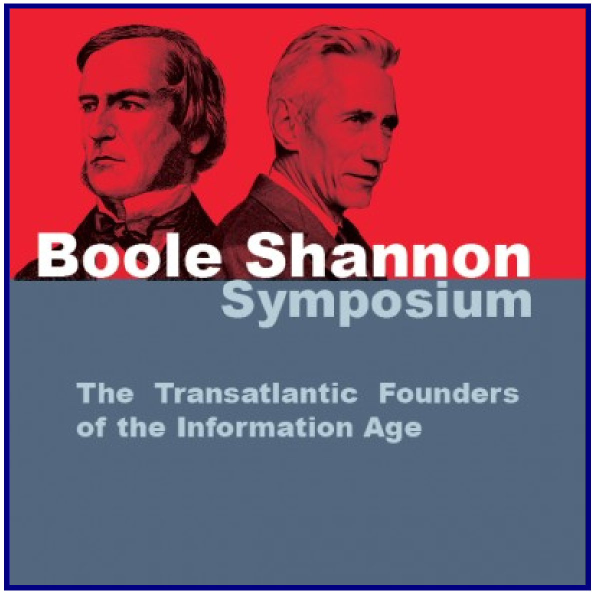


Boole/Shannon Symposium
Singleton Auditorium, MIT
18 March 2016

Boole/Shannon & Edmund C Berkeley

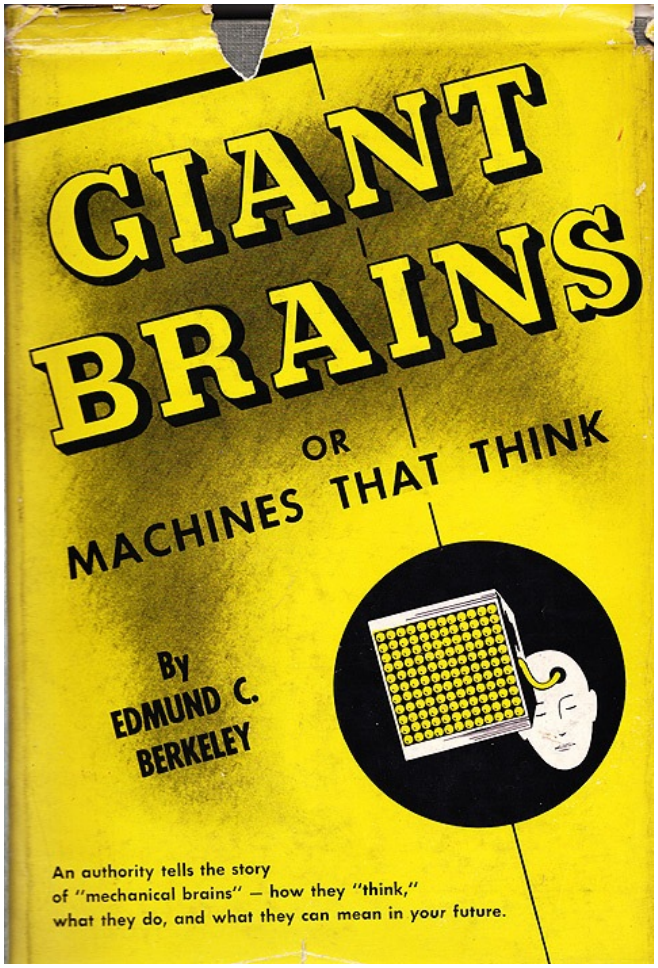
Robert M Gray
Professor Emeritus, EE Department, Stanford University
Research Professor, ECE Department, Boston University

Edmund Callis Berkeley

22 February 1909 — 7 March 1988

ACM co-founder (1947)

Author of



(1949)

Berkeley, Boole, and Shannon

1926 **Edmund Berkeley** enters Harvard, math major

1927 Berkeley attends a lecture on symbolic logic by George D. Birkhoff (of Ergodic Theorem fame (1930)) at Harvard, who recommends *The Laws of Thought* by **George Boole**

1930 BA in Mathematics and Logic. Gives a graduation talk on "Modern methods of thinking," a merging of mathematics and logic into Boolean algebra

Romantic ideas of being a pure mathematician, but takes a job as a clerk in the actuarial department of Mutual Life Insurance Company in New York City.

1932 Claude Shannon enters the University of Michigan, takes a course that introduces him to the work of **George Boole**. Graduates in 1936 with bachelor's degrees in EE and math.

1934 Berkeley moves to Prudential Insurance. Learns of **IBM punch card machines** used for statistical processing. Personal research on implementing Boolean algebra for insurance applications, e.g., verifying contract clauses.

Visits Soviet Union on honeymoon,
Lives in Knickerbocker Village in Manhattan

1936—1937 Shannon graduate studies at MIT. Works on Vannevar Bush's **Differential Analyzer**, sees potential applications of Boolean algebra to simplification and design of relay and switching circuits for telephone call routing applications and for implementing Boolean equations.

MS thesis: "A Symbolic Analysis of Relay and Switching Circuits (1937)," published in *Transactions of the American Institute of Electrical Engineers* (1938)

1937–1938 Edmund C. Berkeley, "Boolean Algebra (The Technique for Manipulating AND, OR, NOT, and Conditions) and Applications to Insurance," *The Record of the American Institute of Actuaries* Evaluating risk, rules for writing policies

1939 **Complex Number Calculator** based on relays completed by George Stibitz at Bell Telephone Laboratory. Stibitz knew of Shannon's work, but did not use it.
Berkeley visits Bell

1940 Berkeley introduced to Claude Shannon by letter by Alonzo Church, begins correspondence with Shannon

1941 Shannon joins Bell Labs

Berkeley continues correspondence with Shannon and visits Bell Labs, learns of Shannon's 1938 paper and the relationship between Boolean algebra and switching circuits

Notes parallels of Complex Number Calculator with tabulating/punch card machines at Prudential

Berkeley decides to popularize Shannon's paper and potential applications of symbolic logic to computing, especially for insurance applications

Berkeley invites Shannon and Stiblitz to visit Prudential and discuss whether Bell Labs' electric relay computers could be applied to the "calculation of insurance company tables and individual policy calculations"

1942 Berkeley joins U.S. Naval Reserve

1944 Berkeley assigned as Naval Liaison at Harvard Computation Laboratory

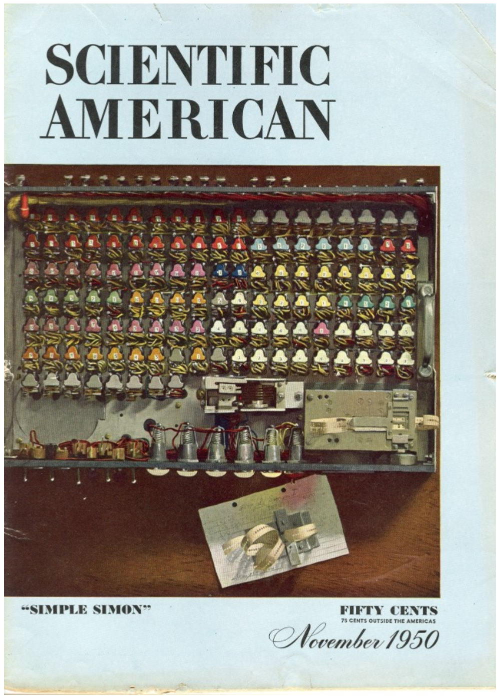
Helps run Mark I relay computer (**Automatic Sequence-Controlled Calculator**), designed by Harold Aiken, built by IBM

Helps design Mark II

Berkeley "realized that these mechanical brains would have no difficulty with any symbolism, and could do not only numerical operations but also logical ones to the fullest extent necessary"

1946 Berkeley leaves active military duty, returns to Prudential, continues research on applications of symbolic logic. Active in promoting open research and sharing in computing machinery community.

1947



Berkeley designs and builds *Simon* computer for for home or office use

Berkeley co-founds ACM for computing professionals

Oh, for heaven's sake, not another association.

— John von Neuman

1948 Leaves Prudential to form his own company, E.C. Berkeley and Associates (later renamed *Berkeley Enterprises*): “symbolic logic, computers, robots, mathematics operations research, language”

FBI opens file on Berkeley, reports he had been interested in communism in 1930, had the Soviet Union in 1934, associated with communist sympathizers at Knickerbocker, associated with communist front organizations

1949 “The relations of symbolic logic and large-scale calculating machines,” paper presented at ACM meeting

Symbolic logic can help implement iterative algorithms

Giant Brains or Machines that Think published with goal of explaining modern computing and its implications to a general audience.

1950 “The relations between symbolic logic and large-scale calculating machines” published in *Science*

> *“As a result of work by Claude Shannon, Boolean algebra has proved to be useful in designing and checking electrical circuits using relays or electronic tubes. This application of symbolic logic is important in the design and construction of automatic computers.”*

1950-1972 Founds and publishes *Computers and Automation*, first computer magazine

1954 Berkeley begins discussions with Shannon regarding consulting for an educational mechanical/electric computer kit for Berkeley Enterprises

1955 Begins selling Geniac = "Genius almost-automatic computer" suggests: genius + ENIAC

Goal: teach computers, logic, and sound reasoning to boys 10—14 and older students

Sold through 1960, afterwards sold by Oliver Garfield. Berkeley's Geniac evolved into Brainiac in 1958

Berkeley receives a memorandum from the Navy regarding "Alleged activities, associations or attributes of security significance" and a request that he respond to 5 pages of questions and that he resign from the Naval reserve. Caught in the McCarthy era. Guilt by association, forced to resign from the Navy in 1956 following secret Navy Security Board hearings (HUAC hearings were public).

1956 Berkeley becomes active in SANE and other peace organizations

Life Magazine article on Berkeley & Geniac in March

Geniac ad in September *Scientific American*

I got a Geniac for my 13th birthday (born on Samhain in 1943)

Marty Hellman (2016 Turing Award laureate with Whit Diffie) was given one about a year earlier at age 10

Kit came with masonite wheels, bolts, wires, flashlight bulbs, and documentation, including a manual of 33 projects (more than 10 designed with Shannon)

Also came with a copy of Shannon's 1938 paper!

(reprinted by Berkeley Enterprises)

BERKELEY BECKONS "SQUEE" WITH FLASHLIGHT WHOSE BEAM, STRIKING PHOTOCELLS MOUNTED IN TUBES ON TOP, MAKES IT "FIND" AND PICK UP BALL

ROBOTS FOR FUN

Scientist makes good business out of an odd hobby

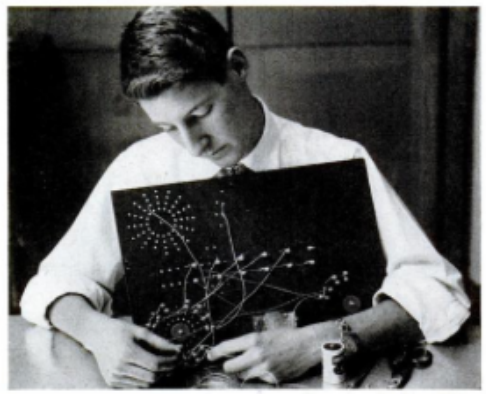
Tinkering with homemade electronic brains to make them behave like people or animals is nothing more than a pastime for many scientists. But a computer engineer named Edmund Berkeley makes a tidy living out of his enthusiasm for the little monsters. In his New York laboratory, Berkeley Enterprises, he concocts electronic creations by the dozen for sale or rental.

They include a mechanical rat which can find its way through a maze, a machine which is unbeatable at ticktacktoe (*next page*) and an inexpensive build-it-yourself computer called the Geniac which solves problems in everything from arithmetic to logic (*p. 176*). Berkeley's current delight is a highly ingenious and thoroughly impractical little device called "Squee" (*above*) which slowly rolls around the floor picking up tennis balls. It would be of little use to tennis players because it operates only in darkness. Furthermore, since the machine is attracted only by light, a player would have to beckon Squee to the ball with a flashlight. But Berkeley is making Squee earn its keep all the same by renting it out to electronics exhibitions where it always stops the show.

BERKELEY'S GLASSES REFLECT DIFFICULT GAME WITH TICKTACKTOE MACHINE →

BUILD-IT-YOURSELF BRAIN

GENIAC KIT, Berkeley's do-it-yourself computer, has 400 parts. Flashlight battery supplies power. It can be assembled in a few minutes and costs $17.95.



BUILDING COMPUTER involves wiring up the underside of kit. Wiring is changed for different operations like multiplication, problems in logic.

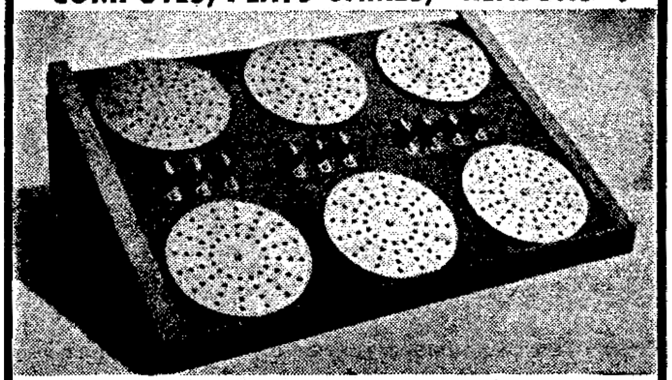
SOLVING A SYLLOGISM, a form of logic, is done by cranking the elements into Geniac. First the major premise is set—for instance, "All men are mortal." Then comes the minor premise, "Socrates is a man." With these done, Geniac automatically lights a bulb beside answer: "Socrates is mortal."

New! A MACHINE THAT COMPOSES MUSIC!

Actual tune composed on Geniac

GENIAC ELECTRIC BRAIN

COMPUTES, PLAYS GAMES, "REASONS"!



BUILD IT YOURSELF in a few hours!

Using a statistical analysis of simple tones plus the special circuitry of GENIAC, the Electric Brain Construction Kit, you can compose original tunes automatically. These new circuits are not available elsewhere!

GENIAC gives a wonderful introduction to the logic machines of our modern age! Over 30 machines can be built with the kit including: adding, subtracting, multiplying and dividing machines, in binary and decimal. There is also a binary to decimal converter.

Syllogisms, computing and coding machines, as well as game playing circuits (think you can beat the machine at Tic-tac-toe and Nim), actuarial analysis and intelligence testing are performed by the 34 different machines you can set up with this kit.

The machines are easy to build—all tools come with the kit and safe—requiring only one flashlight battery for power. Simple enough for a child to build (with complete wiring diagrams), they are fascinating for adults.

GENIAC is a comprehensive introduction to basic computer and problem solving circuits.

WHO ARE OUR CUSTOMERS?

International Business Machines • Westinghouse Electric • Remington-Rand • Albert Einstein Medical College • Barnard College • Naval Research Laboratories • Los Angeles Public Schools • Bell Telephone Laboratories • and thousands of other satisfied customers.

WHAT COMES WITH THE KIT?

Each kit comes with a 64 page experimental manual (Simple Electric Brains and How to Make Them), Wiring Diagrams, a Beginners Manual, GENIAC Study Guide listing additional readings in computer fundamentals, and Minds and Machines a 200 page text on computers and automation, plus a display and assembly rack and plastic parts **$19.95**

Make your own tiny genius computers

GENIACS AND TYNIACS

Scientific—Entertaining—Instructive—Safe

Use our improved construction kits including all parts, and wipers making all switches work well—the improved kits made by the originator of all Tyniacs, most Geniacs, Simon, Squee, etc.

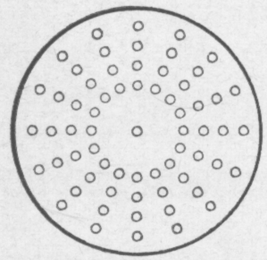


Diagram of our versatile multiple switch, which can be assembled to make any switch combination from 16 decks of 2 positions, 10 decks of 3 positions, etc., to 2 decks of 16 positions.

K 9: GENIAC AND TYNIAC ELECTRIC BRAIN KIT: Contains 64-page Geniac manual, 48-page Tyniac manual with introduction to Boolean Algebra for switching, templates, and over 400 parts (including 6 multiple switches) for making over 45 arithmetical, logical, reasoning, computing, puzzle-solving and game-playing machines (see partial list below). Each Geniac and Tyniac displays intelligent behavior, runs on one flashlight battery, requires no soldering (all connections with nuts and bolts). This kit is the outcome of 7 years of our design and development of small robots, and demonstrates in instructive and easily-put-together models the fascinating variety and power of computing and reasoning circuits.................................**$16.95**
(For shipment west of Mississippi, add 80¢; outside U.S., add $1.80.) Returnable in one week for full refund if not satisfactory.

A few of the **46 GENIACS and TYNIACS—Logic Machines:** Joe McCarty's Logic, Syllogism Machine, Intelligence Test. **Game-Playing Machines:** Tit-Tat-Toe, Nim, Black Match, Sundorra 21. **Computers:** Adder, Subtracter, Multiplier, Divider. **Cryptographic Machines:** Secret Coder, Secret Decoder, Lock with 65,000 Combinations. **Puzzle-Solving Machines:** Fox, Hen, Corn and Hired Man, Space Ship Airlock, Bruce Campbell's Will, Submarine Rescue Chamber, The Uranium Shipment and the Space Pirates.

We offer over **40 PUBLICATIONS, KITS, Etc.** on Computers, Symbolic Logic, Cybernetics, Operations Research, Mathematics, Small Robots, Explanation, Language, Plant Culture, Science, etc. Write for our new **FREE** catalogs.

We are Berkeley Enterprises, Inc. (Affiliate of Edmund C. Berkeley and Associates), producers of scientific kits, makers and exhibitors of small robots (Simon, miniature automatic computer; Squee, electronic robot squirrel; Relay Tit-Tat-Toe as pictured in "Life", March 19, 1956, etc), publishers (the monthly Computers and Automation, P2, $5.50 annual subscription), etc.

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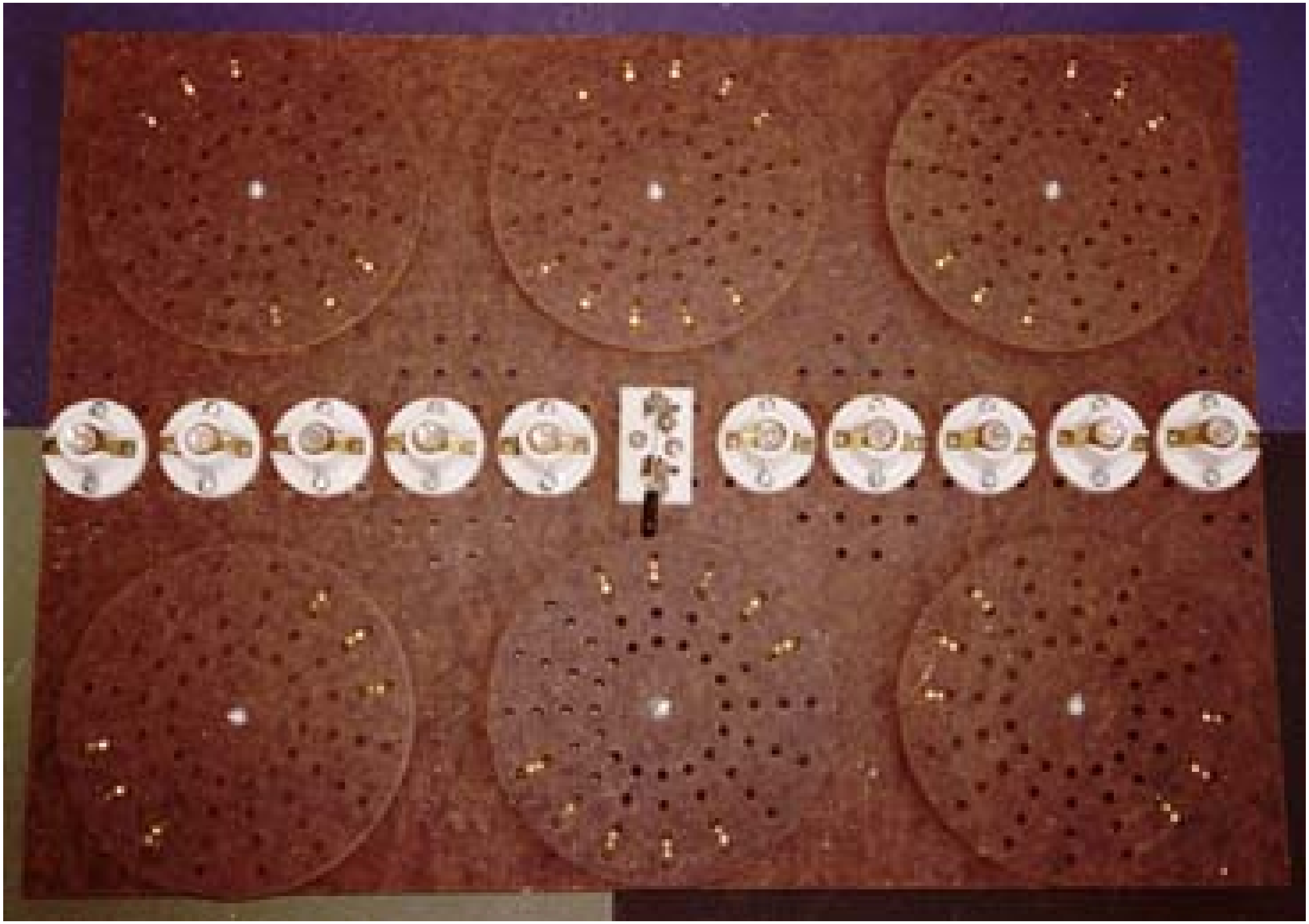


A Symbolic Analysis of Relay and Switching Circuits

By CLAUDE E. SHANNON
ENROLLED STUDENT A'EE

I. Introduction

IN THE CONTROL and protective circuits of complex electrical systems it is frequently necessary to make intricate interconnections of relay contacts and switches. Examples of these circuits occur in automatic telephone exchanges, industrial motor-control equipment, and in almost any circuits designed to perform complex operations automatically. In this paper a mathematical analysis of certain of the properties of such networks will be made. Particular attention will be given to the problem of network synthesis. Given certain characteristics, it is required to find a circuit incorporating these characteristics. The solution of this type of problem is not unique and methods of finding those particular circuits requiring the least number of relay contacts and switch blades will be studied. Methods will also be described for finding any number of circuits equivalent to a given circuit in all operating characteristics. It will be shown that several of the well-known theorems on impedance networks have roughly analogous theorems in relay circuits. Notable among these are the delta-wye and star-mesh transformations, and the duality theorem.

The method of attack on these problems may be described briefly as follows: any circuit is represented by a set of equations, the terms of the equations corresponding to the various relays and switches in the circuit. A calculus is developed for manipulating these equations by simple mathematical processes, most of which are similar to ordinary algebraic algorisms. This calculus is shown to be exactly analogous to the calculus of propositions used in the symbolic study of logic. For the synthesis problem the desired characteristics are first written as a system of equations, and the equations are then manipulated into the form representing the simplest circuit. The circuit may then be immediately drawn from the equations. By this method it is always possible to find the simplest circuit containing only series and parallel connections, and in some cases the simplest circuit containing any type of connection.

Our notation is taken chiefly from symbolic logic. Of the many systems in common use we have chosen the one which seems simplest and most suggestive for our interpretation. Some of our phraseology, as node, mesh, delta, wye, etc., is borrowed from ordinary network theory for similar concepts in switching circuits.

Paper number 38-80, recommended by the AIEE committees on communication and basic sciences and presented at the AIEE summer convention, Washington, D. C., June 20–24, 1938. Manuscript submitted March 1, 1938; made available for preprinting May 27, 1938.

CLAUDE E. SHANNON is a research assistant in the department of electrical engineering at Massachusetts Institute of Technology, Cambridge. This paper is an abstract of a thesis presented at MIT for the degree of master of science. The author is indebted to Doctor F. L. Hitchcock, Doctor Vannevar Bush, and Doctor S. H. Caldwell, all of MIT, for helpful encouragement and criticism.

II. Series-Parallel Two-Terminal Circuits

Fundamental Definitions and Postulates

We shall limit our treatment to circuits containing only relay contacts and switches, and therefore at any given time the circuit between any two terminals must be either open (infinite impedance) or closed (zero impedance). Let us associate a symbol X_{ab} or more simply X, with the terminals a and b. This variable, a function of time, will be called the hindrance of the two-terminal circuit a-b. The symbol 0 (zero) will be used to represent the hindrance of a closed circuit, and the symbol 1 (unity) to represent the hindrance of an open circuit. Thus when the circuit a-b is open $X_{ab} = 1$ and when closed $X_{ab} = 0$. Two hindrances X_{ab} and X_{cd} will be said to be equal if whenever the circuit a-b is open, the circuit c-d is open, and whenever a-b is closed, c-d is closed. Now let the symbol $+$ (plus) be defined to mean the series connection of the two-terminal circuits whose hindrances are added together. Thus $X_{ab} + X_{cd}$ is the hindrance of the circuit a-d when b and c are connected together. Similarly the product of two hindrances $X_{ab} \cdot X_{cd}$ or more briefly $X_{ab}X_{cd}$ will be defined to mean the hindrance of the circuit formed by connecting the circuits a-b and c-d in parallel. A relay contact or switch will be represented in a circuit by the symbol in figure 1, the letter being the corresponding hindrance function. Figure 2 shows the interpretation of the plus sign and figure 3 the multiplication sign. This choice of symbols makes the manipulation of hindrances very similar to ordinary numerical algebra.

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

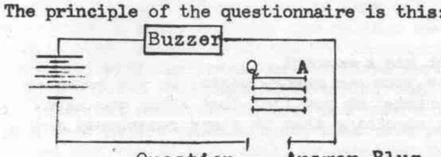
Postulates

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.
4.	At any given time either $X = 0$ or $X = 1$.		

These are sufficient to develop all the theorems which will be used in connection with circuits containing only series and parallel connections. The postulates are arranged in pairs to emphasize a duality relationship between the operations of addition and multiplication and the quantities zero and one. Thus if in any of the a postulates the zero's are replaced by one's and the multiplications by additions and vice versa, the corresponding b postulate will result. This fact is of great importance. It gives each theorem a dual theorem, it being necessary to prove only one to establish both. The only one of these postulates which differs from ordinary algebra is 1*b*. However, this enables great simplifications in the manipulation of these symbols.

Experiment # 10 -- Question-answering Game.

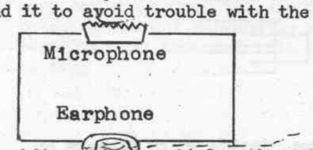
The principle of the questionnaire is this:



When the question plug and the answer plug are connected to the right answer, they are joined by a length of wire.
This is clue enough. If you are still puzzled, take a look at any Electric Game to see how it works.

Experiment # 11 -- Telephone.

The telephone is just a wire carrying a voice. You can make a telephone without electricity, but they carry further with it.
To make an electric telephone you create an electric current that is strong when your voice is strong, weak when your voice is weak, and changes just as rapidly as your speech does.
One way is to talk against little pieces of carbon through which a current is passing. This changes the resistance as your voice hits it— loud voice less resistance.
Try to devise a telephone that works with a different mechanism. Take advantage of what you have learned so far. Examine your own phone. Unscrew the cup and look inside. Replace it and put it back as you found it to avoid trouble with the telephone company.



Voice hits carbon particles through which current is passing. Current resistance drops, current increases.
At the other end this increased current causes the plate in the earphone to vibrate more rapidly, reproducing the original sound.

Experiment # 12.

We are now going to use a new method for describing some simple experiments that appear in the GENIAC MANUAL.
This method is called Boolean Algebra and is used by computer engineers to simplify their circuit networks. Boolean Algebra operates like ordinary algebra, but is different from it. Ordinary algebra is concerned with numbers, Boolean Algebra is interested in states or conditions.
For example:
Experiment # 12 (# 1 in your MANUAL).
Problem: Describe in symbols the various states in which a simple on-off switch can exist.
Condition ON, switch is closed, current flowing, Condition 0
Condition OFF, switch is open, current not flowing, Condition I

We could call Condition 0 - a or x or p and
Condition I - a'(for non-a) or x'(for non-x) or p'(for non-p).

Beginners Manual

In describing states of different combinations of equipment we can use any set of letters or numbers that are useful to us.
Experimental: If a switch closed is 0 and open is I, describe the switch arrangement symbolically in MANUAL EXPERIMENT # 2.

Experiment # 13.

In experiment # 12 you were asked to describe the MANUAL EXPERIMENT called "Hall Lights" in symbols.
One solution is:

0 plus 0 means both switches are closed.
I plus I means both switches are open.

Plus means they are in series. A dot between two numbers means they happen at once, or are in parallel.
Thus for 0 • 0 you read " A closed circuit in parallel with a closed circuit is a closed circuit". --------0 • 0 = 0
Read " An open circuit in series with an open circuit is an open circuit". --------I • I = I
Write out the meanings of the following equations:

I + 0 = 0 + I = I
0 • I = I • 0 = 0
0 + 0 = 0
I • I = I

Experiment # 14.

Before we go further in the problem of describing more complicated circuits we can see that system of 0 I for on and off is all that is necessary in building computer circuits to add, subtract, multiply or divide with digital computers. We are primarily interested in whether the circuit is on or off. Much like the game of Twenty Questions Yes or No is sufficient direction when combined in the proper series of questions to allow you to identify any object. If we signify Yes by 0 and Nô by I, we can find the answer to a variety of questions. Look for example at experiment # 11 in your MANUAL, the machine for Douglas MacDonald's Will. We can sort out the different cases into recombinations in a variety of Yes-No answers. The machine's wiring diagram (see Wiring Diagram Manual) just carries out the arrangement of the schematic's easily moved parts.
In this experiment you can see without too much difficulty how to set up the wiring directly from the problem at hand.
Experimental: Choose another paragraph with complicated material in it, your own life insurance policy is a good example, and set the contents in a schematic diagram after the paradigm on page 16. Then set up a pattern of switches to handle the information and lights to give you an asnwer. You will have to correlate the wiring in #11 (MANUAL) with the schematic to understand how your own machine should be built up.
Once you have sketched out the wiring, you can simplify it.

Manual

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26. MACHINE TO PLAY NIM

Problem. There are several ways of playing the game of Nim. One way is to set up four piles of matches, with the number of matches in each pile 4, 3, 2 and 1. The two players take turns. Each player must during his turn take one or more matches from any one pile (and may take the whole pile). The player taking the last match wins the game.

Here is a sample game:

(1) the player going first takes 2 out of the first pile, leaving 2, 3, 2, 1;

(2) the second player now takes 2 out of the second pile, leaving 2, 1, 2, 1;

(3) the first player now takes 1 from the last pile, leaving 2, 1, 2, 0;

(4) the second player now takes 2 from the first pile, leaving 0, 1, 2, 0;

(5) the first player now takes 1 from the third pile, leaving 0, 1, 1, 0;

(6) it is now clear that the second player loses, for whichever match he takes, the first player takes the other one and wins.

The problem is to set up this variation of the game of Nim in a machine. The machine is to signal what move it makes in response to any position left by the human player. The four piles of matches are represented by four switches. Their positions correspond to the number of matches left in the pile at any time. Switch A has positions 0 and 1; Switch B has positions 0, 1, 2; Switch C has positions 0, 1, 2, 3; and Switch D has positions 0, 1, 2, 3, 4. There is also a fifth switch, E, which has two positions, M, for Machine's Turn to Play, and P for Player's Turn to Play.

The machine is to accept any move by the human player, and is to be able to signal unmistakably its own move.

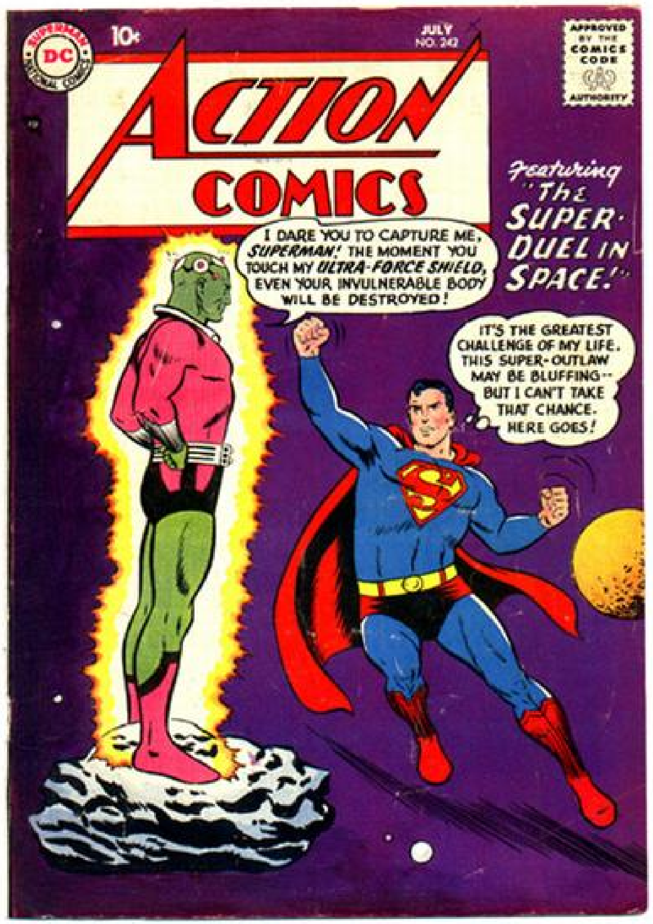
The machine is to play either first or second. If the machine plays first, it should always win; if the machine plays second, it should win if the player makes any mistakes.

Martin Gardner "Concerning the game of Nim and its mathematical analysis," *Scientific American* (1958)

Last Year at Marienbad (1962)

1958 Application: HO Model Train Layout, switches controlled either manually from board or automatically using simple Boolean algebra + relays

Soon after Berkeley's Brainiac appears, another Brainiac appears in *DC Comics*. Berkeley eventually sues for copyright infringement. DC changes story and promotes kit.



Berkeley works with ACM to establish a Committee on Social Responsibilities of Computer Scientists. Berkeley accused of communist sympathies.

1959 I audited a class at San Diego State College taught by my brother A.H. (Steen) Gray Jr, who had worked on SRI/GE/BoA computer ERMA as an MIT 6A Co-op student in 1956 or 57. First banking computer, lots of Boolean algebra.

218 SAN DIEGO STATE COLLEGE

155. Analogue Computers (3) II
Prerequsites: Physics 103 and Math 118B.
Electronic integration and differentiation; solution of differential equations; multiplication, division and function generation; simulation of mechanical systems varying with time, solution of typical problems; auxiliary equipment, layout of large installations.

156. Digital Computers (3) I
Prerequisites: Physics 103 and Math 118B.
The binary number system; electronic and magnetic flip-flop circuits; memory devices; programming; complete computer systems. Auxiliary equipment for inserting information and reading out results rapidly. Typical applications and limitations.

Text:

ARITHMETIC OPERATIONS IN DIGITAL COMPUTERS

R. K. RICHARDS, Ph.D.
Development Engineer
International Business Machines Corporation

D. VAN NOSTRAND COMPANY, INC.
TORONTO NEW YORK LONDON

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1960 April: San Diego Science Fair Project. Poster showed Boolean algebra and logic circuits with logic gates (diodes, transistors) and outputs (light bulbs).

September: MIT Freshman Elective

18.08 ***Topics in Discrete Mathematics***
Prereq.: ——
Year: 1 (2) 2–0–4
Elementary topics in: propositional logic; algebra of sets; permutations and combinations; probability; vectors and matrices; mathematical models and axiomatic method. Kemeny, Snell, Mirkil and Thompson, *Finite Mathematical Structures*. *Levinson*

Discovered I had learned only *binary* Boolean algebra ($\{T, F\}$ or $\{0, 1\}$). More generally: any set with 2 binary operations and 1 unary operation : $(\wedge, \vee, \neg)$ or (and, or, not) or $(\cdot, +, \sim)$ or $(\cap, \cup, ^c)$ satisfying Boolean laws/postulates

set algebra setup for elementary probability theory!!
and hence also (Shannon) information theory. . .

Epilog

1960 Senator Thomas Dodd (D Connecticut) denounces SANE leadership (which includes Berkeley) as being infiltrated by communists and demands that SANE expel all sympathizers.

1972 Berkeley invited to speak at 25th anniversary of founding of ACM, Denounces those in computing who worked on killing devices during Vietnamese War. Many walked out.

1973 ISIT in Ashkelon, first Shannon Lecture

2000 October: Claude Shannon statue unveiling by Bettty Shannon in Gaylord MI, his home town, with Betty Shannon I gave a five minute version of this talk

When I mentioned Berkeley's name, Betty grinned and laughed. Afterwards she talked of him as an amusing pest who regularly nagged Claude Shannon for help.

1988 Berkeley dies of cancer. He was remembered as striving

> *. . . to educate his readers so that they could do as he did: think clearly about important matters, reach wise conclusions, and act bravely in support of their principles. He inspired to be, and was accepted by many as, the conscience of the computer industry because of his devotion to the idea that computers should work for the good of and not the destruction of mankind. He was a teacher.* Eric A. Weiss

Principal Sources

Geniac documentation, Berkeley Enterprises (1956), including Shannon, C. E. (1938) "A Symbolic Analysis of Relay and Switching Circuits," *Trans. AIEE*

Conversation with Betty Shannon (10/2000)

Bernadette Longo, "Edmund Berkeley, computers, and modern methods of thinking," *IEEE Annals of the History of Computing* (2004)

Bernadette Longo, "On the Procrustean Bed: Edmund Berkeley and the Social Responsibility of Computer People," *Old Ideas: Recomputing the History of Information Technology* SHOT SCICIS Workshop (2013)

Bernadette Longo, *Edmund Berkeley and the Social Responsibility of Computer Professionals*, ACM Books (2015)

Mai Sugimoto, "Making Computers Logical: Edmund Berkeley's promotion of logical machines," *SIGCIS 2010 Workshop*