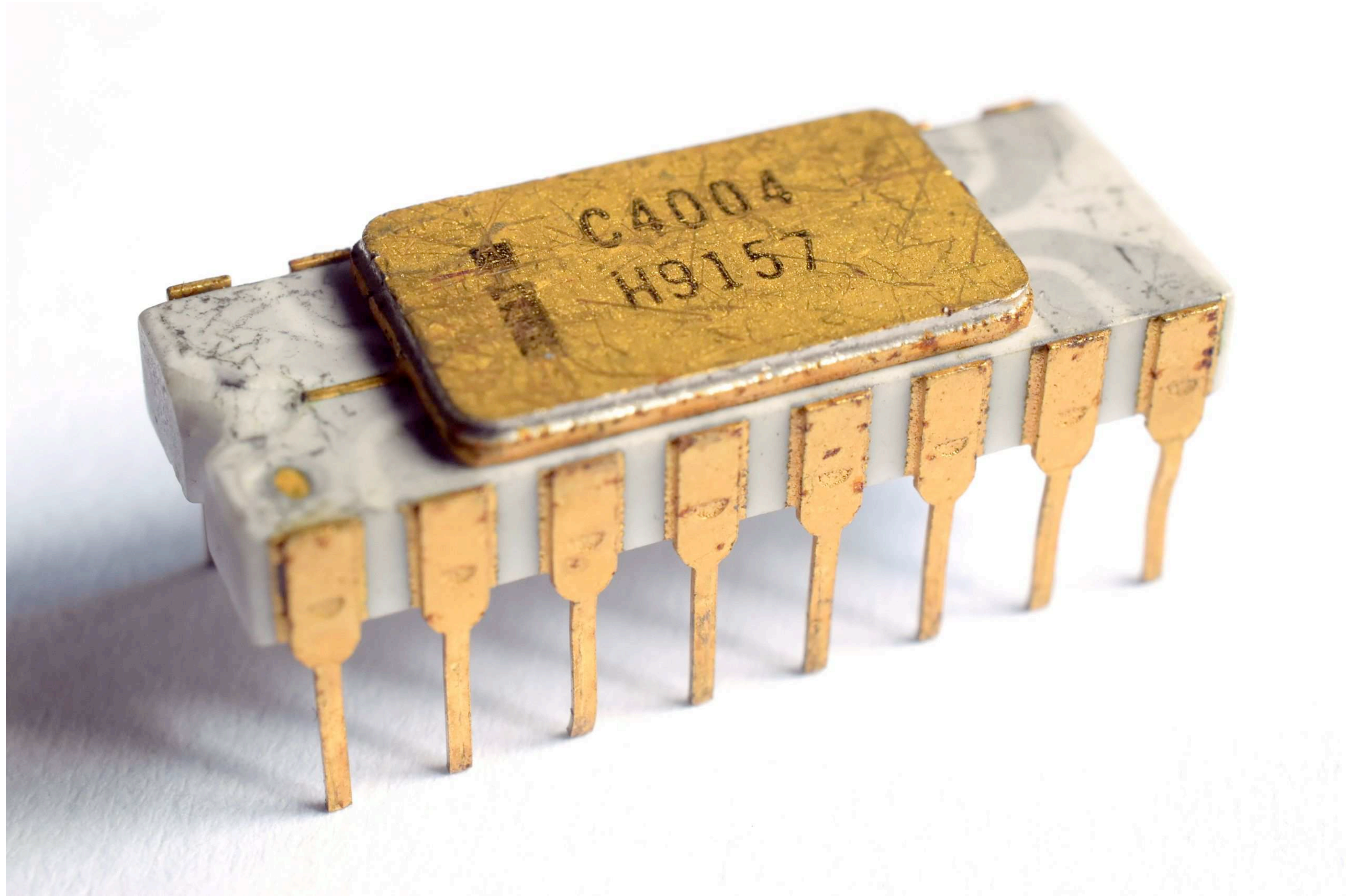
- Le CPU était formé à base de portes NOR à trois entrées





Intel 4004

- Premier processeur intégré commercial
- 1971
- 0,75 MHz = 0,00075 GHz
- Processeur 4 bits
- Adresses de 12 bits
- 2 300 transistors
- Développé comme faisant partie d'un ensemble de 4 circuits pour des machines à calculer
    - CPU, I/O, ROM, RAM

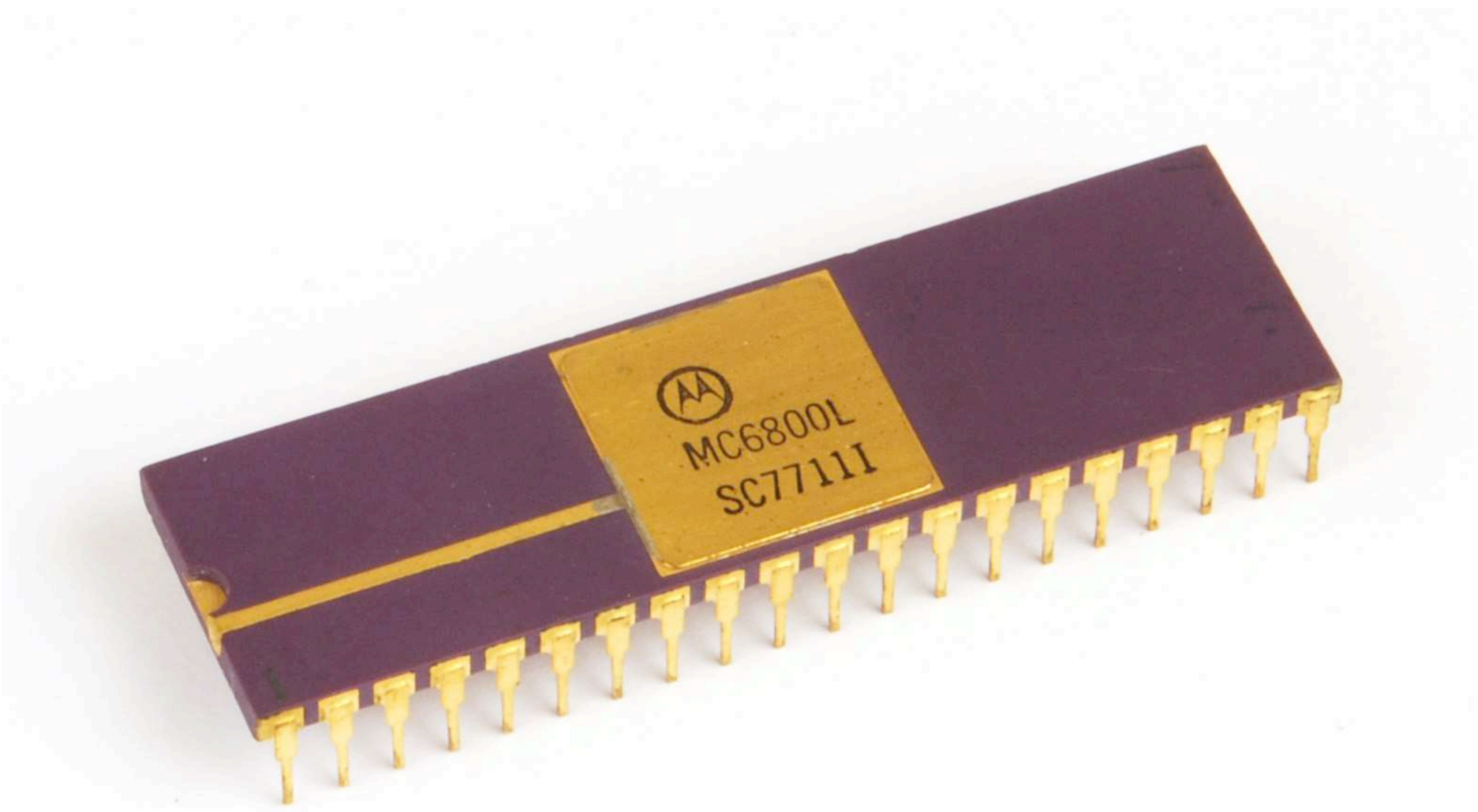


Successeurs du 4004

- Version 8 bits: le 8008
- Versions 16 bits: 8088, 8086, 80186, 80286
- Versions 32 bits: 80386, 80486, Pentium, Pentium II,…
- Versions 64 bits: Intel Core 2, i3, i5, i7….

La concurrence: Motorola 6800

- Processeur 8 bits (16 bits d'adresse)
- Introduit en 1974 par Motorola
- 1 à 2 MHz
- Inconvénient: cher !
    - $360 de 1974 = $2 300 en 2024

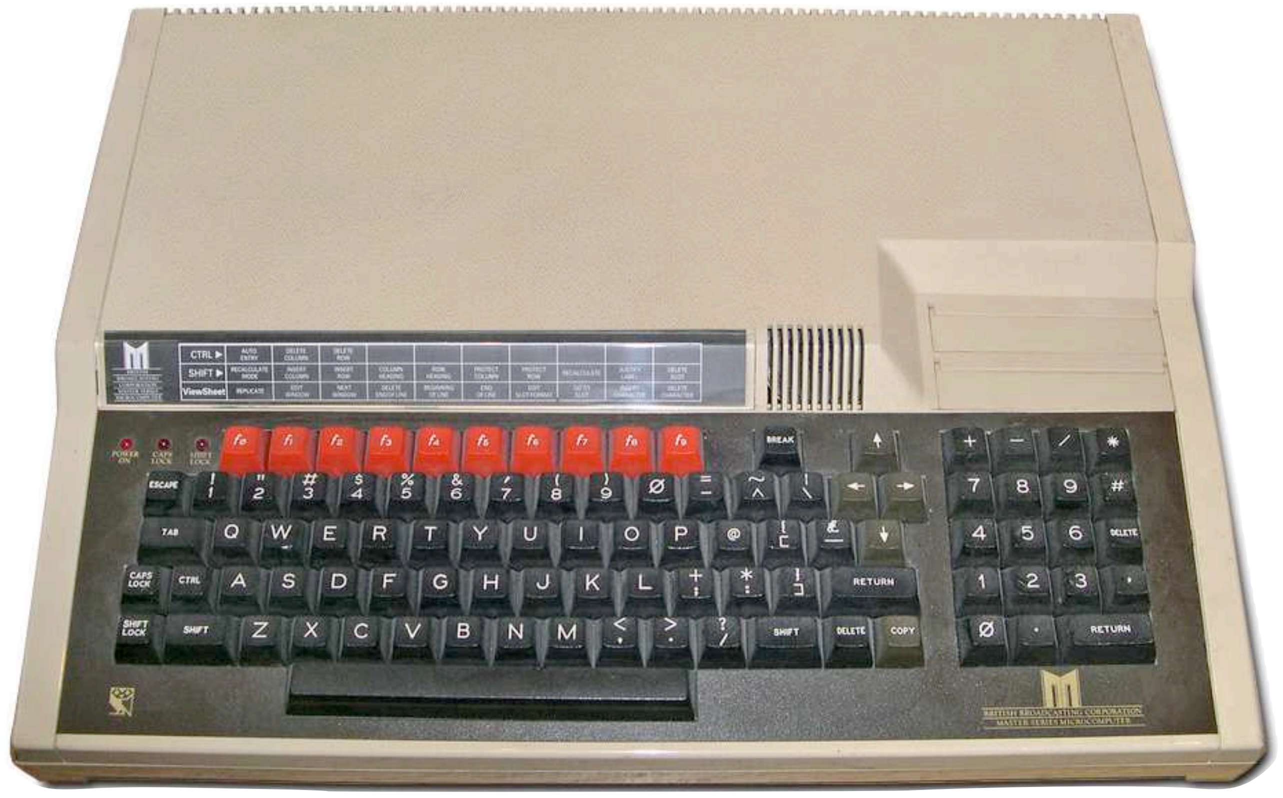


By Swtpc6800 en:User:Swtpc6800 Michael Holley - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=10363668

Alternative: MOS Technologies 6502

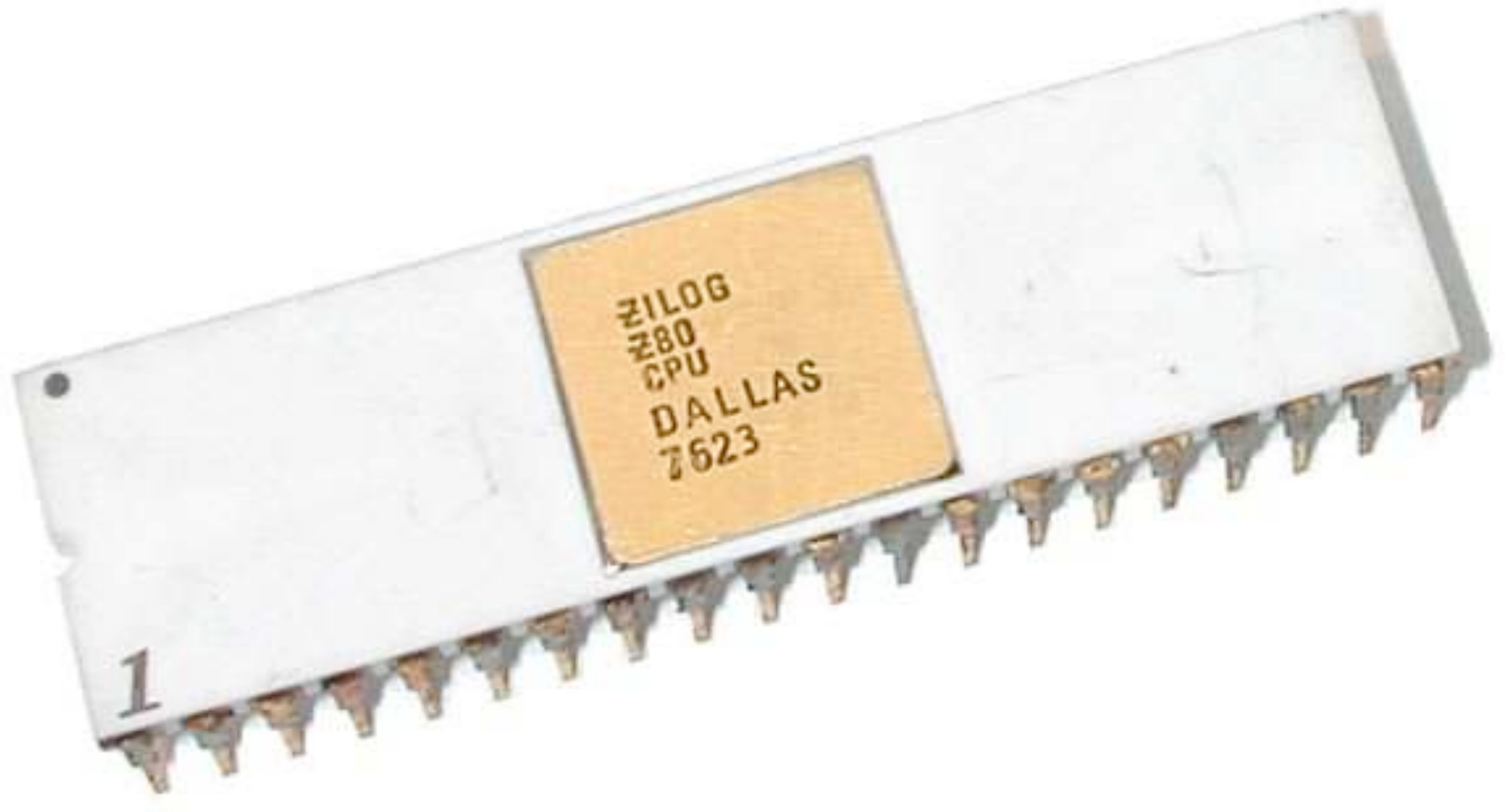
- Conçu par des anciens ingénieurs de Motorola
  - A donné lieu à un procès retentissant
- Processeur 8 bits (16 bits d’adresse)
- Introduit en 1975, encore produit aujourd’hui
- Environ 3 500 transistors
- Prix: $25 en 1975 (entretemps, le 6800 ne coûtait plus que $175 puis $69)

Utilisation du 6502…



La concurrence (le retour)… Le Z80

- Processeur 8 bits (16 bits d'adresse)
- Produit de 1976 (Zilog) à 2024
- 2,5 à 8 MHz
- Concurrent de l'Intel 8080



Utilisation du Z80

La trinité de 1977 (selon Byte)

IBM 5150

- « LE » PC, introduit en 1981
- Processeur 8088 à 4,77 MHz
- 16 ko de mémoire
- disquettes 5 pouces 1/4

To be continued ?