Title: Origins of the Digital Universe

Date: Sep 18, 2011 10:00 AM

URL: http://pirsa.org/11090140

Abstract: Some numbers mean things, and some numbers do things. Making--and breaking--that distinction was central to renowned mathematician John von Neumann's implementation of Alan Turing's Universal Machine in 1945-56. In this lecture, you will learn about the unlikeliest place on earth to build such a device and how this vital 5-kilobyte step in the digital revolution was sparked by a collision of ideas between mathematicians and engineers. Combining soldering guns with science, Von Neumann and his Electronic Computing Instrument tackled previously intractable problems ranging from thermonuclear explosions, stellar evolution, and long-range weather forecasting to cellular automata, network optimization, and the origins of life. In this highly visual and informative presentation, George Dyson will impart the full story - from the people to their processors - and where our digital directions through history may lead us next.

[11 February 1953]
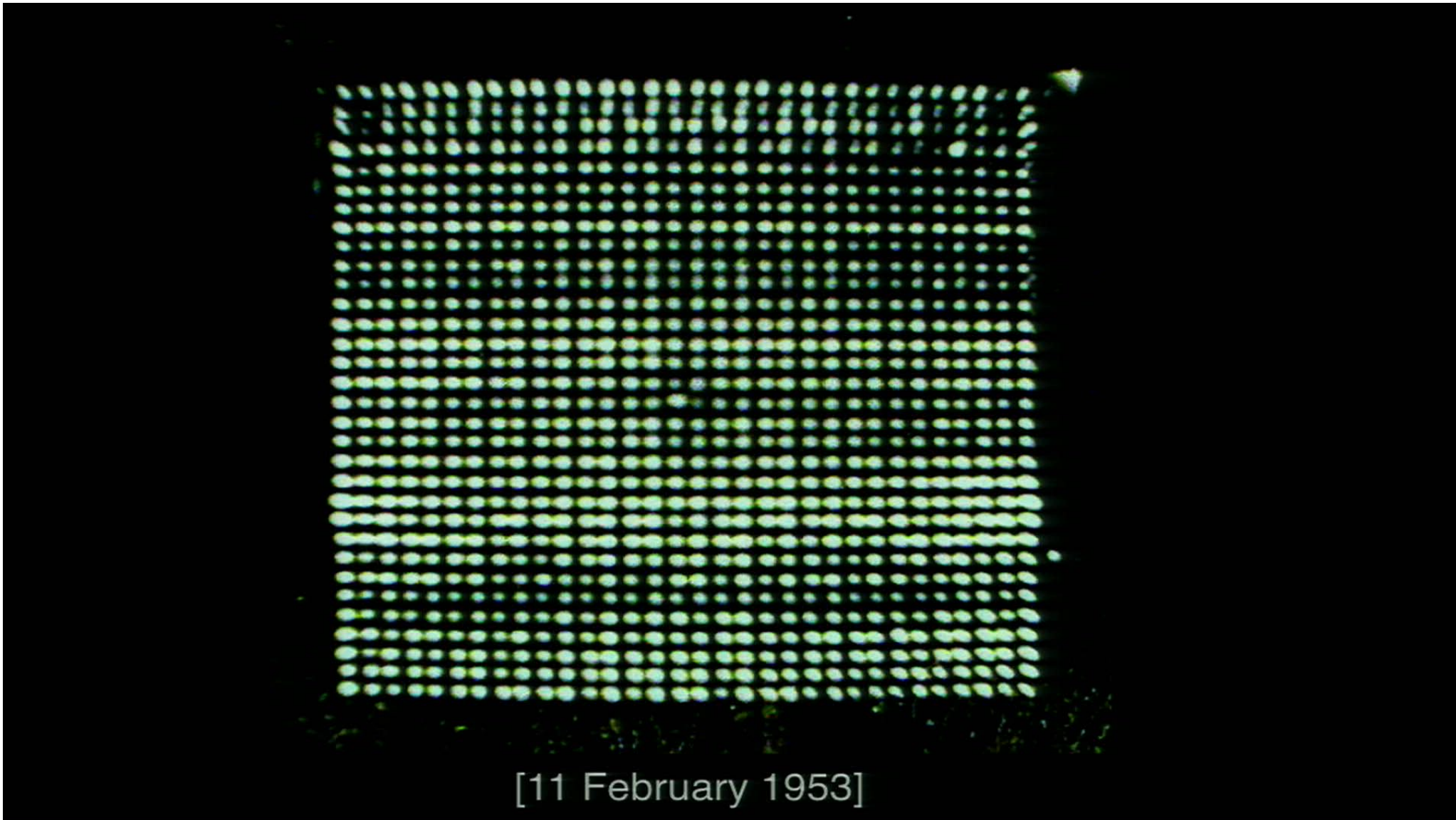
ON COMPUTABLE NUMBERS, WITH AN APPLICATION TO THE ENTSCHEIDUNGSPROBLEM

By A. M. TURING.

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

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 "computa-
bility" 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

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 wheels whose 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. ~~Turn~~ The letter which appears over the bulb is ~~called~~ the result of enciphering the letter on the depressed key with the wheels in the position they have when the bulb lights.

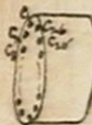To understand the working of the machine it is best to separate in our minds

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 $C_1, \ldots, C_{26}$. 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 ~~qwertzuiasdfghjk~~ 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
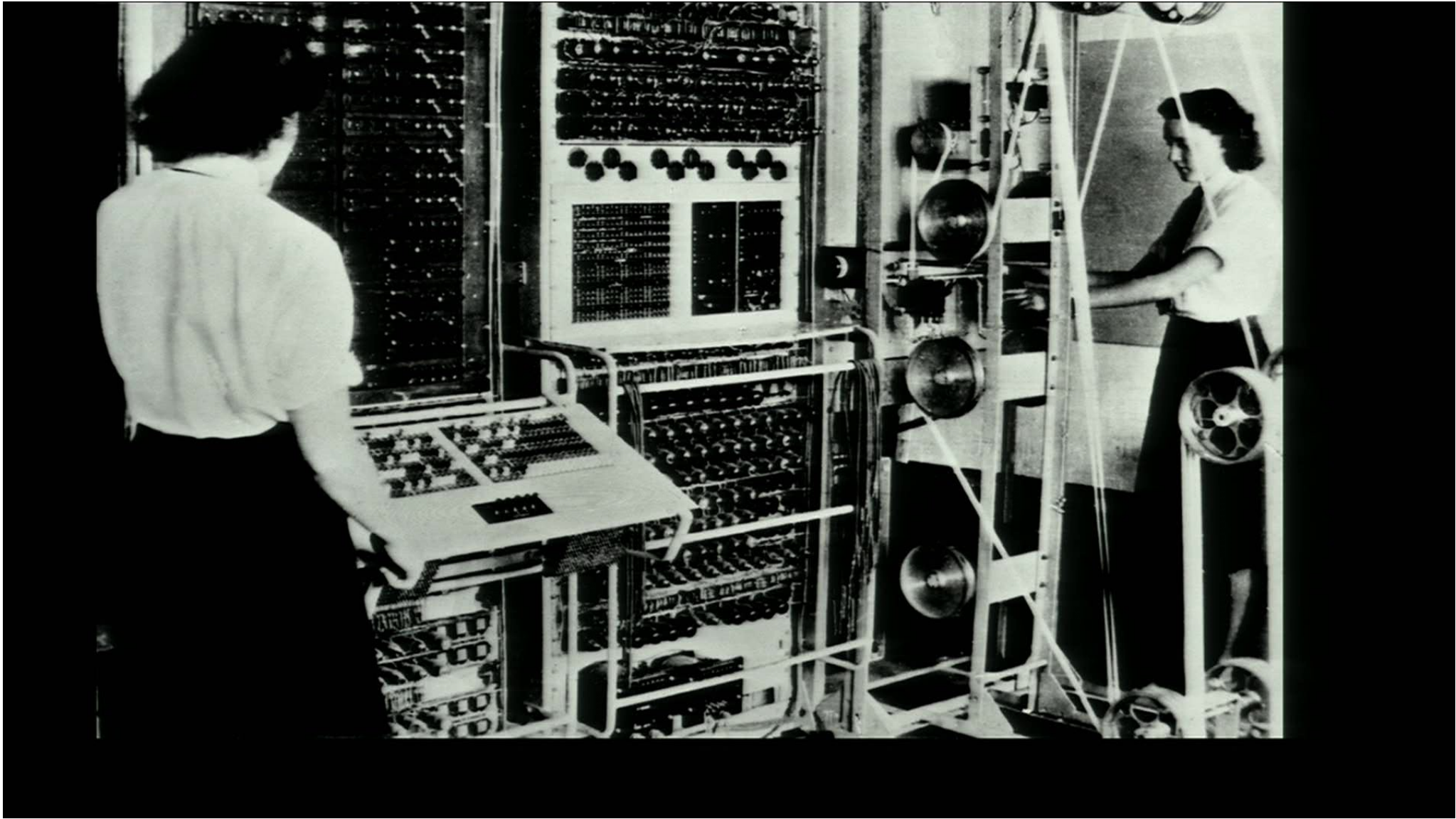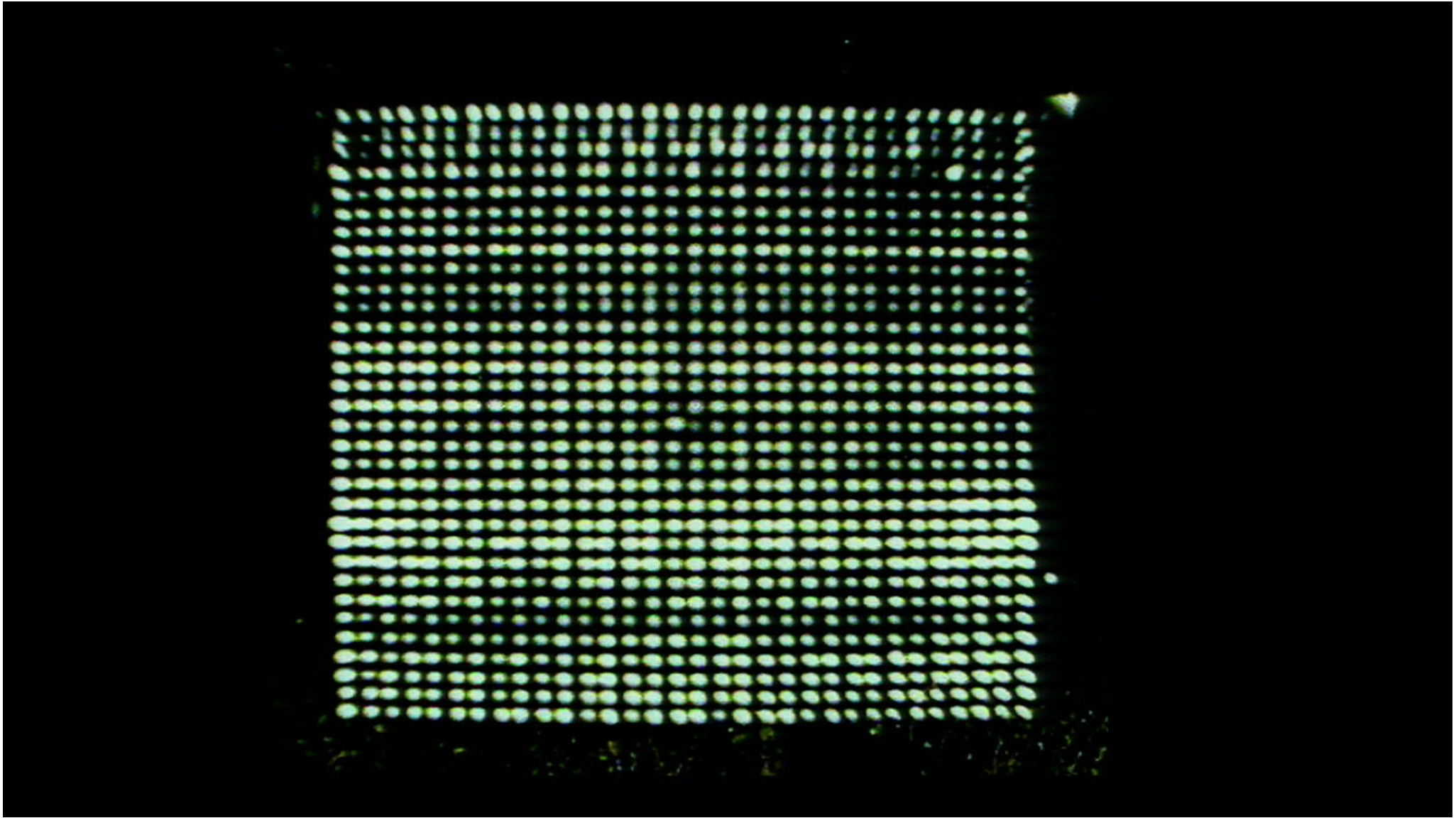
Friedrich-Wilhelms-Universität Berlin

Ausweiskarte

Inhaber dieser Karte

Privatdozent

Dr. Johann Neumann

von Margitta

ist Angehöriger der Friedrich Wilhelms-Universität zu Berlin und hat Zutritt zu dem Universitäts-Gebäude.

Eigenhändige Unterschrift des Inhabers

Louis Bamberger and Mrs. Fuld Give $5,000,000 to Establish Institute of Advanced Learning

Donors of Institute Fund

Initial Endowment Announced For Graduate Foundation In Newark or Vicinity

The gift of $5,000,000 by Louis Bamberger and his sister, Mrs. Felix Fuld, to establish an educational foundation to be called the Institute for Advanced Study was announced today. It will be located "in Newark or its vicinity."

Exclusively for post-graduate work and scientific research, the first of its kind in this country, the institute will bring Newark to the forefront among world educational centers.

The $5,000,000 will be placed by Mr. Bamberger and Mrs. Fuld at the disposal of a distinguished board of

Cites "Duress"

WESTERN UNION

Received at 376 Lexington Avenue, New York, N. Y.

1933 JAN 28 PM 6 50

NC194 9 VIA DLY=PRINCETON NJ 28 607P

DOCTOR ABRAHAM FLEXNER=

VANSTITUTE 100 EAST 42 ST=

MINUTES IN TRANSIT	
FULL-RATE	DAY LETTER
43	

MANY THANKS FOR TELEGRAM AND QUICK ACTION OF APPOINTMENT=

NEUMANN.

Abraham Flexner (1866-1959)

THE USEFULNESS OF USELESS KNOWLEDGE

BY ABRAHAM FLEXNER

[1939]

Prof. Veblen
116
115
Prof. Einstein
Prof. Veblen
114 113
Secretary Secretary
112
Prof. Von Neumann
Common Room
111 110
Secretary
P. Ec
117
Lecture Room
118   119
Mail
120
Switch-Board
101 102 103 104
A104
Prof.
bson
Secretary
A100

FULD HALL

FIRST FLOOR PLAN
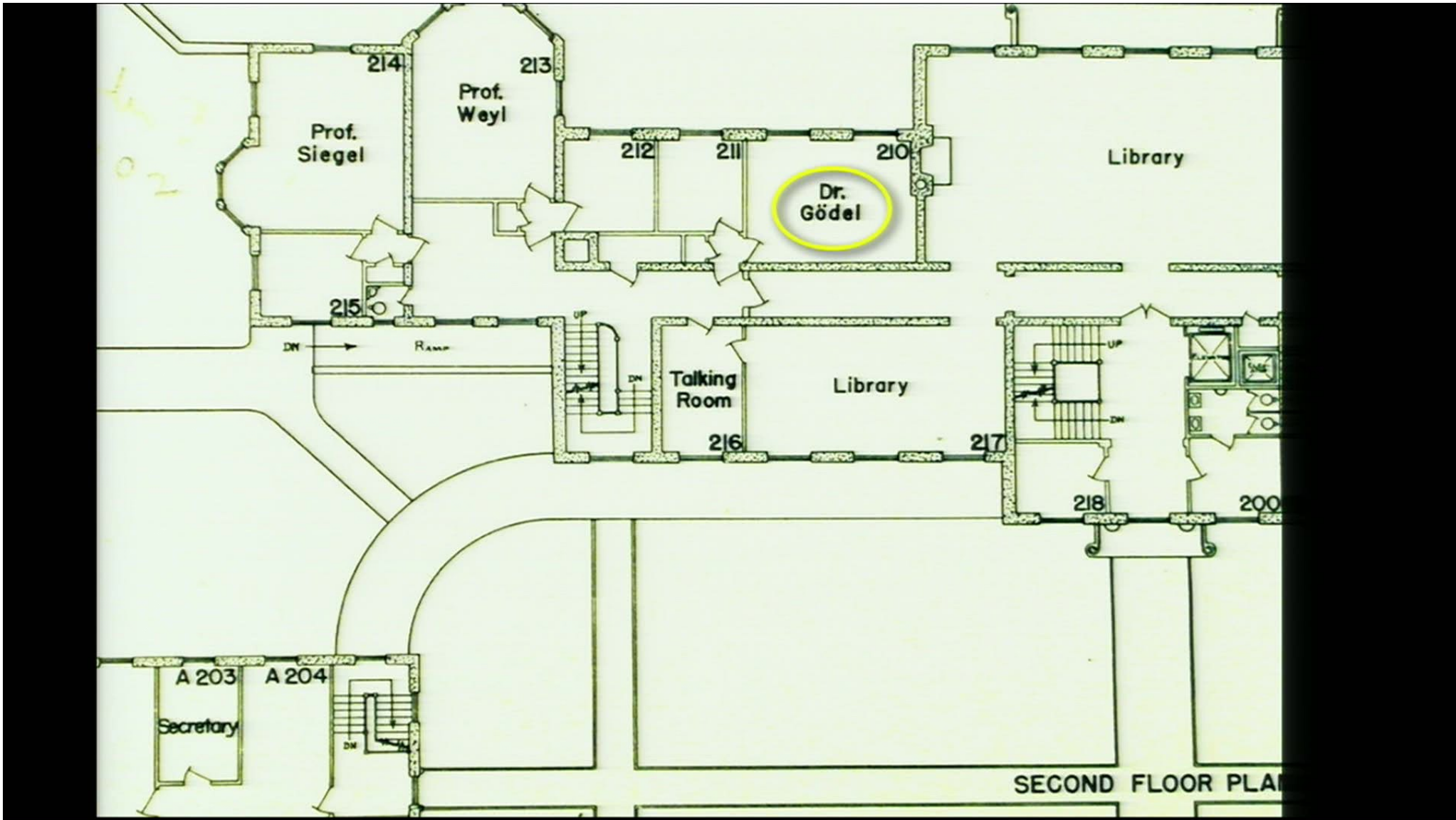
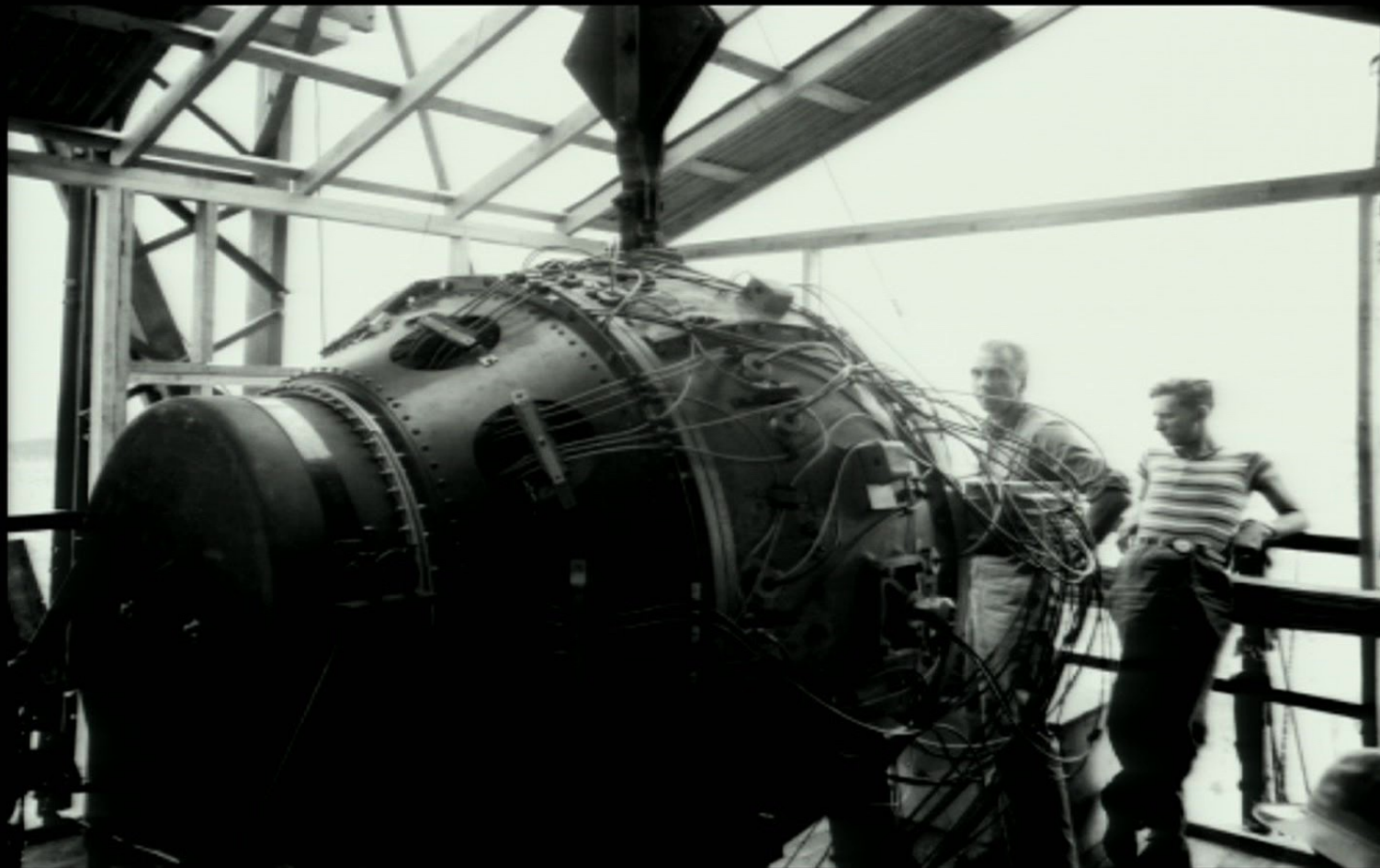SECOND FLOOR PLAN
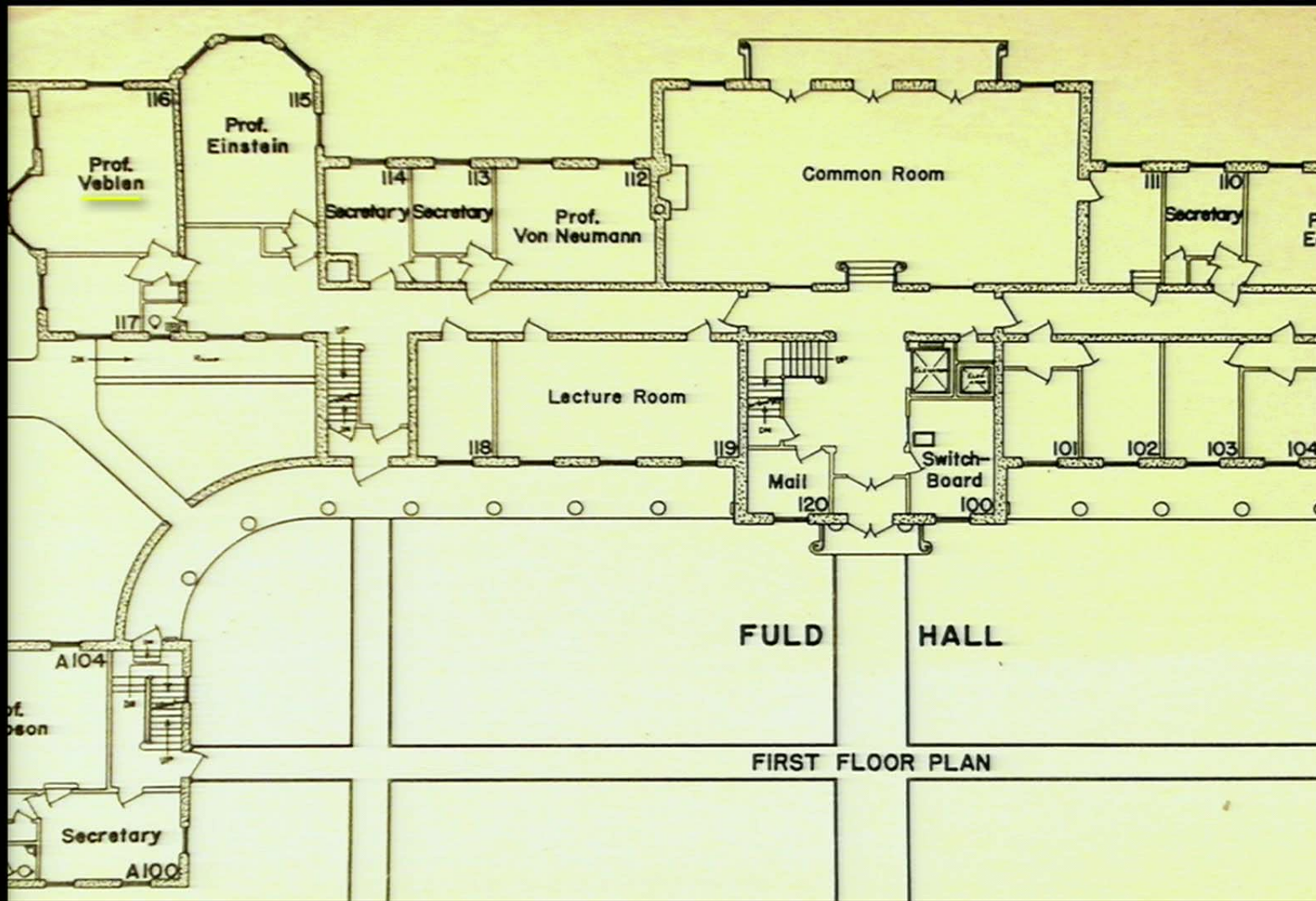
von Neumann   Feynman   Ulam

Crossroads Baker
23 kt - 25 July 1946

von Neumann   von Braun

Report on

THE ENIAC

(Electronic Numerical Integrator and Computer)

Developed under the supervision of the
Ordnance Department, United States Army

MAINTENANCE MANUAL

RESTRICTED

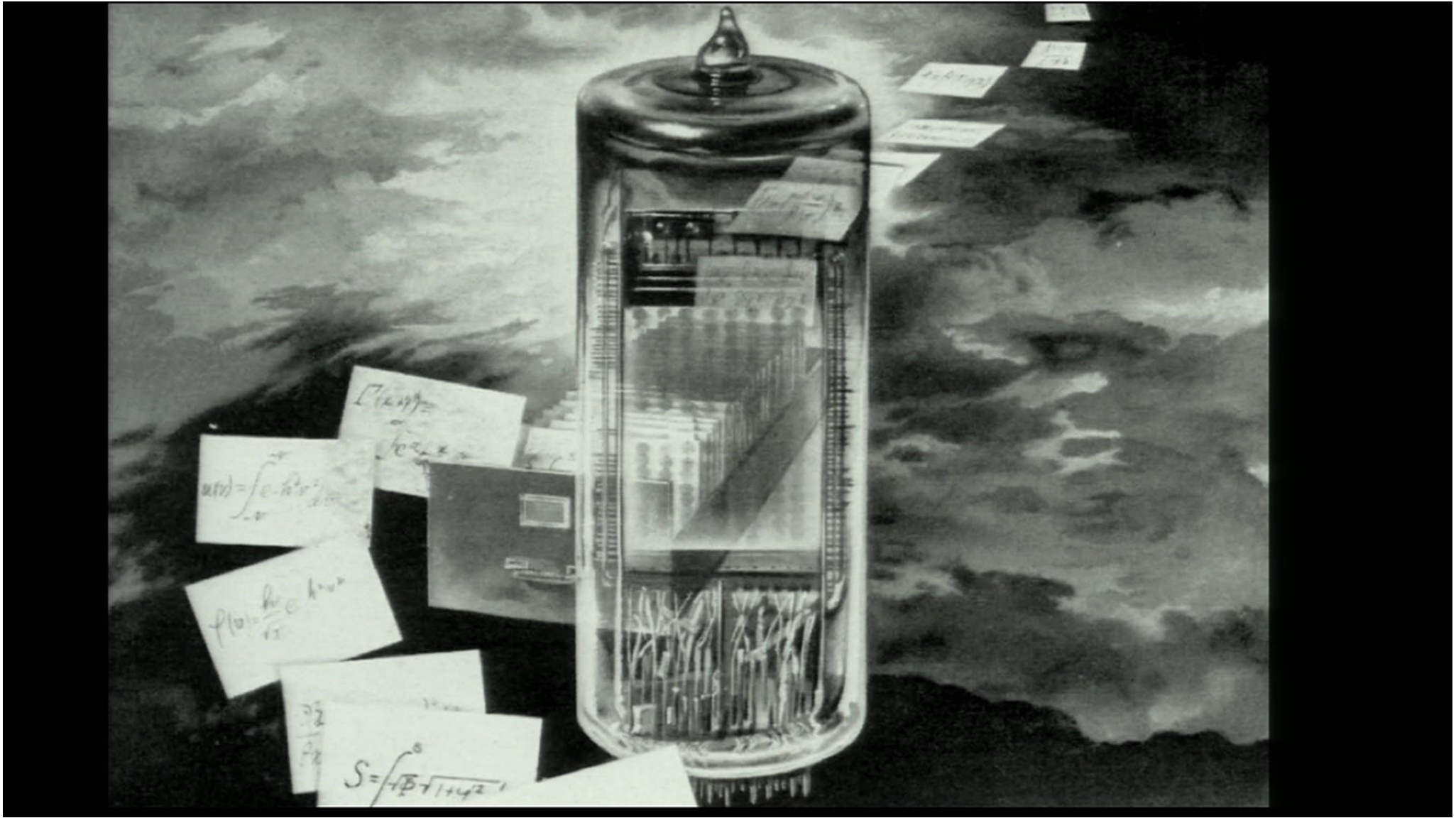This document contains information affecting
the national defense of the United States
within the meaning of the Espionage Act, U.S.
C. 50: 31 and 32. Its transmission or the
revelation of its contents in any manner to
an unauthorized person is prohibited by law.

UNIVERSITY OF PENNSYLVANIA

Moore School of Electrical Engineering

PHILADELPHIA, PENNSYLVANIA

June 1, 1946

Vladimir Kosma Zworykin, 1889-1982

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

The heart of the system is a central clock,
carrying an enormous load...

This [modular] sort of design is favorable for
mass production...

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

— First meeting of the IAS Electronic Computer Project, November 12, 1945

Orders. Let $\frac{1}{2}$ word (40 bd) be 2 orders, each order = C(A) = Command {1-10}{21-30} · Address {11-20}{31-4}

Put A ∈ R₃ in M₁	Put A ∈ R₃ in Order	Reset and data Ctr to A	data Chg Ad. Ctr.	Sh L, R ±		17		
				x, ÷, R, √	1–8,		R Comm into R₃	R Co
1	0	1	0	1	0	1	0	1	0
(1–8) 7, (11,12), (13–16) 17	10,29 21	(13–16)	(1–8), 7 (11,12) 17	(11,12) 21,22	1–8	M/Red into R₃	M with from R₃		

Put Sh(A)/14 M to cr   Sh/12 A cr   M/ch A cr

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.
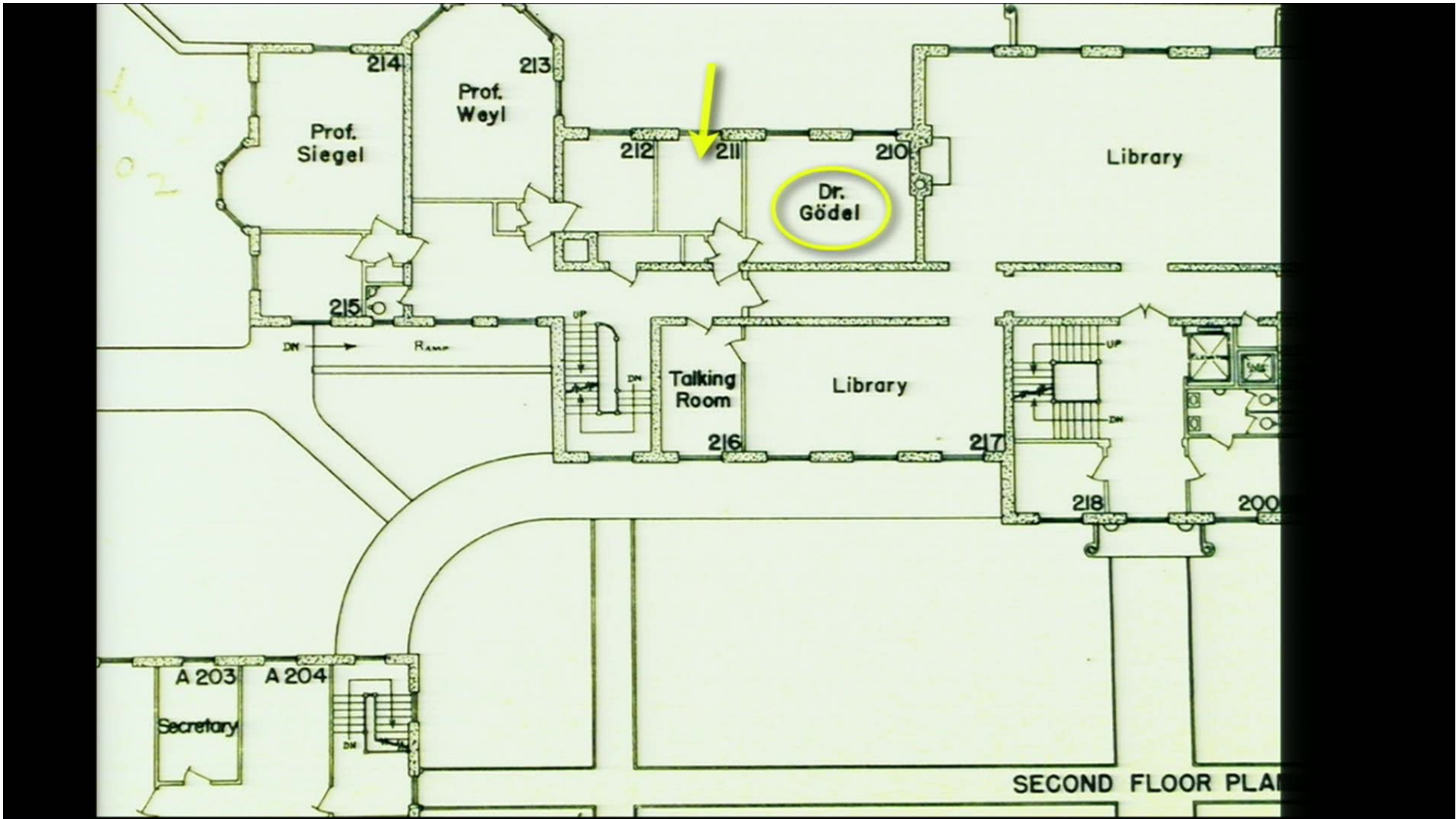
ELECTRONIC COMPUTER PROJECT

STATEMENT OF EXPENDITURES FROM BEGINNING, NOVEMBER 1945 to APRIL 30, 1946.

DISBURSED:

|	
Salaries	$ 3,506.33
Communications	50.49
Supplies & Books	48.83
Travel	317.32
Entertainment & conferences	20.90
Legal Services	591.87
Equipment	169.87
TOTAL to 4/30/46 (Actual Expenditures)	$ 4,705.61

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
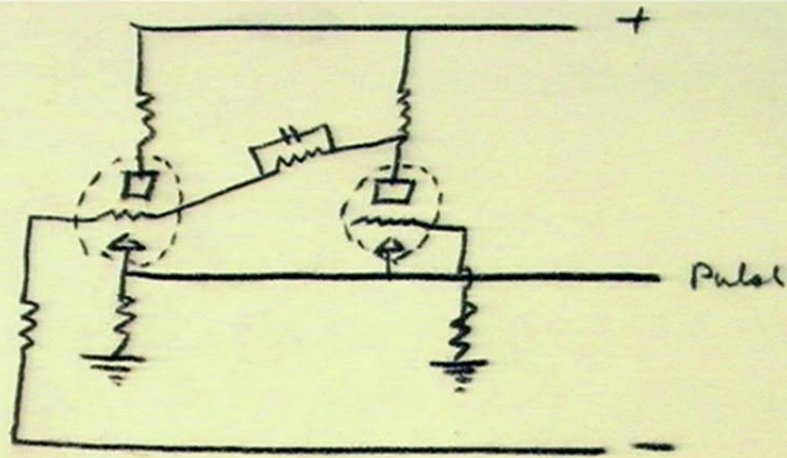
③ Electron-Tube Binary Cell Stability
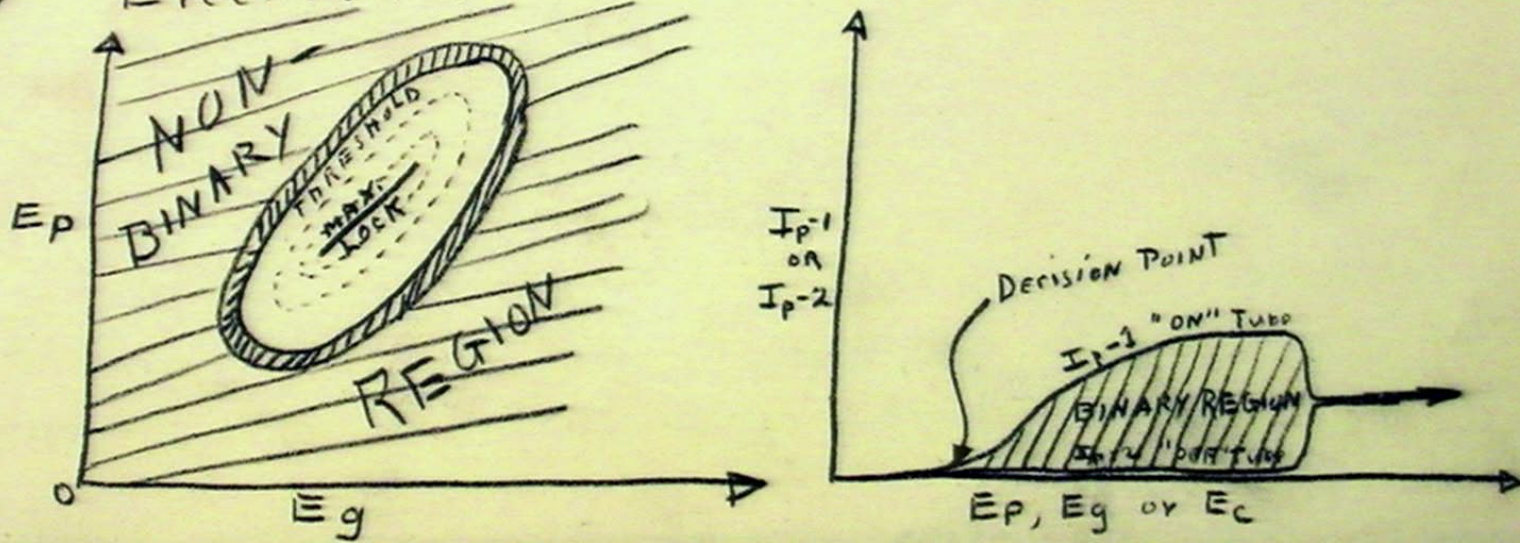
SKETCH 7 CONTINUED

D. TYPICAL COMBINATIONS OF COMMUNICATIVE BANKS OF CELLS

CIRCULAR, EXCHANGE   CENTRAL   EXCHANGE

Row 4
Row 3
Row 1
Row 2

Row 4
Row 5
Row 3
Row 2

E.

E_{++}

$R_{hary} \left(= \frac{E_{++}}{i_c} \right)$

③
③
④
④
②
②
①
①

② ①
② ①

R_{hary} R_{hary}
R_{hary} R_{hary}

0
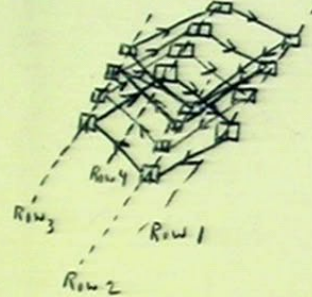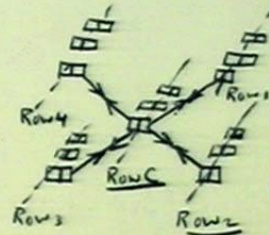
E_{--}
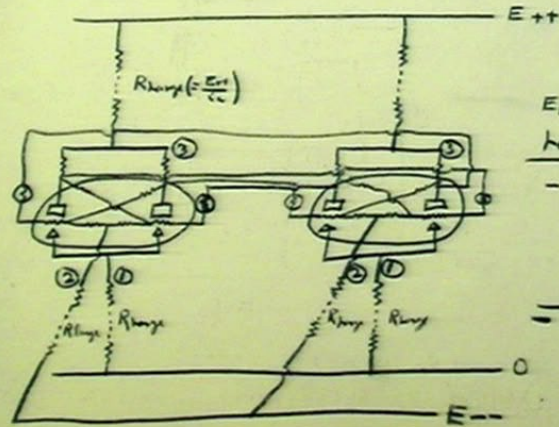
Circuit To Illustrate
Effects of swinging
locked Binary cells

- 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
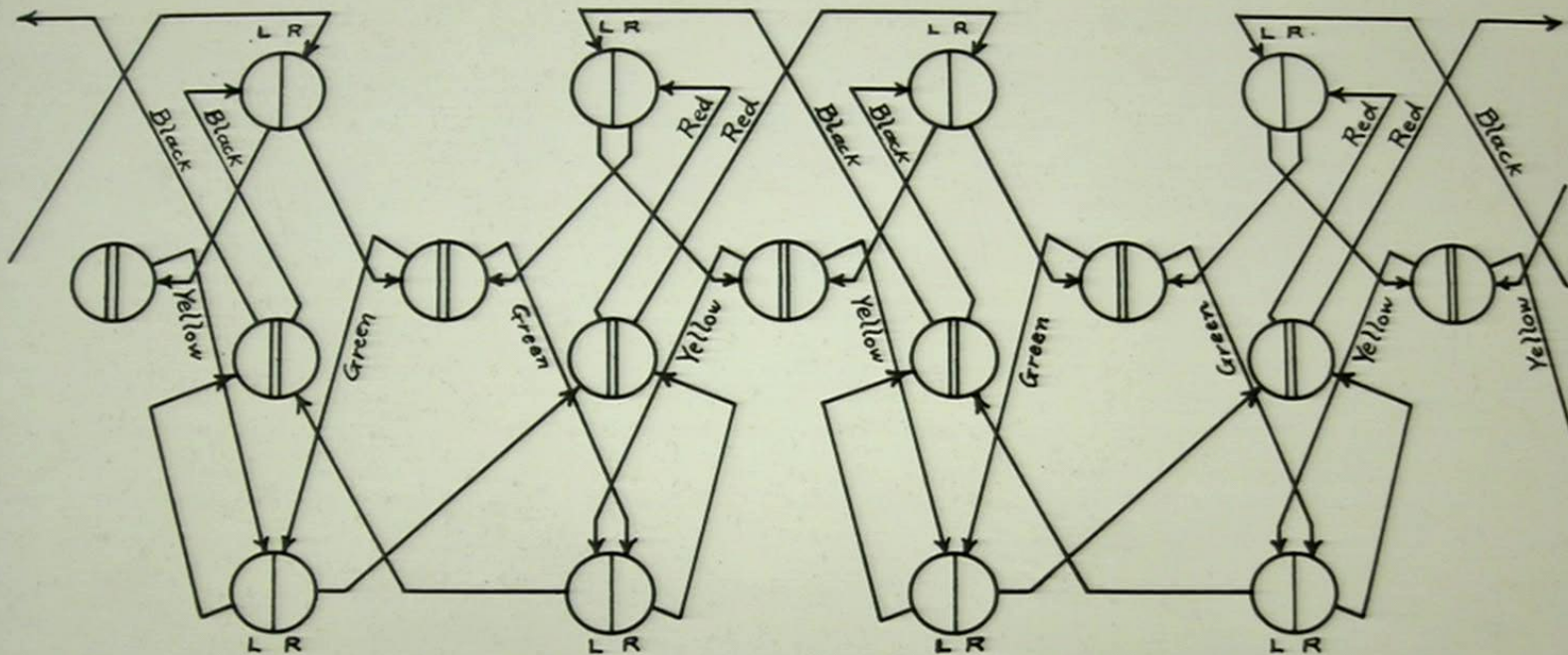
ELECTRONIC COMPUTER PROJECT
Institute for Advanced Study
Princeton, N.J.

SHIFTING REGISTER No. 7
FUNCTIONAL DIAGRAM
C-3-1063

DATE:	DRAWN BY:	CHECKED BY:
March 3, 1948	Peter Panagos	
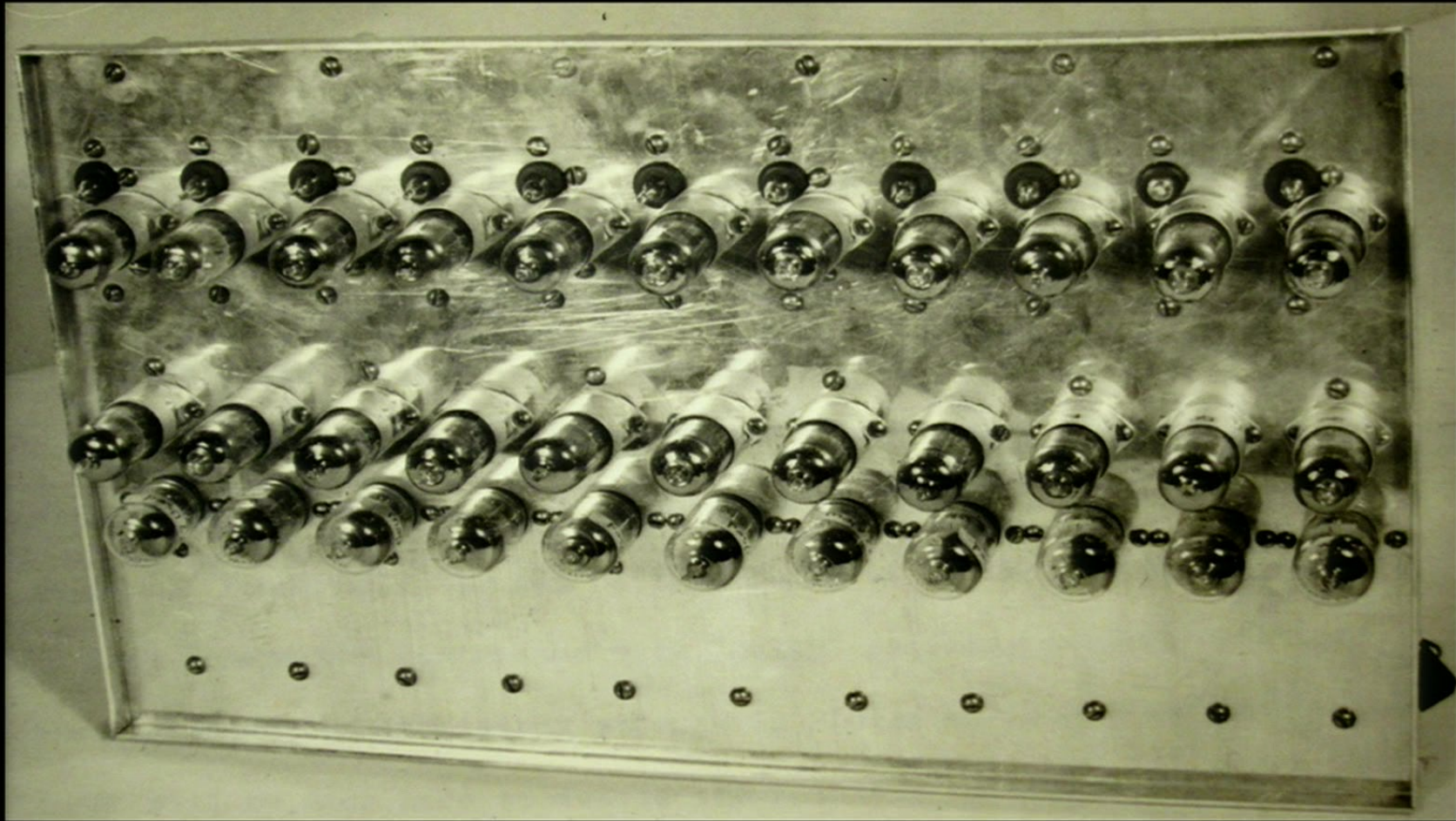
Bldg.

THE INSTITUTE FOR ADVANCED STUDY

Founded by Mr. Louis Bamberger and Mrs. Felix Fuld

PRINCETON, NEW JERSEY

June 4, 1946

Dear John:

I have thought very carefully over the problem of disposing of these fifteen workers who are to arrive the middle of June. The only really useable space in our basement is that adjoining the men's lavatory, to which you are most heartily welcome. Aside from that, the only additional room in this building would be the lecture room and possibly the Mathematics Library, both of which I know you would be reluctant to use. Other space in the basement must, I think, be kept for the common purposes of the Institute, which are much more important than you realize.

Outside the Institute I have thought of two things: application to Princeton University for the use of a laboratory, and application to the R. C. A. for a similar accommodation. Would you consider either of these feasible? So far as Institute property is concerned, I think the best

June 5, 1947

Professor John von Neumann
Institute for Advanced Study
Princeton, New Jersey

Dear John:

I am a little troubled about the tea service in the electronic computer building. Apparently the members of your staff consume several times as much supplies as the same number of people do in Fuld Hall and they have been especially unfair in the matter of sugar. Sugar is rationed and for a member of your staff to come up here as Thompson did and carry down a large quantity of sugar in excess of your rations is not cricket. I understand, furthermore, that the tea is served in several different places. We have never undertaken in the Institute to provide tea service in a large number of private offices and I should like to raise the question whether it would not be better for the computer people to come up to Fuld Hall at the end of the day at five o'clock in the afternoon and have their tea here under proper supervision. The only alternative seems to me to be to establish some central place in the computer building and have proper supervision there.
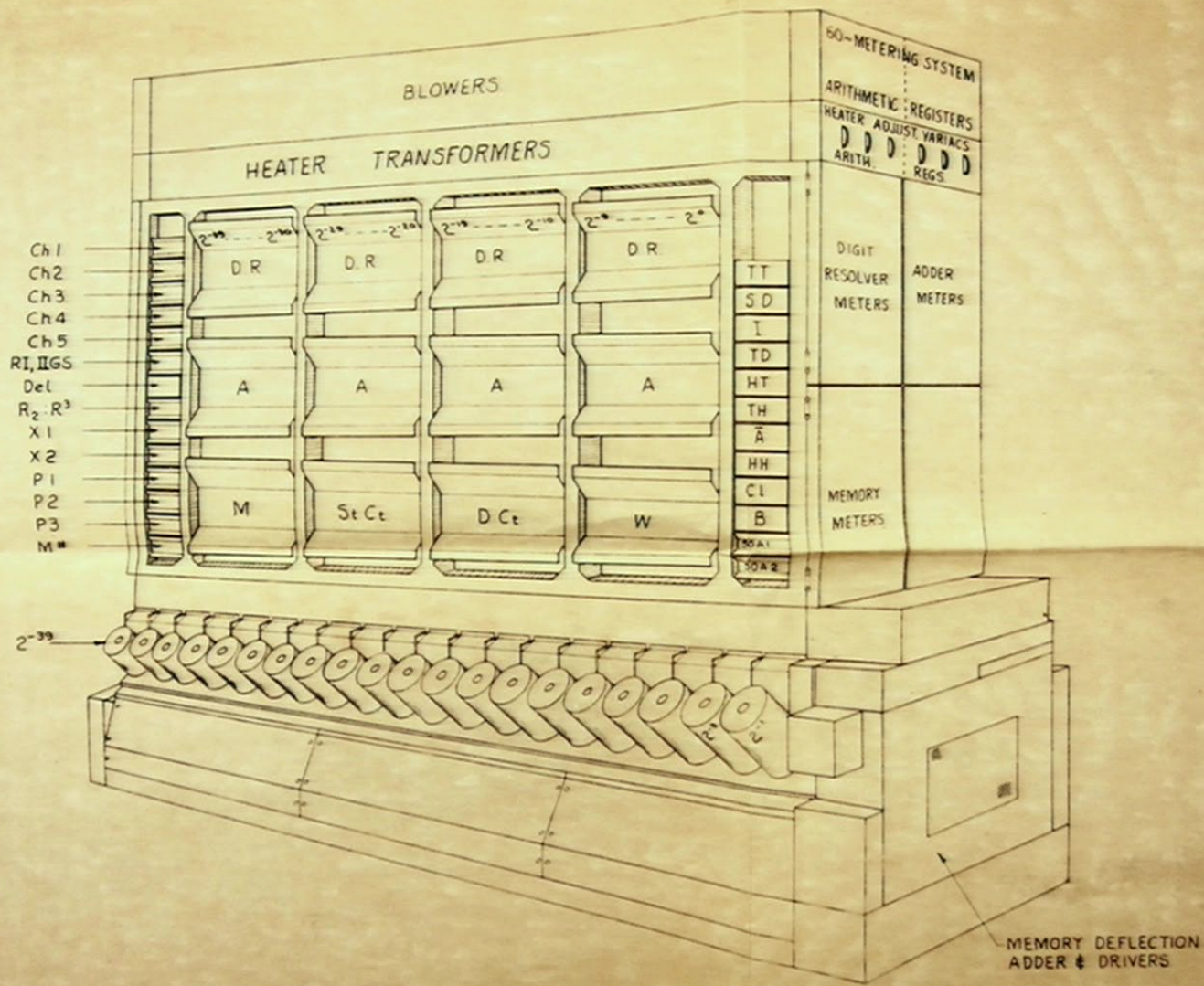
5CP1-A, 5CP7-A, 5CP11-A

OSCILLOGRAPH TUBES

Electrostatic Deflection	HV Accelerator Electrode	Maximum Diameter, 5-11/32"
Electrostatic Focus	"Zero First-Anode-Current" Gun	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. The very small anode-No.1 current permits the use of a low-current voltage-divider system and hence the use of a smaller filter capacitor.

Other design features of these types include a large useful screen surface in relation to bulb diameter; separate base-pin connections for each of the four deflecting electrodes; balanced deflecting-electrode input capacitances to minimize "cross-talk" and to eliminate the necessity for neutralizing circuits; and the diheptal 12-pin base which enables these types to be operated at their rated maximum values under reduced atmospheric pressure equivalent to an altitude of 40000 feet.

The types in the 5C-series are intended primarily for use in balanced electrostatic-deflection circuits, and when so used, give best definition. However, they may be used with un-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
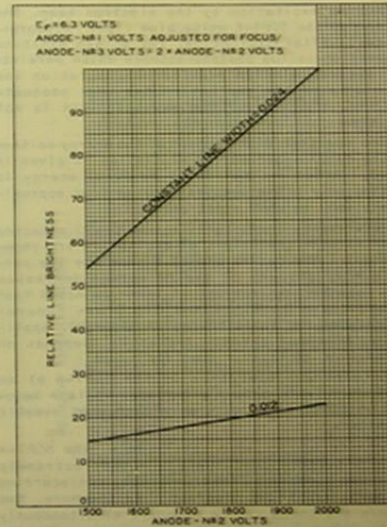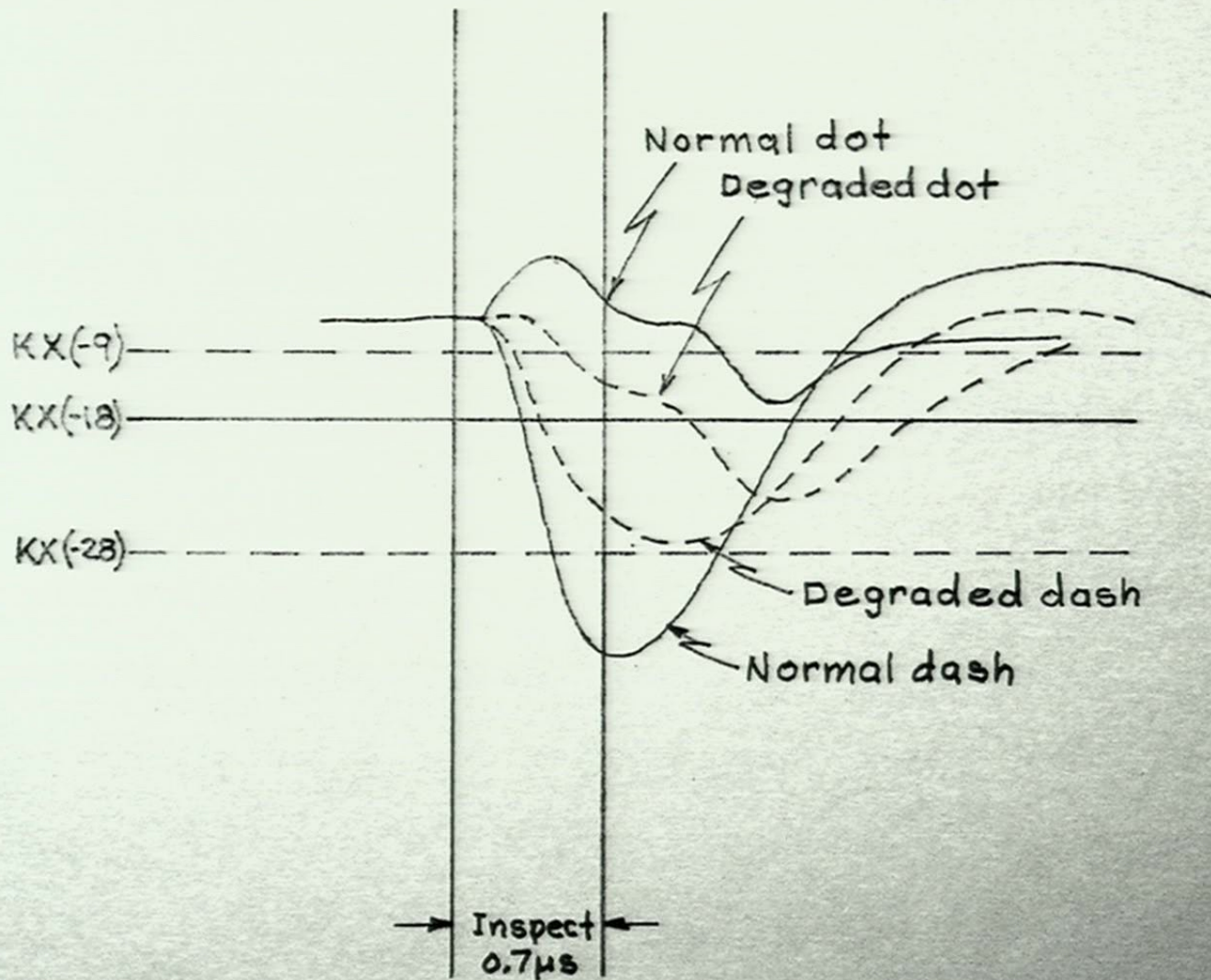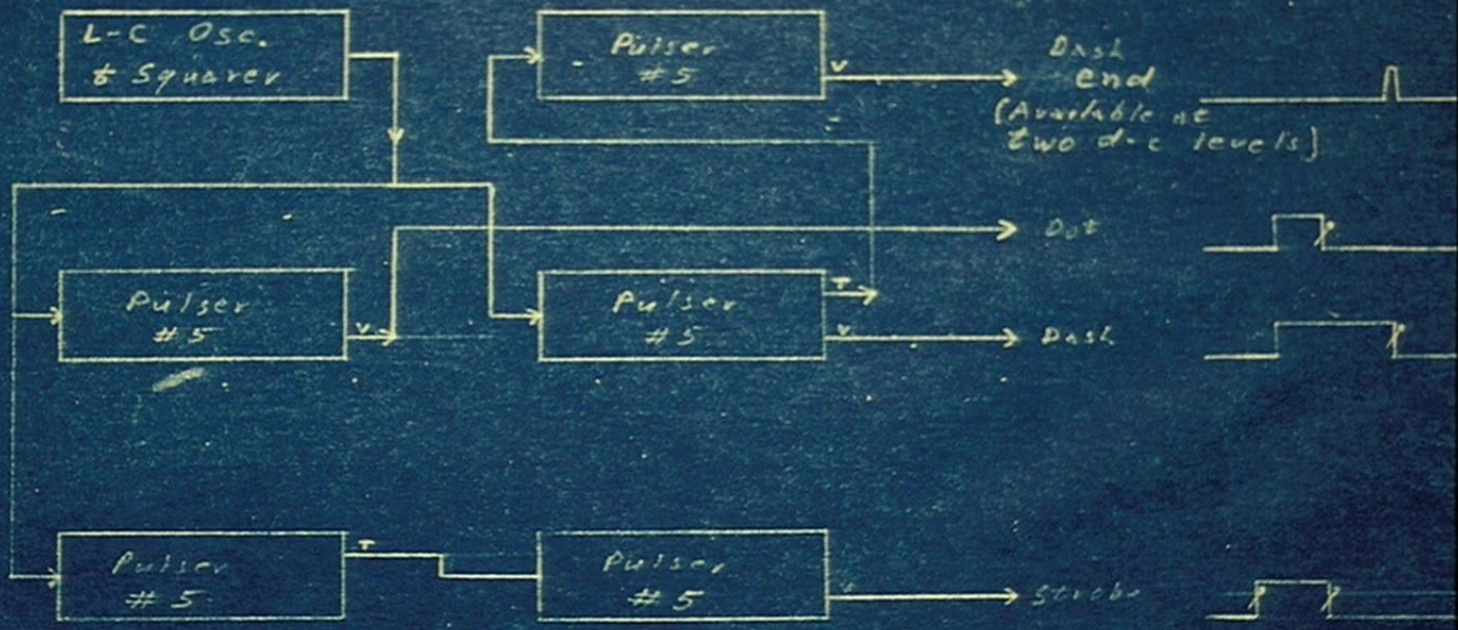

Fig. 1 - Characteristics of Type 5CP1-A

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

CLOCK

Figure 5.5

Williams' Memory Tube
12 July 48

D51 came out →

TUBE# D68 !

Stage

0.1 (0,6)

.8 →

11 Feb 53

.8

.9

AFTER 1 SPARKING (5)

.9 .8

.8

.8

(2000/2000)

.8

AFTER 2 SPARKINGS (5)
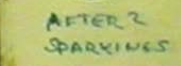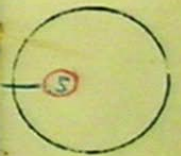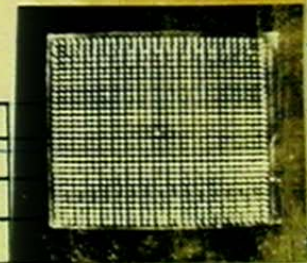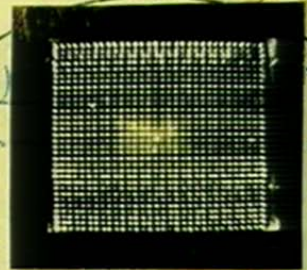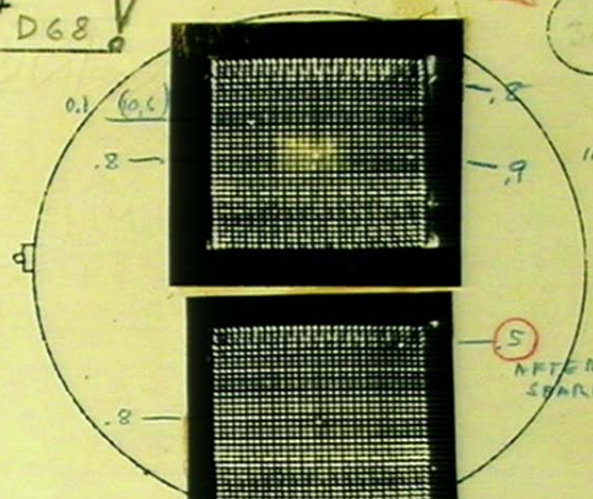
Flaw Focus _____ v.

Rack Read Around						
Position					Foc.	T.W.
1	2	3	4	5	v.	M.A.
2000/2000						
1000/2000 16,000	>10,000	4000	2000	3000	65	.08

rst Flaw .8
Worst 2000/2000 R.A.
Worst 1000/2000 R.A. 100

Machine: Date _____ R.A.

31 Oct 52	>32
11 Nov	>32
9 Dec	>32

Comments: _____
Flaw at 10,6 (obvious) 9 Feb 53

Lectures on

Probabilistic logics and the synthesis of
reliable organisms from unreliable components.

delivered by
Professor J. von Neumann
of
The Institute for Advanced Study
Princeton, N. J.
at the
California Institute of Technology
January 4-15, 1952

Notes by
R. S. Pierce

$$\sum \psi_0^1 \quad D3 \; E436284C$$
$$\sum\sum \psi_1^{12} \quad 532 7B99F31$$
$$\sum\sum \psi_0^{12} \quad 916 A6EA8EB$$

:48 Stopped (31, 18)

$$\ell \sum \quad 8C055732E6$$

50 P.O I 104b.3 $\tau=12$ GE ok. Venby II QE ✓

58 Quit Summary 4 Nov.

Load	13 X	57 min	
PO&V	4X	25 min	
Run (8he)	Good	87 min	
	Bad	25	(machine error)
		37	(Human)
Box		93 min	
Eng		10 min	

engineer gazing
at **you**
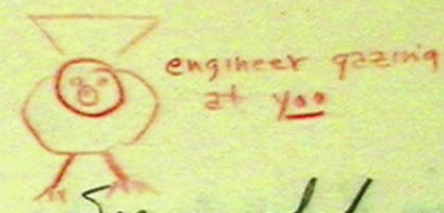
7:45 Engineer gazing at 36 . Seems okeh

7:59 Read in 1030.4 again

8:08 Q I 0

Jetch 74e 4 kc

8:21 8 kc at beginning of 47 $z=2$

8:23 Stopped 22,14 σ 718 σ

R1 FC4

R2 6.4 B C A 6 1 C 1 C = < 12,18 + c |

5 $i = 2$ correct = 12,18

6 $j = 6$

Time	Operation	
6	load #11	Feb. 12 1037.4 $T=0$ Demonstration for
		$Q_\Sigma = 0$ Dr. VonNeuman
08	fetch	(0,10)e Hi-speed
:13	stop	(39,10)e Q_Σ: 46713F1410 ✓
:16	load #6	13 Feb. 1041.4 $T=6$ from 0,7 Q_Σ: 119D72FF6
		Put 12·2⁻⁹ to 1,13
:18	fetch	(28,15)e Hi-speed

store (28,5)e $\Sigma \psi_1^7 = 2076971AD3$

$\Sigma \psi_0^7 = D43B19AB80$

$\Sigma \psi_1^8 = 1DB67CD9EF$

$\Sigma \psi_0^8 = 03FB25E8FA$

$\Sigma \psi_1^9 = 16D6540986$

$\Sigma \psi_0^9 = 35EB492C2B$

Raster suddenly expanded with the top
half extending over the top of the
slave tube. Same was true for the
odd side of memory. Even side had
bottom half extending over bottom of
tube. All voltages appear o.k.
Dash Amplitudes on all stages had follow
appearance

Garbage

normal dot
+ dash bundles
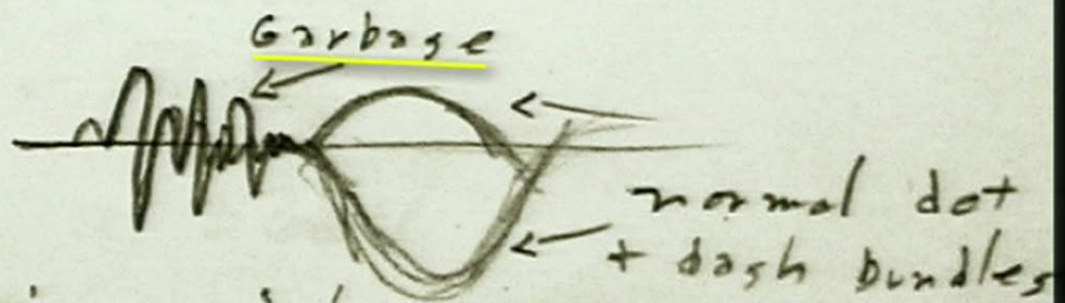
Suspect Deflection circuitry

26 Feb 53

Operation	
Load	Q.S. 4 E 9 A 4 D F 6 0 0 ✓
	change word
	609 (19, 1) ; 610 (19, 2) ; 611 (19, 3) ; 426 (13, 10) ; 427 (13, 11)
	443 (13, 27) ; 444 (13, 28)
	Q.S. 3 C 2 A 9 F 3 D A 0 ✓
Punch	Q.S. ✓
Verify	Q.S.

Maniac lost its memory

no hi voltage

Maniac regained it's memory (see Pandora for details.)

Load	1030.5 automatic
	stop etc. Q.S. 027 : R₁: 0 , R₂: F 4 0 — — —

26 Feb 53

Operation	
Load	Q.S. 4E9A4 DF600 ✓
	change word
	609 (19, 1) ; 610 (19, 2) ; 611 (19, 3) ; 426 (13, 10) ; 427 (13, 11)
	443 (13, 27) ; 444 (13, 28)
	Q.S. 3C2A2F3DA0 ✓
Punch	Q.S. ✓
Verify	Q.S.

Maniac lost its memory

no hi voltage

Maniac regained it's memory (see Pandora for details.)

Load	1030.5 automatic
	stop after Q.S. 027. R₁: 0 , R₂: F40 — — —

Error in card 1 of word 2 of B.O. # 7
Again the word did not get into the
memory, (Stage 13)

1048 B. 4 QS 4GE9E04AQ6 ⌐

Look again at word 2 and it is
empty? According to read-in deck
it should be 0 0 0 4 0 — 0
is now 0 — 0   (Last Card punch wrong)

Turn-off

Before turn off look at stage 13
with scope D.A. reads 32 V. no sign of
any flaw. (Code error, machine not guilty)

...skipped about 25 words on the read-in.

load | P.O.#1 again   this time there are 4 cycles
too many.   QS = 40FE56119A

verify #1F | QS =   Read-ins, Punch outs and verify
attempts all Produce out of Phase results.
this one for instance Produced Lextra action cycle.

load | P.O.#1   this time it should read-in ok. QS
whoops — one word out of Phase.

load | P.O.#1   Damnit — I can be just as stubborn
as this thing. QS = 4713EE 4737 well!

Ncheck = 0003E8

fetch | (27,21)e hi-speed   to duplicate and verify P.O.#2

G.

put a $-Q\epsilon$ order into R_3

if the memory was indeed all

the R_1 switch to make R_1

R_1 became all 1's, R_3 be

and exactly the same th

above happened.

M/C
OFF

THE HELL WITH IT.

('way off !!)

P.O. & stop QE: 387EF 34300 ✓

Looks as though machine working perfectly shall continue 202 H = 3

insert N chuck of 0003C8C000

27, 21e _ full

Mouse climbed into blower behind regulator rack, set blower to vibrating: result no more mouse & a !!! of a racket.

HERE
LIES
MOUSE
BORN
?
DIED
4:50AM
5/27/53

QE: FBAC4 586ED

rack, sit bl

more mouse

HERE
LIES
~~MARSTEN~~
MOUSE
BORN
?
DIED
4:50AM
5/7/53

Auto P.O. & stop 30, 1

24 May 1953

Operation	
load	P.O. #2 QS = A102AD700D—
	Change Ncheck to 2⁻¹
fetch	(27,6)c hi-speed Hope to duplicate
	either 10:50 PM run or 11:18 P.M. run.
stop #3c	(22,14)o QS = 4EE2F19366
	This run duplicates the 10:50 P.M run.
fetch #3D	(30,24)o to verify the output
	QS = 4BE2F19366—

17 + 19

checked 4V floating supply and also had a
little rub' on one or two relays.

1.39 Load   Stopped patt.
QE   Check all stages
verify.   except for on case of 5 dropping down
this now looks promising.

1.48 Try once more to duplicate & verify   200 Hz5
QE ✓

.49 fetch 29, Qe to run 4kc
.52 Stop 10,260. QE B16288B0EE

This now is the 3^(RD) different output

I know when I'm licked

RESPONSIBLE FOR MACHINE	NAME & NUMBER OF PROBLEM	MACHINE PERFORMANCE
Turn On 10:02		m/c give 3 charges -HV = 287V noise disappeared striped pattern Eureka AT 2, 4, 8, 16 ok full speed gain in stage 36
H. Maehly off	CM. ONR # 2	FLINT, 4kc. stop 12 15 (?) loss 31 (Tracing) Try Hi now ok.
H. Maehly off	Kohn, NSF # 5	
H. Maehly off	Deans NSF 4	
H. Maehly	Arb. ONR 2	FLINT Hi
"	Kohn NSF 5	
"	Arb. ONR 2	
" off	CM ONR 2	
" off	Dean NSF 4	FLINT 4kc then 8kc

M/C OK
all troubles
were
CODE
troubles

stop at (18,8)

over to
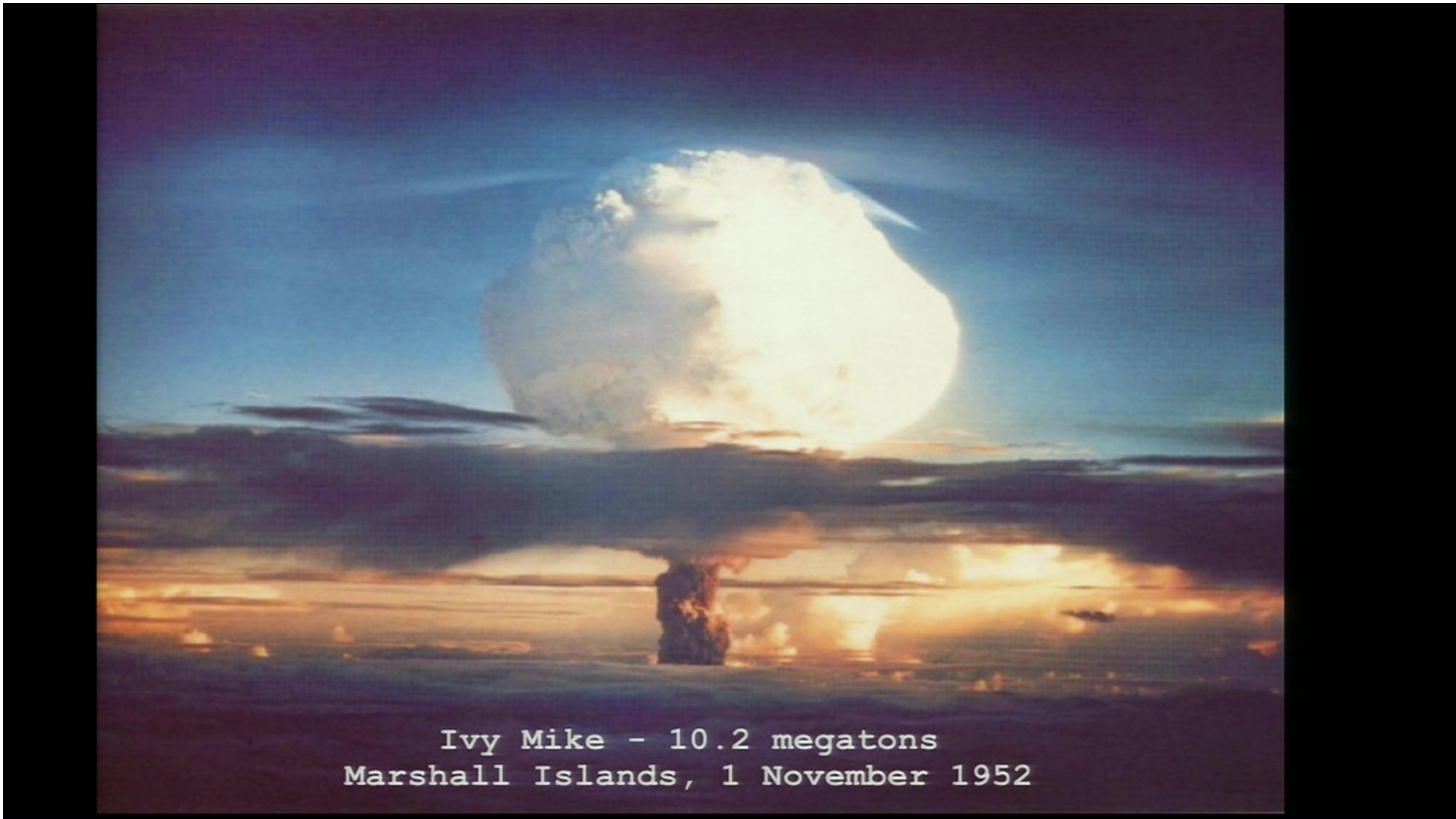
Ivy Mike - 10.2 megatons
Marshall Islands, 1 November 1952

LAMS - 551

This is copy **1** of **8** copies

April 9, 1947

This document contains **22** pages

STATISTICAL METHODS IN NEUTRON DIFFUSION

Work Done By:

S. Ulam
J. von Neumann

Report Written By:

R. D. Richtmyer
J. von Neumann
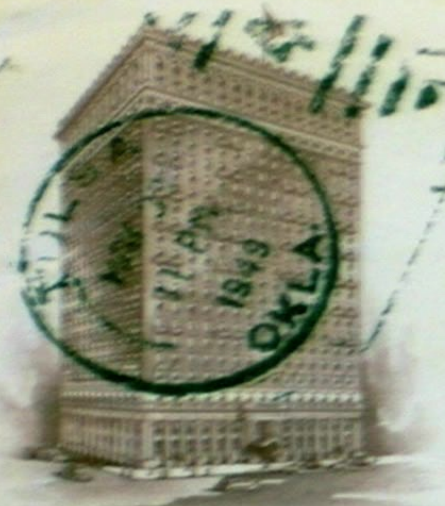
Mrs. Klara Von Neumann,
% Mr. J. Holburton,
Computing Laboratory,
Ballistic Research
Laboratory,
Aberdeen Proving Ground,
Aberdeen, (Md.).

By Airmail!

From: J. Von Neumann,
26 Westcott Road,
Princeton, (N.J.).

THE INSTITUTE FOR ADVANCED STUDY
SCHOOL OF MATHEMATICS
PRINCETON, NEW JERSEY

Klari,
program for the operations
of the AEC - ENIAC problem,
BRL, May 23, ~~XXXX~~ 1950,
et sequ.

The factor 4 is a gift of God

(or of the other party).

—John von Neumann to Edward Teller

7 October 1946

The first language and the first technology on Earth was not created by humans. It was created by primordial RNA molecules—almost 4 billion years ago. Is there any possibility that an evolution process with the potentiality of leading to comparable results could be started in the memory of a computing machine?

Mr. Barricelli

For some reason or other your code has continued to duplicate the 1000-1004 run. Unfortunatly, 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.

TuL.

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.

THE INSTITUTE FOR ADVANCED STUDY

Princeton, New Jersey

To: Prof. S. Chandrasekhar   October 20, 1954
     Prof. M. J. Lighthill F.R.S.
     Sir Geoffrey Taylor
     Prof. Sydney Goldstein
     Sir Edward Bullard

I have been commissioned by the faculty of the Institute to collect a few outside opinions and views on a question of long-range policy which we feel we ought to make up our minds about. Namely, what is a proper rule for the Institute to play in the fields of applied mathematics and electronic computing? We are faced with this question in trying to decide upon some new appointments which are now under consideration. We would be very grateful if you could spare the time to let us have any comments you may care to make upon this question. Of course, this letter, and anything you may say in reply to it, will be treated as confidential.

Our present situation is the following. The School of Mathematics has a permanent establishment which is divided into three groups, one consisting of pure mathematics, one consisting of theoretical physicists, and one consisting of Professor von Neumann. Von Neumann originated in 1946 and has since directed our Computer Project. The Computer Project built and operates a fast digital computer, the cost of the machine and of almost all the staff being paid by government money and not by the Institute.

MACHINE LOG BOOK

DATE: July 15, 1958

TIME	RESPONSIBLE FOR MACHINE	NAME & NUMBER OF PROBLEM	MACHINE PERFORMANCE
	Bizmuth	start	$\varphi \mathcal{E}^t$ = 15,24 = 13,0 = 28,00 = 13,25
		$\mathcal{L}1\varphi \mathcal{E}$ =	
	off		12:00 Midnight

JUL 1 1 P.M.
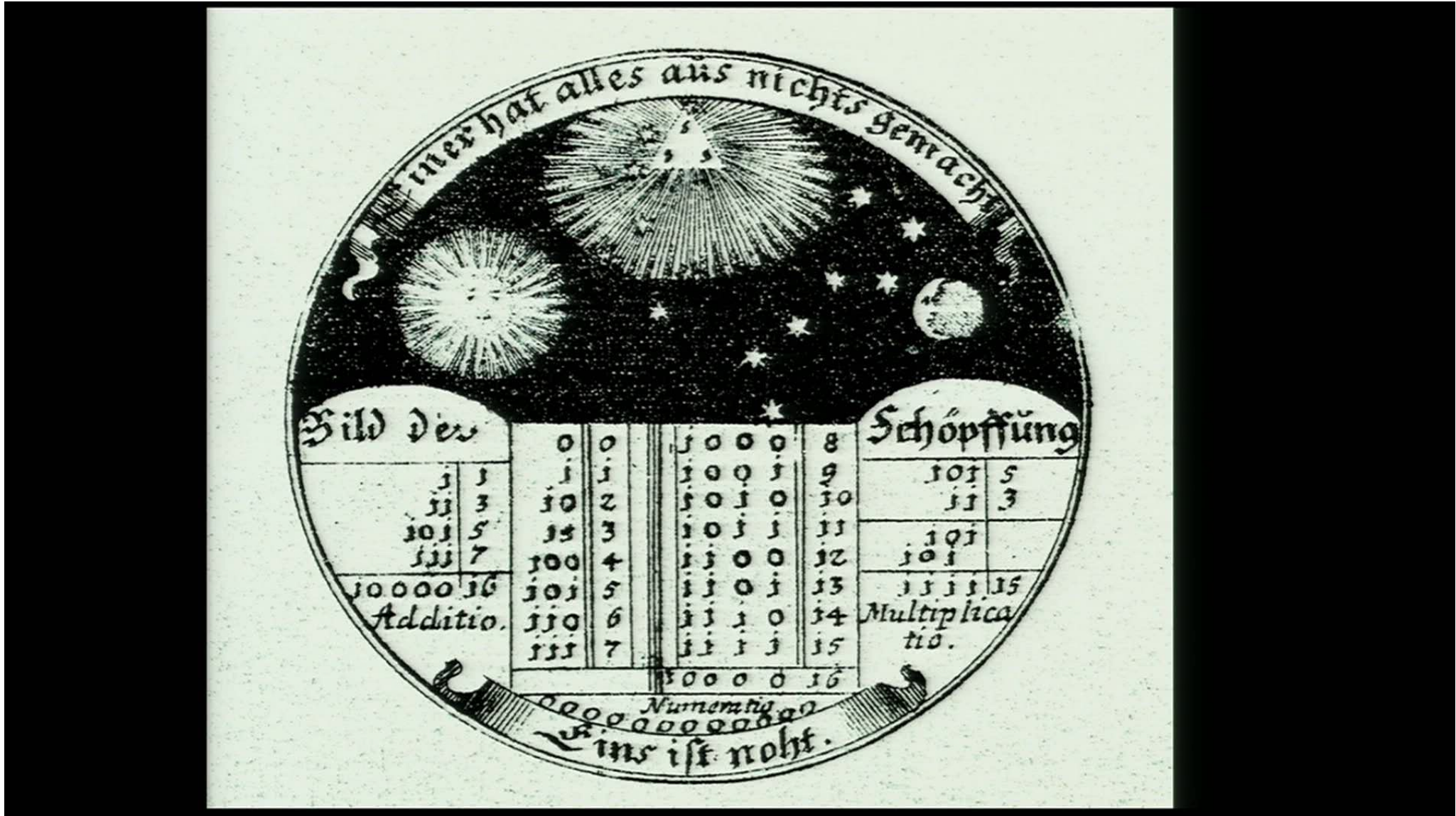
	10^{17}	Lifetime of the Sun $(10^{10}$ years)
Stellar Evolution	10^{16}	
	10^{15}	
	10^{14}	
	10^{13}	1 Million Years
	10^{12}	
Biological Evolution	10^{11}	
	10^{10}	
	10^{9}	Human Lifespan (90 Years)
	10^{8}	
	10^{7}	1 Year
	10^{6}	
Meteorology	10^{5}	8 Hours
	10^{4}	
	10^{3}	
	10^{2}	
	10^{1}	
	10^{0}	Blink of an Eye (.3 seconds)
Shock Waves	10^{-1}	
	10^{-2}	
	10^{-3}	
	10^{-4}	
	10^{-5}	Williams Tube memory access time
	10^{-6}	
Nuclear Explosions	10^{-7}	
	10^{-8}	Lifetime of a Neutron in a nuclear explosion

We talked somewhat randomly but this was the pattern of it: You said you were... struggling in space and time: in space because your physical body gets in the way; in time because of the slowness of elementary reactions... These problems you said might be overcome with a mechanical device... that would project a book page on a photosensitized surface on the ceiling, a phosphorescent pencil for writing on it, and a device with options: to move pages forward and backwards... the luminous pointer to be in several colors with a method of erasure. . .

We talked somewhat randomly but this was the pattern of it: You said you were... struggling in space and time: in space because your physical body gets in the way; in time because of the slowness of elementary reactions... These problems you said might be overcome with a mechanical device... that would project a book page on a photosensitized surface on the ceiling, a phosphorescent pencil for writing on it, and a device with options: to move pages forward and backwards... the luminous pointer to be in several colors with a method of erasure. . .

You said such an invention was difficult but not impossible... The idea is to be able to read and write "pure bred in consciousness without physical interference."