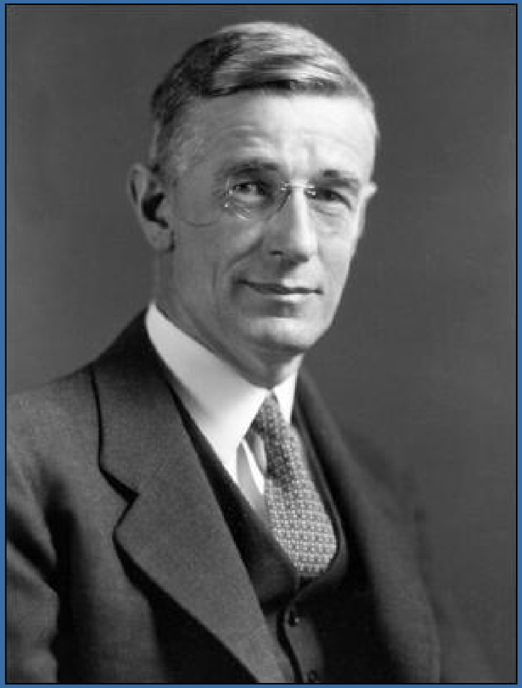
From the World Brain to the World Wide Web

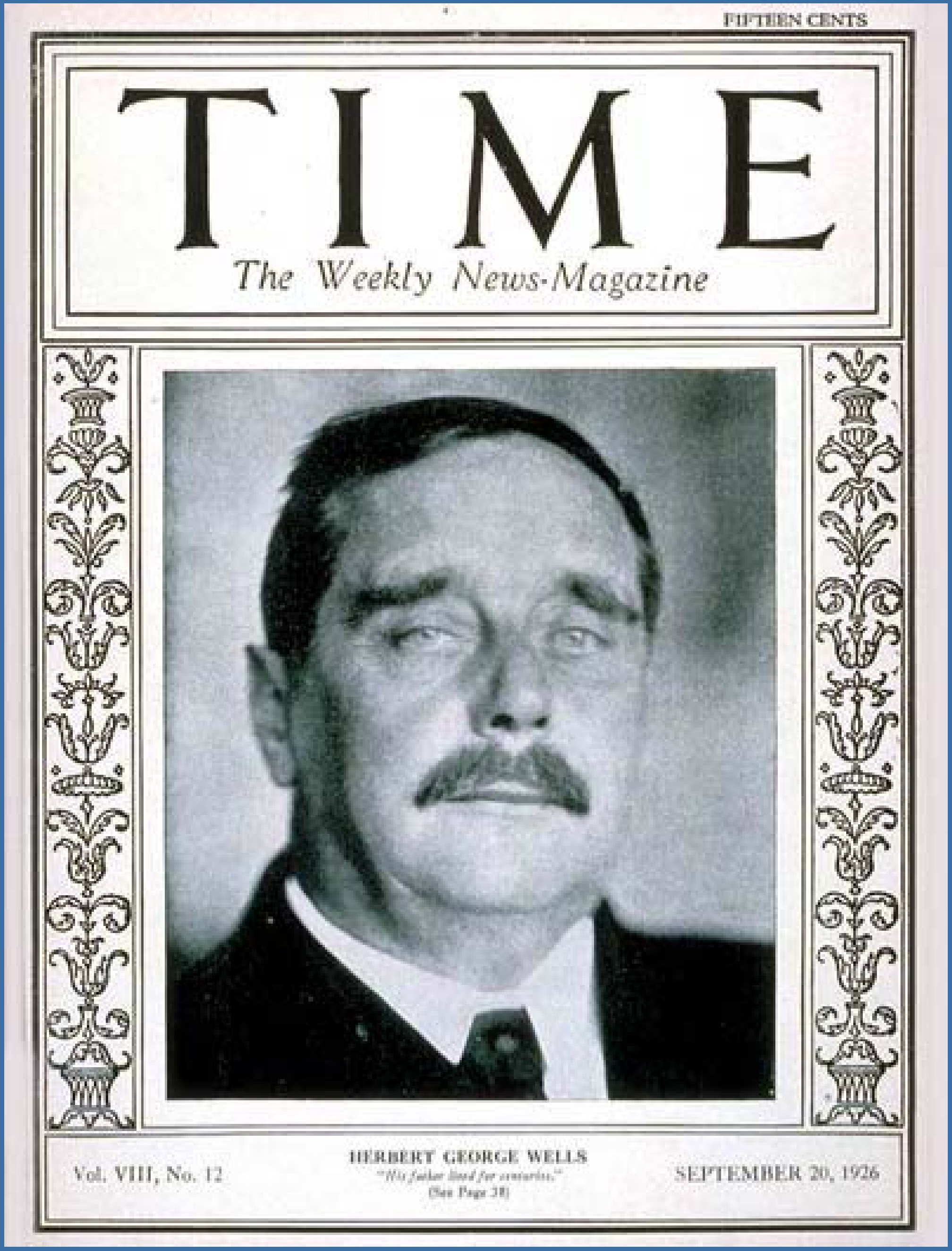
Martin Campbell-Kelly
Warwick University

H. G. Wells, 1866 - 1946

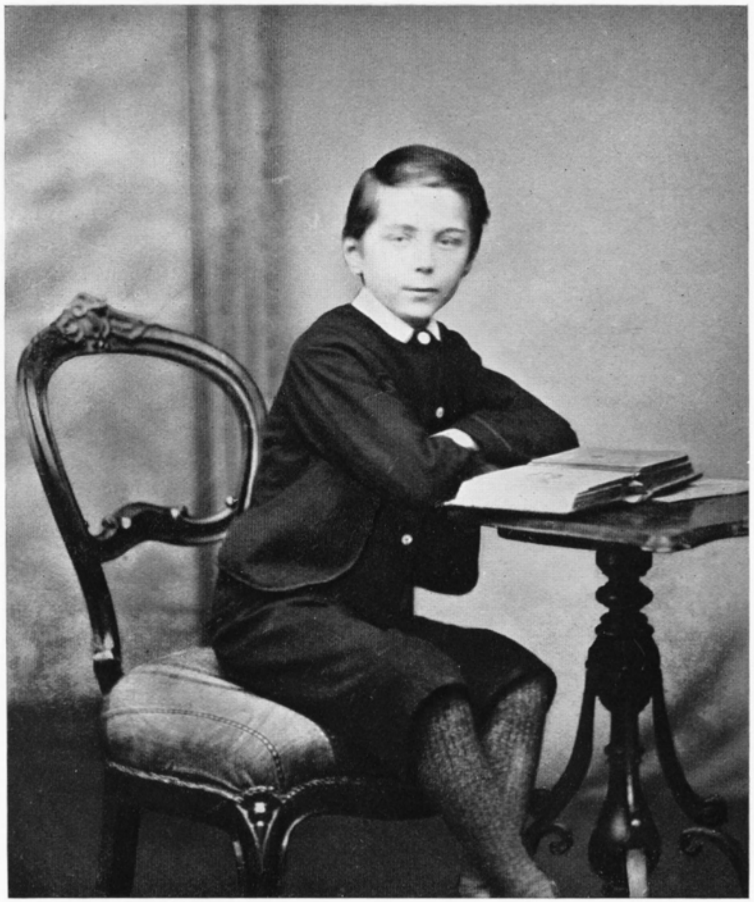


Vannevar Bush, 1890 - 1971

J.C.R. Licklider, 1915 - 1990

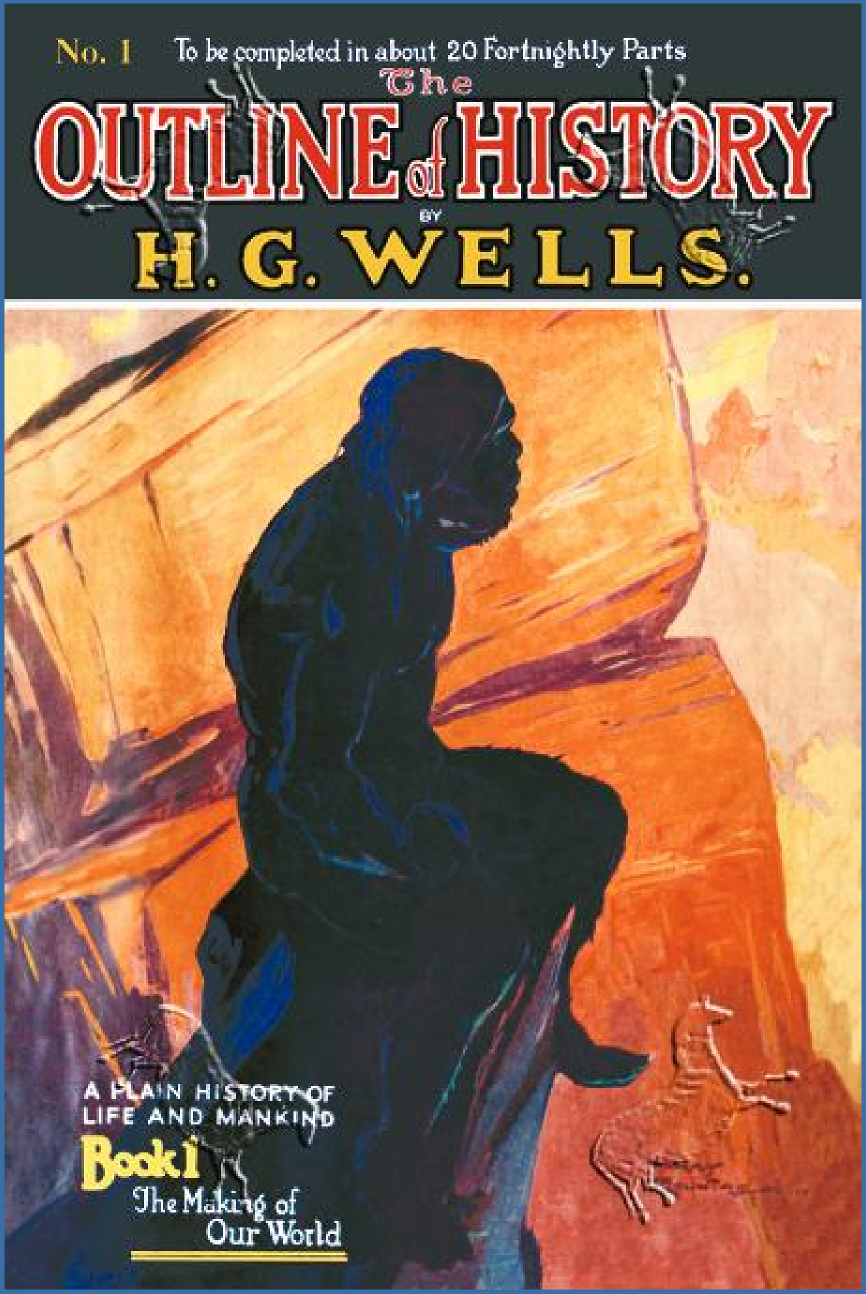


H. G. Wells, 1866 - 1946

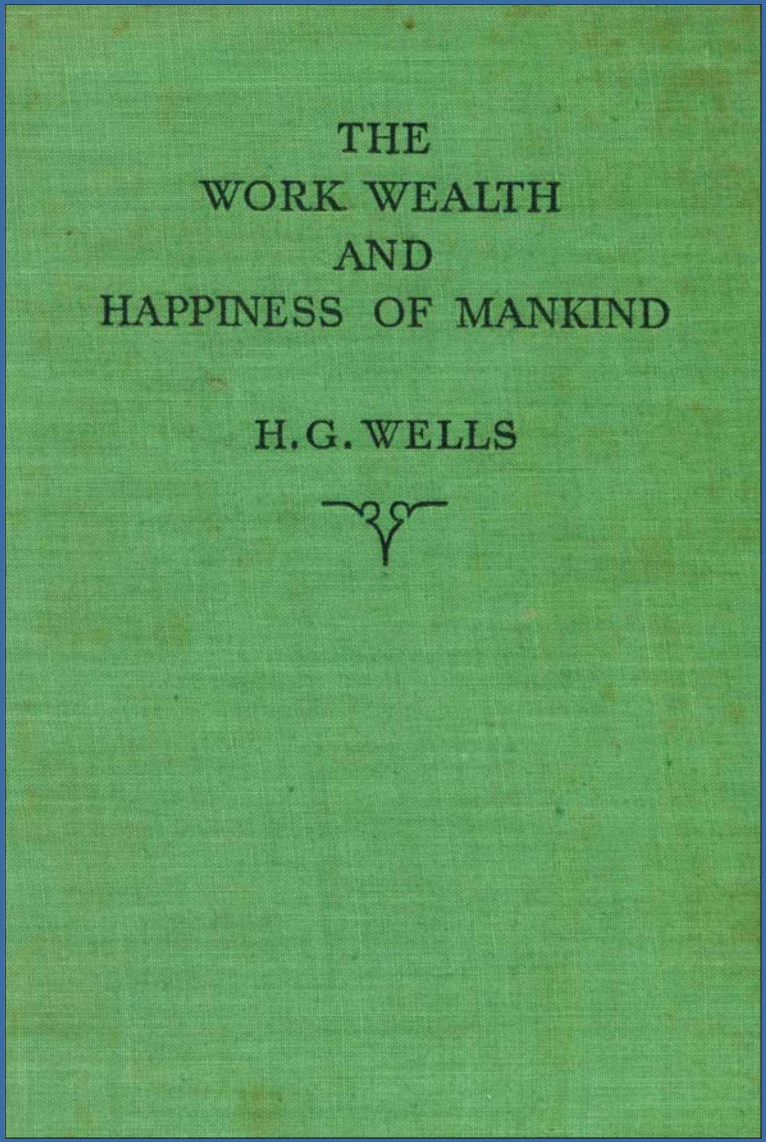


H. G. WELLS C. 1876

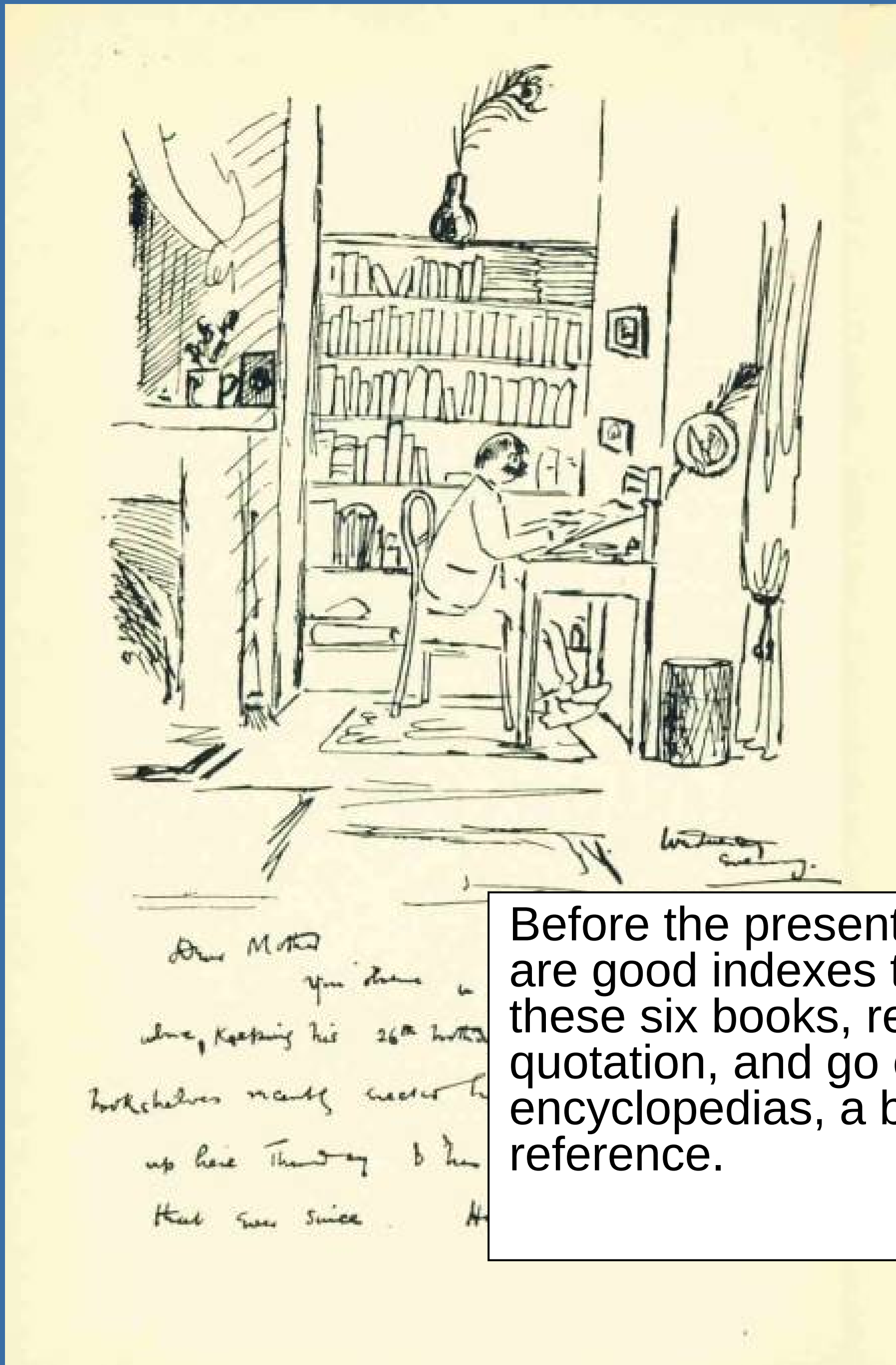
H. G. Wells, aged 10



H. G. Wells, Outline of History, 1920



H. G. Wells, Work, Wealth and Happines of Mankind, 1932

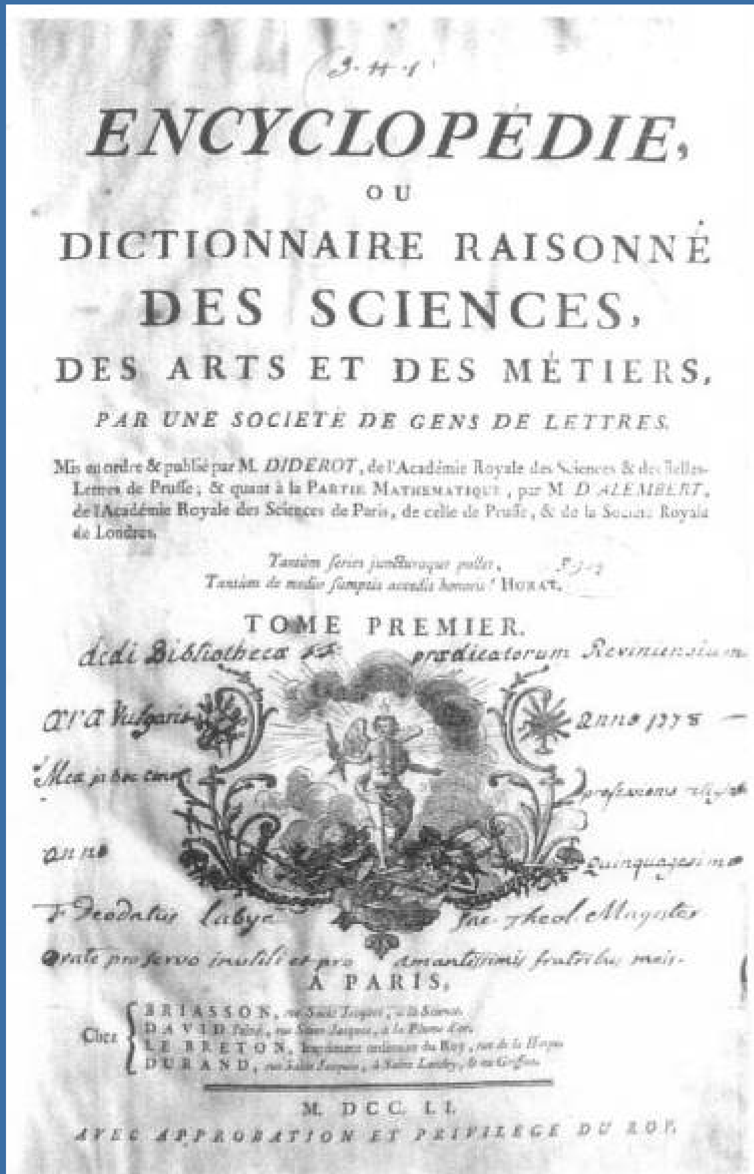


Before the present writer lie half a dozen books, and there are good indexes to three of them. He can pick up any one of these six books, refer quickly to a statement, verify a quotation, and go on writing. ... Close at hand are two encyclopedias, a biographical dictionary, and other books of reference.

Wells, *Outline of History*, 1920

(*By courtesy of the Trustees*)

A CELL OF THE WORLD'S BRAIN: THE CENTRAL READING ROOM OF THE BRITISH MUSEUM LIBRARY



ENCYCLOPÉDIE,
OU
DICTIONNAIRE RAISONNÉ
DES SCIENCES,
DES ARTS ET DES MÉTIERS,
PAR UNE SOCIETÉ DE GENS DE LETTRES.

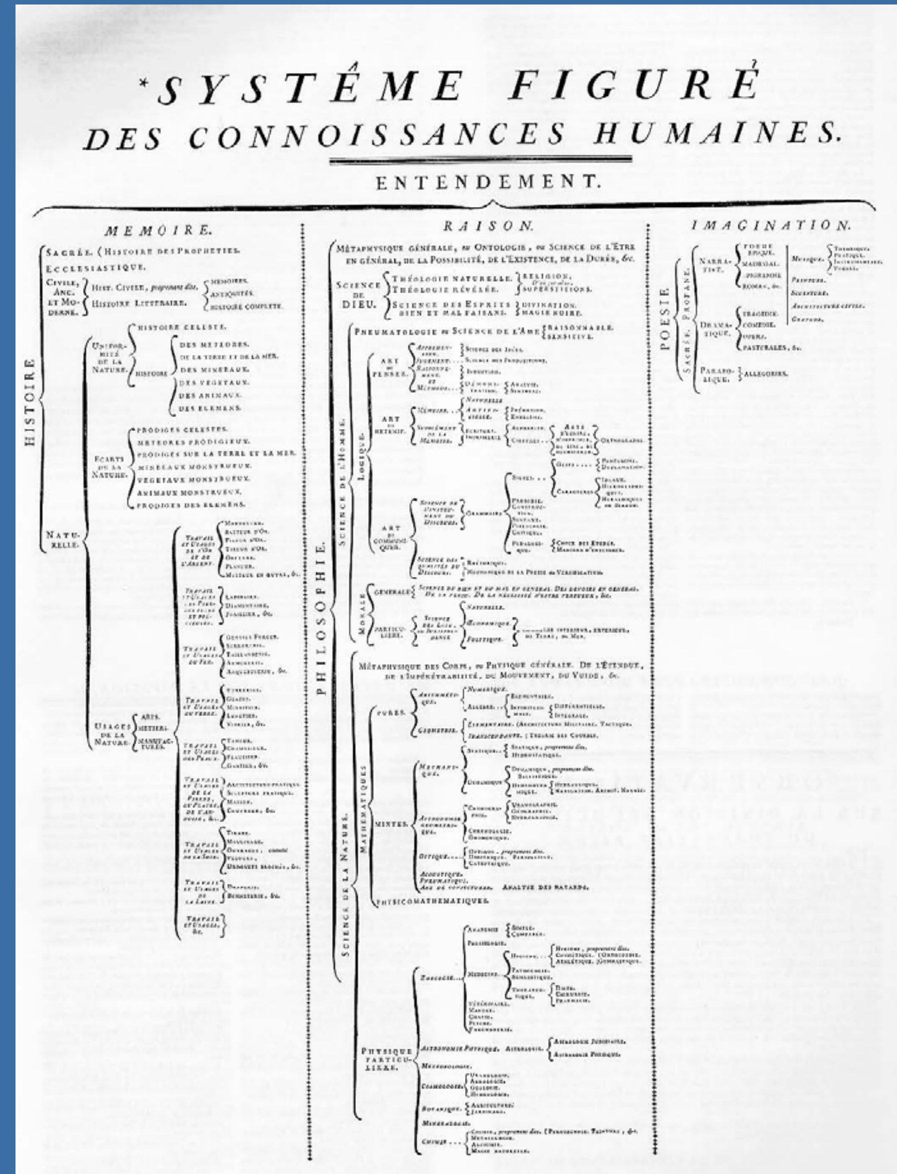
Mis en ordre & publié par M. DIDEROT, de l'Académie Royale des Sciences & des Belles-Lettres de Prusse; & quant à la PARTIE MATHEMATIQUE, par M. D'ALEMBERT, de l'Académie Royale des Sciences de Paris, de celle de Prusse, & de la Société Royale de Londres.

Tantùm series juncturaque pollet,
Tantùm de medio sumptis accedit honoris! HORAT.

TOME PREMIER.

A PARIS,
Chez BRIASSON, DAVID l'aîné, LE BRETON, DURAND.

M. DCC. LI.
AVEC APPROBATION ET PRIVILEGE DU ROY.



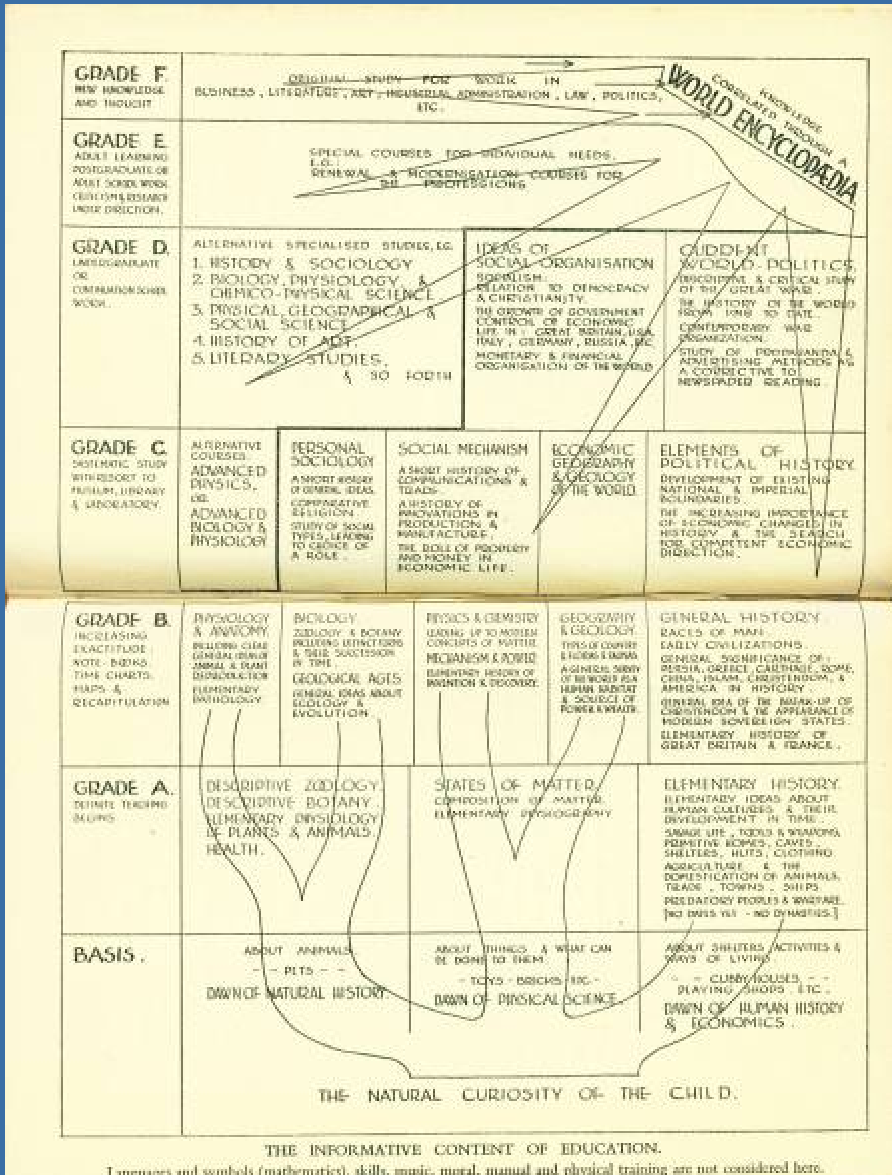
*SYSTÊME FIGURÉ DES CONNOISSANCES HUMAINES.

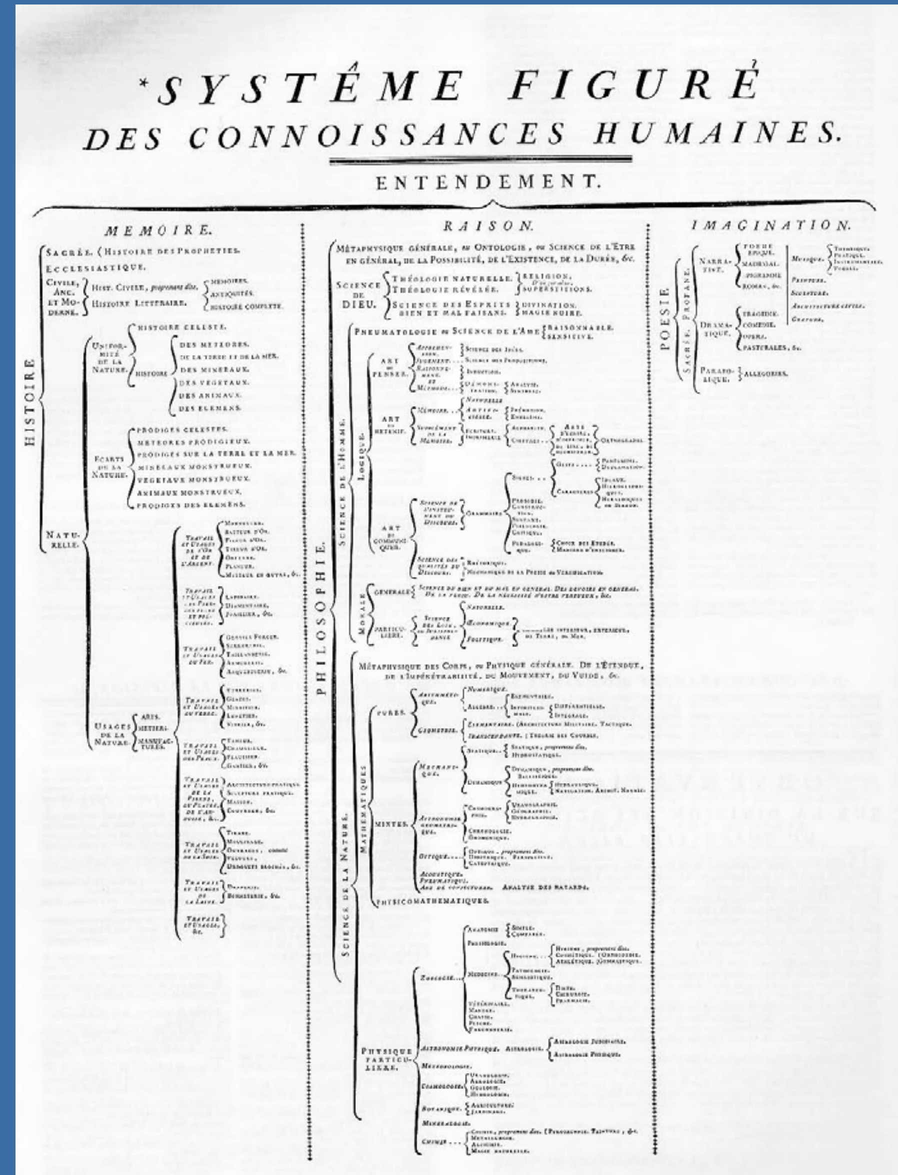
ENTENDEMENT.

MEMOIRE. RAISON. IMAGINATION.

HISTOIRE. PHILOSOPHIE. POESIE.

Classification of knowledge in the *Encyclopédie, c.*1750





Classification of knowledge in the *World Brain,* 1938

WORLD BRAIN

by

H. G. WELLS

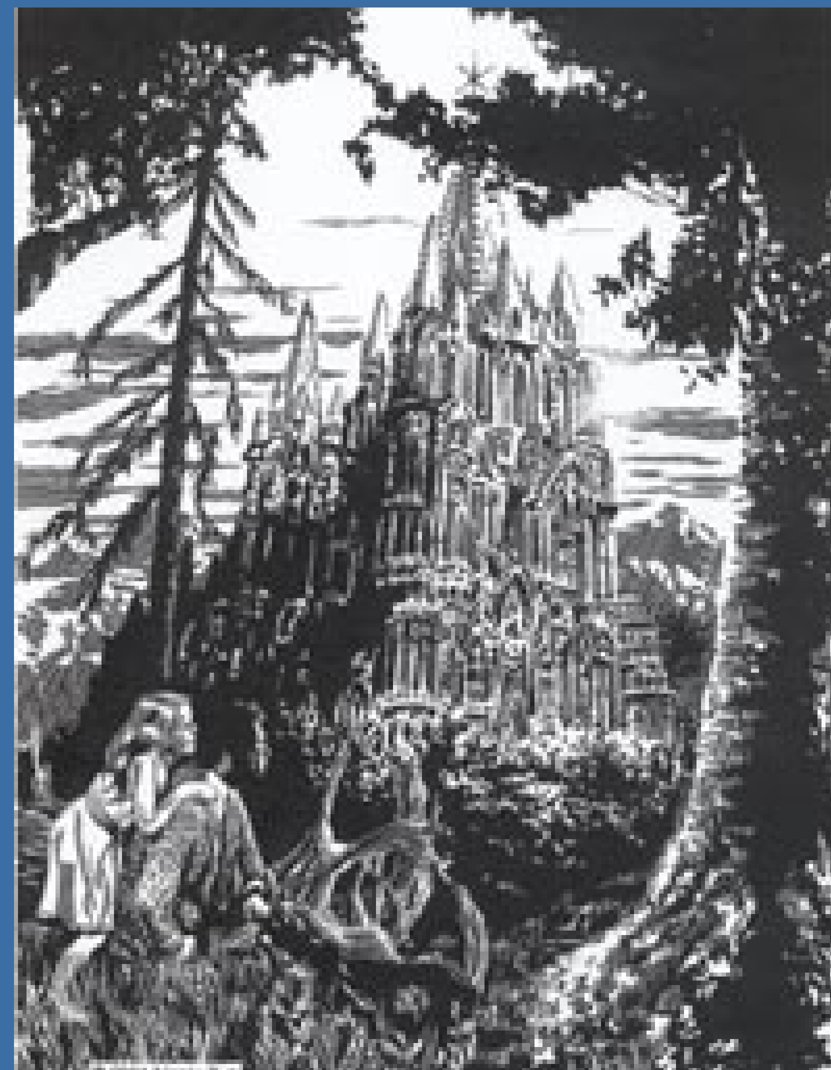
1938

METHUEN & CO. LIMITED
36 Essex Street, Strand, London, W.C.2

The general public has still to realize how much has been done in this field and how many competent and disinterested men and women are giving themselves to this task. The time is close at hand when any student, in any part of the world, will be able to sit with his projector in his own study at his or her own convenience to examine *any* book, *any* document, in an exact replica.

- *World Brain*, 1938

Burning of the Library of Alexandria



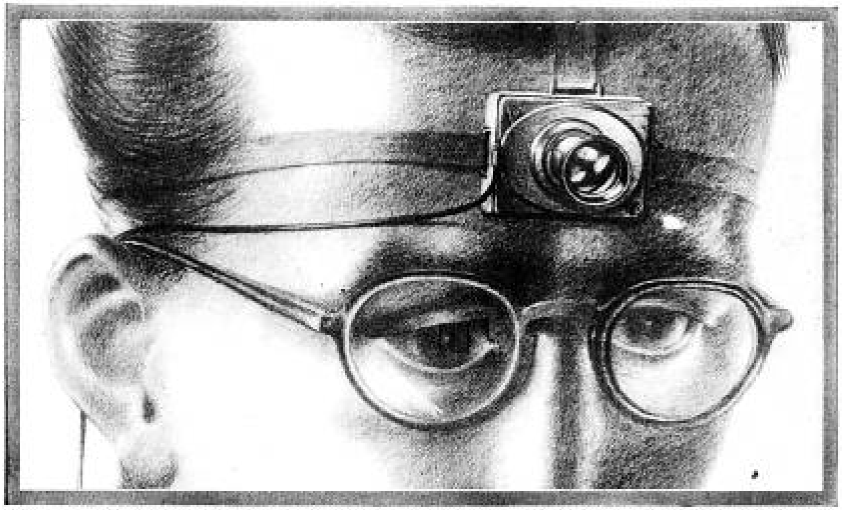
The Palace of Green Porcelain
-- The Time Machine, 1895

Vannevar Bush, 1890 - 1971

As a boy in Chelsea, Bush had his own workshop, with shelves in a Quaker Oats box for chemicals and odd treasures in salt-cod box. On the bench is what looks like a dry cell hooked up to a clock. *(MIT)*

Vannevar Bush, c.1905

Bush's profile tracer. Mounted between two bicycle wheels, the mechanism automatically plotted the change in elevation versus horizontal distance traveled as the vehicle was pushed along a terrain.



A SCIENTIST OF THE FUTURE RECORDS EXPERIMENTS WITH A TINY CAMERA FITTED WITH UNIVERSAL-FOCUS LENS. THE SMALL SQUARE IN THE EYEGLASS AT THE LEFT SIGHTS THE OBJECT

AS WE MAY THINK

A TOP U. S. SCIENTIST FORESEES A POSSIBLE FUTURE WORLD IN WHICH MAN-MADE MACHINES WILL START TO THINK

by VANNEVAR BUSH

DIRECTOR OF THE OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

Condensed from the *Atlantic Monthly*, July 1945

This has not been a scientists' war; it has been a war in which all have had a part. The scientists, burying their old professional competition in the demand of a common cause, have shared greatly and learned much. It has been exhilarating to work in effective partnership. What are the scientists to do next?

For the biologists, and particularly for the medical scientists, there can be little indecision, for their war work has hardly required them to leave the old paths. Many indeed have been able to carry on their war research in their familiar peacetime laboratories. Their objectives remain much the same.

It is the physicists who have been thrown most violently off stride, who have left academic pursuits for the making of strange destructive gadgets, who have had to devise new methods for their unanticipated assignments. They have done their part on the devices that made it possible to turn back the enemy. They have worked in combined effort with the physicists of our allies. They have felt within themselves the stir of achievement. They have been part of a great team. Now one asks where they will find objectives worthy of their best.

* * *

There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less to remember, as they appear. Yet specialization becomes increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial.

Professionally our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purpose. If the aggregate time spent in writing scholarly works and in reading them could be evaluated, the ratio between these amounts of time might well be startling. Those who conscientiously attempt to keep abreast of current thought, even in restricted fields, by close and continuous reading might well shy away from an examination calculated to show how much of the previous month's efforts could be produced on call.

Mendel's concept of the laws of genetics was lost to the world for a generation because his publication did not reach the few who were capable of grasping and extending it. This sort of catastrophe is undoubtedly being repeated all about us as truly significant attainments become lost in the mass of the inconsequential.

Publication has been extended far beyond our present ability to make real use of the record. The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships.

But there are signs of a change as new and powerful instrumentalities come into use. Photocells capable of seeing things in a physical sense, advanced photography which can record what is seen or even what is not, thermionic tubes capable of controlling potent forces under the guidance of less power than a mosquito uses to vibrate its wings, cathode-ray tubes rendering visible an occurrence so brief that by comparison a microsecond is a long time, relay combinations which will carry out involved sequences of movement more reliably than any human operator and thousands of times as fast—there are plenty of mechanical aids with which to effect a transformation in scientific records.

Machines with interchangeable parts can now be constructed with great economy of effort. In spite of much complexity, they perform reliably. Witness the humble typewriter, or the movie camera, or the automobile. Electrical contacts have ceased to stick when thoroughly understood. Note the automatic telephone exchange, which has hundreds of thousands of such contacts, and yet is reliable. A spider web of metal, sealed in a thin glass container, a wire heated to brilliant glow—in short, the thermionic tube of radio sets is made by the hundred million, tossed about in packages, plugged into sockets—and it works! Its gossamer parts, the precise location and alignment involved in its construction, would have occupied a master craftsman of the guild for months; now it is built for 30 cents. The world has arrived at an age of cheap, complex devices of great reliability, and something is bound to come of it.

A record, if it is to be useful to science, must be continuously extended, it must be stored and, above all, it must be consulted. Today we make the record conventionally by writing and photography, followed by printing; but we also record on film, on wax disks and on magnetic wires. Even if utterly new recording procedures do not appear, these present ones are certainly in the process of modification and extension.

NEW WAYS TO EXTEND THE RECORD— THE CYCLOPS CAMERA AND DRY PHOTOGRAPHY

Certainly progress in photography is not going to stop. Faster material and lenses, more automatic cameras, finer-grained sensitive compounds to allow an extension of the minicamera idea are all imminent. Let us project this trend ahead to a logical, if not inevitable, outcome. The camera hound of the future wears on his forehead a lump a little larger than a walnut. It takes pictures three millimeters square, later to be projected or enlarged. The lens is of universal focus, down to any distance accommodated by the unaided eye, simply because it is of short focal length. There is a built-in photocell on the walnut such as we now have on at least one camera which automatically adjusts exposure for a wide range of illumination. There is film in the walnut for a hundred exposures and the spring for operating its shutter and shifting its film is wound once for all when the film clip is inserted. It produces its results in full color. It may well be stereoscopic and record with two spaced glass eyes, for striking improvements in stereoscopic technique are just around the corner.

The cord which trips its shutter may reach down a man's sleeve within easy reach of his fingers. A quick squeeze, and the picture is taken. On a pair of ordinary glasses is a square of fine lines near the top of one lens, where it is out of the way of ordinary vision. When an object appears in that square, it is lined up for its picture. As the scientist of the future moves about the laboratory or the field, every time he looks at something worthy of the record, he trips the shutter and in it goes, without even an audible click. Is this all fantastic? The only fantastic thing about it is the idea of making as many pictures as would result from its use.

Will there be dry photography? It is already here in two forms. There have long been films impregnated with diazo dyes which form a picture without development, so that it is already there as soon as the camera has been operated. An exposure to ammonia gas destroys the unexposed dye, and the picture can then be taken out into the light and examined. The process is now slow, but someone may speed it up, and it has no grain difficulties such as now keep photographic researchers busy.

REDUCING THE WRITTEN RECORD TO MANAGEABLE SIZE—MICROPHOTOGRAPHY

Like dry photography, microphotography still has a long way to go. The basic scheme of reducing the size of the record, and examining it by projection rather than directly, has possibilities too great to be ignored. The combination of optical projection and photographic reduction is already producing some results in microfilm for scholarly purposes, and the potentialities are highly suggestive. Today, with microfilm, reductions by a linear factor of 20 can be employed and still produce full clarity when the material is re-enlarged for examination.

Assume a linear ratio of 100 for future use. Consider film of the same thickness as paper, although thinner film will certainly be usable. Even under these conditions there would be a total factor of 10,000 between the bulk of the ordinary record on books, and its microfilm replica. The *Encyclopaedia Britannica* could be reduced to the volume of a matchbox. A library of a million volumes could be compressed into one end of a desk. If the human race has produced since the invention of movable type a total record, in the form of magazines, newspapers, books, tracts, advertising blurbs, correspond-

CONTINUED ON NEXT PAGE

Dr. Vannevar Bush is head of the Office of Scientific Research and Development, which marshaled the scientific brains of the U.S. in the service of the war. As such he has performed one of the greatest, though most secret, jobs of the war, as important in its sphere as that of the Army chief of staff. Under his direction 6,000 scientists worked on such projects as the development of radar and the atomic bomb.

In the July issue of the *Atlantic Monthly* Dr. Bush published an article in which he set a great task for men of science in the peacetime world. Man has piled up a staggering body of knowledge—so staggering, in fact, that men of learning have great difficulty in finding and using the parts they want. It is the task of science, Dr. Bush says, to make this store of knowledge more available, to aid the human memory. Says the *Atlantic*, "Like Emerson's famous address of 1837 on 'The American Scholar,' this paper by Dr. Bush calls for a new relationship between thinking man and the sum of our knowledge."

LIFE is indebted to the editors of the *Atlantic Monthly* for permission to bring a condensed version of this important article to its larger audience.

WHAT DR. BUSH FORESEES

Cyclops Camera

Worn on forehead, it would photograph anything you see and want to record. Film would be developed at once by dry photography.

Microfilm

It could reduce *Encyclopaedia Britannica* to volume of a matchbox. Material cost: 5¢. Thus a whole library could be kept in a desk.

Vocoder

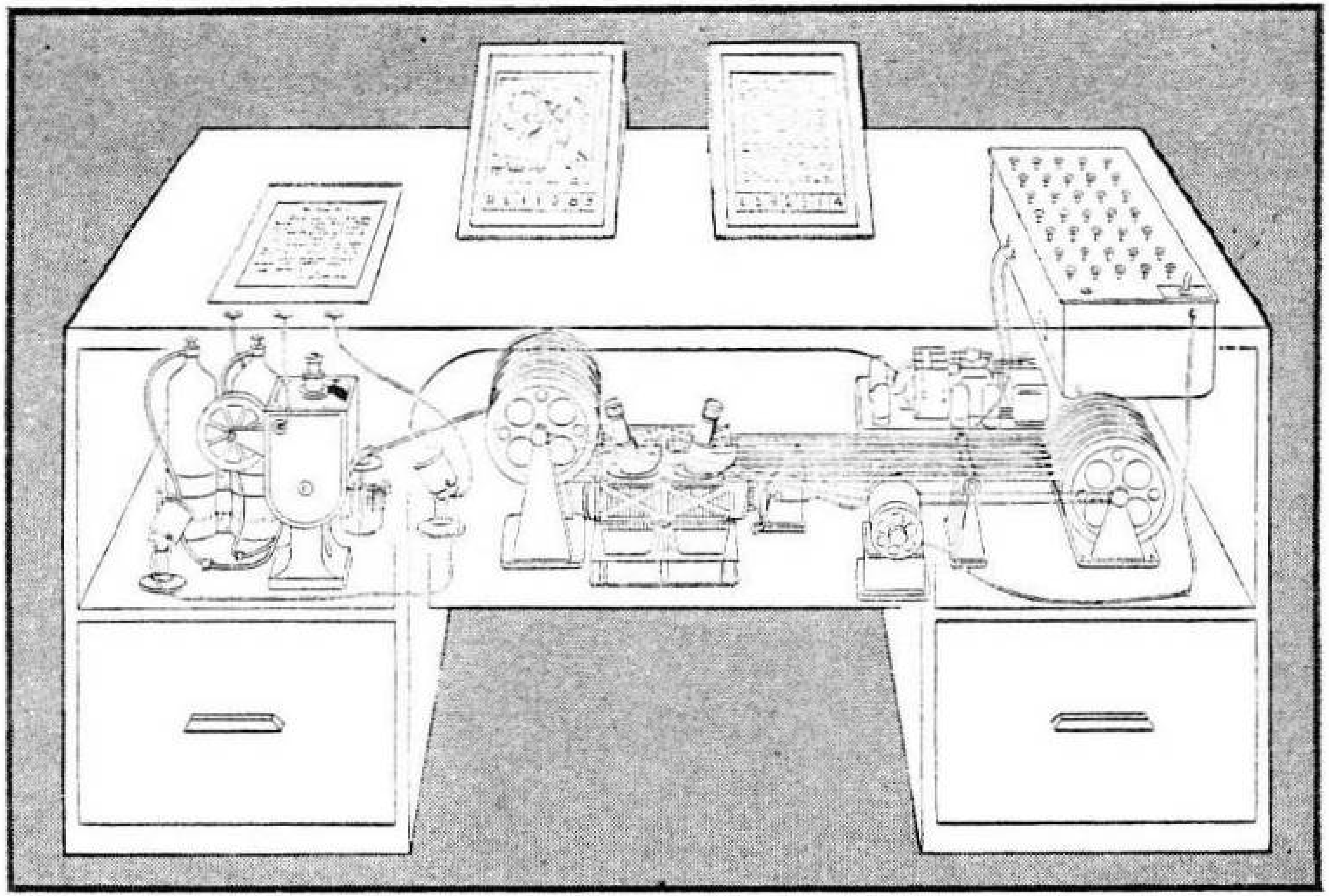
A machine which could type when talked to. But you might have to talk a special phonetic language to this mechanical supersecretary.

Thinking machine

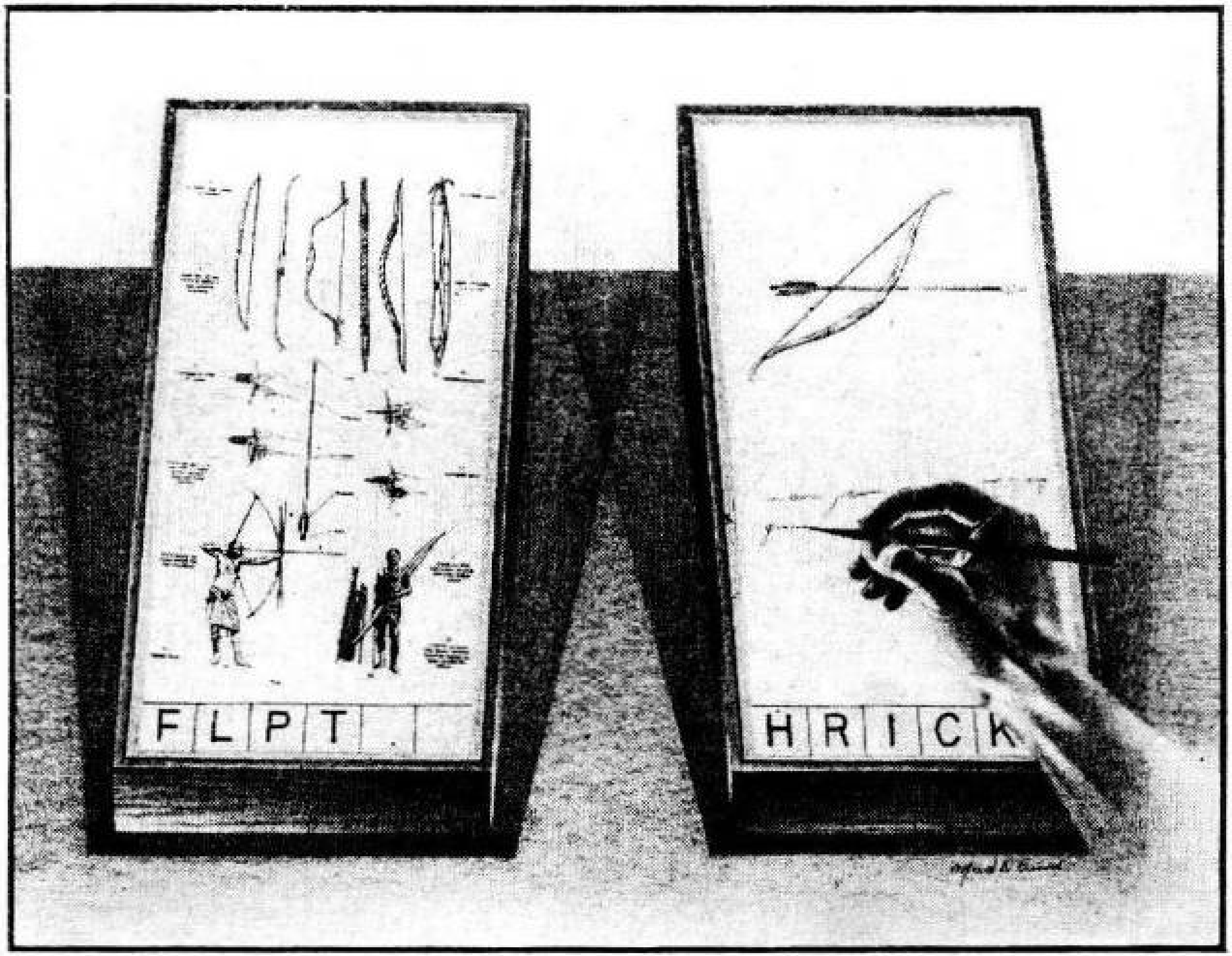
A development of the mathematical calculator. Give it premises and it would pass out conclusions, all in accordance with logic.

Memex

An aid to memory. Like the brain, Memex would file material by association. Press a key and it would run through a "trail" of facts.



MEMEX in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicro-film filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference.



MEMEX IN USE is shown here. On one transparent screen the operator of the future writes notes and commentary dealing with reference material which is projected on the screen at left. Insertion of the proper code symbols at the bottom of right-hand screen will tie the new item to the earlier one after notes are photographed on supermicrofilm.

THE BUSH RAPID SELECTOR

by PHIL HIRSCH

A high-speed microfilm retrieval system that adds some new wrinkles to the state of the art has been operating for about a year at the U. S. Navy's Bureau of Ships in Washington. Known as the "Bush Rapid Selector" (after Dr. Vannevar Bush, formerly of MIT, who developed the basic concept and built the first model), the equipment scans a 6,000-ft., 60,000-frame reel of microfilm in 12 minutes and automatically reproduces on a second film those frames containing desired information.

There is a series of dots above each frame on the source microfilm; they identify the title, subject, author, and other indexing facts about the adjacent document. Material is retrieved by feeding into the Rapid Selector a dot pattern which contains the indexing information describing the item wanted. The equipment then scans each frame and when it finds a similar pattern, copies the image of the corresponding document onto the output film.

Like other retrieval systems, this one provides a means of locating documents automatically when the searcher has only a few clues. He may, for example, want information on a certain subject, but lack a specific bibliographic reference. The retrieval system, when fed the proper subject codes, will search the documents stored in the library, then locate and reproduce all those that fit the subject specifications.

The Rapid Selector at the Bureau of Ships is installed in the Publications Division; it was developed, under Navy sponsorship, at The National Bureau of Standards.

The Rapid Selector's microfilm library accommodates 3 x 5-inch cards, blueprints measuring up to 2 x 3 ft., and just about any document in between capable of being photographed. This is one feature that distinguishes the device from two commercially available microfilm retrieval systems—Recordak's "MiraCode" and FMA's "FileSearch." Both of the latter are designed for legal-size documents.

There is one other important difference. The Rapid Selector re-photographs "on the fly." No matter how many documents it locates and copies, the scanning operation doesn't slow down. MiraCode and File-Search, by com-parison, stop scanning when they have found a de- document. They provide a "browsing" capability wh- isn't built into the Bush machine.

Actually, although all three systems operate in basi- the same way, they aren't competitive because they're de- signed for different kinds of retrieval work. The significance of the Rapid Selector installation at BuSh- is that it expands the potential application of the mi- film concept, for government as well as commercial us-

The documents being put into the Rapid Select- microfilm library include R&D reports, ship plans, specifications, and technical manuals. All of this mate- is photographed by a Photo Devices planetary ca- Normally, the film image is 1/18th the size of the orig- but a maximum 20x reduction is possible. The micro- picture provides a resolution of 120 lines per milli-

Code area of film for the Rapid Selector

Before being photographed, each document is read by an information specialist, who then codes the significant index facts on a mimeographed form. The coding operation consists essentially of assigning numbers to the document that stand for its date of issuance, security classification (e.g., classified, unclassified, secret), author, subject matter, and so on. The numeric equivalents for each item in this bibliographic profile are listed in previously-prepared guidebooks.

The codes are punched into an IBM card, which is then placed in a reading device connected to a set of lights located behind the microfilm camera. Essentially, this hookup converts the holes in the card into dots on the film. After the code has been recorded, the document itself is photographed.

A standard 35-mm acetate-cellulose base film is used in the camera. After processing, it is put through a Kalvar printer-processor and a second generation film copy is made on Mylar. The original becomes a master record copy and the Mylar copy is used for document searching.

Documents are retrieved by punching the identifying codes into an IBM card. The code card is fed into a reader which controls a photocell array in the Rapid Selector's search unit. The holes in the card produce a distinctive electronic pattern in the photocell complex. Any microfilm frame that has a similar dot pattern is automatically re-photographed onto the output film. This latter image is a third-generation (negative copy) of the original document.

A conventional 35-mm film, stored in 100 ft. lengths on daylight reels, holds the output. This film usually is processed by a commercial firm to obtain better control, although the Bureau of Ships has equipment to do the job itself. The copy film, after being processed, can be viewed directly, or reproduced onto paper, with the help of a microfilm reader-printer.

The Rapid Selector scans about 10 ft. of film—approximately 100 frames—per second. When a match is made, it takes about 12 milliseconds for the frame containing the desired document to travel from the reading head to the photo head. During this interval, the output film is accelerated from zero to a speed of 10 ft. per second. Thus, when the image is reproduced, although both films are moving, they are stationary with respect to each other.

Being able to copy a picture on the fly represents an important advance in the development of microfilm retrieval systems. With a large library of documents, used frequently, it could make possible increased utilization of equipment and film, and reduce capital and operating expenses.

It takes about 20 minutes for the information analyst to read, code, and photograph a document going into the Rapid Selector's microfilm library. The time required to search a 6,000-ft. reel is about 12 minutes. According to an estimate made a few years ago by the National Bureau of Standards, the total cost of the Rapid Selector's hardware is about $85,000. Operational costs were estimated at five cents per page for file input and three cents for each page retrieved.

The big data-storage capacity of the Bush machine may turn out to be its most important advantage: 77 characters, recorded in binary coded digit (BCD) form, can be accommodated on a section of 35-mm film 5/8ths-inch long. By comparison, the typical microfilm aperture card holds only 55 characters, and it measures 3¼ x 7⅜ inches.

Actually, there's no limit to the Rapid Selector's storage capacity. If the amount of indexing information related to a particular document is too much for one 5/8ths-inch code frame, it's a simple matter to appropriate additional frames when the document is under the planetary camera.

Abstracts, as well as entire documents, can be coded, microfilmed, and then retrieved by the Rapid Selector. The search can be programmed so that either abstracts, or documents, or both together, can be photo-copied on a single pass of the source film. This feature may make the Rapid Selector a more efficient retrieval system for many applications that now require a computer.

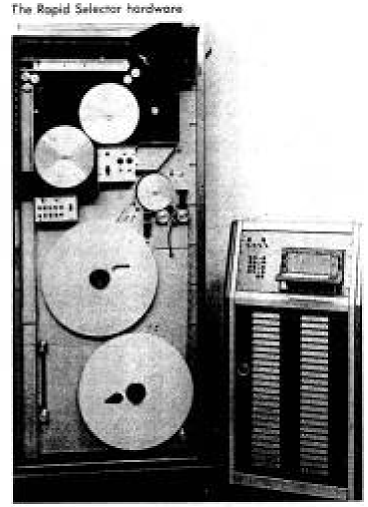
For example, various specialized libraries around the country have computers which can produce technical abstracts automatically. The data needed for the abstract is culled from the original document, translated into machine language, then stored on magnetic tape. When a request is made for information on a particular subject, the tape cycles through a computer and the pertinent abstracts are printed out on a high-speed typewriter.

The Rapid Selector probably could handle this job much more economically. Far less coding would be required because only a relatively few index terms, rather than every word of the abstract, would have to be put into machine language. The Rapid Selector equipment also costs far less than the computers now being used for information retrieval operations.

Another conceivable application involves commercial documents—such as invoices, business correspondence, freight manifests, and inventory forms. Now, many companies store such forms on microfilm and put the pertinent figures from each document on punched cards, paper or magnetic tape. The latter media provide the input for data processing. The Rapid Selector offers a way of telescoping these two kinds of storage into one.

In such a system, the input to the data-processing equipment would consist of microfilm, rather than punched cards or tape. The data needed for accounting operations would be in the code adjacent to each document. There would be a substantial space saving, possibly a considerable increase in data processing speed. ■

The Rapid Selector hardware



J.C.R. Licklider, 1915 - 1990

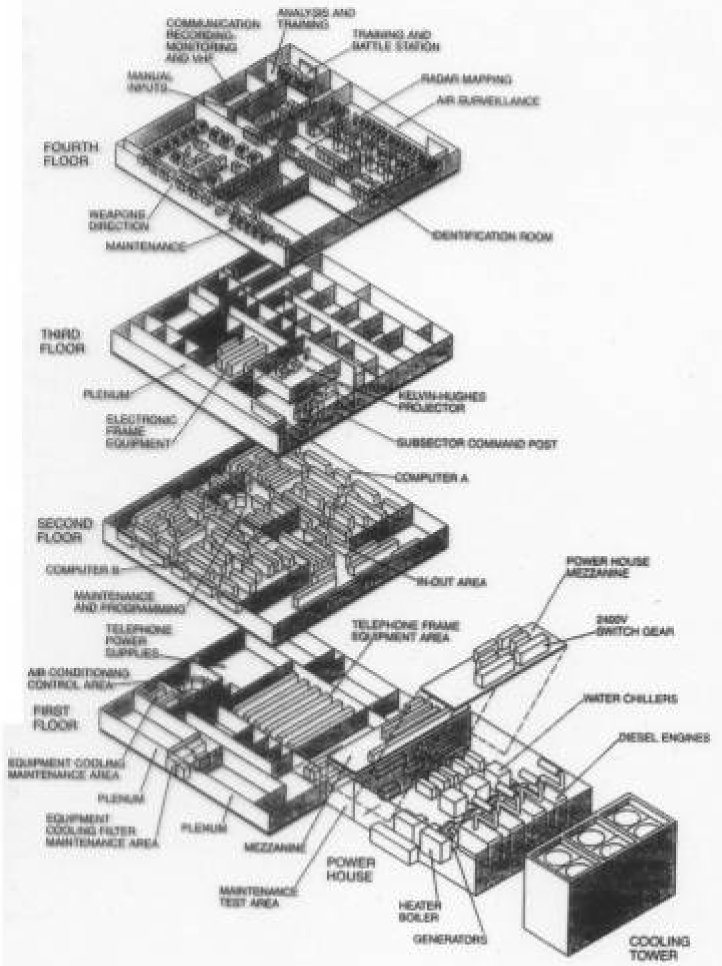


Figure 3.1
Interior of a typical SAGE direction center. Two IBM FSQ-7 computers filled the entire second floor. Drawing by Bernard Shuman, courtesy MITRE Corporation Archives.

The SAGE center at McGuire Air Force Base

The SAGE Project, 1949-62

Direction Center at McGuire Air Force Base, New York

A FEW MEMBERS OF THE 4000-MAN SAGE TEAM WATCHING OVER AMERICAN AIRSPACE ON THEIR CRT SCREENS AND ANALYSING ALL THE SIGNALS IN ORDER TO BE ABLE TO DIRECT DEFENCE WEAPONS AGAINST AN ENEMY INTRUDER. **1955**

Man-Computer Symbiosis

Summary

Man-computer symbiosis is an expected development in cooperative interaction between men and electronic computers. It will involve very close coupling between the human and the electronic members of the partnership. The main aims are 1) to let computers facilitate formulative thinking as they now facilitate the solution of formulated problems, and 2) to enable men and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs. In the anticipated symbiotic partnership, men will set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking. Preliminary analyses indicate that the symbiotic partnership will perform intellectual operations much more effectively than man alone can perform them. Prerequisites for the achievement of the effective, cooperative association include developments in computer time sharing, in memory components, in memory organization, in programming languages, and in input and output equipment.

1 Introduction

1.1 Symbiosis

The fig tree is pollinated only by the insect *Blastophaga grossorun*. The larva of the insect lives in the ovary of the fig tree, and there it gets its food. The tree and the insect are thus heavily interdependent: the tree cannot reproduce wit bout the insect; the insect cannot eat wit bout the tree; together, they constitute not only a viable but a productive and thriving partnership. This cooperative "living together in intimate association, or even close union, of two dissimilar organisms" is called symbiosis [27].

"Man-computer symbiosis" is a subclass of man-machine systems. There are many man-machine systems. At present, however, there are no man-computer symbioses. The purposes of this paper are to present the concept and, hopefully, to foster the development of man-computer symbiosis by analyzing some problems of interaction between men and computing machines, calling attention to applicable principles of man-machine engineering, and

Man-Computer Symbiosis, 1960

SECRET

October 9, 1957

MEMORANDUM OF CONFERENCE WITH THE PRESIDENT
October 8, 1957, 8:30 AM

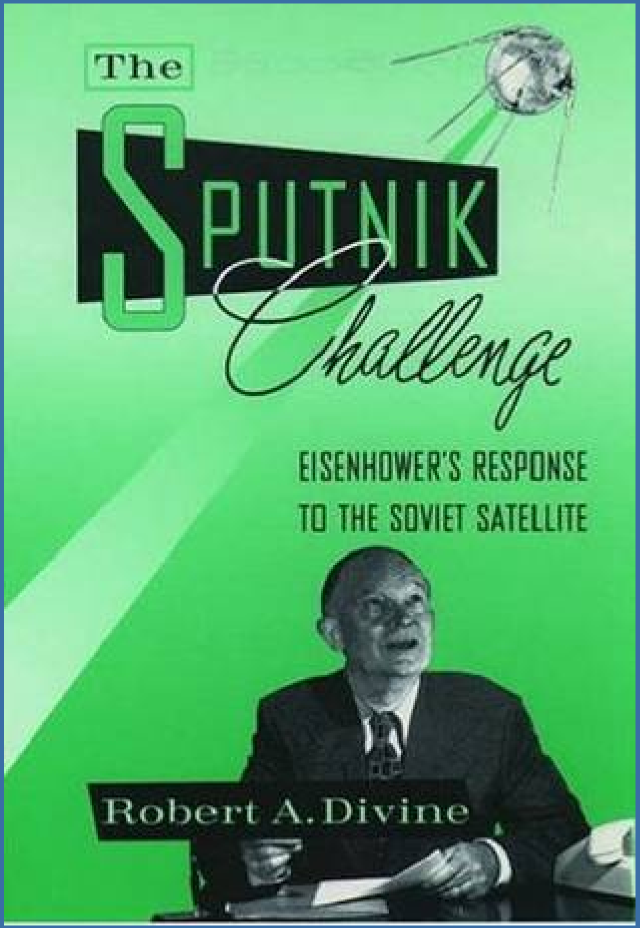
Others present:
Secretary Quarles
Dr. Waterman
Mr. Hagen
Mr. Holaday
Governor Adams
General Persons
Mr. Hagerty
Governor Pyle
Mr. Harlow
General Cutler
General Goodpaster

Secretary Quarles began by reviewing a memorandum prepared in Defense for the President on the subject of the earth satellite (dated October 7, 1957). He left a copy with the President. He reported that the Soviet launching on October 4th had apparently been highly successful.

The President asked Secretary Quarles about the report that had come to his attention to the effect that Redstone could have been used and could have placed a satellite in orbit many months ago. Secretary Quarles said there was no doubt that the Redstone, had it been used, could have orbited a satellite a year or more ago. The Science Advisory Committee had felt, however, that it was better to have the earth satellite proceed separately from military development. One reason was to stress the peaceful character of the effort, and a second was to avoid the inclusion of materiel, to which foreign scientists might be given access, which is used in our own military rockets. He said that the Army feels it could erect a satellite four months from now if given the order -- this would still be one month prior to the estimated date for the Vanguard. The President said that when this information reaches the Congress, they are bound to ask why this action was not taken. He recalled,

SECRET

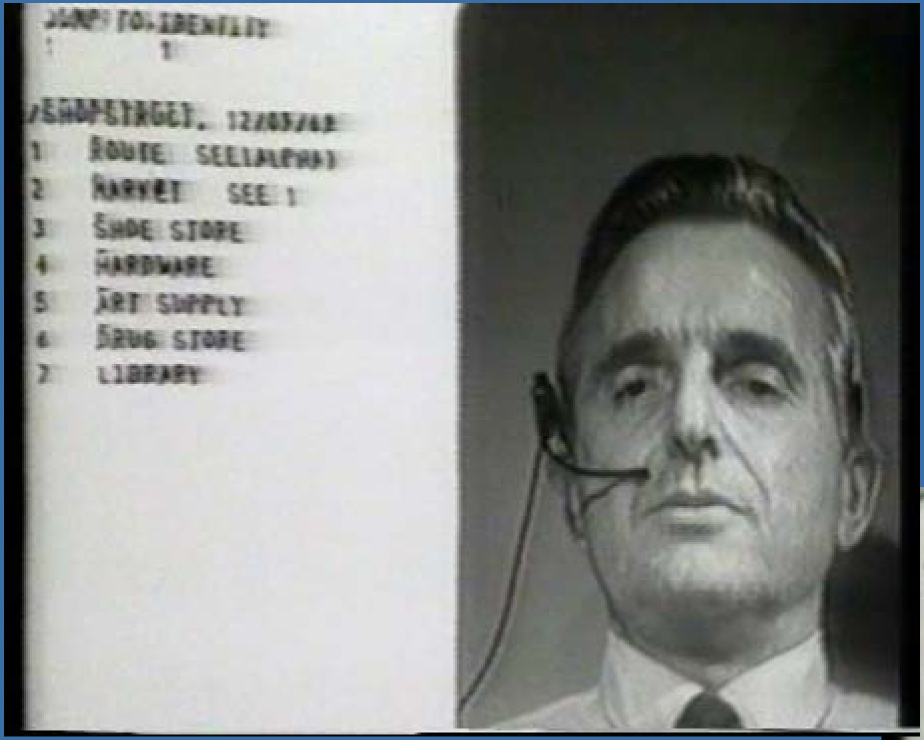
DECLASSIFIED
E.O. 11652, Sec. 11
MR 76-49 Document #65
By JW. Date 11-17-76

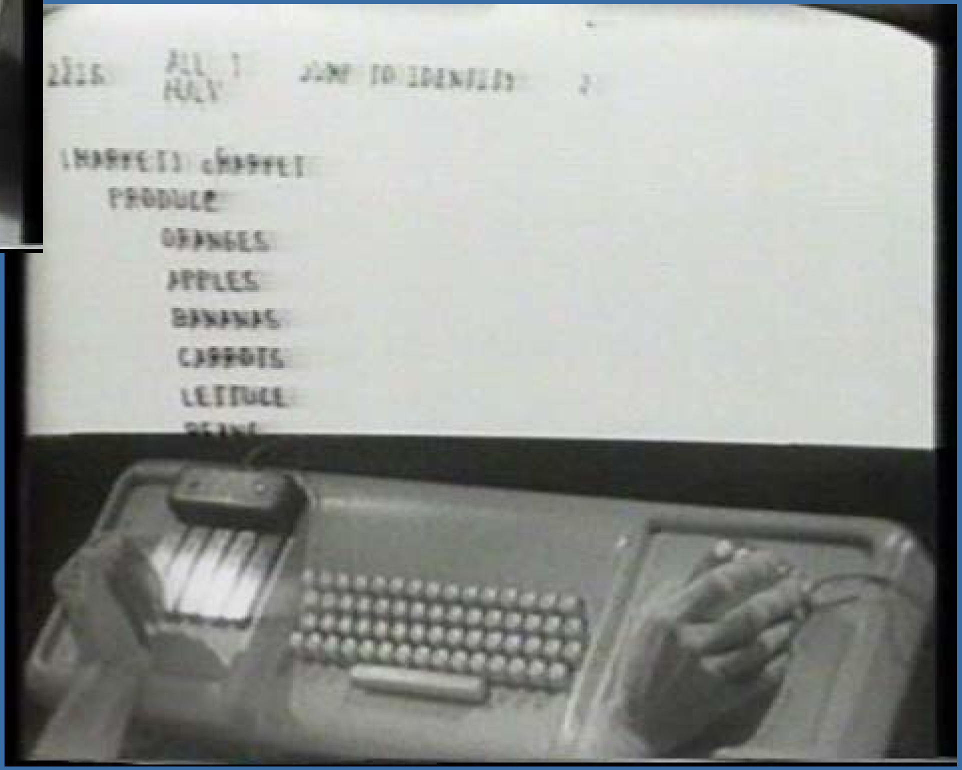


4. Project MAC time-sharing system at the Massachusetts Institute of Technology has 160 terminals on the M.I.T. campus and nearby and is also available from distant terminals. As many as 30 terminals can be connected at one time, with each user carrying on a direct and in effect uninterrupted dialogue with the computer. The terminals are for the most part simple teletypewriters such as the IBM 1050 (6) and Teletype models 33 (19), 35 (5) or 37 (10). Some are in offices, some in large "pool" rooms, some in laboratories and a few in private homes (1). In addition to students and staff members doing their own research, the users shown here include secretaries preparing papers for publication (13), authors Fano (8) and Corbató (24) and a psychiatrist at the Massachusetts General Hospital (18).

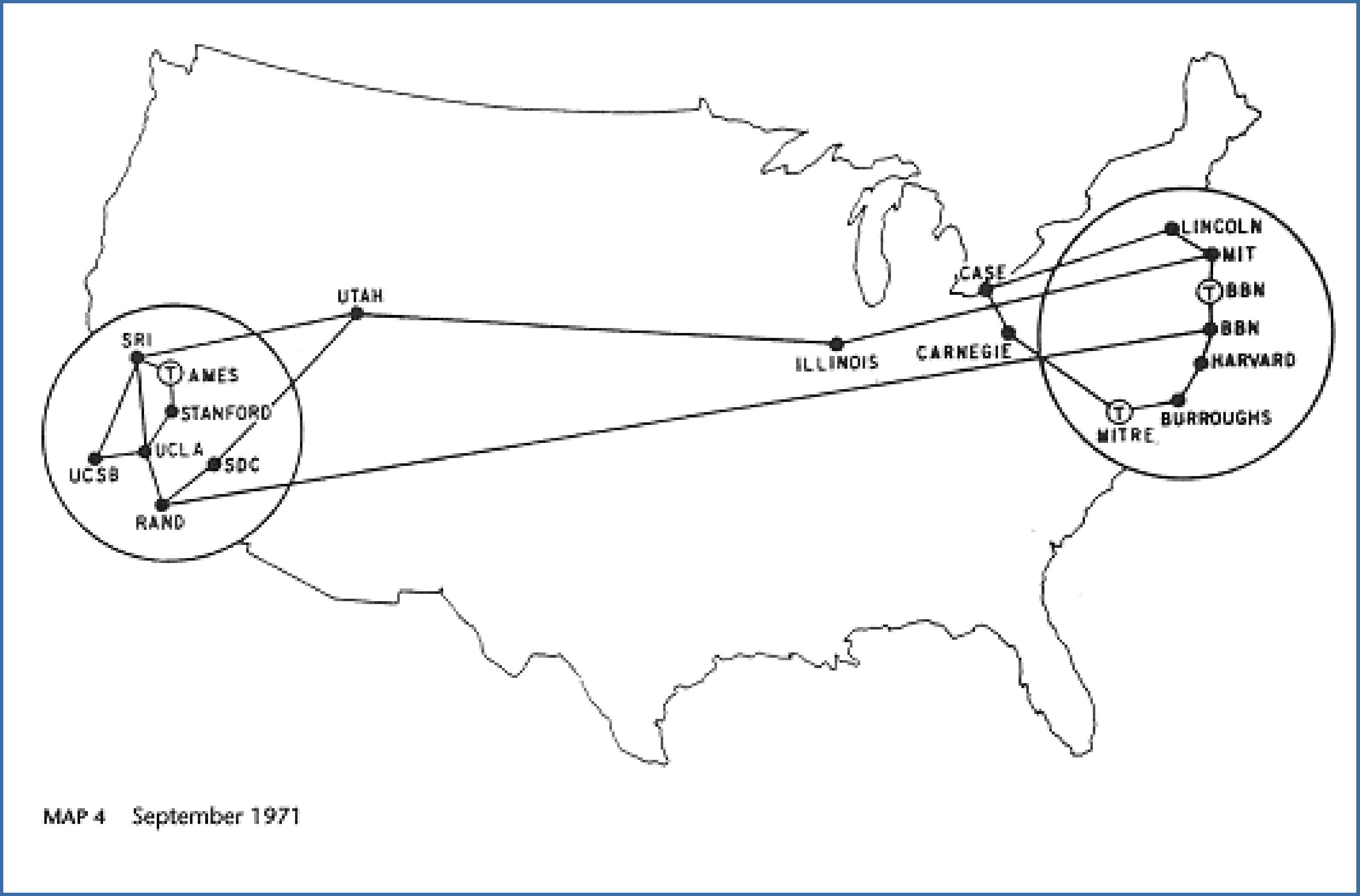
Project MAC at MIT

- *Scientific American*, 1966

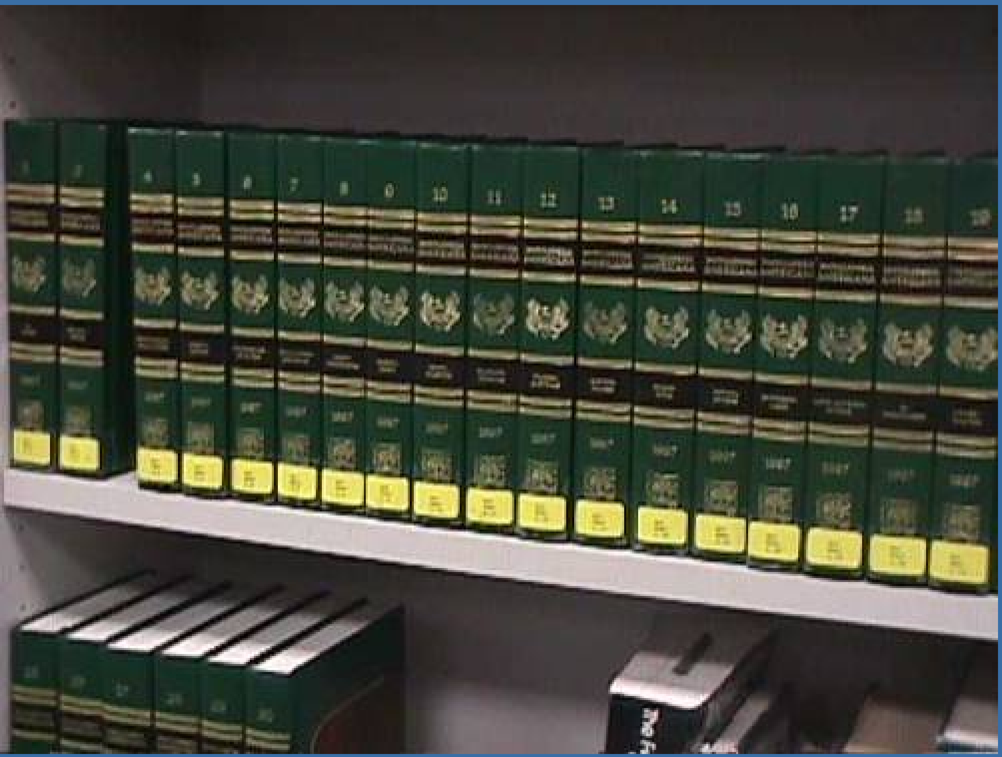




Douglas Engelbart at the National Computer Conference, San Francisco, 1965



Arpanet in 1971



Grolier Encyclopedia on CD-ROM, c.1985

World Wide Web

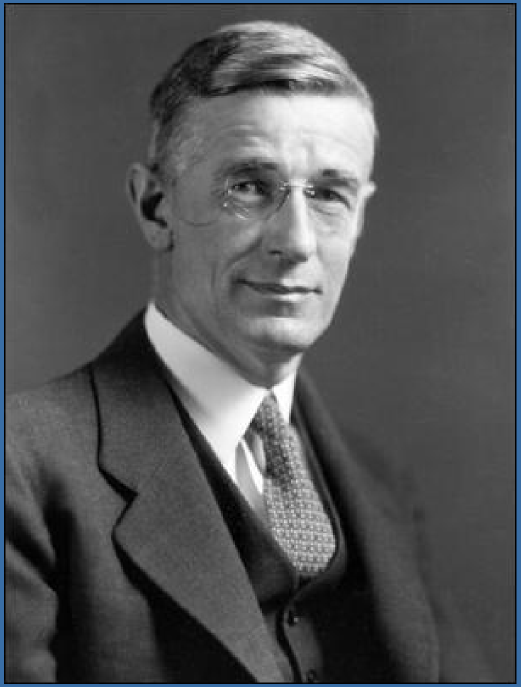
The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an executive summary of the project, Mailing lists , Policy , November's W3 news , Frequently Asked Questions .

What's out there?
    Pointers to the world's online information, subjects , W3 servers, etc.
Help
    on the browser you are using
Software Products
    A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , Tools , Mail robot , Library)
Technical
    Details of protocols, formats, program internals etc
Bibliography
    Paper documentation on W3 and references.
People
    A list of some people involved in the project.
History
    A summary of the history of the project.
How can I help ?
    If you would like to support the web..
Getting code
    Getting the code by anonymous FTP , etc.

The first web page, CERN 1991

Wellsian indexers at Yahoo in 1994



H. G. Wells, 1866 - 1946

Vannevar Bush, 1890 - 1971

J.C.R. Licklider, 1915 - 1990