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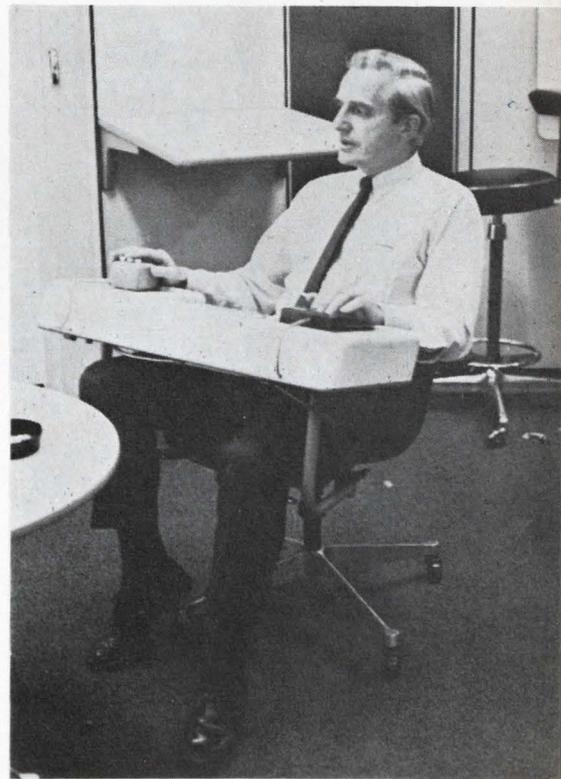
Chairman. Douglas Engelbart, who heads SRI computer project, sits in special console-equipped chair developed by Herman Miller for experimental system.

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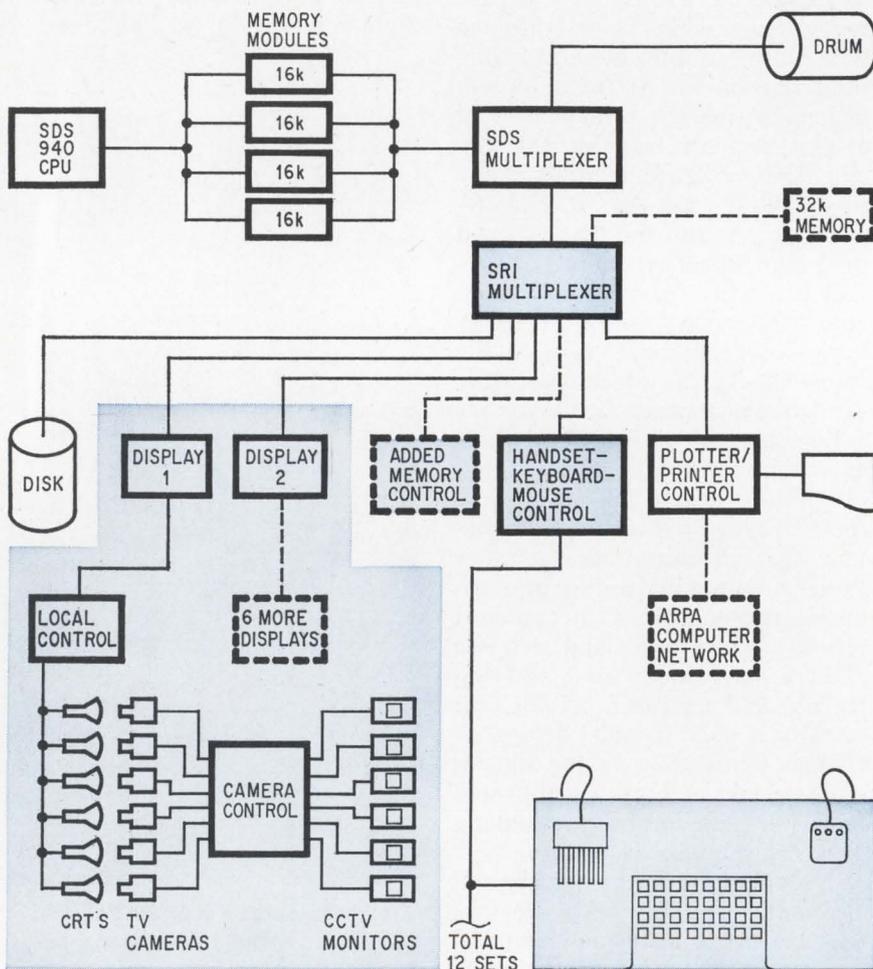
Double bus. The SRI system's computer memory is simultaneously accessible from the processor as well as special and conventional peripheral equipment.

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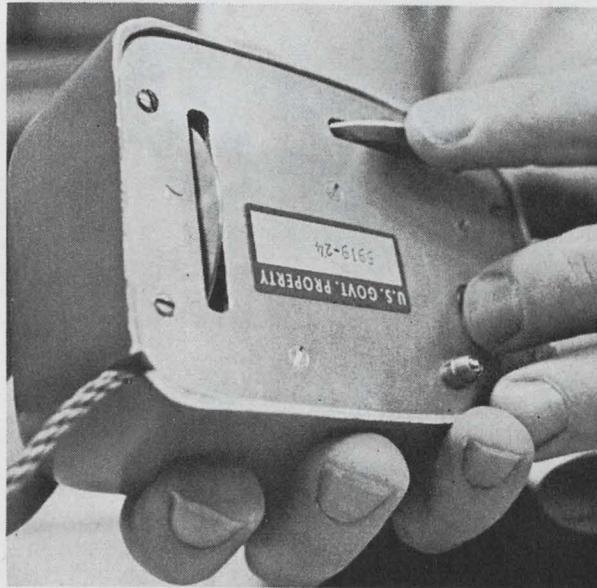
Inputs. Conventional keyboard is in parallel with 5-key handset, whose combinations correspond to individual keys. At user's right hand is a "mouse," the movements of which on any smooth surface are duplicated by a spot, or "bug," on the display. Shown inverted at left, the mouse has two wheels and a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

ond. 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.
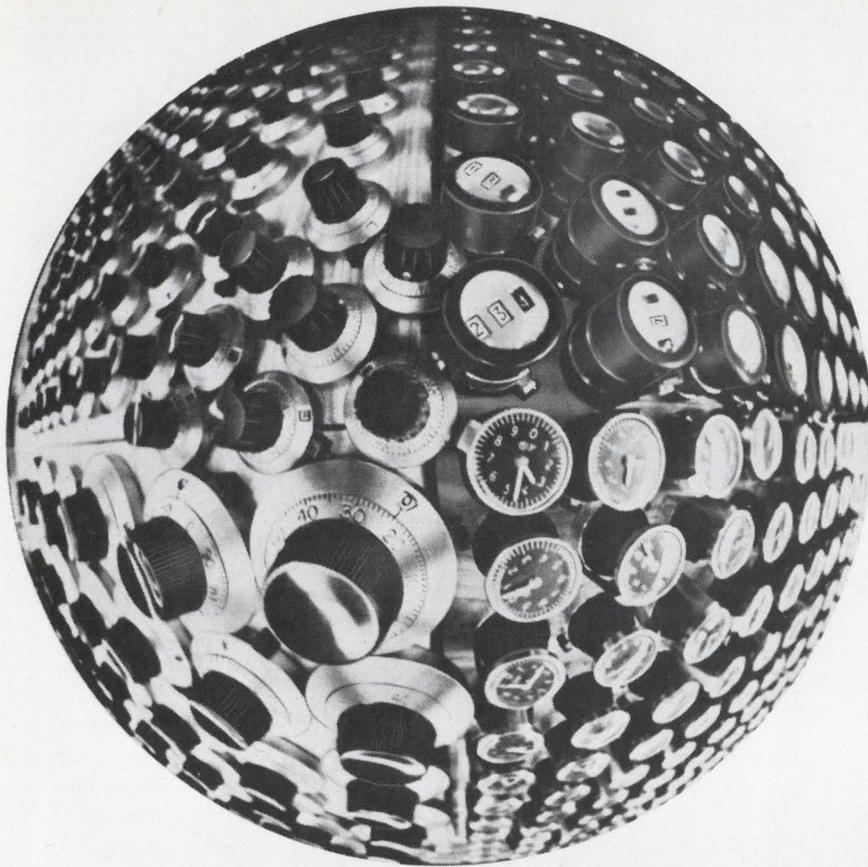
The slow refresh rate, however, permits a single controller to generate separate displays on several crt's, and the flickering is absorbed in the tv camera's vidicon. A vidicon image remains nearly constant for a short time before beginning to drop off—as contrasted with the nearly exponential decay 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.
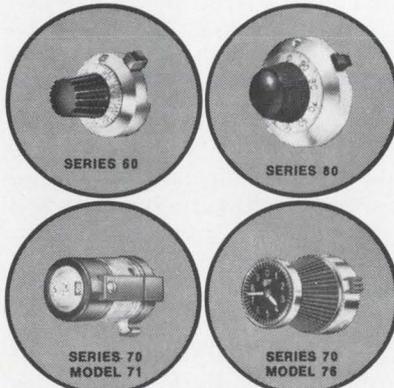
Animal kingdom.

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. ■ ■