THE MOUSE THAT ROARED

A Research Project Documentary
By Jack Kelley, IDSA, ASFD

THE MOUSE THAT ROARED

A Research Documentary on the Development of the World's First Modular Panel Computer Workstation Designed to Accommodate the World's First Computer Mouse and related equipment, in a variety of working postures

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Bernt — call with Questions
Best — Jack

INTRODUCTION

On July 16, 1968, a product line was introduced that would forever change Herman Miller as a manufacturer of office furniture and forever change the way office spaces were planned and utilized. On this date, Action Office II (AOII), a flexible modular panel system that divided space and accommodated worksurfaces, hanging shelves and file cabinets, became a reality to the commercial office market.

This documentary is about a research project between Stanford Research Institute (SRI), in Menlo Park, California, and Herman Miller's Research Division (HMRD) located in Ann Arbor, Michigan. The year, 1968, is significant because in addition to the introduction of AO II, it was the year that this project was initiated between Dr. Douglas Engelbart, Director of the Augmented Human Intellect Research Center at SRI and Robert Propst, Director of HMRD.

The SRI project began before most of the commercial world was aware of the Action Office II system. This world didn't know much about computers as well. However, Bob and Doug had similar understandings on how they preferred, and wanted, to work. Bob was an inventor and problem solver, and Doug, also an inventor, was developing ways to enhance human interaction with the computer. One of his significant inventions was the computer mouse. The importance of this computer input device has been extensive since 1984 when Apple commercially introduced it, sixteen years after it was invented. Today, every computer does, or can, use a mouse. Other Engelbart inventions have had significant impact on computer systems up to and including the Internet.

The objective of this project was to develop a functional, human factored (ergonomics had not been defined at this time) and comfortable computer interface work environment. Bob assigned Jack Kelley, his AOII lead designer and research associate to the project. Jack's responsibilities were to understand the functional relationships of Doug's computer components, identify problems, to gather and confirm criteria and to recommend, and consequently design, develop and prototype the solutions.

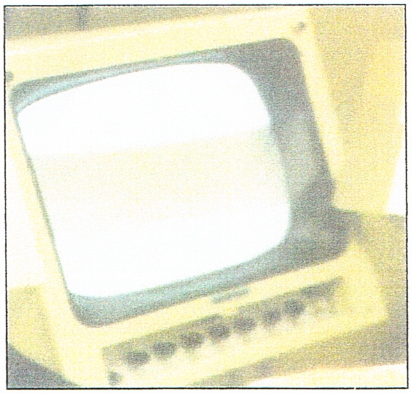
Another objective of the project was to have a comprehensive functioning workstation communication hardware package to assist Engelbart's live presentation on how his concepts worked at the Fall Joint Computer Conference. The Conference was to be held in December of 1968 at the Convention Center in San Francisco.

The uniqueness of this project was two-fold. From the technology standpoint a powerful direction in computer function was recognized and from the furniture standpoint, it was the very first modular panel and console workstation designed specifically for interacting with the computer.

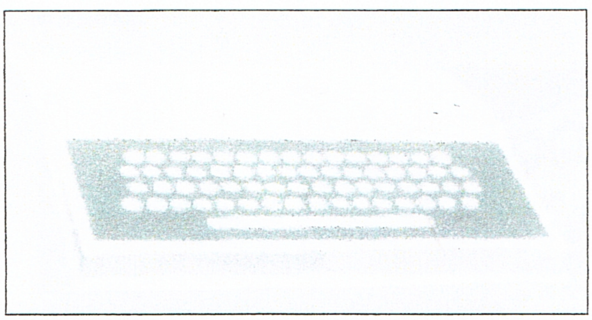
THE SRI HARDWARE AND EQUIPMENT

Engelbart and his staff developed and accumulated a wide variety of components that, when electronically connected, fed data into a room sized computer at their SRI research center. The computer, in turn, would respond with calculated intelligence that the SRI team had programmed into it. The new work environment would have to incorporate the following pieces of equipment:

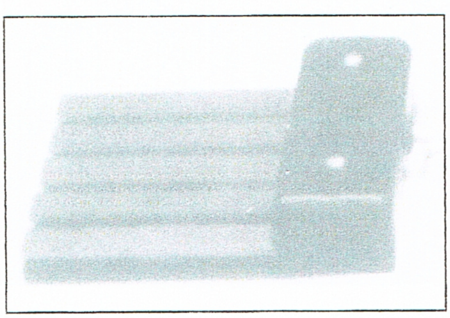
Monitors (3) large and bulky with heavy glass cathode ray tubes (CRT)

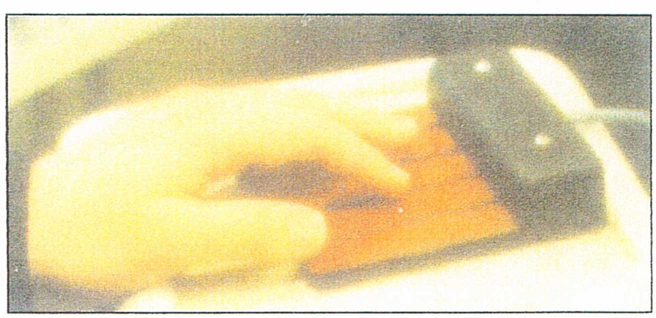


Keyboard (1) an input device utilizing an IBM Selectric keyboard

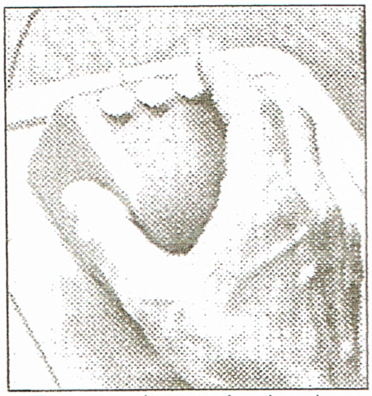


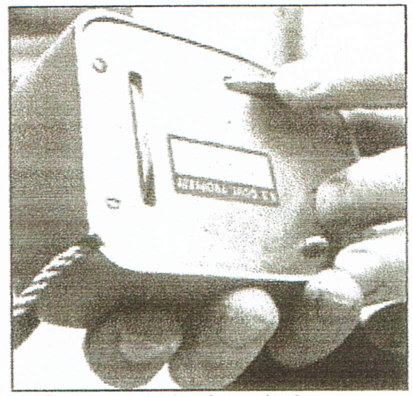
Binary Key set (1) a five finger-like paddle keying input device that duplicated the function of the standard keyboard but at a much faster speed. (an Engelbart invention)





The Mouse (1) a radically new input device, also invented by Engelbart, that activated and directed a cursor on the monitor CRT screen.


The mouse in operational mode


Operational wheels on the bottom

The Computer (1) A huge central unit to which the aforementioned devices provided input. The project had little or no concern with this device other than hoping it kept working.

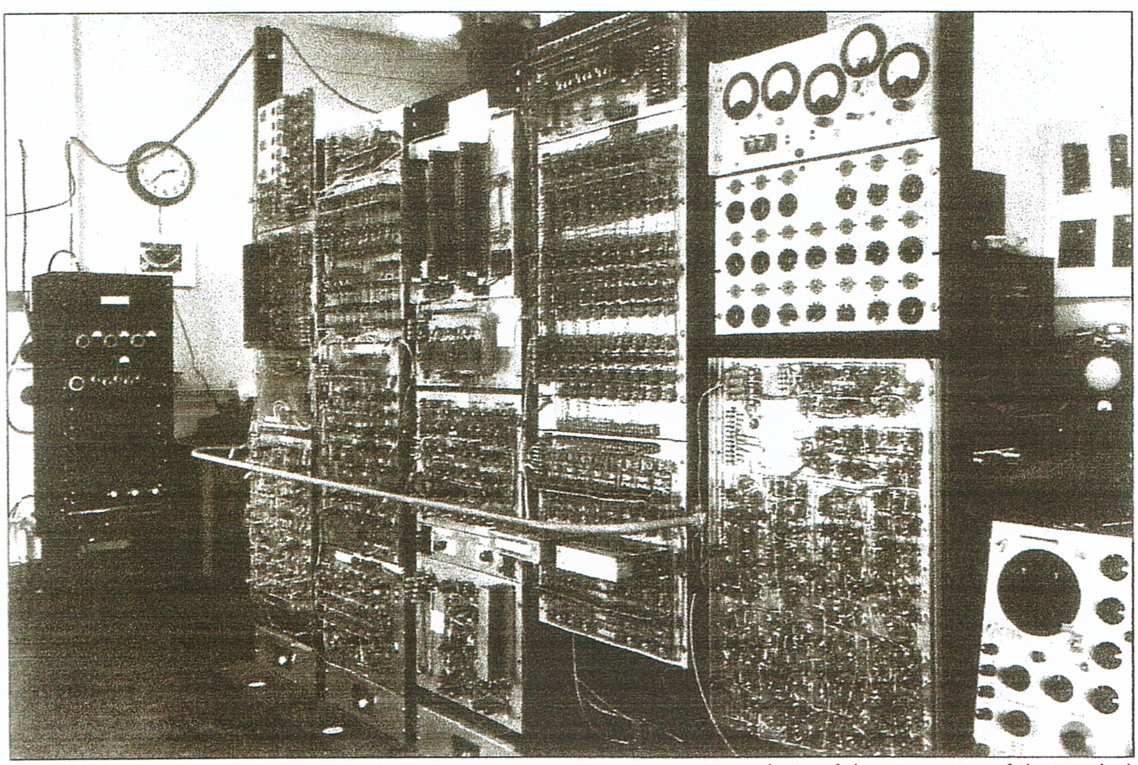
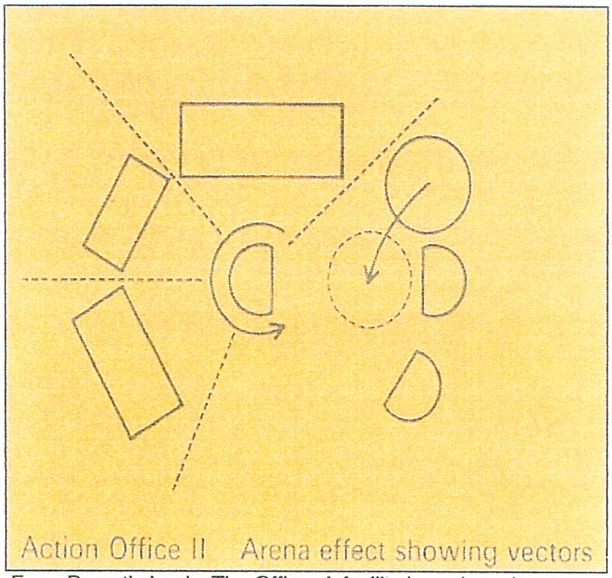


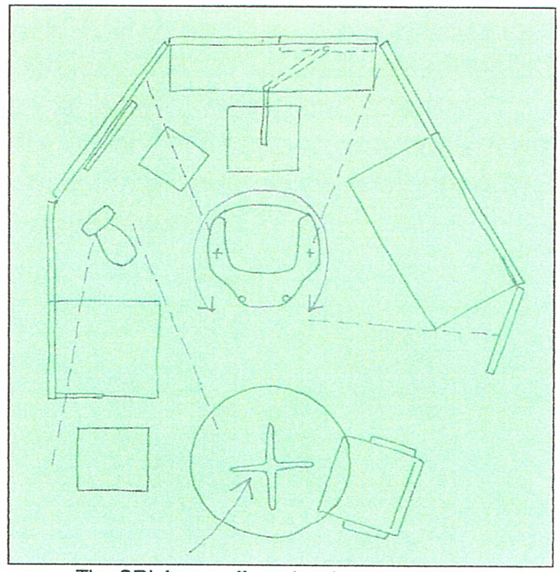
photo of the computer of that period

BLENDING WORK PHILOSOPHIES

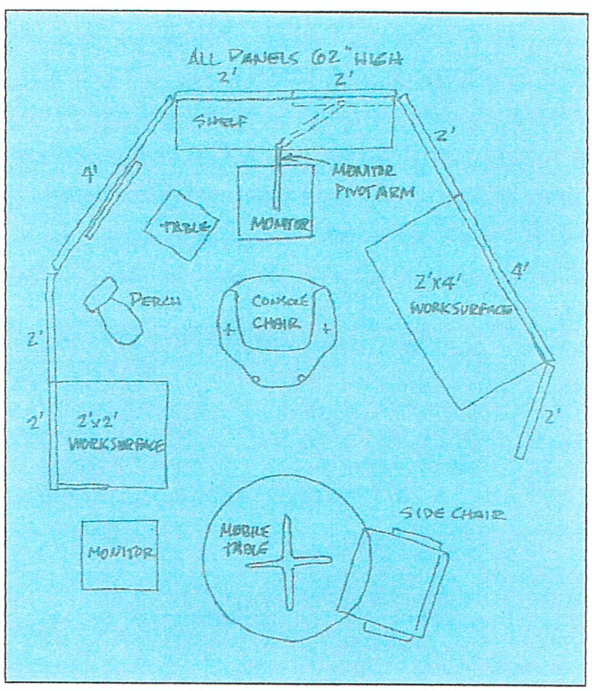
A planning effort was made to apply Propst's concept of the arena effect. It also would identify where work vectors could be established. The following illustrations show the application of these concepts.



From Propst's book, *The Office, A facility based on change*


The SRI Arena effect showing vectors

To support multiple work postures and activity, the way Engelbart (as well as Propst) desired to work, AO II panels were specified. They provided the surround and adjustable vertical height and horizontal locations for worksurfaces, display tack boards and easel pads. Freestanding equipment such as mobile tables on wheels were used to provide user-relocatable task and work vector areas.



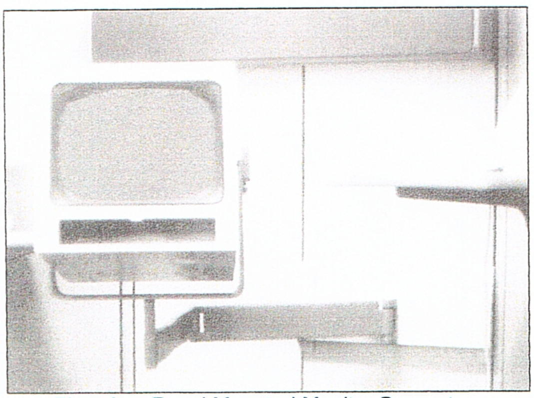
SRI work station layout with components identified

THE HARDWARE SOLUTIONS, and how they worked

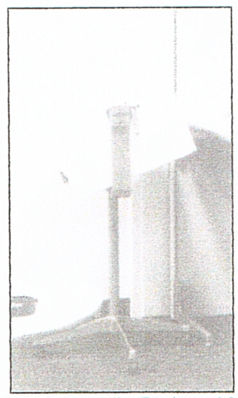
From the industrial design process of analyzing the functional tasks required to interface with the SRI computer utilizing Engelbart's creative programming and input devices, additional products were identified to effectively support these tasks.

Monitor Flexibility

The CRT monitors, weighing about 40 pounds each, had to be more mobile, adjustable and user friendly. Three types of monitor supports were built. Two pedestal mounted units on wheels each at a different height for viewing, one for sitting and one for standing. Angle of view was easily adjustable. The other CRT support was a pivot arm assembly that attached to an AOII panel that allowed the monitor to be positioned in a wide range of configurations without knee or foot obstruction.



Pivot Arm Panel Mounted Monitor Support



Mobile Pedestal Monitor Supports

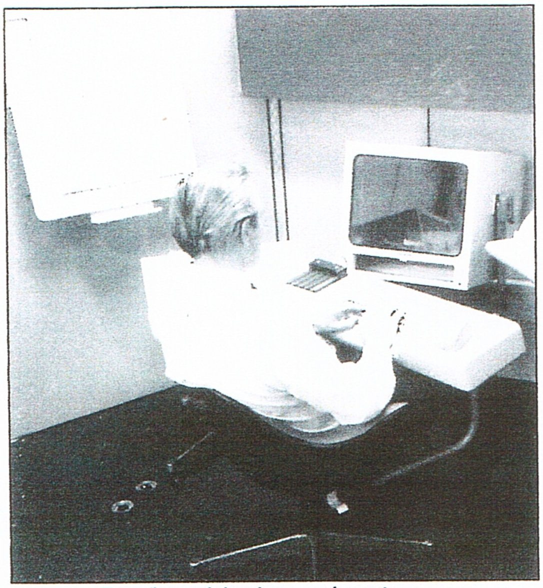
Console Development

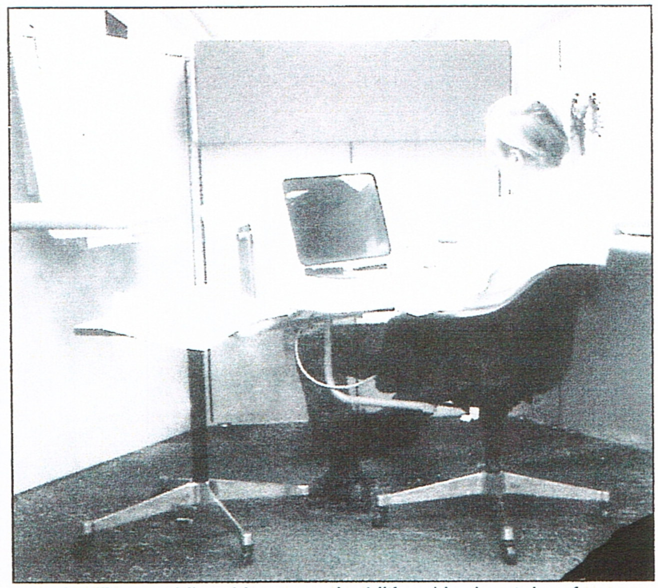
What was also needed was a single component or an "all in one" console that would house and accommodate the three input devices. Kelley designed and built a portable console that contained a Selectric Keyboard and two outboard pads, one for the Binary Keyset and one for the Mouse. The pads also incorporated naugahide surfaces for easy and positive location of either input device, used either right handed or left. The naugahide surface enhanced the movement of the Mouse's activation wheels. Because of its portability, the console could be used on worksurfaces and tabletops. The console was also designed to mount on a swivel structure with two arms attached to an upholstered armchair. This enabled the user to sit in comfort and still interact with the SRI computer. The user could also swing the console away, without detaching from the chair, to enable ingress and egress to the chair with ease. This is how they worked:

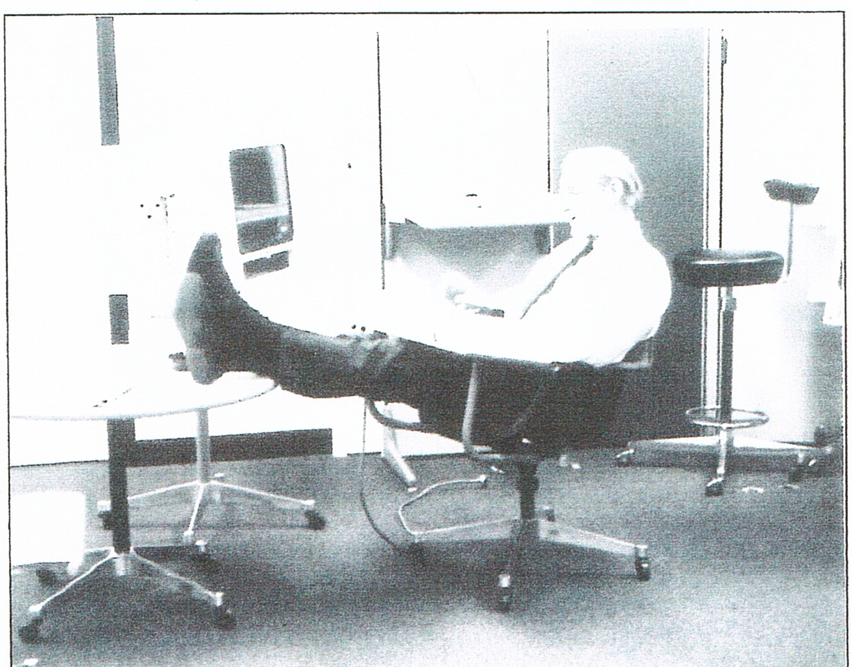
Overhead view of the "all in one" Console showing the Keyset, Keyboard and Mouse

THE HARDWARE SOLUTIONS, and how they worked, continued

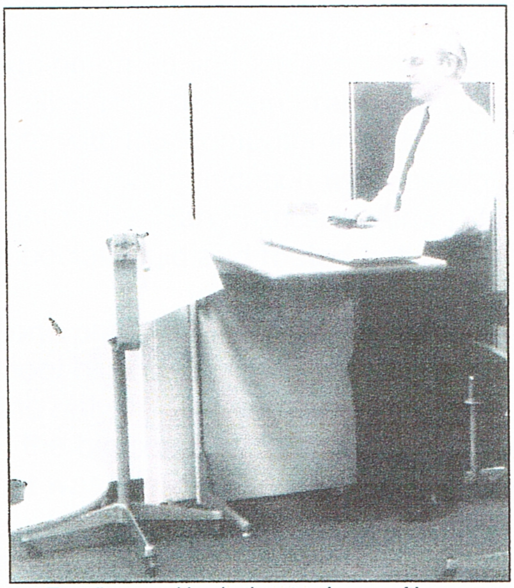
The "all in one" console that was mounted on a swivel-tilt chair enabled an expanded variety of sedentary work styles.

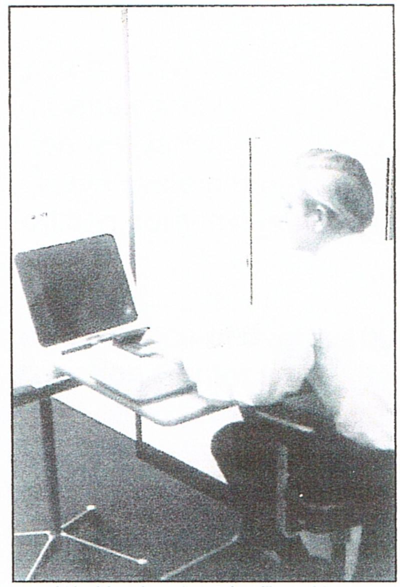

Engelbart sitting in a work vector

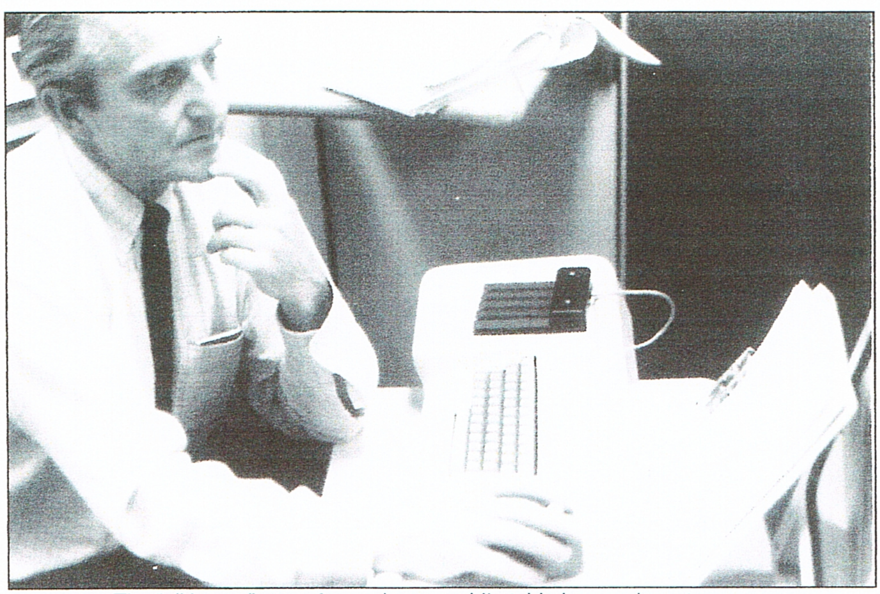

Ancillary mobile tables extend additional horizontal surface


Engelbart in a relaxed position with the console chair, and monitor pedestal

VARIABLE WORK POSTURES


Engelbart working in the stand-up position


Working in a "perched" position


The "all in one" console used on a mobile table in a work vector

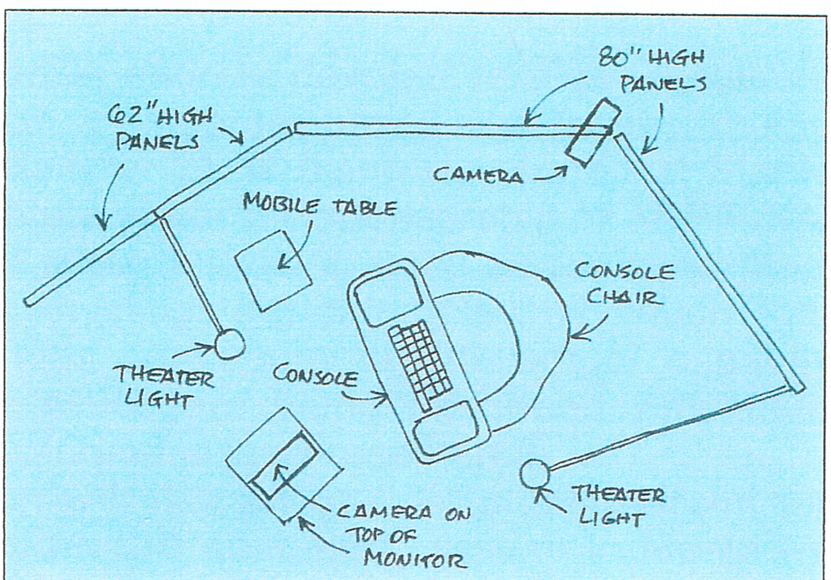
THE BIG SHOW

On December 9, 1968 computer history was made in San Francisco. At the Fall Joint Computer Conference, Dr. Doug Engelbart and his SRI team gave a 90-minute demo that, as WIRED magazine called it, "The Click Heard Around the World". This reference obviously was pointing out the introduction of the mouse. In addition to the mouse, videoconferencing, hyperlinks, network collaboration and text editing were also introduced for the first time. Talk about frosting on the cake!

What was going on behind the scene was also a big story. The computer was in Menlo Park, forty miles from the San Francisco Convention Center and Engelbart had to communicate with this computer in order to present the relevance of his working ideas. Two methods of communication were used: a microwave system that was set up with an interim link at the San Francisco Airport and in addition, forty miles of coaxial cable that was especially laid and routed between the two sites.

How does one present a TV screen sized image to an audience of over a 1000 people? First, a 22 foot high screen was mounted on the Convention Center stage. Next was obtaining the only video projector on the west coast that could project images large enough for the big screen. It was an Eidophor, a highly sophisticated projector, made in Sweden that was around 6 feet tall and weighed almost a ton.

Kelley attended the demo rehearsal, provided input for the AOII panel surround of the console chair and monitor workstation . He also photographed the demo set-up in the auditorium.



Layout of the stage components for the Engelbart demonstration

monday afternoon

december 9

3:45 p.m. / arena

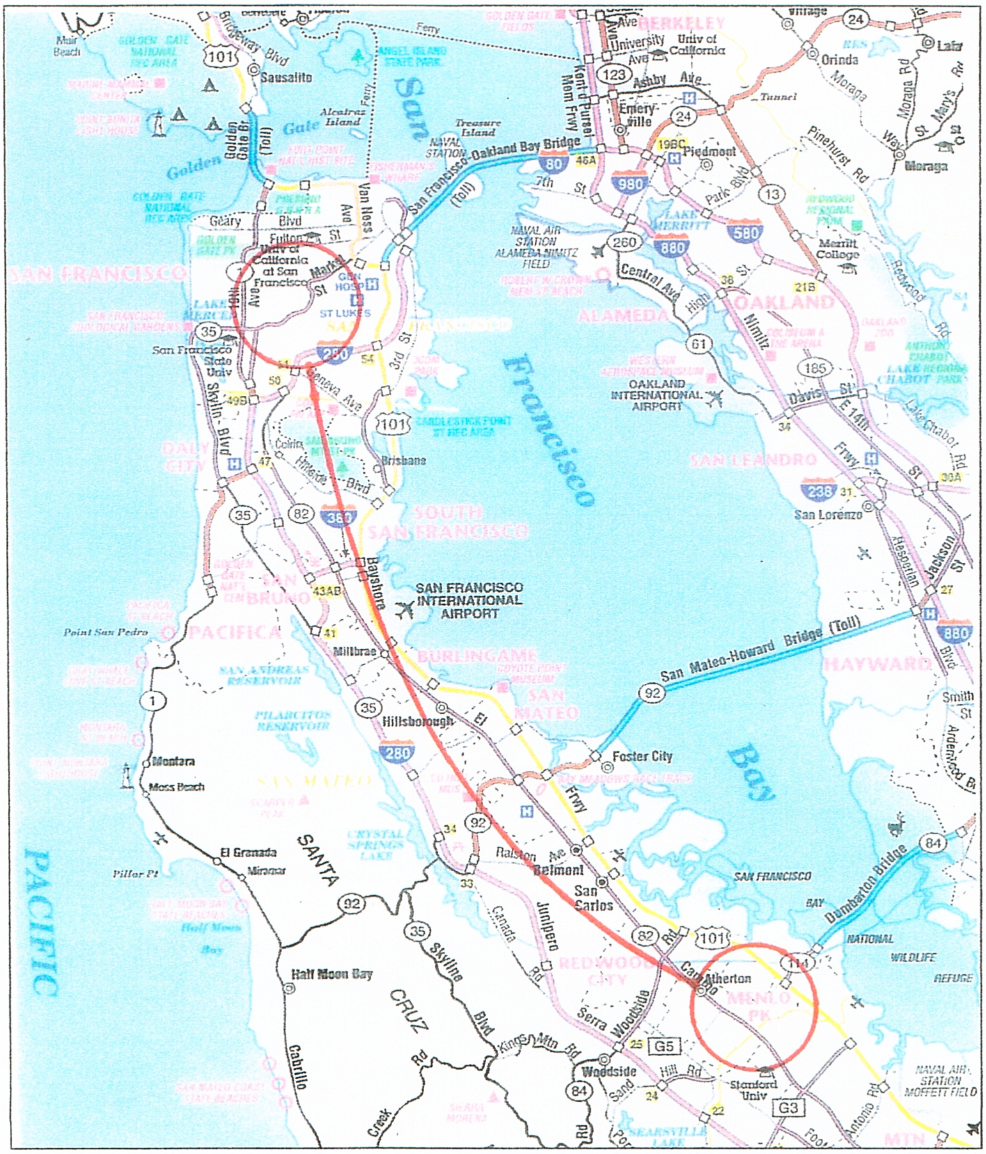
Chairman:
DR. D. C. ENGELBART
Stanford Research Institute
Menlo Park, California

a research center for augmenting human intellect

This session is entirely devoted to a presentation by Dr. Engelbart on a computer-based, interactive, multiconsole display system which is being developed at Stanford Research Institute under the sponsorship of ARPA, NASA and RADC. The system is being used as an experimental laboratory for investigating principles by which interactive computer aids can augment intellectual capability. The techniques which are being described will, themselves, be used to augment the presentation.

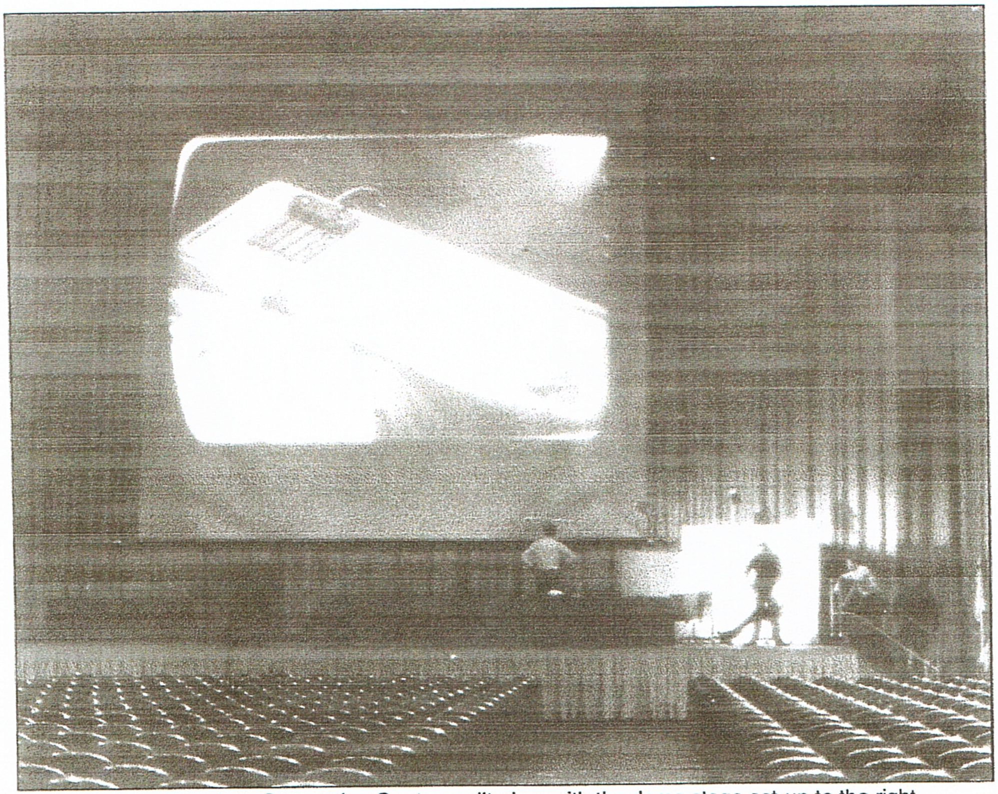
The session will use an on-line, closed circuit television hook-up to the SRI computing system in Menlo Park.

Following the presentation remote terminals to the system, in operation, may be viewed during the remainder of the conference in a special room set aside for that purpose.

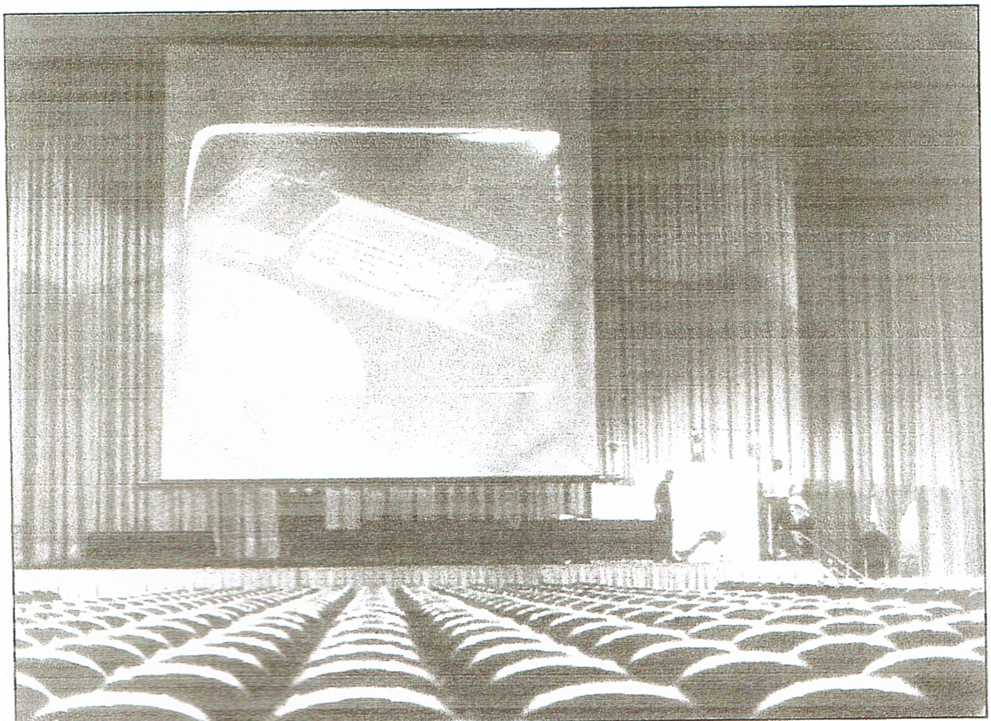


The forty mile Menlo Park to San Francisco routing of the Coaxial Cable to connect the SRI computer to the equipment at the Convention Center presentation site.

THE BIG SHOW, continued

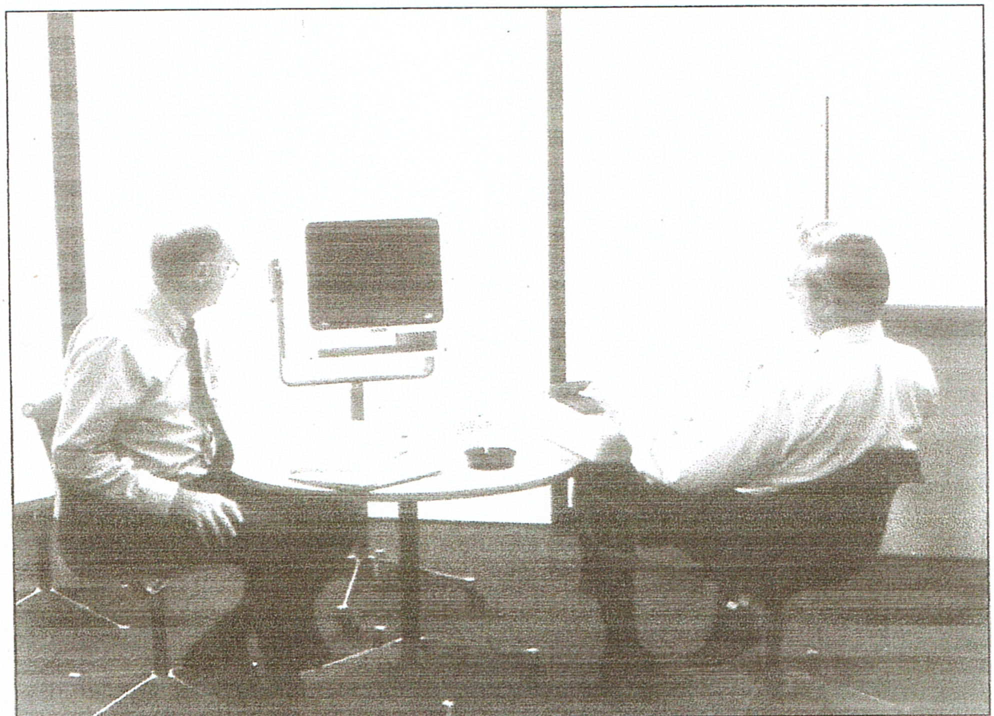


The San Francisco Convention Center auditorium with the demo stage set-up to the right



Auditorium photo while adjusting projector contrast with Engelbart sitting in the console chair

SRI / HMRD PROJECT TEAM PRINCIPALS



Bob Propst and Dr. Engelbart

Dr. Engelbart and Jack Kelley

Jack Kelley
Industrial Designer, Sailor
Problem Solving Research and Design

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C.C. Rider, boat
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Grand Haven

Tel: 616-402-3382
email tututu@aol.com

Web sites on Engelbart's Mouse History

http://sloan.stanford.edu/mousesite/1968Demo.html

http://video.google.com/videoplay?docid=-8734787622017763097

http://www.americanheritage.com/articles/magazine/it/2002_3_48.shtml

http://www.wired.com/wired/archive/12.01/mouse.html

On the following pages, there is a copy of the article written for Electronics Magazine, published in January of 1969, that reported on Engelbart's Fall Joint Computer Conference presentation in December of 1968

$1.00 A McGraw-Hill Publication
January 20, 1969

Electronics

Getting more mileage from computers

SRI group is developing an experimental system to bridge capacity gap that's attributed to users' limited experience with advanced equipment

By Wallace B. Riley
Computers editor

The computer field, for all the advances in speed and performance that have been recorded during recent years, still has a way to go in realizing the full potential of machines and associated hardware and software over a broad range of applications. In a nutshell, the systems design art has outstripped the ability of owners and operators to make the best use of what's available to them.

That's the opinion of Douglas C. Engelbart, who's doing something about the situation, as well as others in the field. He heads the Augmented Human Intellect Research Center at the Stanford Research Institute in Menlo Park, Calif. Since the early 1950's, Engelbart and his colleagues have been addressing themselves to this capacity gap, which, he says, is largely attributable to lack of experience. At the moment, the center's crew has designed and assembled an impressive and complex system of hardware and software that represents a sort of halfway house on the road to the solution of the problem.

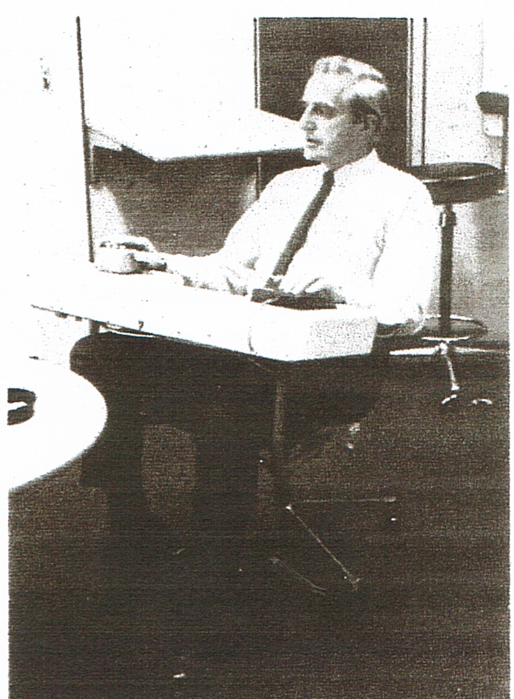
The center's work is being underwritten by the Pentagon's Advanced Research Projects Agency, the National Aeronautics and Space Administration, and the Air Force's Rome Air Development Center. Earlier, the Air Force's Office of Scientific Research was a participant.

Most observers applaud Engelbart's efforts and give high marks to his ideas and progress to date. And, in the main, such criticisms as are advanced are from traditionalists or those who express preferences for different individual hardware elements.

The principles and goals of the center's work are abstruse enough for Engelbart, himself, to resort to analogy when outlining them. For openers, he compares the state of the computer art to transportation around the turn of the century, when only a few automobiles were chugging about the countryside. Their usefulness was limited because roads were scarce and service facilities were largely confined to blacksmith shops. By contrast, today's cars, which come equipped with all the equipment and instructions needed to operate them satisfactorily, are the beneficiaries of a vast support network that includes superhighways, rules of the road, filling stations, mechanics, parking lots, and the like. A great deal of practical experience has accrued from the evolving designs of automobiles, says Engelbart. Partly because of hothouse growth, the same is not true of commercially available computers.

Foreshortening. Engelbart's organization is working toward plugging the breach. To this end, they've integrated a computer system that includes, among other things, an unusual display presenting the contents of a file, a standard typewriter keyboard along with two other input devices for modifying the file, and a set of functions that permits a user to add, delete, or change information in the file almost as fast as he can think—and far faster than an observer looking over his shoulder can follow.

A user can work comfortably and efficiently for hours with the system. He can compose new material and study data already on file, modifying or displaying it to various depths—a procedure that's analogous to looking at labels on file drawers, labels on folders in one of the drawers, headings on the papers in the folders, or the contents of the papers. In addition, the operator can edit, move big chunks of data around quickly, and make as many copies as he wants, either in the computer or as paper printouts, more readily than he could with typewriter, pencil and paper, or other media. An operator can also work with vectors and alphanumerics to draw pictures and



Chairman. Douglas Engelbart, who heads SRI computer project, sits in special console-equipped chair developed by Herman Miller for experimental system.

. . . most definitions of the user system are almost laughably inadequate . . .

diagrams in the file.

"The true measure of any kind of system is its value to the user," says Engelbart. By this yardstick, the center's set-up appears very valuable indeed—at least to those unburdened by traditional ways of thinking about intellectual processes. But the center's track is by no means completely clear. Returning to his transportation analogy, Engelbart points out that "traffic jams" could prove a serious problem for interactive computation. "However, transportation systems are inherently limited to two dimensions—three in the case of air transportation," he says. "Computer systems have the potential for multidimensional expansion, with no limit in sight today."

Virtually all computer experience accumulated to date centers on equipment and associated services, including software. What's needed, Engelbart believes, is a vast body of user-related knowledge to extend the level of interaction with the system. He finds most definitions of the user system almost laughably inadequate. And, he says, the same is true of the interface between the user system and the computer system.

Old school ties

For example, a great deal of work has been done to develop equipment and techniques that combine advanced electronic equipment with the most primitive data-manipulation methods. These include various kinds of pens and tablets for "drawing" on a cathode-ray tube—a situation that ties electronic manipulation of data to traditional pencil-and-paper techniques. This procedure is grossly inadequate, says Engelbart, because the data rate is necessarily several orders of magnitude slower than the user's train of thought.

Test case. The kind of problem that must be solved in designing a user system and its interface with a service system is illustrated by an analysis of what's involved in inserting a character in a word or adding a word in the middle of a sentence. The task includes three elements—the command, "insert," the entity to be inserted, and the place to insert it. To design such a capacity into a system, along with dozens of related functions, requires thinking several levels above the user-system/service-system interface and even further above specific hardware or software design details.

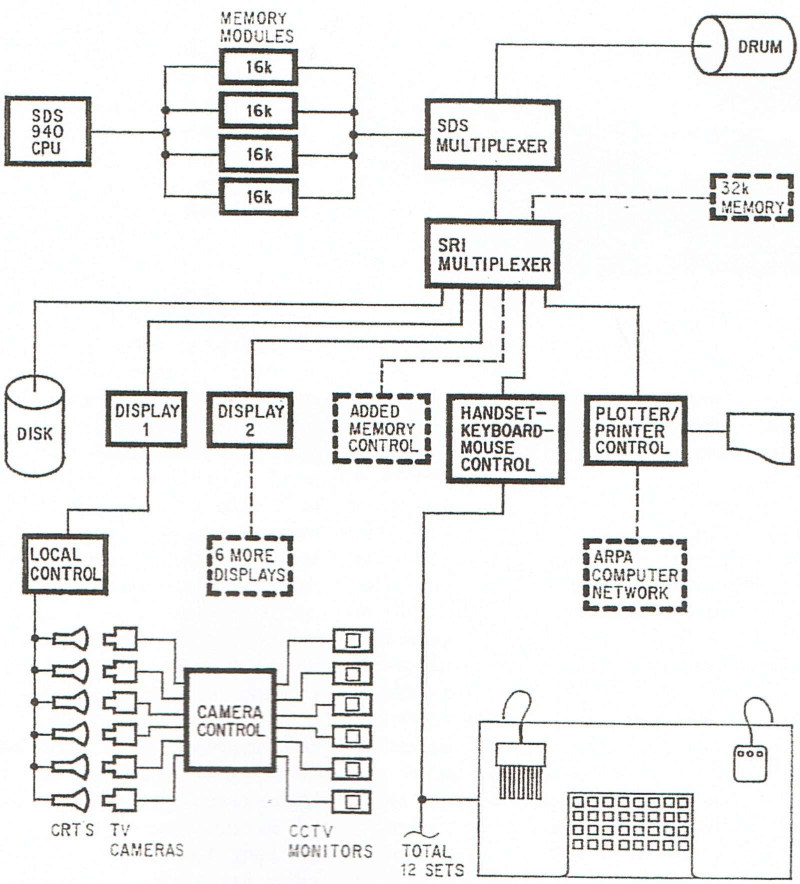
At the outset, Engelbart faced the problem of just how to begin. He realized that neither engineers nor users could adequately define an entire system that would prove to be most useful. Fortunately, his research team included individuals with a wide range of interests, aptitudes, and skills. Engelbart's happy inspiration was to use his staff, which now numbers 17, as its own subject group—building, experimenting, asking "why not . . ?" and then trying something else in a heuristic bootstrapping operation. The staff thus develops the tools and techniques required to carry out its assignment, living up to the project's goal of augmenting human intellect.

Conglomerate

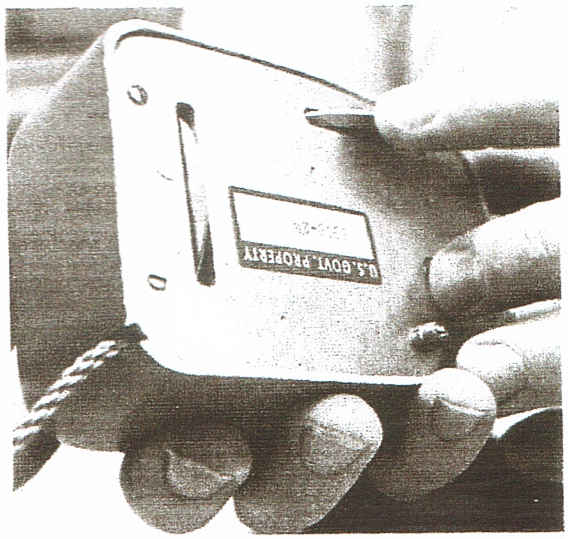
In their working system, Engelbart and his research team have used some quasi-conventional hardware and software, together with some unusual new design—originated at the institute or borrowed from other organizations working in the computer field.

At the heart of the center's project is a Scientific Data Systems 940 computer with four memory banks of 16,384 words each. Controlling the 940 is a time-sharing program developed at the University of California at Berkeley and later made commercially available by SDS.

One of the 940's distinguishing features is its double memory bus,



Double bus. The SRI system's computer memory is simultaneously accessible from the processor as well as special and conventional peripheral equipment.



Inputs. Conventional keyboard is in parallel with 5-key handset, whose combinations correspond to individual keys. At user's right hand is a "mouse," the movements of which on any smooth surface are duplicated by a spot, or "bug," on the display. Shown inverted at left, the mouse has two wheels and a ball bearing for three-point support.

which permits the central processor and peripheral equipment to use memory simultaneously in most cases without interfering with one another. Only when the data sought is in the same module must one or the other give way.

With the double bus, the displays can be refreshed without loading down the central processor. Since displayed information is usually in one module, while the processor is working with another, refreshment can be handled directly from the main memory without an intervening buffer.

Bus schedule. All the conventional and off-beat equipment is connected to the second bus. The former includes a fast magnetic drum, a disk file, and a line printer, as well as provision for eventual connection to the Advanced Research Projects Agency's nationwide computer network [*Electronics*, Sept. 30, 1968, p. 131]. This apparatus has to be multiplexed onto the second bus. The standard SDS multiplexer doesn't have the capacity for this, so it handles only the drum and another special multiplexer designed and built by the center staff. A complex priority scheme wired into the multiplexers decides which device gets access to the memory when two or more conflict.

One of the unusual devices in the system is a crt display with a closed-circuit television link. A controller in the multiplexer drives six conventional display systems, which include the necessary character and vector generators, digital-to-analog converters, and the like. The crt in each display, however, measures only 5 inches in diameter and faces a television camera that transmits the image over a coaxial cable to a receiver, which replaces the usual display. The tv camera has 875-line, rather than 525-line, resolution. In addition, such equipment is cheaper than a scan converter.

Good deal. This approach has several advantages. The 5-inch crt's are much cheaper than larger units of less precision. Some of the saving on the tube cost goes for the tv setup, but there are other benefits that could be realized in no other way. One of the most important is that the crt's need be refreshed only 15 times per second. This slow rate causes a flicker on the crt display that is severely fatiguing to watch—for direct viewing a refresh rate of 30 per second is a minimum and 60 per second is preferred.

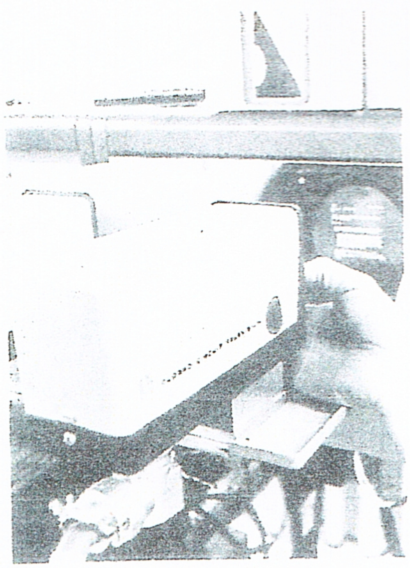
The slow refresh rate, however, permits a single controller to generate separate displays on several crt's, and the flickering is absorbed in the tv camera's vidicon. A vidicon image remains nearly constant for a short time before beginning to drop off—as contrasted with the nearly exponential decay of the crt phosphor. Broadcast tv cameras are adjusted to minimize this lag time; the center's cameras are adjusted to maximize it. As a result, the image is retained long enough so that the flicker in the tv receiver is hardly noticeable to most persons, except where parts of the display change rapidly.

Another advantage is that only a single coaxial cable is required from each television camera to its receiver; five cables would be needed to drive a remote display directly. And finally, a simple switch in the tv control system inverts the polarity of the signal. As a result, the display is black on white, rather than the white or green on black that is typical of most displays.

Animal kingdom.

The principal input device in the system is an ordinary keyboard, of the same type used with many crt displays. Characters, words, or statements, "typed" on the keyboard, appear on the display. They may show up at the top or at a point indicated by a "bug," a spot serving as a pointer, controlled by a "mouse," which is a small device resting on the tabletop near the user's right hand. The mouse is supported at three points—two wheels on perpendicular axes and a ball bearing for stability. As the user pushes it this way and that on the table, the wheels turn; analog sensors detect the motion, causing the bug to move on the screen, in tandem with the mouse's table track. When moving rapidly, the bug seems to have a long tail; upon close examination, however, the bug is seen to move in a series of small jumps, leaving a fading footprint, which creates the illusion of the tail. The lag time in the vidicon causes this; it's the only really noticeable effect and has no serious consequences on the system's operation.

Most of the commands in the system are represented by combinations of two or three characters. When issuing commands from a



Remote pickup. Closed-circuit tv provides low-cost precision display.

standard keyboard, the user must move his hands around on the keyboard and take his eyes from the display. Both actions tend to generate confusion and fatigue. To overcome these difficulties, the center staff has designed a small five-key handset that duplicates nearly every function on the keyboard. There are 31 ways to depress the five keys (not counting the "all-up" combination). These correspond to the 26 letters of the alphabet plus five special characters in an easily memorized code. With his left hand on the handset, his right hand mov-

. . . the mouse is slated for more human engineering . . .

ing the mouse and operating three control buttons on top of it, and his eyes on the screen, the user can work for hours with minimum fatigue.

At ease. One recent development that pleases Engelbart and his staff very much is a swivel chair that includes the keyboard-handset-mouse setup; it was developed by Herman Miller Inc., a leading furniture company that has become interested in the center's activities. Lounging in the chair with a tv set before him, a user can work creatively in comfort.

The center staff has ambitious plans for the future. For example, it expects to enhance the system's memory capacity through the special multiplexer and to add six more displays. Further experimental work has also been done with several new versions of the basic five-key handset. One staffer has even suggested a special glove with miniature switches in the fingers. More human engineering on the mouse appears likely as well. At the moment, it's basically comfortable to work with, but the three control buttons are awkwardly located for some functions.

More importantly, the center hopes to refine the system for group interaction, including multiple access to files for both reading and writing information. Since members of the groups may not be in the same room—they may even be continents apart—this requires computer-controlled audio circuits. Furthermore, with the closed-circuit tv in the display system, computer-controlled picture juggling should be possible—complete with such effects as split screens and superimposed images so that different files can be compared.

One of Engelbart's more exotic ideas is to have a tv camera on the display itself, pointing at the user and transmitting a shot of his features to the central system. This would permit members of an interactive group to see each others' faces—a potentially important feature since in personal meetings much information is often transmitted through gestures and facial expressions. ■ ■

Electronics | January 20, 1969