SOFT COPY DISPLAY

DR. BOYLE: Ladies and gentlemen, we are now going to talk about the soft copy displays needed in cartography, looking at it from the hardware side. We had a preliminary preview of this in the Monday discussion with Waldo Tobler's group. We think we have to define this more closely in engineering terms in order to find out our needs. This is very much a matter of making certain suggestions to you to get your reactions -- what do you want in cartography?

Mr. Pucilowski from the U.S. Electronics Command will unfortunately not be able to come. CDC was also not able to come. I do not know whether Pucilowski could not come because he did not like the spelling of Ft. Monmouth, which came out in the program as Ft. Mammouth -- (Laughter) -- but, at any rate, we have two very expert people here. We have Gene Slottow, who is certainly one of the fathers of plasma displays; and Bob Durbeck from IBM, at San Jose, who has also done some very exciting work in new types of displays.

Before they start I will give some of my thoughts on this matter.

The workhorse of most cartographic interactive display operations at the moment is the Tektronix series, particularly the 4014 display. Very good quality displays, but they do have limitations in their ability for cartography. We have to use the lights dimmed in the room; they are not quite large enough; we cannot overlay an optical image -- that is, an existing map separation and a digital one, because the linearity of the cathode ray tube is not exact enought to enable this to be done. This is one of the reasons that I have felt that the plasma display, where we have a whole array of mechanically fixed pixel points, enabling non-linearities to be programmed out, has considerable advantages for the future of the map community. We can have large size, even full map dimensions. Another advantage of the plasma display, is the fact that it is erasable point by point, just the same as it is writable point by point. It is a storage device, and you can enter information in vector form and then scan it to output in raster television form.

There are many interesting and useful side issues relative to the different displays which I hope will come up and I hope we can develop in our discussion. Ideas of requirements are certainly much more vague in this than in the digitizing and storage areas. We need your help, we want your comments to start to move. There are many possibilities, but the needs are not quite clear.

There is another area of displays which I do not think either of the gentlemen here will be talking about, but has recently been coming to the fore. Many people are now using map information in geographic information systems and have said to me, "I have to put on a show of my thematic maps, and I need one of those big Sony or Advent projection displays." I say, "Well, you know, it is not very good resolution" -- "That doesn't matter. We'll take the lower resolution, but we know that this method goes over well with a crowd of people who just want to see general imagery on a geographic information display basis."

I do think there is now a requirement coming up for these relatively low cost television projection display units tied into a mass memory. It has to have its own refresh memory, of course, to make it equivalent to the storage display, when tied onto a computer. I have not actually seen one myself. There are many such as the Ramtek display, which uses an ordinary colour television monitor. Presumably, these can be attached to a projection unit.

Maybe Dick Clark could say a little more about the unit they have at the Experimental Topographic Laboratory, where they have one of these Advent displays. They are using only two colors of the three color projection tube, the green and the red. They feed these from the computer and if you sit in the audience wearing red and green glasses, you see three-dimensional images generated by the computer on the screen. We are not quite certain where the use would be, but it is delightful to watch, and, again, maybe the method for geographic information systems and thematic maps which have to talk to politicians and the general public.

I have learned in my travels that much depends upon the presentation of data to the uninformed user if geographic information systems are going to go. They do not really like these small displays that have to be examined closely. They want to stand back and look at it on a wall; they do not mind if it is not quite such a good image.

I am now going to ask Bob Durbeck to start. He is from IBM in San Jose. He is going to open the discussion and tell you about some of the work they have been doing. I think he is also going to ask you questions. He is going to give you ideas and say, "What do you think? What would you like to do in these areas?"

DR. ROBERT C. DURBECK: Thank you very much. First I would like to say that it is a pleasure for me to be here today. I also want to make it clear that I am very new as far as cartography goes. My only direct association to this field prior to your conference here starting Monday is that I worked as a surveyor for part of one summer. To calibrate you on my background and interests, I am manager of the Exploratory Technology Department in San Jose Research at IBM. We have been involved in such things as display systems (which I will be talking about today) in magnetic recording, and in beam-addressable recording (similar to some of the work and projects you heard about earlier today). We have also been involved in printing, image processing, and even some semiconductor work. I hope to share with you some of my overviews on displays, which may be conditioned a bit by my involvement in all these different technologies and efforts.

As I said before, Monday was really my first introduction to the problems and issues you face with automated cartography. I find some of the decision-making processes (such as whether you automate or how you would go about it, what equipment you would select and so forth) are very similar to some of the decisions we go through in many technical areas. In preparation for this panel discussion, I listened very closely to the earlier panel discussion on Monday on display requirements for cartography. I must admit, at the end of that discussion, although I felt I had learned quite a bit about some exciting work at JPL and the University of Southern California, I really did not learn too much about what your display hardware requirements really are. For example, Carl Youngmann was sufficiently vague in his presentation that I find myself in a very unique "carte blanche" situation where I can guess what you really want. I will be talking more about that later.

Following our panel presentation here, I hope we can open this session up into a dialogue of what you think you would like for large-scale, high-resolution color displays, and what possibly could happen in technology in the next decade. I will allude to some things that may be appearing on the scene. I would also like to share some of my initial guesses of what you could use for displays fruitfully with you, but I will spend most of my time discussing a group of display technologies which I think have the potential of being useful to you. Let us assume that you build up your display data bases and that you have all of this information in your data files. Let us also assume that you wish to temporarily exhibit a map format with overlays and so forth before you commit this to hard copy--perhaps you never want a hard copy, thus, the term used earlier, "soft copy." I am presuming (and guessing) that it would be very valuable for you to have a very high resolution display, with many millions of picture elements (which I will shorten and call PELS), with several colors as a minimum, with gray scale, and with overlay capability (either slides or other types of overlay). My basic premise is that a group of technologies that could basically offer this capability are those involving light valves. I believe that they offer a very promising scenario for future high resolution, high picture content, displays.

What do I mean by a light valve? The foils the projectionist is using here are static light valves. The slides used in the Kodak carrousel back there are light valves. The type of light valve I am talking about, though, is a dynamic one. It can be changed rapidly. You can write on it, erase it, and put new images on it. You can project it, either onto a screen this large, for example, if you so desire on a front projection screen, or you can back project it on to a smaller screen for direct viewing. You all have seen numerous examples of the latter; some slide projectors come equipped with a back projection screen.

Maybe now we can have the first foil (foil No. 1). I will start with foils and will be moving to slides and back to foils, so hopefully it will not be too confusing. This first foil is meant to show the questions I had (and have) concerning what type of displays are really needed for cartography. I am not now considering the type of displays that are used for interactive design. What I am talking about here are displays where you will want to display a large map or large parts of a map.

Questions. What type of speed do you need? How many picture elements or PELS do you need per second? What is minimally acceptable, what is the desired speed? How many colors and hues and gray scale levels do you really need? What size of display do you want? How about the total number of picture elements? Are a million satisfactory? Probably not. Are ten million? Perhaps you need 50 million. These are the types of questions I would like to get back to after we have had our formal presentations here--in terms of a question and answer period with the audience.

Could I have the next foil (foil No. 2), please. Let me just say that you are not alone, as they say in the science fiction world. There are a lot of other potential users of displays who have the same type of questions and probably have the same type of generic, high picture content, display needs that you do.

Let's look at the area of computer-aided design, for example, for engineering drawings, for laying out semiconductor chips where they need very high resolution (where we are talking about tens of thousands of circuits on a chip), at computer simulation, special document distribution, and computer-aided instruction. We saw a slide presented earlier that typified the latter type of application. For electronic mail, where you may have a letter transmitted--not physically--but electronically, you may not really want a hard copy. You may want to only view it on the display screen. And it may contain NCI--"non-coded information," may contain a picture, or may have a signature. The total picture element content needed to display NCI is quite high.

Let's consider business displays and conference room type applications (just like you are looking at right now). You may want a similar display in a conference room where you can dynamically change the image. The next level above this is to go into teleconferencing, where you can have groups of people talking to one another across the country, for example, and where you can each be looking at the same display and be updating it in real time. Other potential applications include, of course, military war room--even newspaper composition, where newspaper editors would like to see what the page of the newspaper looks like before they go to press; you can project up an image of the page for editing. Light valve projection technologies are capable of doing these types of applications.

In the field of scientific data presentation, one of the key possible applications there is in seismic data for oil drilling and, of course, there are many others.

So, you are not alone. The encouraging word here is that I think over the next decade there will be technologies that will deliver high resolution color displays, not only for cartography but for all these other applications. The total aggregate of applications will mean it will be economically feasible for these types of displays to appear at a reasonable cost. May I have the next foil (foil No. 3), please....just a little bit of background about the range of displays that are potentially possible. I have taken my own classification here, starting on the left (in foil No. 3) from the low end displays (down to one or two line type prompting displays) all the way up over here to the right where you have very high performance, high quality systems that require very new display technologies. In between we have the bulk of the modern display applications today: highly interactive graphic systems (using light pens), Tektronix type storage tube, and many of the commercial alphanumeric type CRT displays.

Now, what technologies span these ranges of applications? Could I have the overlay on that foil now, please. This combined foil (included in foil No. 3) is a little busy, but hopefully it will be readable. Let's talk about the very low end displays for just a moment (and then I am going to drop that particular area and not talk about it for the rest of the day). Typically here one thinks of light emitting diodes, electrochromic displays, liquid crystal displays, and some mechanical type displays. Here we are talking about a few dozen or at most a couple hundred characters. As you get into the low end graphics and interactive systems, you find that the CRT, our good old enclosed glass tube, is the predominant technology there. Also, a relatively new technology that I think Gene Slottow will be talking about a lot more in the next talk is the gas panel technology shown there. That technology is growing, and is the flat panel display for certain application area. In the region where we get into highly interactive graphic systems and medium quality non-coded information, the CRT is still king. It represents at least 90 percent or maybe 95 percent of the total. For comparison sake I have shown TV quality with the arrow.

Now the gas panel, obviously, can be and has been extended up to much higher PEL content and greater utilization than shown in the foil, but it faces severe competition with the CRT. The CRT can be extended somewhat, and one of the types of extension is the Tektronix storage tube, which provides good resolution capability, and is becoming extensively used.

But the generic technology class which looks like it could expand out further, out into the greater demand and needs for higher and higher quality, more function, color, gray scale, so forth, seems to be high resolution light valves. I will be talking about these light valves for the remainder of my presentation. It is my opinion that these light valve technologies will be the area to really look for in the future for the types of displays that I think you will want in cartography.

Could I have the next foil (foil No. 4), please. Let me go over just a few of the advantages of projected light valves in general, and then I will get into some specific technologies within the light valves category that have been developed over a number of years, and then I will lead up to something new that looks quite interesting today. Basically, when you have a light valve, the same single technology and hardware can be used to make a variety of display sizes. You can have anywhere from a ten inch by ten inch to a wall size display--same basic technology, depending on just how you design your optical projection system. You can have either wall or back projected displays. If the light valve resolution is high, you are almost unlimited as to the number of picture elements that you can have. I will put some numbers on that a little later. It is quite high compared with what we are used to today. If you project, you obviously can always have image overlays. You can have slides as overlays. You can have previously written images that have been developed used as overlays. You can have color by co-projection. It is also possible to implement a moving cursor with a joy stick.

If you have non-structured light valves (and I will get into what I mean by that--but just remember "non-structured," means no structure in the light valve) then the number of PELS is really only limited by the addressability of the projected light valve. In other words, the technique with which you write on the valve and the acceptable size and cost of the projection optics may be more limiting. The light valve itself, as will be shown, is basically not the limiting factor.

May we have the next foil (foil No. 5), please. Let me just take you through a few of the typical erasable light valve technologies that have been developed over the last half decade. I do not pretend that this list is exhaustive. For example, I will not talk about the GE projection system, and I will not mention the Sandia work on ferroelectrics. But let me start first with the Deformographic system that has been developed at IBM, and that some other people have worked on, too. The FAA has purchased a few of these systems developed by IBM, and have used them in an experimental mode for air traffic control. Essentially, the technology uses an E beam, like in a CRT, which writes on a dielectric elastomer package, and the resulting charge deforms the elastomer. Then by reflecting light off the elastomer through a Schlieren optical system an image is created on the screen. I will say more about that later.

There has been work done by Westinghouse on large arrays of micromechanical deflectors. Again an E beam is used to develop a charge on the little deflectors. When you shine a collimated beam of light on those deflectors that have been deflected due to the charge, you direct light onto the screen. Thus you can write an image in that way. Xerox has worked for many years on the Ruticon system, which is another variant. They optically image a CRT, or a TV type system, onto a photoconductor coupled with an elastomer. Then the phenomena is very similar to the Deformographic system, just a different way of introducing deflections into the elastomer. There also has been work done, most notably by Hughes (but also by Xerox), on an optically addressed liquid crystal light valve, and Hughes has a commercial product out today based on this technology. Basically they image a CRT, like a TV image, via fiberoptic face plate, onto a photoconductor which acts as a voltage divider to selectively switch the liquid crystal. It is not quite the same technology as used in the liquid crystal watch, but it is similar in concept, and I will mention more about that later.

More recent work has been on laser-addressing liquid crystal cells, where you thermally write spots on the liquid crystal using the power of the laser. IBM has been working on this approach, some of this work is in my area. Western Electric has also followed up on some of the earlier work in this field at Bell Telephone Laboratory. It turns out you can use either semiconductor lasers (little gallium arsenide lasers which are about the size of a grain of salt) or you can use fairly large gas lasers to address these liquid crystals. You thermally write with the laser on the liquid crystal cell. You can erase images very rapidly with an electric field. I will be saying more about this technology later.

May I have the next foil (foil No. 6), please. This is a pictorial of the Deformographic system, the first one that was mentioned on the last foil. Here you address the backside of a dielectric disk--I believe they actually use mica. You deposit a charge with a deflected CRT beam. This charge then creates minute little deformations on the elastomer on the other side. If you image with a light source as shown, and have a Schlieren optical projection system, then these minute deformations on the elastomer show up as black on the screen. That is the way that technology works. The FAA has used several of these systems.

Let me say that this system is very good in a vector mode. You can get tens of thousands of vectors up on the screen. It is not quite as good in a raster mode because of the adjacency effects of the minute deformations; they tend to write one another out. But in a vector mode you get a very large number of vectors.

May I have the next foil (foil No. 7), please. The next system I will discuss is the Westinghouse mirror matrix display. What they have is a large array of very small deflectable flaps. These are 50 micron in size or 2 mils, if you feel more comfortable with English units. Essentially what they developed was a technique based on semiconductor processing technology to etch out these tiny little flaps. They are like tiny little toadstools, only they have cuts in them, if you look at them from on top. An E beam then addresses these flaps and deposits a positive charge (because of secondary emission it actually becomes a positive charge rather than negative). When you develop this charge these little flaps deflect because of the capacitive effect.

Could I have the next foil (foil No. 8), please. When these flaps deflect, they redirect the projection light such that it reaches the screen whereas it normally doesn't. Let me show you the optical system (foil No. 8). Here you have the light source. Here also is that array of mirror matrix targets I was just referring to. If we take an undeflected little valve or flap, the projected light is reflected back and it hits the stop. It hits the mirror and gets deflected out, so that the light never reaches the screen. Now we look at a target element that is deflected; the light is deflected around this light stop and gets to the screen. Thus, the image of the flaps that are deflected appears on the screen. Westinghouse worked hard developing this, and came to a fairly fruitful conclusion: It is a viable technology. The difficulties come about when you start to require up near a million PELS or higher. The yield on making every one of those little flaps work gets to be a problem, and also the contrast ratio for adequate light levels on the screen becomes a problem. But, no doubt about it, the technology provides a fairly high overall resolution system.

May I have the next foil (foil No. 9), please. This is the Ruticon system of Xerox. Essentially, shown here is the projection light source, and the CRT which is imaged onto a combined photoconductor-elastomer system. Everything else is very similar to the other projection systems. Where the light source rays are undeflected (where there is no modulation or no deformation in the elastomer) no light gets to the screen. Where deformed, light will get past the stop and be imaged onto the screen. I have seen some very good images based on this technology.

May I have the next foil (foil No. 10), please. The Hughes system is a little more sophisticated in terms of modern thin film techniques in the sense that it requires a many-layered photoactivated liquid crystal cell. Essentially what they have developed is a dielectric mirror. That is, a mirror that is non-conducting. They project an image onto the photoconductor. Where the light impinges, the resistivity of the photoconductor is reduced, and this creates a charge pattern on one side of the dielectric mirror. This charge pattern then appears across the liquid crystal, locally changes the birefringence of the liquid crystal, and the charge pattern appears as a projected image. The cell has no storage, however, so that you have to have the subject image on at all times when you want to view it in projection.

What is the advantage of doing this? Well, you can project the image from a small CRT, say, a one- or two-inch CRT, with which you can get high resolution and many spots very economically. You also do not have the problems of linearity and so forth you do with high divergent CRT tubes, and the result is you can project a small image up much larger. Thus, it is a way of converting a CRT into a large projection screen display fairly economically.

Hughes has a unique way also of introducing color directly into this technology, but I will not get into that today.

May I have the next foil (foil No. 11), please. Now, how do you in general introduce colors from light valve displays? Well, you do it by super-position of images. The schematic on this foil is that of the Hughes approach, but it is a fairly well known technique. If you have a white light source you can have three targets with green filters, red filters, for example, and blue filters--three primary colors--and produce many colored images, depending upon what you are writing on each of the three channels (which could be considered the light valves in this case). If you had a two-color system, for example, with just two filters, you can produce either of the two primary colors on the secondary color, or black on the secondary, or black on either of the two primary colors. Thus, you have those options even with just two channels or light valves. If you go to three light valves, your color combination possibilities go up substantially.

May I have the next foil (foil No. 12), please. The technology I want to spend a little more time on now is one we are presently working on as a research project. Essentially what we do is use a laser to thermally write on a liquid crystal cell. Here on the left side of the foil is the laser beam. Here in the center is a liquid crystal cell, where the liquid crystal material is sandwiched between glass plates and two conductive coatings; one is transparent for projection. When you align the liquid crystal by an electric field, all the molecules are lined up in the same direction and the liquid crystal looks clear, like water. When you thermally address the cell with the laser, you locally heat it and it then rapidly cools and provides scattering in the given area (focal-conic structures). Where these molecules are completely disoriented, they scatter light very well at angles of up 20 to 30 degrees, typically, so that when you project the cell onto a screen, those spots appear black. You can erase the cell by just applying an AC field across it for 10 to 20 milliseconds.

Could I have the next foil (foil No. 13), please. I am going to, in a few moments, show you a slide of some light valves fabricated based on this technology, plus some slides of images that have been projected from these light valves. But first I want to cover what one can do with this technology, where we are today and how far we feel we can extend it. To begin with, you can write these microimages with spots as small as 6 microns, although we typically work with 12 micron spots. You can project this image very large, of course. You also can have the overlays that we talked about before. The fact that you have an unstructured target means that the number of PELS is not limited by ultra high linearity requirements on the addressing beam. If instead you have individual deflectable tiny elements or flaps that you address with a beam; you have to make sure you hit those flaps consistently on center or you introduce Moiré patterns. Here, with a non-structured light valve, you do not have that problem.

We are aiming this technology to provide at least a million picture elements or above. One million is the lower end. To date, we have demonstrated up to three million picture elements. We see no reason why it is not possible to achieve at least 16 million PELS. If you exclude any of the potentially unseen problems of addressing the liquid crystal cell, we feel that technology should be capable of supporting up to 50-60 million PELS. We have demonstrated 36,000 characters. That is about the number of characters on a newspaper page. The technology will do limited gray scale and limited color. Right now we have a three-color system plus black. There is inherent storage in the display element. The display image will remain as long as you want, but can be erased rapidly. It does not require an expensive refresh buffer like a CRT. You really only have to have enough buffer to cover the next line or two, so there is great economic savings there.

I would like to switch now to some slides which show what one is able to do with this type of technology. These images are representative of light valves in general, but these happen to be done with the laser liquid crystal technology. First slide (slide No. 1). This is one of our people in the laboratory, Anthony Dewey by name, with our first display demonstration. In the slide you can see one of our early images. In the pair of tweezers that you can just see, he is holding a gallium arsenide laser that writes this entire display. A very tiny thing. The package that goes around it is the size of your fist, but the galium arsenide laser is very tiny.

Could I have the next slide (slide No. 2), please. This slide shows you an example of one of our light valves. Included is a quarter for size reference. There are almost 20,000 characters written on this cell, 16 pages of about 1200 characters each. The PELS written look milky here. When we project them they look very black and dense on the screen. In fact, depending upon the optical projection system, we have shown contrast ratios up to as high as 40 to 1. However, practical engineering trade-offs indicate you would probably be operating at more like 15 to 1. These are reflective cells. We write on one side of the cell, project off the other. We also did some work on transmissive cells. This type is also shown on the slide. It is a completely different technology but gives basically the same results.

For those of you who have any background in liquid crystals, we are using the class of smectic liquid crystals. I won't say any more about that, except that when the liquid crystal molecules are uniformly lying in one direction, they are very transparent. When we put them in the scattering mode, via the thermal writing process, they form a focal-conic texture.

Could I have the next slide (slide No. 3), please. This slide shows the quality of characters obtained with the first display demonstration unit. May we have the next slide (slide No. 4), please. This is the first of several illustrations of some of our early work. I am sure you recognize this gentleman. This slide gives you an idea of the contrast we can get from this display. This was done with a million PELS display, a thousand by a thousand PELS. May I have the next slide (slide No. 5). This is a type of resolution chart. This was scanned data. We scanned it much in the same way you people do with photographs in cartography. We scanned it, digitized it, stored it on a disk file and wrote it directly out onto the liquid crystal cell. Again, from this slide you get an idea of the attainable resolution and of the contrast ratio from this image.

Next slide (slide No. 6), please. As shown on this slide, we can introduce color. I mentioned before that this was done with two liquid crystals. You can also do it on the same liquid crystal with two separate images and protection systems. This shows that what you can do by having only two primary colors, in this case green and red. You also have the secondary color as background and you can have black in addition to all of this. As shown, it is possible to get nice, crisp colors out of this technology. If you don't like that particular color combination--may I have the next slide (slide No. 7)--we can write one in another color. You can change colors rather rapidly just by changing the color filters, and we can do that with a turret arrangement. May I have the next slide (slide No. 8), please. This gives you an example of many characters on the display, and shown here is only 14,000 characters. This is, again, a million PEL display. These pictures were taken about two months ago. Within the last month we have upgraded this system to 2.36 million PELS, and have displayed 32,000 characters.

May I have the next slide (slide No. 9), please. This shows our second demonstration unit along with the liquid crystal cell used. Next slide (slide No. 10), please. Here again is how we created the colors I showed on the earlier slides. It is a subtractive color system so that if you write an image on the green light valve, and if you write a second image on the red one, and you put them together, what do you see? Well, these characters appear red, these characters appear green, and when both images are co-written, they appear black.

Next slide (slide No. 11), please. This again was a scanned image. There is no gray scale here. It is done strictly by pseudo half tone, by dot clustering. We artificially create a larger dot by using many smaller dots to simulate the technique used by newspapers and magazines. May we have the next slide (slide No. 12). That happens to be the building I work in, and it gives you an idea of another type of display we can project. That finishes the slides. Could I have the last foil (foil No. 14), please. Let me just say to those of you who might be interested in some of this work, there are several reports available already on this technology. The two that are out thus far include one in the SID proceedings of last year, and there is also an updated report in the proceedings of the Society of Photoptical Instrumentation Engineers. In the next SID proceedings there will be two papers related to this technology.

Thank you.

DR: BOYLE: Thank you very much. That was most interesting. (Applause.)

Let us have Gene Slottow have his talk now, and then we will go to questions after that. I am certain there will be quite a number of questions about this first talk as well. Gene?

Some Key Questions

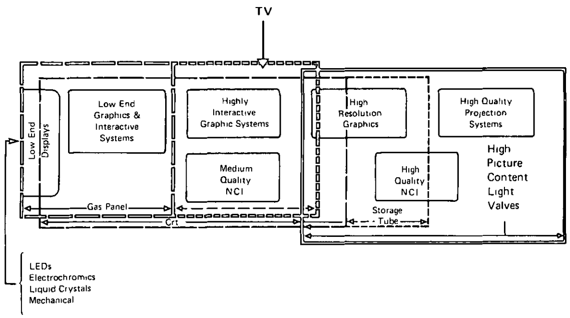
- SPEED (pels per second) – ?
  - minimum acceptable speed
  - desirable speed
- COLORS AND HUES – ?
  - minimum number acceptable
  - desired number
- SIZE OF DISPLAY – ?
- NUMBER OF PICTURE ELEMENTS (pel) – ?
  - minimum number acceptable
  - desired number
- $ – ?

Foil No. 1

Other Potential Users of High Resolution, Color Displays

- Computer Aided Design
  - engineering drawings
  - semiconductor chip layout
- Computer Simulation
- Special document distribution
- Computer-aided instruction
- Electronic Mail
- Business Data Display
  - conference room
  - board room
- Scientific Data Presentation
  - seismic data
  - medical teleconsultation
- Teleconferencing
- Military war room
- Newspaper composition

Foil No. 2



Foil No. 3

Advantages of Projected Light Valves for Large, High Resolution Displays

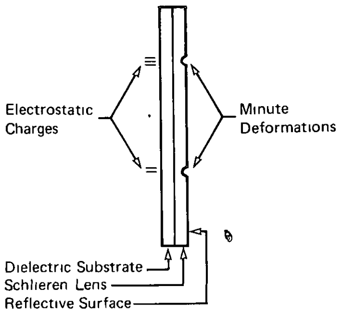
- Single technology and basic hardware can be used for a variety of screen sizes and shapes
- Wall or back projection
- Very high number of picture elements (pels) possible if light valve resolution is high
- Overlays, color by co-projection, and cursors easily implemented
- With "non-structured" light valves, number of pels essentially limited by addressability of projected light valve and acceptable size of projection optics.

Foil No. 4

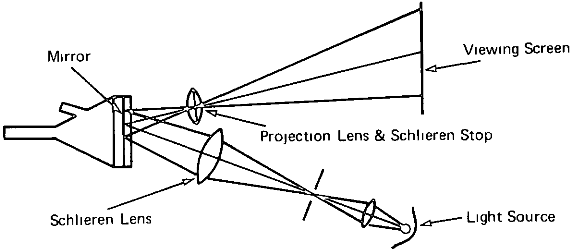
Light Valve Technologies

- Deformographic
  - IBM
  - E-Beam/Elastomer
  - Better for vector mode than raster
- Micro Mechanical Deflectors
  - Westinghouse
  - E-Beam/Light Valve Matrix
- Ruticon
  - Xerox
  - CRT/Photoconductor/Elastometer
- Liquid Crystal Light Valve
  - Hughes, Commercial Product
  - CRT/Fiberoptic Face Plate
  - Photoconductor/Liquid Crystal
- Laser Liquid Crystal
  - IBM and Western Electric
  - Ar or GaAs Laser/Liquid Crystal
  - Thermal Write Process, Field Erase

Foil No. 5



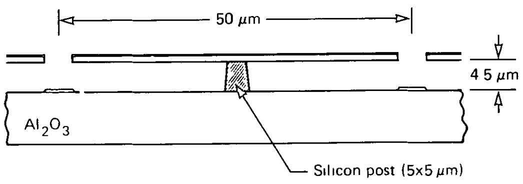
a) Deformographic Mirror Structure



b) Schlieren Optics

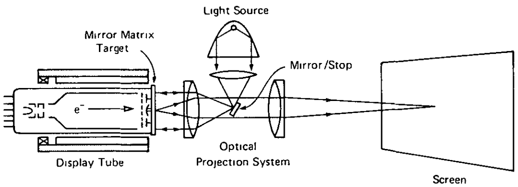
Foil No. 6

Westinghouse Mirror Matrix Display



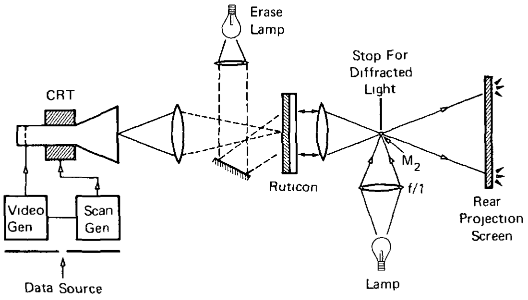
Foil No. 7

Westinghouse Mirror Matrix Display



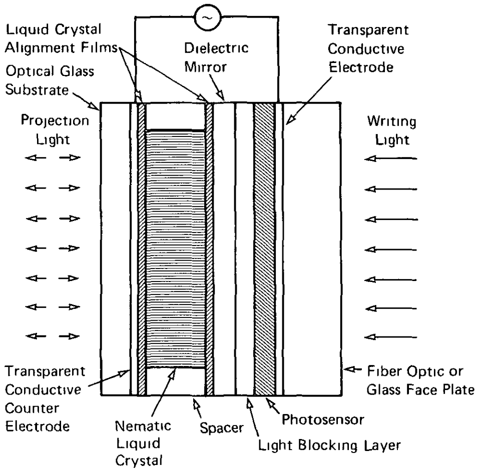
Foil No. 8

Ruticon Display System



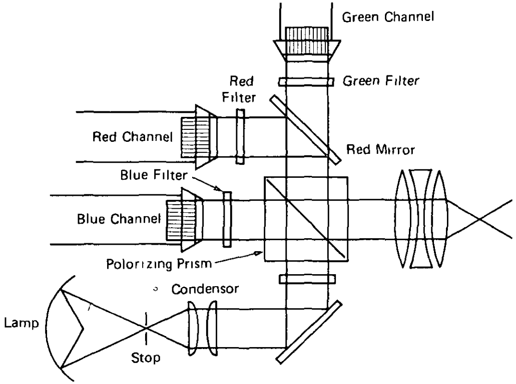
Foil No. 9

Hughes AC Photoactivated Liquid Crystal Light Valve



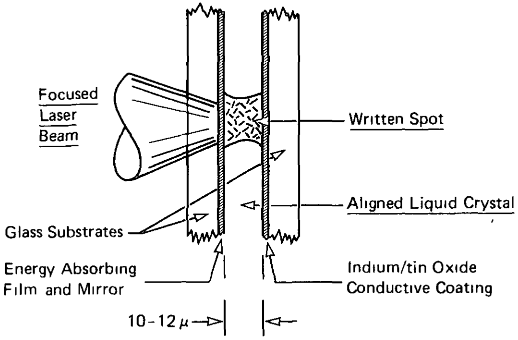
Foil No. 10

Schematic of Liquid Crystal Light Valve Color TV Projector



Foil No. 11

- Approach is to thermally "write" on the liquid crystal Rapid cooling of the material after heating leaves liquid crystal in a disordered state. (storage)
- The disordered state scatters light
- Electrically erasable



Foil No. 12

Laser Liquid Crystal Display

Characteristics of Technology

- Microimages written on liquid crystal cell with laser
- Projection display (wall or back projection screen)
- Graphic or pictorial overlays
- Unstructured display element allows very large number of pels without ultra high linear performance demands
- Aimed at high end; $\geqslant 10^6$ pels
  - up to $\sim 16 \times 10^6$ pels with single gas laser
  - projection optics and L C. cell will support up to $\sim 6 \times 10^7$ pels
- Up to 36,000 characters demonstrated
- Grayscale and limited color (three colors plus black)
- Inherent storage in display element, no refresh needed
- Selective erase – easily implemented

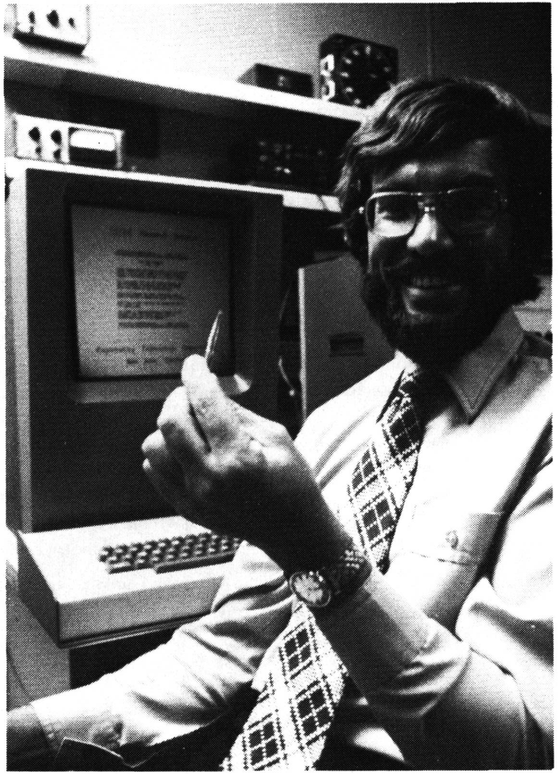
Foil No. 13

References:

Dewey, A.G., et al , "A 2000-Character Thermally-Addressed Liquid Crystal Projection Display", SID Proceedings, May 1977.

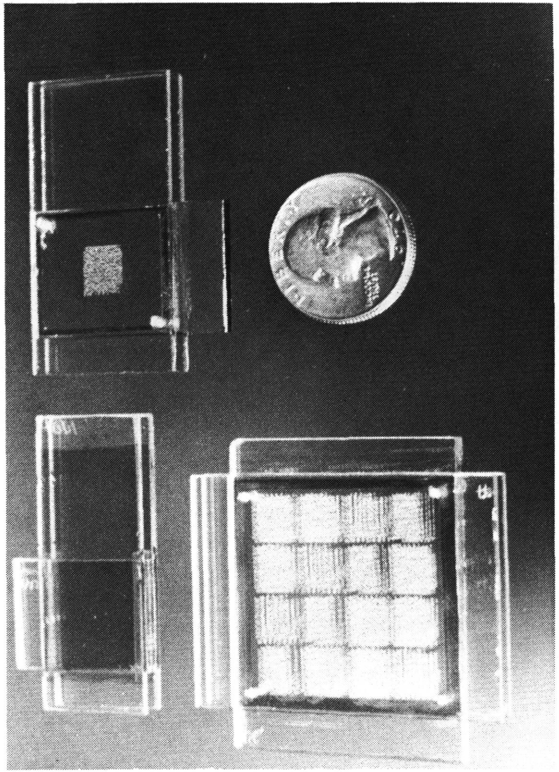
Dewey, A G , et al., "A Laser Addressed Liquid Crystal Projection Display", Proceedings of Society of Photo-Optical Storage Materials and Methods, San Diego, August 25-26, 1977

Foil No. 14



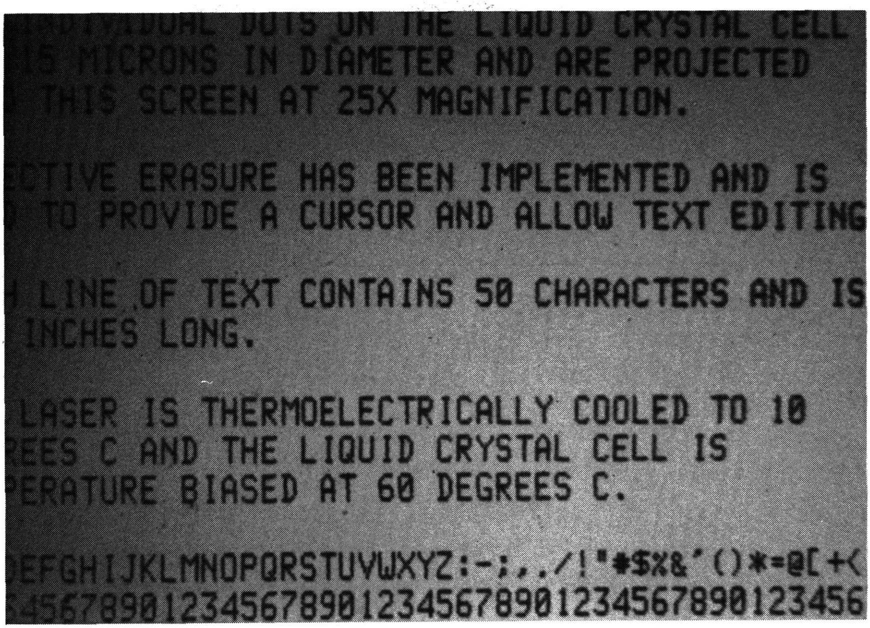
SLIDE NO. 1

FIRST DISPLAY DEMONSTRATION UNIT



SLIDE NO. 2

LIQUID CRYSTAL CELLS



NDIVIDUAL DOTS ON THE LIQUID CRYSTAL CELL
15 MICRONS IN DIAMETER AND ARE PROJECTED
THIS SCREEN AT 25X MAGNIFICATION.

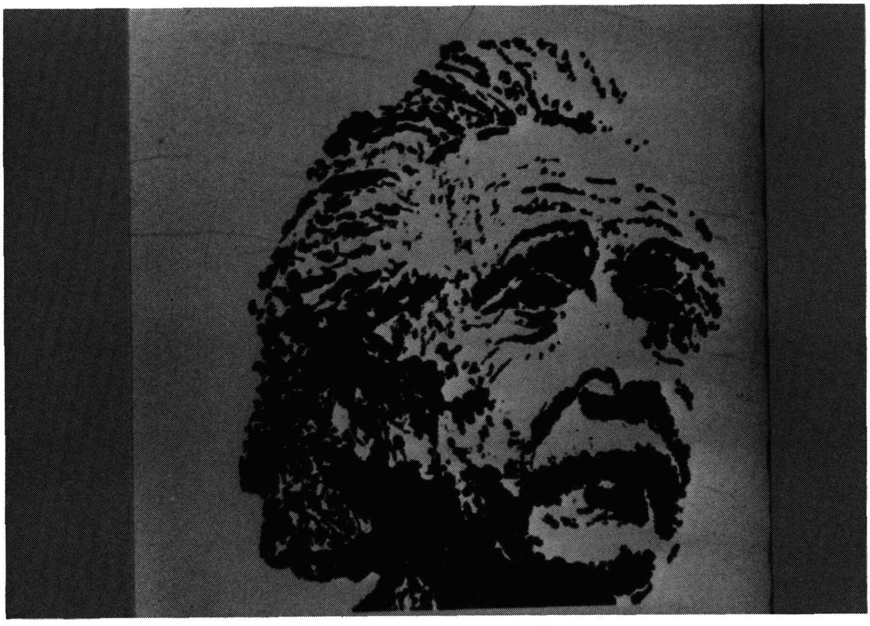
CTIVE ERASURE HAS BEEN IMPLEMENTED AND IS
TO PROVIDE A CURSOR AND ALLOW TEXT EDITING

LINE OF TEXT CONTAINS 50 CHARACTERS AND IS
INCHES LONG.

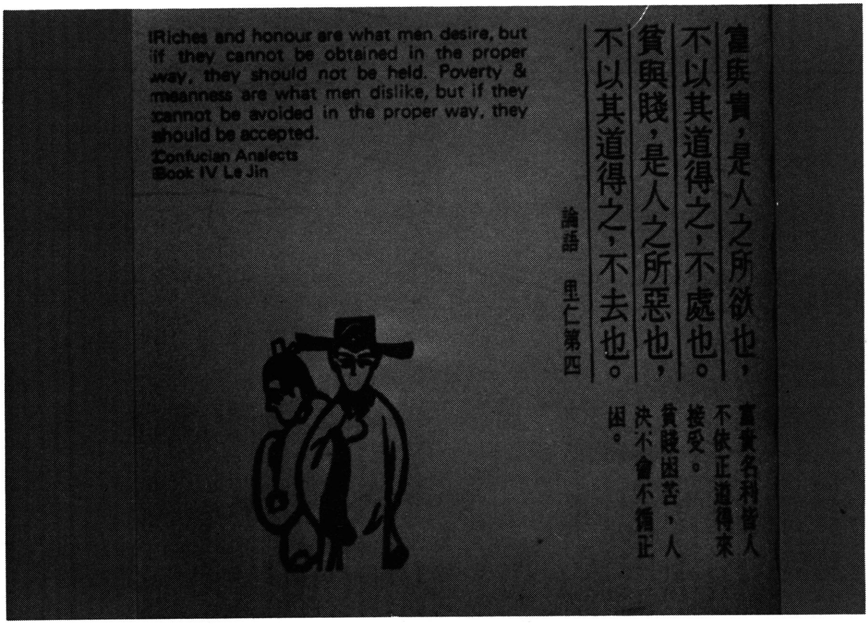
LASER IS THERMOELECTRICALLY COOLED TO 10
REES C AND THE LIQUID CRYSTAL CELL IS
PERATURE BIASED AT 60 DEGREES C.

EFGHIJKLMNOPQRSTUVWXYZ:-;,./!"#$%&'()*=@[+<
4567890123456789012345678901234567890123456

SLIDE NO. 3 - CHARACTERS ON FIRST DISPLAY UNIT



SLIDE NO. 4 - 10^6 PEL, B & W DISPLAY



Riches and honour are what men desire, but if they cannot be obtained in the proper way, they should not be held. Poverty & meanness are what men dislike, but if they cannot be avoided in the proper way, they should be accepted.

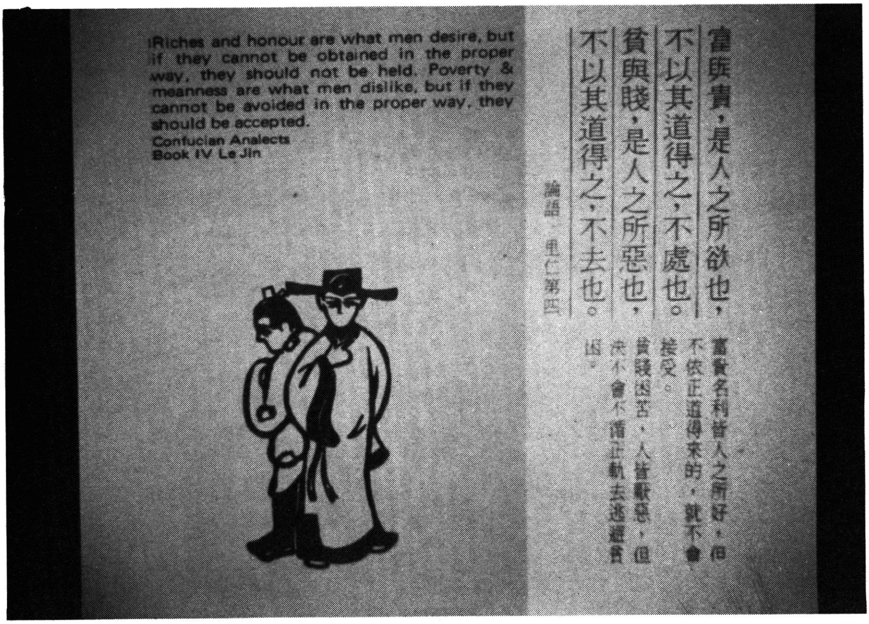
Confucian Analects
Book IV Le Jin

富與貴，是人之所欲也，
不以其道得之，不處也。
貧與賤，是人之所惡也，
不以其道得之，不去也。

論語 里仁第四

富貴名利皆人
不依正道得來
接受。
貧賤困苦，人
決不會不循正
困。

SLIDE NO. 5 - 10^6 PEL B & W DISPLAY



Riches and honour are what men desire, but if they cannot be obtained in the proper way, they should not be held. Poverty & meanness are what men dislike, but if they cannot be avoided in the proper way, they should be accepted.

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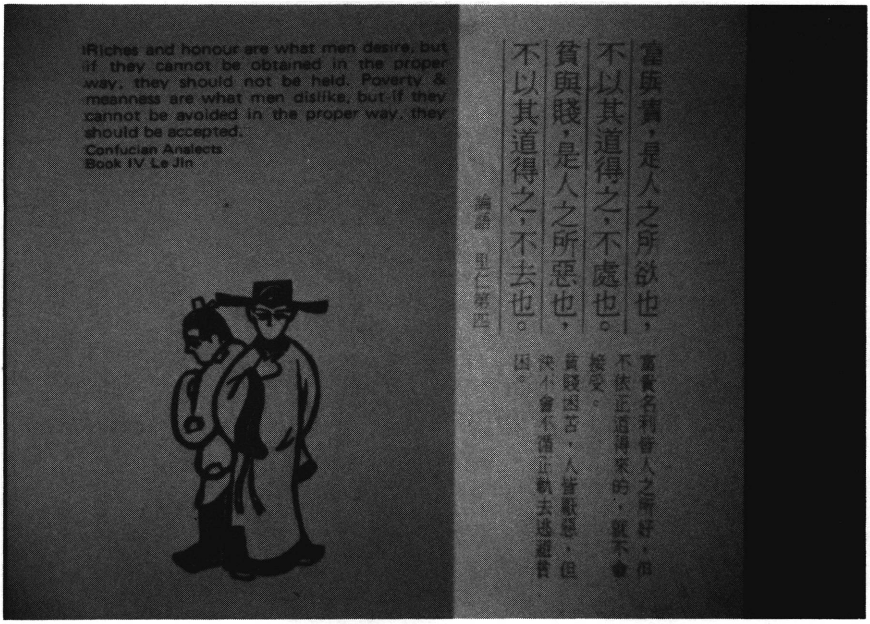
論語 里仁第四

富貴名利皆人之所好，但
不依正道得來的，就不會
接受。
貧賤困苦，人皆厭惡，但
決不會不循正軌去逃避貧
困。

SLIDE NO. 6 - 10^6 PEL THREE-COLOR PLUS BLACK DISPLAY
PRIMARY COLORS - RED & GREEN



'Riches and honour are what men desire, but if they cannot be obtained in the proper way, they should not be held. Poverty & meanness are what men dislike, but if they cannot be avoided in the proper way, they should be accepted.'

Confucian Analects
Book IV Le Jin

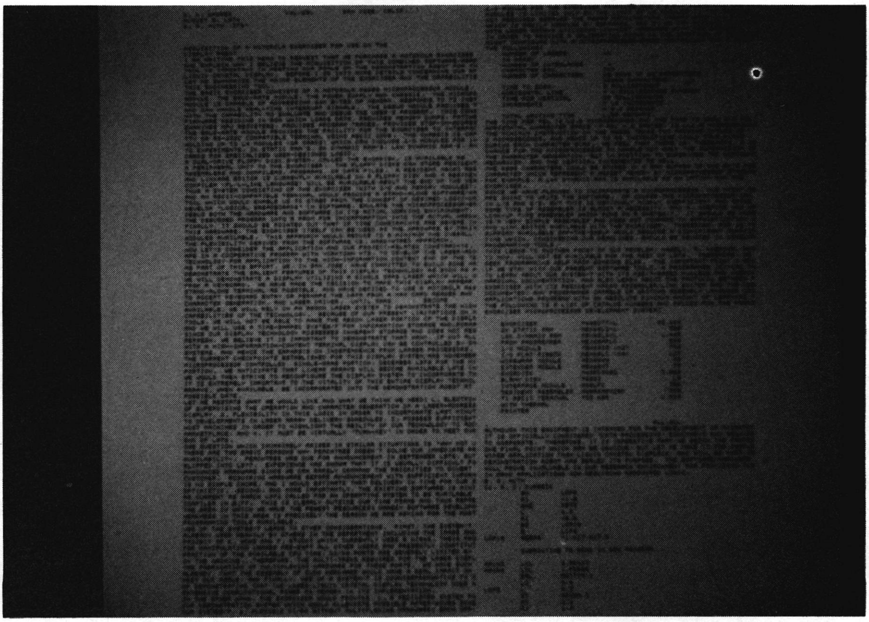
富與貴，是人之所欲也，不以其道得之，不處也。貧與賤，是人之所惡也，不以其道得之，不去也。

論語　里仁第四

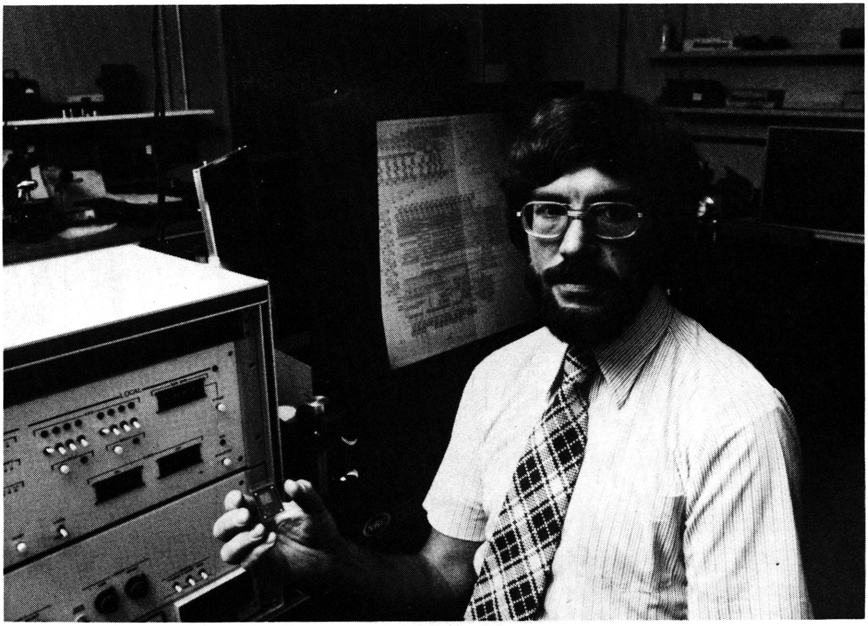
富貴名利皆人之所好，但不依正道得來的，決不會接受。

貧賤困苦，人皆厭惡，但決不會不循正軌去逃避貧困。

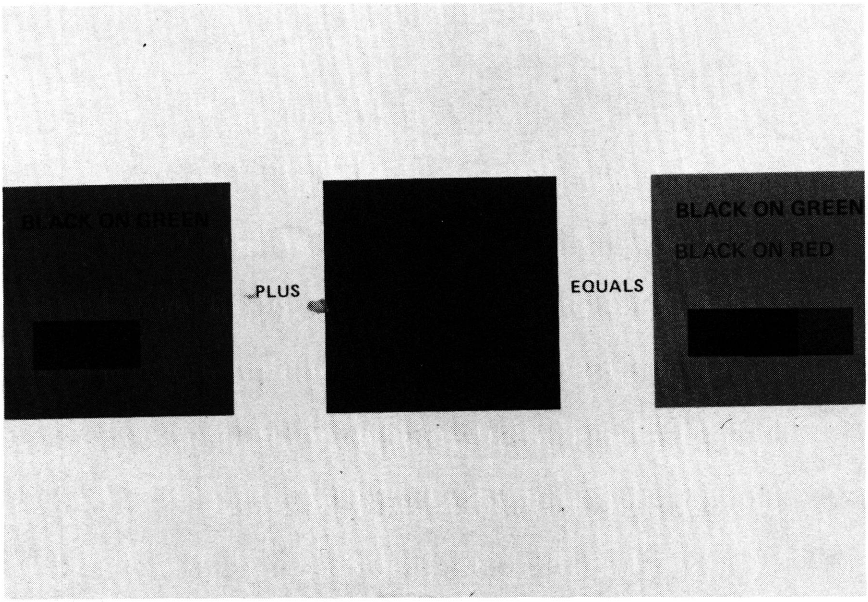
SLIDE NO. 7 - 10^6 PEL COLOR DISPLAY - PRIMARY COLORS: BLUE & GREEN



SLIDE NO. 8 - 10^6 PEL DISPLAY, 14,000 EQUIVALENT CHARACTERS

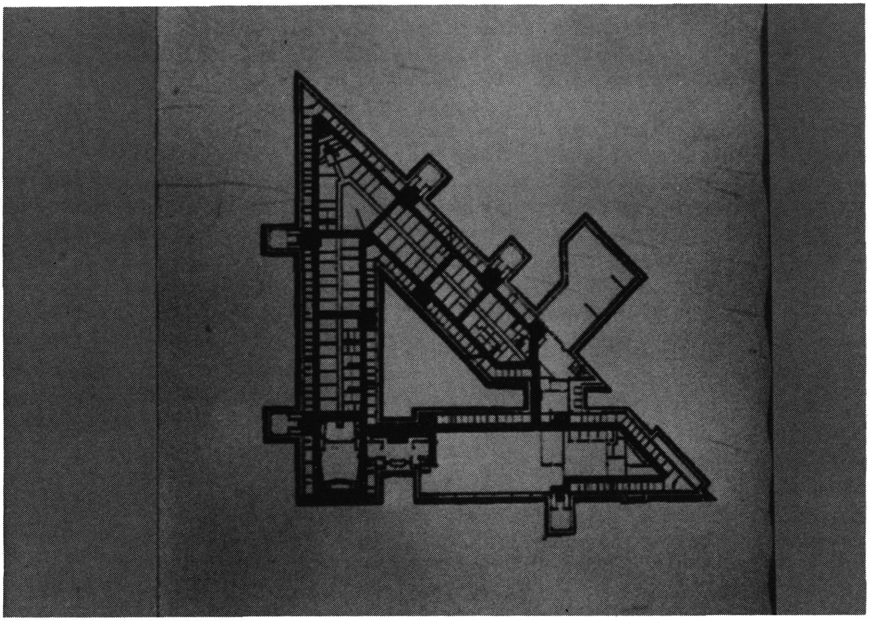


SLIDE NO. 9 - SECOND DISPLAY DEMONSTRATION UNIT



SLIDE NO. 10 - COLOR COMBINATIONS WITH TWO PRIMARY COLORS

SLIDE NO. 11 - 2.36 x 10^6 PEL, TWO COLOR DISPLAY (SIMULATED HALF-TONE BY DOT CLUSTERING)



SLIDE NO. 12 - 10^6 PEL, B & W IMAGE

PLASMA DISPLAYS

DR. GENE SLOTTOW: Gas discharge displays in the form of the A.C. plasma display panel are commercially available today with over 250,000 light emitting elements. Furthermore experimental panels have been fabricated with over one million light emitting elements. This capability for storing and displaying large amounts of information suggest that these displays may find applications in cartography. In this talk I hope to provide a brief introduction to the A.C. plasma display, to convey some feeling for the appearance of images on the display and to indicate some trends in development.

Gas discharge devices can present information in a variety of ways. In the Nixie^{R} numeric indicator, for example, an appropriate voltage impressed across a selected shaped cathode produces a visible glow in the shape of the desired numeral. In more recent numeric indicators appropriate combinations of segment discharges form the numerals. More attractive and more complex characters are formed by dot discharges selected from an array of discharge sites. Only this last approach has value for the high information displays useful in cartography.

When the number of dots in a display is as high as one hundred thousand, this device can provide attractive and useful displays for both alphanumerics and graphics. Such a large number of discharge sites can only be managed when the access electrodes are shared by many sites. The concept is illustrated in Figure 1 which represents an early plasma display panel. On the outer side of the front dielectric sheet is a group of horizontal electrodes. Each electrode is associated with a row of electrical discharge sites. On the outer side of the back dielectric sheet is a similar group of vertical electrodes. Each electrode is associated with a column of discharge sites. Each discharge site is then associated uniquely with the electrodes that intersect at that site. The aperture plate between the dielectric sheets provides strength for the entire structure, and also confines the discharges. In later versions of the plasma display panel the aperture plate is eliminated, the pressure and the electric field being adaquate to confine the discharges.

Figure 2 shows a section view of the device. The upper electrode in the plane of the page is othogonal to the lower electrodes coming out of the page. At a single site the circuit is equivalent to three capacators in series as shown in the lower part of the figure. When a sufficiently high voltage is impressed across the electrode, the voltage across the center capacator exceeds the threshhold for electrical discharge. When the discharge takes place, however, it will extinguish itself because the electrons moving to the upper surface and the ions moving to the lower surface reduce the voltage below the level needed to maintain a discharge. The pulsed discharge and the associated pulsed light by themselves do not provide a very adequate display. but the accumulation of the charges on the surface which reduce the voltage across the device will actually enhance it if we reverse the polarity of the voltage applied across the entire device. The conditions are thus established for another discharge which, in turn, prepares for a third discharge. An alternating voltage applied across the electrodes produces a sequence of discharges. In appropriate gases there is a range of voltage which will sustain a discharge sequence but, by itself, will not produce any discharges at all. The plasma display in this mode is bistable.

Turning a cell "on" is equivalent to producing a starting discharge by placing an apropriate voltage across the elctrodes which intersect at that site. This establishes the surface charge needed to start the sequence. To turn a cell "off" a controlled discharge is established which removes enough of the surface charge to terminate the sequence. After this, although an alternating voltage is present across the electrode at that site, no discharges are produced and no light is emitted. In the "on" state light is emitted once every half cycle. Figure 3 shows an early plasma display panel, vintage 1966, which looks like an 8x8, but was only connected to a 4x4 driver.

Figure 4 shows the structure of the Owens Illinois Digivue^R panel which does not contain an aperture plate. Glass base plates provide strength for the entire panel. Electrodes are deposited directly on these base plates and are covered by dielectric films. The electrodes are not transparent but they are only about three thousandths of an inch wide and the light that conveys the information actually comes from around the electrodes.

One way to visualize the plasma display structure is to think of a thermopane window. On the inside surface of one of the two panes a set of horizontal electrodes is imbedded. Similarly on the inside surface of the second pane a set of vertical electrodes is imedded. The intersections of these electrodes defines the discharge sites which can emit light.

Figure 5 shows a commercial plasma display panel fabricated about 1968. This panel contained 128 electrodes on each surface. This picture also shows the flat plasma panel being used as an optical projection screen. This arrangement allows the superposition of digitally generated information on the optically generated image.

In a possible application current information could be superimposed on an optically projected map.

Figure 6 also illustrates the superposition of images, this time on a 512x512 Digivue panel fabricated about 1970. We begin to see now what these devices look like, and from that perhaps we can estimate how useful they might be in cartographic applications.

Figure 7 shows the use of a 512x512 display to graphically illustrate the structure of the panel itself. The drawing, of course,is not to scale. The dielectric films are about one thousandth of an inch thick, while the gap is about five thousandths of a inch.

Figure 8 shows a standard set of characters on a 512 512 panel. Most of the upper case letters are formed from dots of a 7x9 matrix while the lower case letters use smaller numbers of dots. More precisely, each character is built on an 8x16 matrix which includes both the space between lines and the space between characters in the same line. This is a standard character set in the PLATO cmputer based education system at the University of Illinois, and is stored in read only memory at each teminal.

It is easy to prepare alternate character sets which are transmitted to the terminal where they are stored in random access memory. Figure 9 shows an experimental character set which was designed to resemble the widely used characters found in much printed material. Most of the characters are formed on the 8 16 matrix, but the upper case M and W required a 12x16 matrix. Figure 10 shows the appearance of gothic script on a 512x512 panel. Figure 11 shows the appearance on the 512x512 panel of a mathematical graph, in this case the sum of two sine waves close together in frequency.

Finally, Figure 12 shows a map of the United States on the 512x512 panel. Also shown are the locations of the more than 1000 terminals in the University of Illinois PLATO computer based education system.

Most of the images I have shown so far contain characters or line drawings that do not require gray scale. The one exception is the section view of the panel in which there is some shading. More complex images with limited gray scale can be shown by the use of ordered dither, a procedure much discussed and investigated recently at the Bell Telephone Laboratories. In this technique, which is related to half tone photographic processes, the luminance is sampled at positions on an image which correspond to the picture elements on a plasma display. If the sampled luminance exceeds a threshhold value the corresponding element in the plasma display is turned "on." If below threshhold it will be turned "off." Within a submatrix chosed by the user the threshhold is different for each picture element. With this technique the full resolution of the plasma display is retained in the halftone process, and the contouring effects so often seen in digitized images do not appear. Figure 13 shows an example of an ordered dither image on a 502x512 plasma display.

There is another approach to limited gray scale in which a discharge site can exhibit several "on" states with different intensities. While the basic ideas have been confirmed experimentally, it has not yet been possible to implement the procedure on large panels.

How about color in plasma display panels? Although to my knowledge there are no commercially available devices, good color has been obtained from phosphors that are deposited within the panel, and are excited by radiation from the gas discharge. With a gas that emits little visible radiation, visible light comes almost entirely from the phosphor. With neon the resulting color is a mixture of the neon orange and the phosphor color. Work has been done on both single color and on multiple color displays.

For cartographic applications it would be desirable to have displays larger than 512x512. Again, nothing is commercialy available, but a few 1024x1024 panels were fabricated by Owens Illinois for the U.S. Air Force When these panels were made in 1973 they were tested by addressing 16x16 sections. It was not until 1975 that Roger Johnson at Science Application Associates connected them to electronics that could address and sustain the entire panel. Figure 14 shows four 512x512 images displayed smultaneously on the 1024x1024 panel. Although the panel has some broken lines, the photograph conveys some of the visual effect o the million bit plasma display.

The interest in large panels has stimulated the development of structures that depart considerably from the basic "thermopane" structure but which still retain the essential relations among exciting electrodes, dielectric, and gas, Figure 15 shows a plasma display developed by Control Data Corporation for use with army maps. The map is supported flush against the back of the panel and is viewed by an observer through the transparent panel.The observer also sees the computer generated information superimposed on the map.

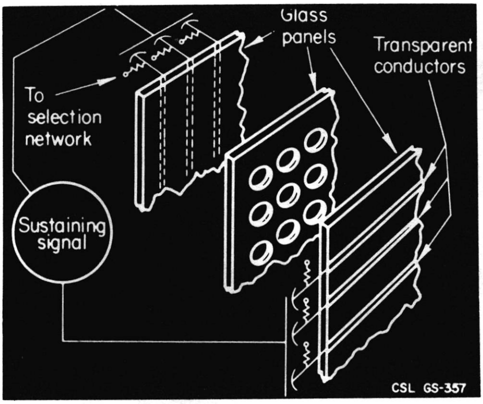
The gas in this device is confined to the interiors of narrow capillary tubes made of glass. The exciting electrodes run along the capillaries on one side of the panel, and across the capillaries on the other side. Pulsed discharge sequences are sustained at the selected intersections. It is expected that 1024x1024 panels at 30 lines per inch can be made in this way, and that by using a modular approach, any desired size can be reached by adding modules.

In conclusion I would like say something about status and trends for plasma displays. These devices, in both A.C. and D.C. forms are widely used for small numeric indicators and for alphanumeric displays of several hundred characters. For several thousand characters and for graphics, only the A.C. device is sufficiently well developed. Here the cathode ray tube provides formidable competition. The plasma display, however, has its advantages. It is rugged physically, it requires little volume, and the quality of its images is very high. The high image quality is particularly important when a user works close to his terminal for extended periods of time. At present the cathode ray tube display is less expensive than the plasma display, but with the economies of volume production, and particularly with the current development of integrated circuits for plasma displays this cost difference should disappear.

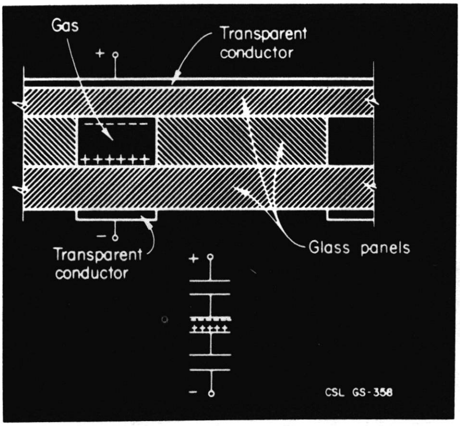
If you would like to learn more about plasma displays, there is a large and growing literature that is readily available. The following two references have extensive bibliographys and will provide a useful guide to this literature.

(1) R.N. Jackson and K.E. Johnson,"Gas discharge displays: a critical review," in Advances in Electronics and Electron Physics,vol. 35, New York and London: Academic Press,1974
(2) H.G. Slottow, "Plasma Displays," IEEE Transactions Electron Devices, vol. ED-23, pp. 760-772,July,1976

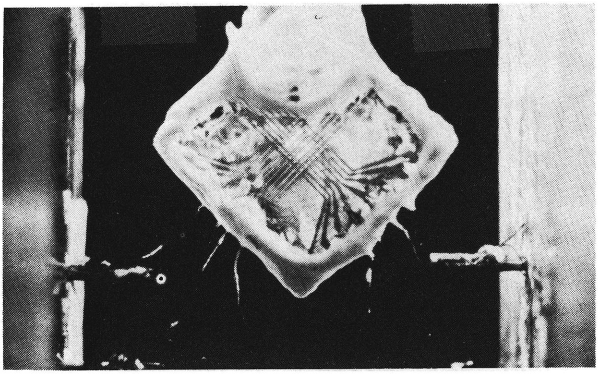
Thank you very much for your attention.



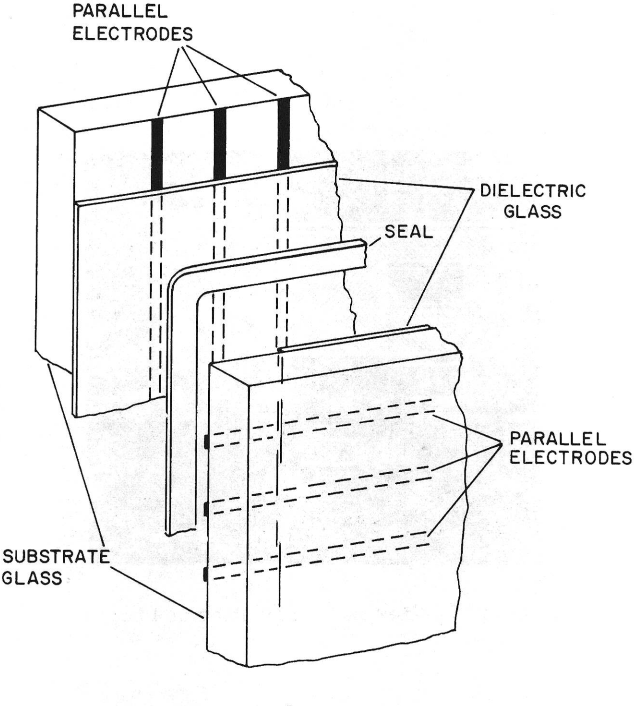
1 Early Plasma Display Structure



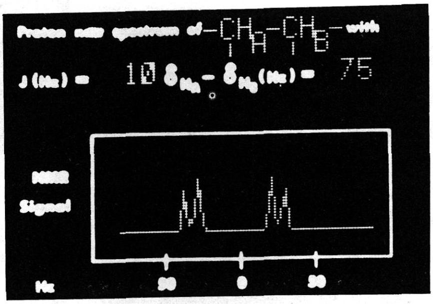
2 Section View of Early Plasma Display



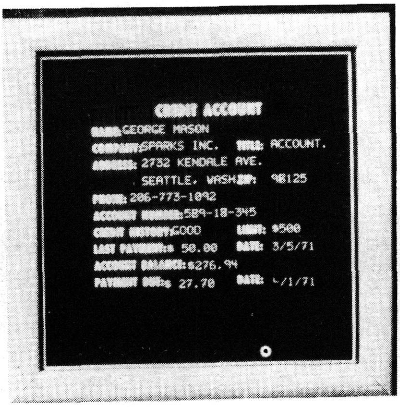
3 Photograph of Early Plasma Display (1966)



4 Owens Illinois Digivue^R Plasma Display Structure



5 Superposition of Computer Generated and Optically Generated Images on 128x128 Digivue^R Plasma Display 33 Electrodes per Inch



CREDIT ACCOUNT

[illegible] GEORGE MASON

[illegible] SPARKS INC. [illegible] ACCOUNT.

[illegible] 2732 KENDALE AVE.

SEATTLE, WASH [illegible] 98125

[illegible] 206-773-1092

[illegible] 589-18-345

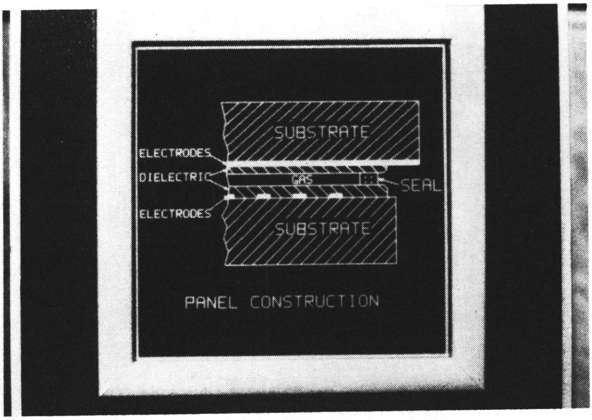
[illegible] GOOD [illegible] $500

[illegible] $ 50.00 [illegible] 3/5/71

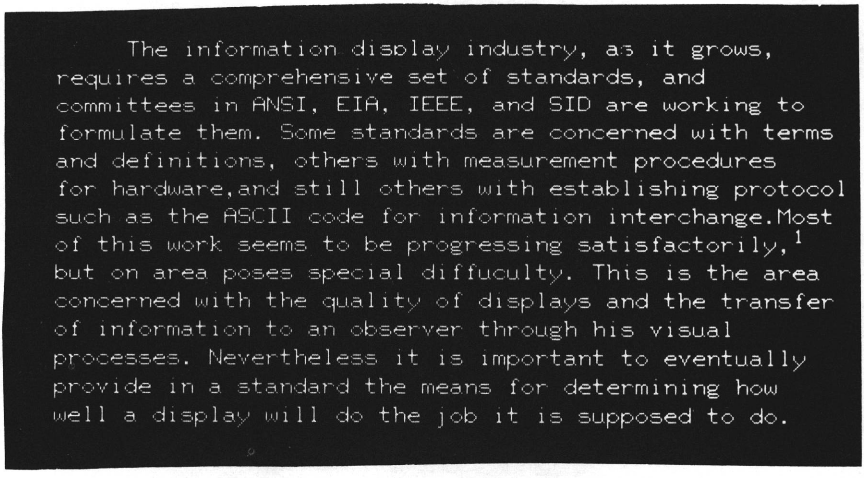
[illegible] $276.94

[illegible] $ 27.70 [illegible] 4/1/71

6 Superposition of Computer Generated and Optically Generated Images on 512x512 Digivue^R Plasma Display 60 Elctrodes per Inch

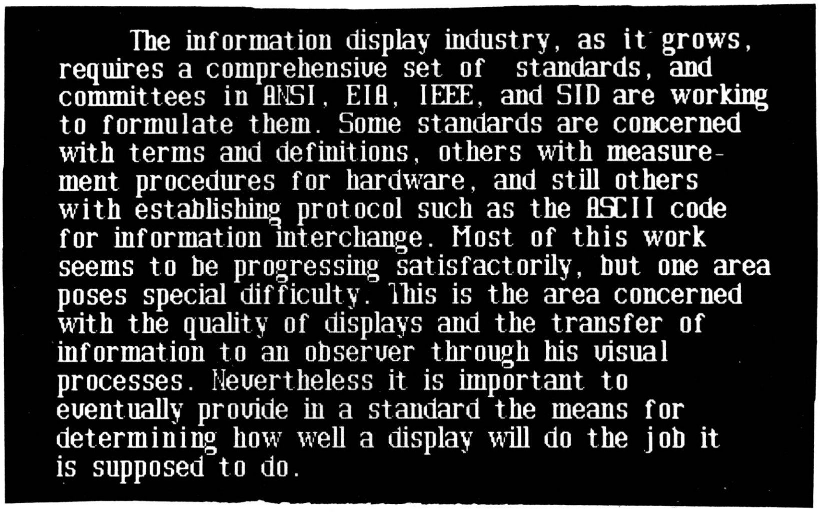


7 Image of Panel Structure on 512x512 Panel



The information display industry, as it grows, requires a comprehensive set of standards, and committees in ANSI, EIA, IEEE, and SID are working to formulate them. Some standards are concerned with terms and definitions, others with measurement procedures for hardware,and still others with establishing protocol such as the ASCII code for information interchange.Most of this work seems to be progressing satisfactorily,[1] but on area poses special diffuculty. This is the area concerned with the quality of displays and the transfer of information to an observer through his visual processes. Nevertheless it is important to eventually provide in a standard the means for determining how well a display will do the job it is supposed to do.

8 Standard Character Set in Plato



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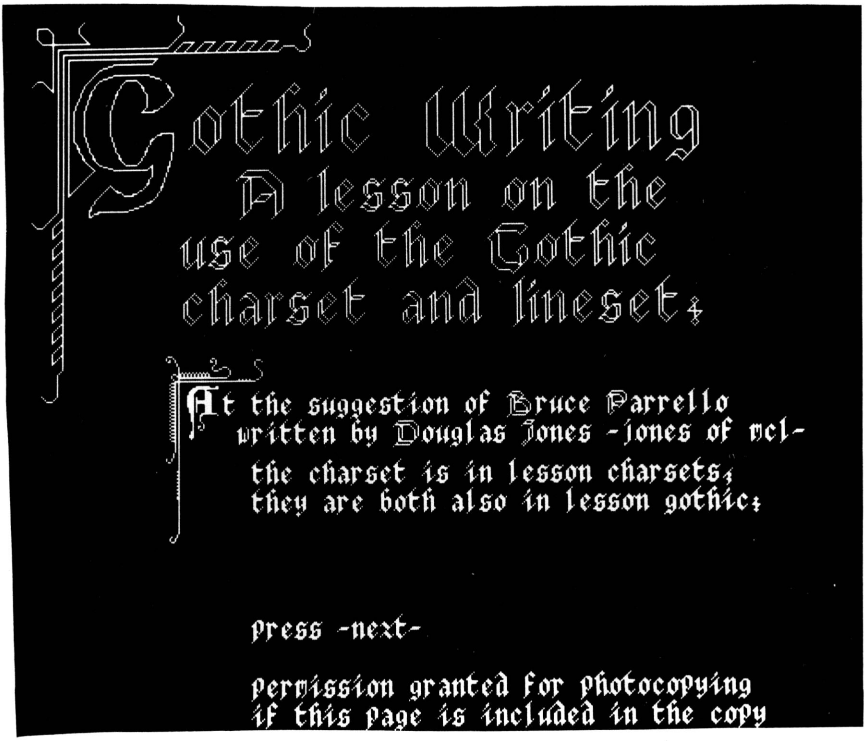
9 Experimental Character Set in Plato



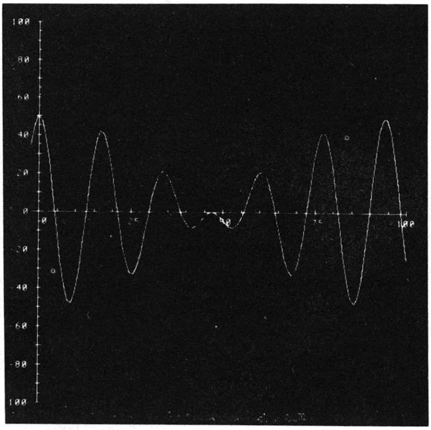
Gothic Writing
A lesson on the
use of the Gothic
charset and lineset.

At the suggestion of Bruce Parrello
written by Douglas Jones -jones of mcl-
the charset is in lesson charsets,
they are both also in lesson gothic.

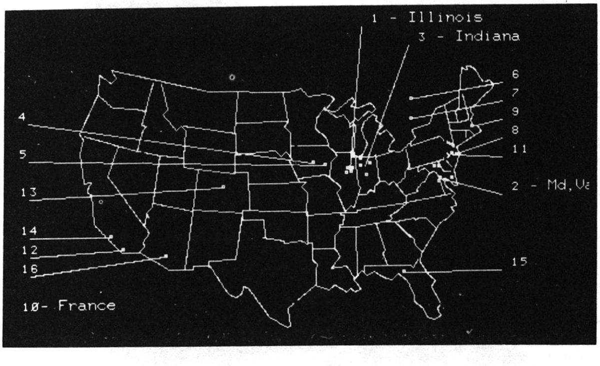
press -next-

permission granted for photocopying
if this page is included in the copy

10 Gothic Script in Plato

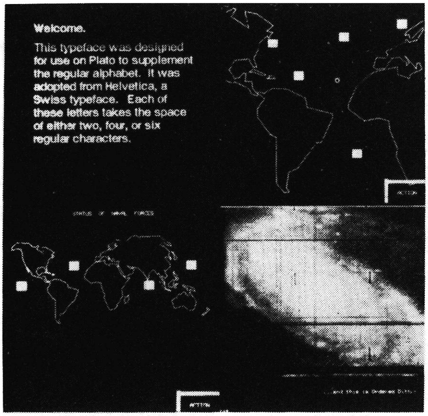


11 Two sine Functions close together in Frequencey
512x512 Panel



12 U.S. Map showing Plato Sites 512x512 Panel

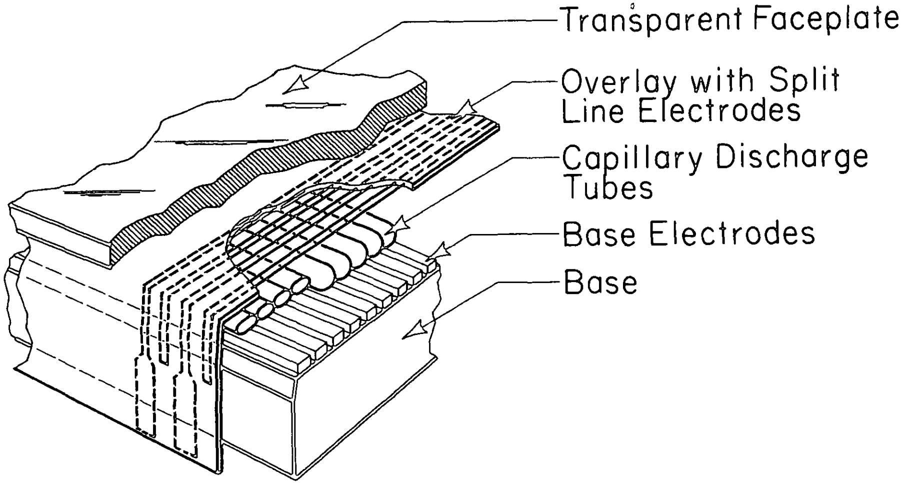
13 Ordered Dither Image on 512x512 Panel



Welcome.

This typeface was designed for use on Plato to supplement the regular alphabet. It was adopted from Helvetica, a Swiss typeface. Each of these letters takes the space of either two, four, or six regular characters.

14 Four Images on 1024x1024 Plasma Display Panel
83 Electrodes per Inch



15 Structure of Control Data Capillary Plasma Display Panel

DISCUSSION

SOFT COPY DISPLAY

DR. BOYLE: Thank you very much indeed. For the last few minutes the floor is open for any questions that you might have on these technologies.

MR. TOM WAUGH: Tom Waugh, University of Edinburgh. I was a bit disappointed in some respects in the discussion on soft display, because the kind of time scales we are talking about, the kind of resolutions we are talking about by 1982 for some of these things seems a bit disturbing, when in fact there are some very big high cost displays around already. The laser scanner, RD-1, for example, made by Laser Scan in Cambridge, England, has a 4,200 million picture element, resolution of 70,000 lines at a screen a meter wide, variable intensities and so on and so forth. There is also a very good passive plotter as well. There are, indeed, many of those devices already around. It also has the advantage that it has cartographic editing software, which they will sell you for a mere $10,000.

However, one of the things I would like to ask or suggest in this discussion is whether or not we actually do want very large accurate displays? I have a feeling that most editing or for most cartographic tasks the size of, say, for example, the Techtronix 4014, about two feet on a side, is probably large enough for an operator to handle. What is more useful is the kind of thing demonstrated in that Hewlett-Packard, which has a very fast zoom-in zoom-out capability, so one can go in and take a look at a bigger picture than the display actually shows, very fast. But not many displays actually have that capability and at a reasonable price. I think the pressure to get very large high quality displays might be misplaced to a certain extent in the cartographic field. What we should be aiming at is displays of about two feet on a side with fairly good resolution but with backup support which allows zooming in and out of larger virtual pictures.

DR. BOYLE: Thank you, Tom. I do not think I will ask the producers of the technology to answer that, but somebody in the audience may like to comment. I think we are in doubt as to whether we want these large displays. Some people say they must have them, some people say they are not necessary. I am very interested in other people commenting on that for the future.

MR. DURBECK: I could answer the first part of that question on laser scan. Actually, that is a large scale display technology, but it writes very, very slowly, and is not reversible. I believe they use a strip of media, and they have to re-write the image, and it does not fall on the normal classification displays. Also, it is very expensive. It is probably in the quarter million dollar cost range, so it is not the normal display tool that one normally talks about.

MR. JIM WHEELER: Jim Wheeler, M. B. Associates. Some years ago I was involved in quite a number of different elements in the display game for aeronautical work, and since then I have done some work with simulators, and have had a bit of experience with the cartographic game. One of the three things that are important in displays generally, and they are not necessarily completely addressed here, I think, to satisfy my own interest, and that is accuracy, resolution and light intensity. For example, cathode ray tubes in past years I found difficult to get better than about a tenth of a degree of angular accuracy out of them, for example, when used in heads-up displays in aircraft. I see nothing to increase that accuracy very much. So, if you really want precise cartographic information rather than relative, you have to do a bit of work to get the accuracy.

It is also quite a push to get enough light intensity for normal sunlight viewing. In the gas tube displays I did a little work which ended up in the gas tube display operation which Beckman is now operating. I think one of the things that Dr. Slottow has not indicated, and perhaps he would comment on this, is what is the resolution, number of elements per inch or per millimeter that is now obtainable. And the other advantage it seems to me of the gas tube display, or the LED display, is that when you build the unit, you can build in the accuracy and it stays there. You do not have non-linearities in curvature. In the liquid crystal operation, which the gentleman from IBM discussed, we had no indication of the intensity nor of the problems of getting the accuracy that might be necessary for very precise cartographic work. The other question which Dr. Boyle, or someone else in the audience might answer, and that is, the questioner before me asked about whether a zoom task with a blowup of a local section is what you really need for cartography, or whether you need the large scale display. If you have a large scale display and adequate optics, of course, you can image this and produce a whole map at one time, and that might have an advantage over the zoom process, or it might not. But if someone could comment on this I would appreciate it.

DR. SLOTTOW: Let me begin. The question was about the light output, the intensity, essentially -- luminance, really, and the irregularity of the plasma display panel. These electrodes are put down by photolithographic process. This gentleman is correct in saying one of the advantages of this kind of display is that you have very, very accurate placement of the discharges which occur at the intersection, and they do not change because it is just a matter of the lithographic process used in the first place. The density of lines is 50 per inch. So that means you have 3600 elements, picture elements, per square inch. This is on a 512 by 512 array. That is over 260,000 elements. Now, a number of smaller ones have been made. A number of displays of this type that you find in IBM products are 50 lines per inch, and somewhat smaller number of elements. But, there the amount of information that is desired to be displayed is, of course, less. The best that has been done, to my knowledge, so far is 1024 by 1024 elements at a density of 83 lines per inch. I showed some pictures from the face of that tube. Brightnesses or luminances are typically in the order of 40-, 50-foot lamberts.

As far as one comment, too, about the zooming. Of course, with this technology you can do the same kind of zooming that you see out there in the Tektronix because that is really a matter of the software system.

MR. DURBECK: Regarding the same issues with the laser liquid crystal. What we are able to do is about an accuracy of about one-quarter spot diameter today, so that means in our present 1500 by 1500, we are getting an accuracy of about one part in 60,000. I think we could do better if we really tried. We demonstrate that every day, every time we go back and erase the single dot. If we missed it, we would not erase it or we would re-write a wrong one. We have not had any trouble that way. As far as intensity, this depends upon the light source that you put into it. I can give you a couple of different examples. If you take a simple hundred watt tungsten halogen bulb impinging on a 15 by 15 inch screen -- this is typically what we do in the lab, you have an output of around -- it is about the same number that Gene mentioned -- it is around 60-foot lamberts, which is very bright, actually. You will find that even with the room lights completely on, you tend to turn the bulb down a little bit. Around 40 to 50 is more comfortable. But that could be increased by just increasing the bulb. If you want to go to full wall size display, you would have to go an arc lamp, and there you are almost unlimited. But, obviously, on a wall screen projection you cannot have much in the way of room lights. But in a back projected, even up to several feet by several feet, you can get quite high relative contrast, certainly well in excess of ten to one, even with full room lighting. By the way, several of these robots are available for viewing, and if some of you feel inclined you can come down and see some of these.

DR. BOYLE: Could I just add to this question on zooming? One of the important things, of course, is the speed of addressing the points. Are these two methods as fast as the ordinary CRT, or do we have a time difference when you are re-addressing?

DR. SLOTTOW: Let me give you some numbers on that. The frequency of the sustained voltage that maintains the image is typically 50,000 Hertz. There are several different modes of addressing. One is to address a single point at a time. If you address a single point at a time, either writing or erasing, you will then change 50,000 points per second. But, actually, any type of matrix display you can do better than that because you can address more than one dot at one time. The one thing that you cannot do with any kind of a matrix display where you have some kind of a coincident selection system, is that you cannot take a square and then write, let us say, three different dots at the corners but not write the fourth one. Because if you, for example, pick the top two, you selected two vertical lines, if you take two on the side, you have selected two horizontal lines, then you have automatically selected that fourth corner. Of course, what you do, you just write the top two and then one of the bottom ones. You can in fact write up to a line at a time if the circuitry that you put into the system will allow it. So, on a 512 by 512 system, that would allow you to write or erase at a rate of 25 million bits per second, which you normally would not do. In the circuitry that has been provided in the more recent devices, you can write up to eight or sixteen dots at a time, and that is a limitation only on the circuitry, not in the panel itself. This corresponds to about 800,000 bits per second.

I should point out a very important fact, and that is that as these new technologies develop, there are always problems with them. One of the problems -- at least an apparent problem -- with the plasma display was that it was not compatible or presumably not compatible with microelectronics. So you had to sort of work out the schemes that got you around that problem in the beginning. Since then, though, the interest and the demand for this technology has gone up to the point where specially designed circuits from, say, Texas Instruments, are now available. The microelectronics for this technology is available or is becoming available. I think there are several different models of circuitry out in the TI catalogs. I think if we would ask what is the most important thing that has happened in the last couple of years to plasma display technology, I would not say somebody has shown color, or somebody has shown gray scale; I would say it is the microelectronics, the logical integration that has become available for the plasma display technology, so you can now take the next steps in your stride.

DR. BOYLE: Do you want to make a comment?

MR. DURBECK: Yes. As far as the update time, it depends upon where you are. If you are working on the upper end of the stream, you want to update suddenly something in the lower end, it could take as long as about 200, 250 milliseconds. If you are updating the same region you are working, it could be as low as 35, 40 milliseconds. It is in that time range.

DR. BOYLE: I wonder, if to answer the last part of the question, I can ask if you have given any thought as to whether we do want large screen displays in cartography. I would be very interested to hear your comments on this.

MR. EDSON: I guess my answer to that is somewhat philosophical. I think that one of the problems we face in developing automated systems is credibility.

I can visualize the city councils -- and this is fairly typical -- where a great number of variables are pulled together and displayed as some graphic, showing the dire consequences of this or that happening or not happening, and at the end of this no one really believing that this analysis has any real meaning or credibility, whereas the use of a large display as this analysis is actually generated with a group like that, is going to permit a group of decision makers to actually perform the basis of the analysis as it goes along, step by step, display each of these and the result of various subcomponents of this analysis, and finally coming to a conclusion that everyone does in fact believe, and on which they will base a sensible decision. I think I can see it used for that sort of thing, where we need to work together, groups of decision makers working together on a large display. I really think it is in the future.

DR. BOYLE: Thank you. One last question.

MR. JIM STEWARD: I am Jim Steward, AMOCO Production Company. I really did not come to ask any questions as much as to comment on what Tom said. It has almost been answered by the speaker ahead of me.

In the oil business we have the cartography problem that you talk about in terms of geography, but we also have the problem of decision making. And that problem is a very severe one to us, because we are constantly asking or trying to interpret subsurface things like geology and geophysics and all the combinations thereof. It becomes a group decision. So it is necessary to have multiple people working on display. This, despite all these zooming techniques, throws out the small screen very quickly. Now, granted, you could put ten people in a room and give them each a Tektronix and have these Tektronix operating in parallel and make it possible for anyone to alter and to be seen back and forth between each other. But I do not think this will work any more cheaply or probably even as well as one large display. We have been looking at this problem for quite some time, looking for a large display, and then talked with the gentlemen on your panel. But I think that Tom -- I wanted to chastise him, really -- I think he is like a lot of people who can see in his own situation that, yes, the human being does not need to look at a 40 inch by 40 inch map which is the standard in the oil industry, but they are so used to looking at it that you are going to have to go through a process at least of building these big display devices and maybe backing down ten years from now. But I do not think you are ever going to satisfy them without doing it first.

I have a favorite story I would like to tell to show you the kind of thing you can get into if you are not careful and if you do not think about the user. About 15 years ago I can remember when we had our first program that we had borrowed from somebody that we had finally adapted to our system to give a nice three-dimensional look on the face of a CRT, at that time a 40/02A of a subsurface geology picture. We were so proud of it, and we showed it. Among the people we showed it to early in the game was one of the senior vice-presidents of the company. I never got quite as big a chewing out in my whole career as I got from that gentleman, because he told me, "You're wasting your time, you're wasting the company money. If I have a geologist on my staff who can't see three dimensions on an ordinary contour map, I don't want him working for me." So, we had to continue that work for at least six or seven years on the q.t. We never really told him we were continuing to upgrade and work on this. We did it for the simple reason that I think all the rest of you -- particularly the younger people -- try and find a geologist coming out of college now from the good schools who is not working with a computer, who is not using three-dimensional display pictures, and it is a tough problem to find someone like that. We are ready for those people now. You are going to go through this. Tom's idea that, "Do you really need it?" I think you could probably do a lot of psychological work to prove you did not need it. But if you are going to be successful you must remember that the user is still king, and the user wants it in the board room. He wants a display, he wants to work as a group. These big systems are necessary. I think you will find that you are not going to sell as many of these units as we sell the little CRT's to put on everybody's desk. But there is a market here, and I think the people should use it.

DR. BOYLE: I think that is a good point on which to end. I would like to thank our team members of the panel who have worked so hard. Thank you.