Some of Dick Garwin's IBM-related Work 1952-1993

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Presentation at IBM Yorktown Heights

September 15, 2017

Nothing about:

Science

Non-conservation of parity,

Liquid and solid He-3,

Gravity-wave detection experiments,

Non-IBM applications

First hydrogen bomb, 1951-2

Arms control such as ABM Treaty of 1972 and Comprehensive Test-Ban Treaty of 1996,

Nuclear power

Near-real-time imagery from space,

Putting out the 500 burning wells in Kuwait in 1991,

BP oil spill of 2010,

Fukushima Daiichi reactor meltdowns of 2011, etc

-- all but the first of which were done after I joined IBM in December 1952

And here is the sort of thing I **will** talk about, but there are too many, so I have chosen six.

Computer technology

Spin-echo serial data storage, 1954

Thin-film-cryotron computer technology and the (first) IBM superconducting computer project, 1956-

Carrier-current remote answer-back in Lever House, 1955

Copying and printing technology

Choice of organic photoconductor technology for the IBM .. copier, 1965

IBM 3800 240-page-per-minute computer-room printer, 1970-

Misalignment-tolerant (book-mirror) optics for laser printers, 1980

Human-computer interaction

Gaze-controlled computers, 1981

Nose/head-controlled computer, 1982?

Touch input for color monitor on original IBM PC, 1980

and **Touch-input smart lecterns, 1982**

"Air bag protection" for laptops, 1993

Algorithmic innovation

Fast Fourier Transform (FFT—Cooley-Tukey algorithm), 1963

-- since 1970, mostly joint work with Jim Levine and Mike Schappert.

Questions welcomed, also by email or in small meetings later. Dick is RLG2@us.ibm.com

Aug. 29, 1967 R. L. GARWIN 3,339,165

MAGNETIC SWITCHING DEVICE

Filed Nov. 30, 1956

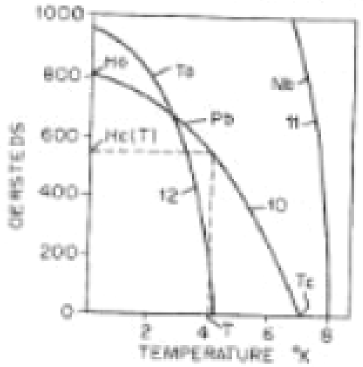


FIG. 1

FIG. 2

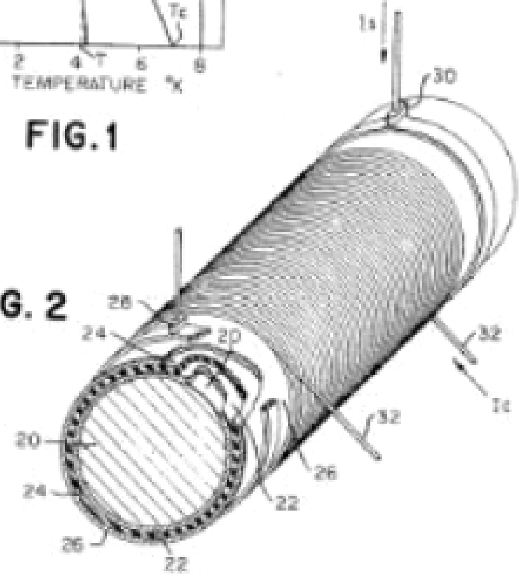
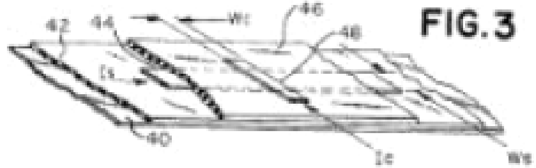


FIG. 3



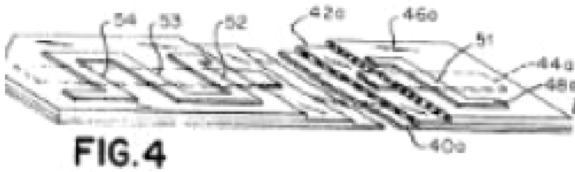


FIG. 4

INVENTOR.
RICHARD L. GARWIN

BY

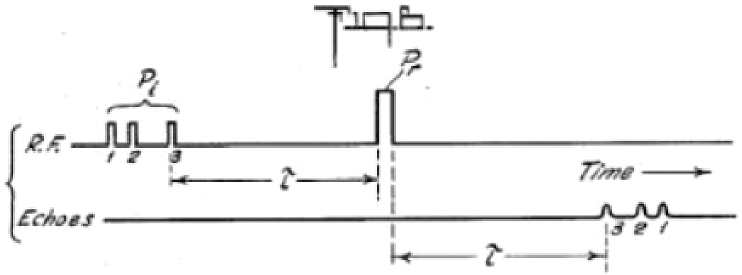
Paul M Enlow

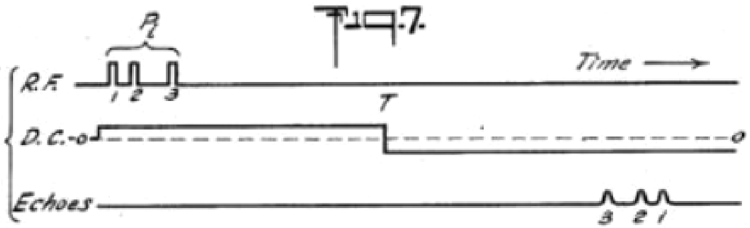
AGENT

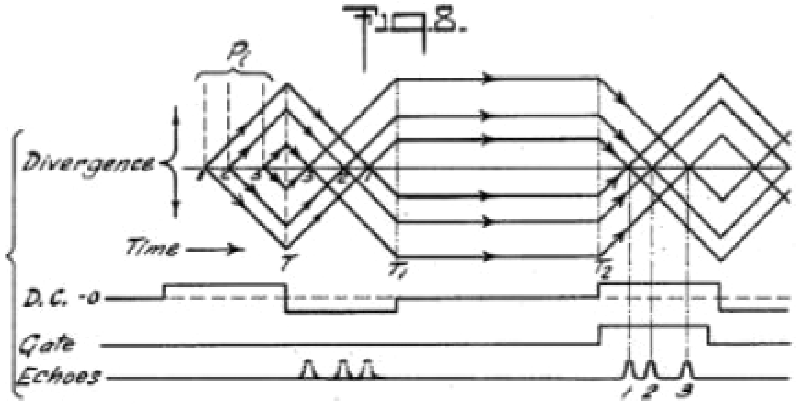
Oct. 15, 1957 R. L. GARWIN 2,810,108

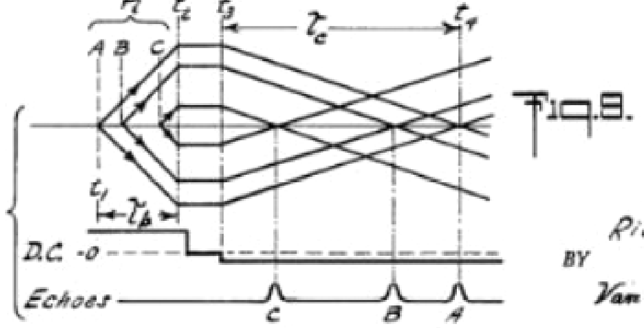
SPIN ECHO MEMORY TECHNIQUE AND APPARATUS

Filed July 15, 1955 3 Sheets-Sheet 3









INVENTOR.
Richard L. Garwin
BY
Van Deventer & Shively
ATTORNEYS

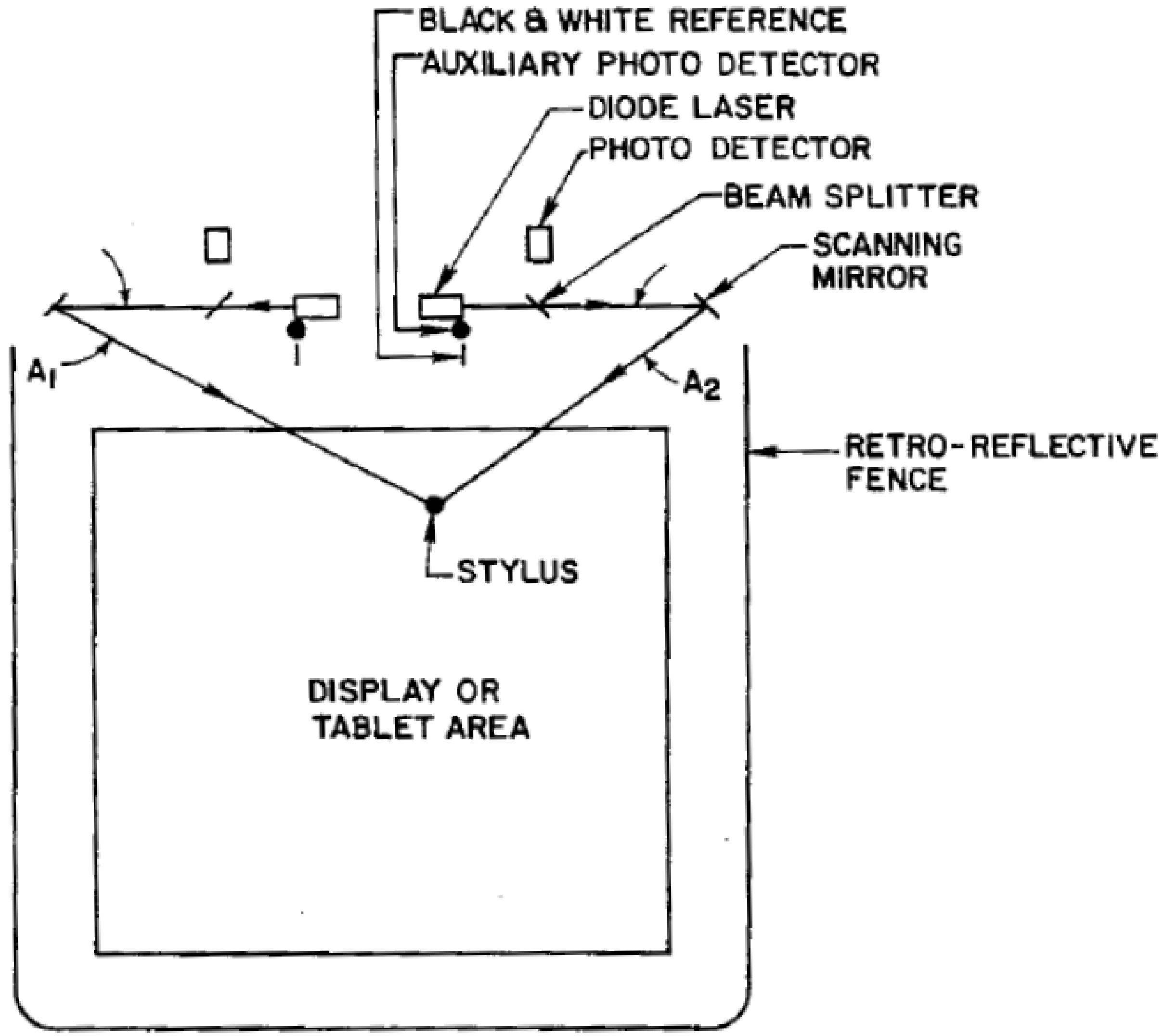


FIGURE 1: Device geometry and parts arrangement.

1976 ITL Meeting on Displays
June 8-9, 1976; Kingston, NY

IMPACT OF DISPLAY TECHNOLOGY
of CAPABILITY for
TRACKING OF EYE POSITION AND CENTER OF ATTENTION

June 7, 1976
R.L. Garwin/8-862-2555
IBM Fellow/General Sciences Dept.
7-043
IBM Thomas J. Watson Research Center
Yorktown Hts, NY 10598

EYE-POSITION SENSING (vast reduction in requirement for emitted light)

Some types of light sources provide light which is inherently highly directional (e.g., lasers); other types, although nearly isotropic emitters, are very small (e.g., LEDs) and may have a greater energy per unit area than is necessary in the display itself. The latter may be magnified by lenses attached to the emitters, converting them into larger effective emitting areas and at the same time reducing the solid angle of the emitted light so that the emitted energy is constant. Clearly, if the small solid angle can be directed at the viewer's eye the light source need not be so powerful as if all the emitted light were scattered isotropically by a matte screen.

At a viewing distance of 30 cm, hemispherical emission would put the emitted light into a 6000 sq cm area; a very restricted "exit pupil" of 1 cm high by 10 cm wide would occupy 10 sq cm; illuminating the viewer's pupils only would require less than 2 sq cm. Thus the emitters for this last case would require only 1/3000 the light output of the hemispherical emitters. Naturally, the display head will have to be adjusted either manually or automatically so that the restricted exit pupil does indeed cover the viewer's eyes. Such a directional source would then allow, for instance, a laser source of a fraction of a milliwatt, if a watt would have been necessary on a matte screen.

The Kodak Ektalite 120 microfiche viewer has such a restricted exit pupil, and it is able to use a battery to operate its bulb rather than the 150 watt bulb which is typical of other viewers. Fig. 1 sketches the ellipsoidal mirror optics of the viewer; a real image is formed on the mirror, which is aluminized self-skinned foam plastic, slightly hazed for enlarging the exit pupil. The Polaroid SX-70 camera viewing system uses a similar technique; the ellipsoidal mirror of Fig. 1 is replaced by the Fresnel

06/07/76 "Impact of Display Technology of Capability for Tracking of Eye Position and Center of Attention," 1976 ITL Mtg. on Displays, June 8-9, 1976, Kingston, NY. (060776 TPR) mirror shown in Fig. 1a, where the angles of the ellipsoidal mirror have been transferred to a plane. Controlled dispersion of the light from the real image on the Fresnel mirror is obtained by impressing the Fresnel shape with a master whose surface has been modified with shallow circular recesses (we would use anisotropic indentations if we wanted to obtain the two-eye, 1 cm by 10 cm exit pupil; pairs of canted indentations if we wanted two distinct 1 cm by 1 cm exit pupils for the two eyes).

The Ektalite 120 viewer is small enough to swivel easily on the desk to move the exit pupil side-to-side to cover the eyes; vertical adjustment is done by a two-finger unclamp mechanism. In general, one could sell a stripped display with manual adjustment of the restricted exit pupil, with a more expensive model tracking the viewer's eye and adjusting itself. This is analagous to the auto-refocus optional on many home slide projectors for about $20 increment. Eye tracking can make effective use of the retroreflective properties of the eye as an imaging system (cf. "Laboratory Oculometer", NASA Contractor Report NASA CR-1422 by John Merchant-- Honeywell Radiation Center-- October 1969), or could track on a retroreflective jewel clipped to the bridge of an ordinary pair of glasses. It is important to note that some displays (e.g., ROLED) have much of the mechanism required to do this tracking function, so that the added cost for the function is very much a function of the type of display, as is the reduction in the display cost.

Fig. 2 shows how an additional moving mirror can be added to the ROLED in order to make a smaller exit pupil in the vertical dimension. The light can be converged horizontally by mounting the lenses for the individual LEDs on a slightly smaller pitch than the LEDs themselves.

Fig. 3 is a block diagram of the small-exit-pupil display.

TRACKING OF FOVEA CAN IMPROVE INTERACTIVITY AND REDUCE DISPLAY REQUIREMENTS.

1. The fovea of the eye is provided with a denser array of sensors than is the remainder of the retina; the visual acuity in the foveal 1 deg is about 0.2 mr (milliradians) while that for the rest of the eye is about 2 mr. If a character display is used to present 66 lines of characters, with 20 pixel per character vertical pitch, the viewing distance and size of display should be such as to match the 1/20 line to the 0.2 mr visual acuity. Since 1 deg is about 16 mr, only 16/0.2 or 80 pixels vertically-- 4 character lines-- are seen sharply at any time, and only five or six characters horizontally. I have viewed scenes (not text)

through a dual resolution system which matches the visual acuity vs. position, and find that one has the impression of high acuity everywhere. The key point is that a display need provide only 100 x 100 high-acuity elements in the center of the field, and not (66 x 20) squared but only (66 x 2) squared elements in the periphery. This 30,000 pixel display can be a very different beast from the full 2,000,000 pixel display. Indeed, only 1/100 the data need be transferred to the display head (although if it is character coded the benefit is less), and video refresh over modest bandwidth lines becomes possible.

2. Possible benefits are thus:
   a. reduced bandwidth,
   b. eye-pen capability,
   c. reduced mechanical and optical requirements for some kinds of display.

In (c), it is clear that a video display could be built of a ROLED of about 200 coarse LEDs horizontally, if the image of another 100 fine LEDs could be moved horizontally by a galvanometer mirror anywhere in the field that the fovea is directed. The corresponding coarse LEDs would be turned off in the region of overlap.

3. How track the fovea?
The NASA reference gives us one way--to compare the position of the corneal glint with the center of the bright (because retroreflective) pupil. Alternatively, and briefly, if the display uses highly-limited exit pupil, there is enough light returned from the retina to the neighborhood of the display LEDs themselves to map the retina; cross-correlation or feature identification of the retina can then be used in such a display with little additional mechanism. This method could also provide verification of the identity of the display user, since retinal features are quite specific to the individual.

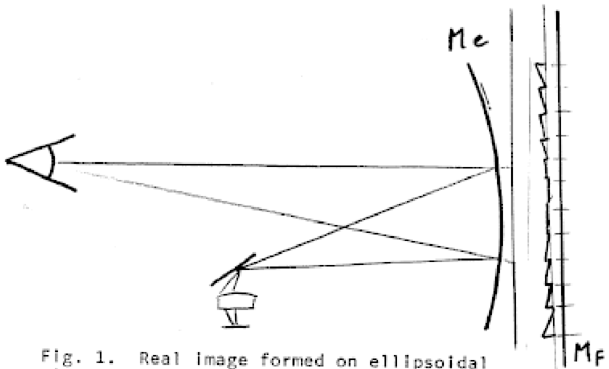


Fig. 1. Real image formed on ellipsoidal mirror M_e, exit pupil size controlled by haze.

Fig. 1a. Fresnel mirror, M_F, as alternative to M_e.

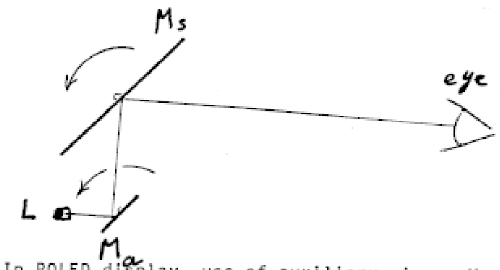


Fig. 2. In ROLED display, use of auxiliary mirror M_a to take light at constant angle from the LEDs as the main scanning mirror M_s rotates. This allows use of LEDs with smaller emission solid angle.

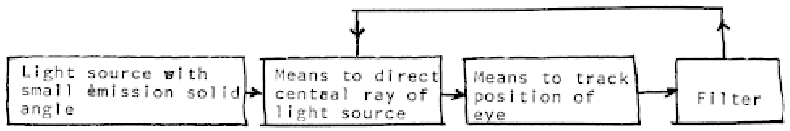


Fig. 3. Block diagram of display using servoed exit pupil.

Comput. Biol. Med. Vol. 14, No. 1, pp. 77-89, 1984.
Printed in Great Britain.

0010-4825/84 $3.00 + .00

PERFORMANCE OF AN EYETRACKER FOR OFFICE USE

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(*Received 3 September 1981; in revised form 15 February 1983*)

Abstract—The design, construction and performance of an eyetracker is discussed. The device provides real-time signals giving the direction of a user's gaze, with a precision of 0.3 degrees of arc and an update time of 17 ms. It is usable by a wide range of subjects in normal office-type conditions.

Eyetracker Infrared Pupil-cornea Video camera Signal processor Digital computer

INTRODUCTION

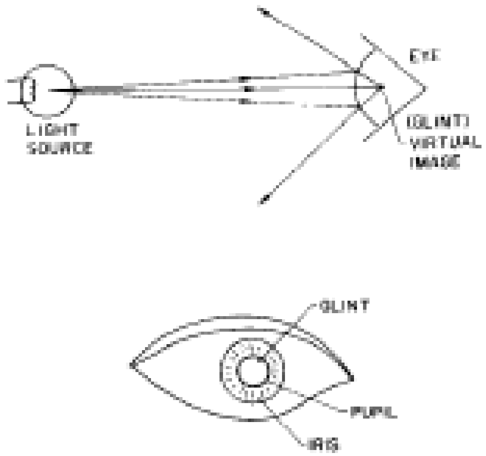
Numerous techniques exist for determining the direction of a viewer's gaze [1–3]. These have been used primarily for physiological and psychological experimentation. There are several interesting possibilities for the use of such devices with computers, either to enhance the performance of displays or to provide alternate modes of input. Some of this work is described separately [4]. Here, we describe the principles, construction and performance of an eyetracking device which we have built for use as a laboratory tool. The speed and accuracy are adequate for a wide range of useful tasks, while the human factors allow it to be used under non-laboratory conditions and with other than ideal subjects.

BASIC PRINCIPLES

The photo-receptors on the human retina are not uniformly distributed, but instead show a pronounced density peak in a small region known as the fovea [5]. In this region, which subtends a visual angle of about 1°, the receptor density increases to about 10 times the average density. The nervous system aims the eye to keep the image of the region of current interest centered accurately on the fovea. The appearance of high resolution in all directions is thus an illusion maintained by a combination of physiological mechanisms (rapid scanning with brief fixations) and psychological ones. As an example, a character on a typical computer display screen subtends an angle of about 0.3° at normal viewing distance. Such characters can barely be resolved unless the eye is quite accurately aligned, and for a duration of about 0.2 s. Therefore, it is possible to accurately determine where a person is looking by measuring, with a suitable device, the orientation of the optical axis of his eye lens relative to his foveal region.

An adjunct to a computer display must be unobtrusive and usable by a wide range of subjects under reasonable ambient conditions. Unfortunately, most eye-tracking devices are workable only in a clinical or laboratory environment, with restrictions on head motion, position, ambient lighting and so forth, and are not generally usable with eyeglasses or contact lenses. A technique pioneered by Merchant [3], offers a workable compromise between accuracy and convenience of use. It allows a reasonable range of head motion, tolerates a range of eyeglass types and works in ambient light. We have adapted his technique to our needs.

Figure 1 shows an eye illuminated with light from a small source. A bright virtual image of the light source is formed by reflection from the roughly spherical front surface of the eye (the cornea). As the eye rotates, the location of this corneal "glint" remains nearly fixed in space



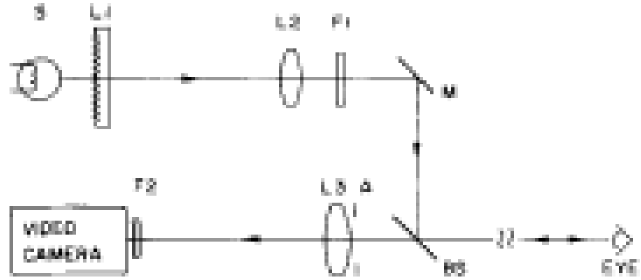


Fig. 2. Arrangement of eyetracker. S: Type EL-1B microscope illuminator bulb.
F1, F2: Type RG830 filters. BS: Beam splitter.
M: Folding mirror. A: Adjustable aperture.
L1: 51-mm F. L. × 63-mm dia. Fresnel lens.
L2: 250-mm F. L. × 42-mm dia.
L3: 180-mm F. L. × 40-mm dia.

Fig. 1. Appearance of an eye illuminated by small source, showing formation of the

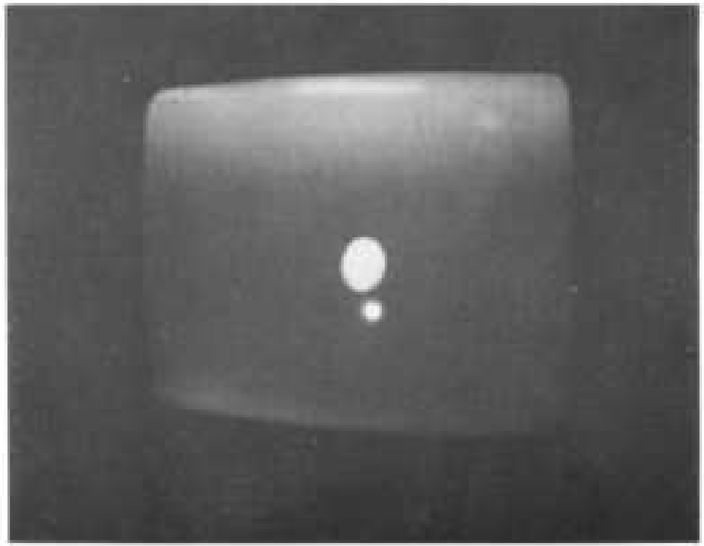


Fig. 3. Video image of the eye as observed on the slave monitor. The large disk is the pupil observed in light retro-reflected from the retina. The bright spot is a de-magnified virtual image of the illumination source formed by specular reflection from the curved front surface of the cornea.

Fig. 4. Photograph of the eyetracker. The illumination system is inside the white tube in the background. The TV camera is at the left. The gimballed aiming mirror is just to the left of the display terminal.

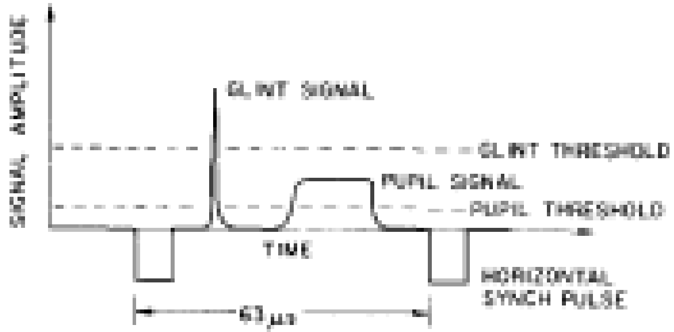


Fig. 5. Video signal for a raster line which crosses the glint and then the pupil. Typical threshold levels are indicated (dashed lines) as well as the horizontal synch pulses.

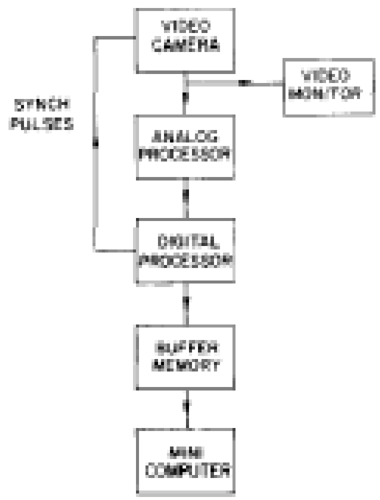


Fig. 6. Block diagram of the signal processing system.

Performance of an eyetracker for office use

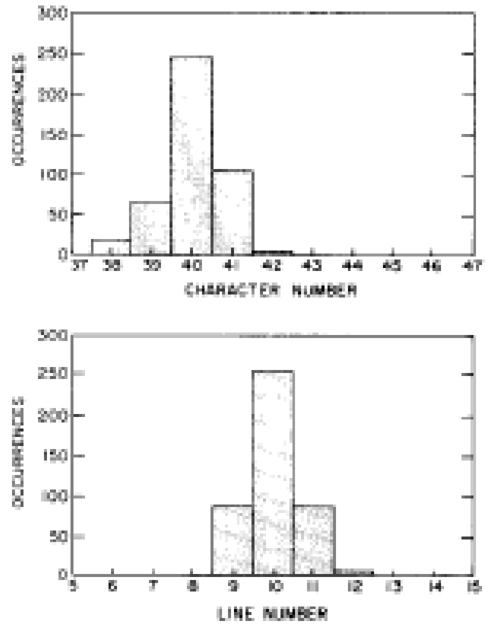


Fig. 8. Distribution of 450 fixation measurements using an artificial eye (see text). The co represent the apparent aiming point (column and row number) on a 10 × 6.5 in display ter rows of 80 columns) at 18 in viewing distance.

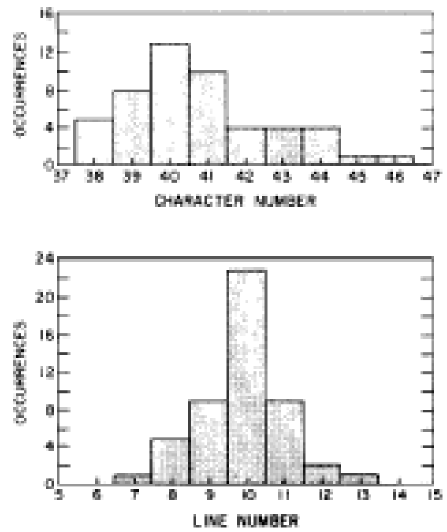
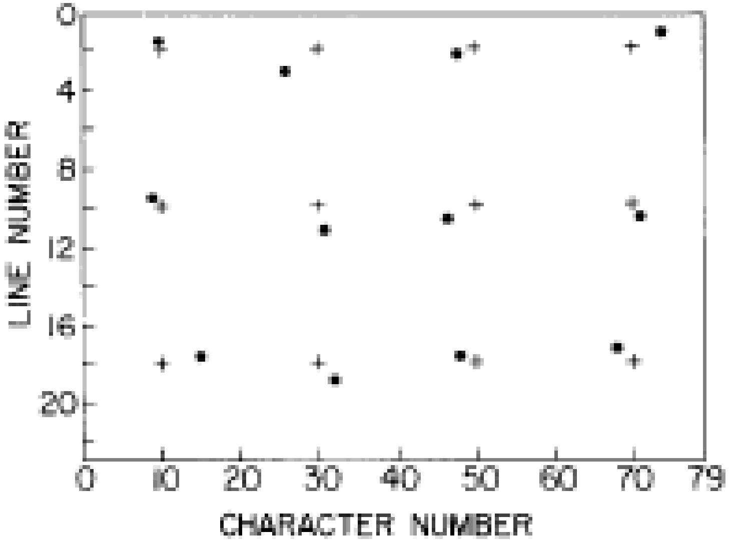


Fig. 9. Distribution of 50 fixation measurements for a human eye, aimed at a character located at column 40, row 10 on the computer terminal.



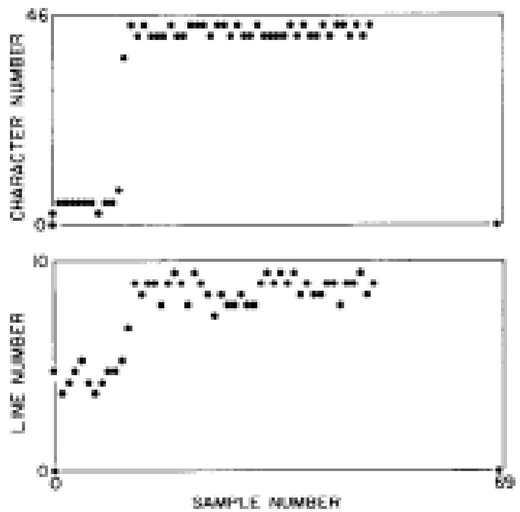


Fig. 11. Tracking record. A target was moved from screen location (5,5) to location (39,9). The sampling interval was 20 ms.

06/00/87 "Touching Terminals... They Don't Come Any Friendlier than the InfoWindow System," article by J. Sullivan on pp. 50-51 of Think. (060087..JS)

Touching Terminals...

They don't come any friendlier than the InfoWindow System

While Americans were discovering "all-natural foods," "natural" fibers and even "natural" hair coloring, Jim Levine was looking for a way to make a "natural" computer.

"I was looking for something that would make the computer simpler and more natural to use. Most people want computers to be like television sets. You turn them on and they work. No special skills required."

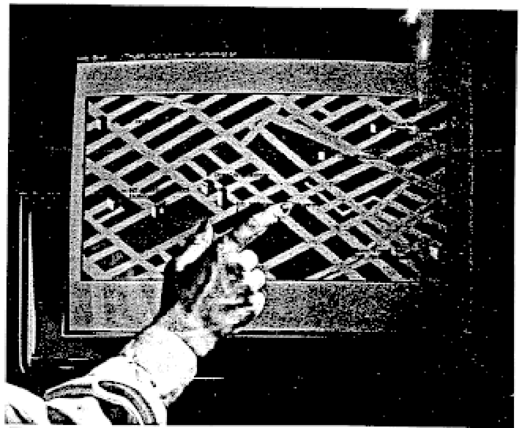
The comparison brings a slightly amused smile to IBM Fellow Dick Garwin, Levine's manager at the Thomas J. Watson Research Center in Yorktown Heights, N.Y., and the man who hired him more than 20 years ago at IBM's former Watson lab in New York City. Most recently, the two worked together on the "touch screen" technology that helps make IBM's new InfoWindow System so inviting to use.

"There will always be those of us who feel quite comfortable using a keyboard and a few commands to do what we need to do," says Garwin, whose well-used 3277 terminal occupies a prominent place in an office overflowing with research journals. "But there's no doubt that touch screens will make a big difference to people who have never learned—or don't want to learn—how to make a computer do what you want it to do."

A touch screen does just what the name implies—it allows a user to walk up to a terminal and make the computer perform a selected function by simply touching the screen. In the classroom, for example, a student can review a history lesson on the American Revolution by pressing a box on the screen that says "American Revolution." At a car dealership, the prospective buyer can look at next year's lineup of new cars by touching a box marked "1988." And instead of walking all over town, shopping for anything from gifts to the right insurance policy can now be done by placing a finger on an InfoWindow screen.

by Joanne Sullivan

060087..JS



Through the InfoWindow touch screen at the IBM Gallery of Science and Art, visitors can find other interesting places to visit in New York City with just a touch.

It is a deceptively simple idea—to touch a computer screen and make it work. In reality, scientists in and outside IBM have been searching for the perfect touch screen for more than a decade.

Levine and Garwin began working on the concept well over a decade ago. But it wasn't until 1984 that one location—Research Triangle Park in Raleigh, North Carolina—decided to incorporate the idea into an actual product.

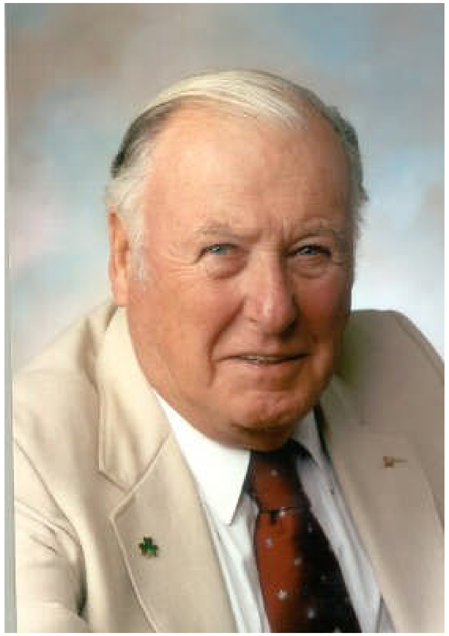
"When I first started working on touch screens in the early '70s, the idea was solid, but somewhat premature," recalls Levine. "Most people were still tied to time-sharing systems which weren't capable of giving the immediate feedback that a touch screen requires."

The birth of the IBM Personal Computer, however, changed all that. Once again, Levine and Garwin turned their attention to the touch screen.

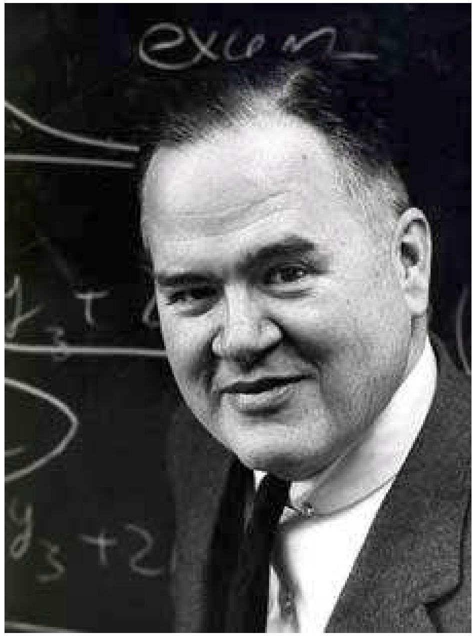
Their first model, recalls Levine, was made with "off-the-shelf" parts.

"We took some piezoelectric pills [electromechanical sensing devices], molded a piece of plastic to fit over a PC screen, added a bit of electronics, and stuck it in front of a PC with double-stick-foam tape." And to Levine's and Garwin's delight, it worked.

Cooley-Tukey FFT Algorithm



James Cooley



John Tukey