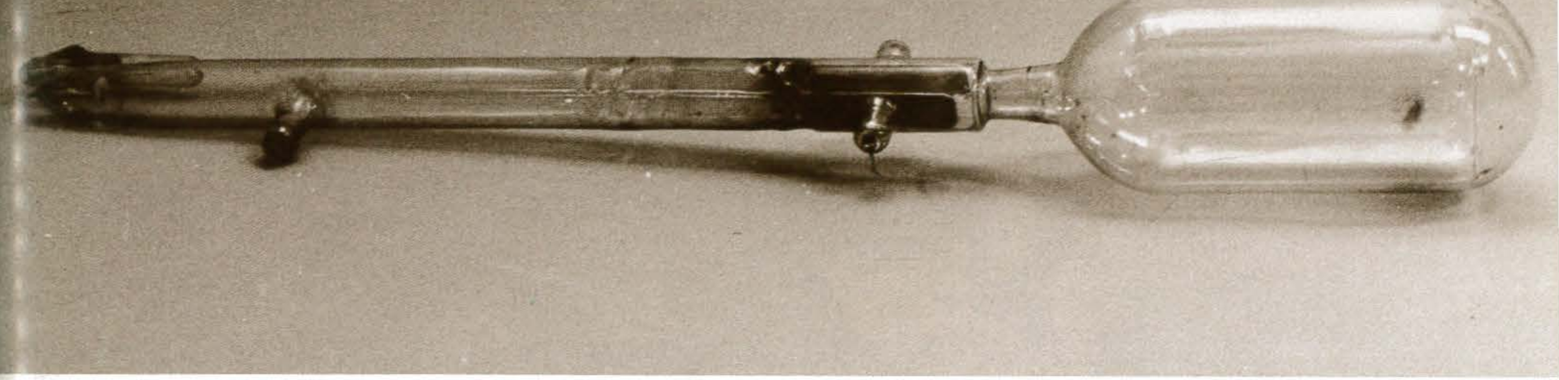
≡ Official Monthly Publication of the Society for Information Display

# INFORMATION DISPLAY

June 1997
Vol. 13, No. 6

## CRT CENTENNIAL ISSUE

The first CRT: Karl Ferdinand Braun's indicator tube of 1897 changed the world.



ogener Glimmerschirm. Die Glaswand *E* muss möglich
eichmässig und ohne Knoten, der phosphorescirende Schir

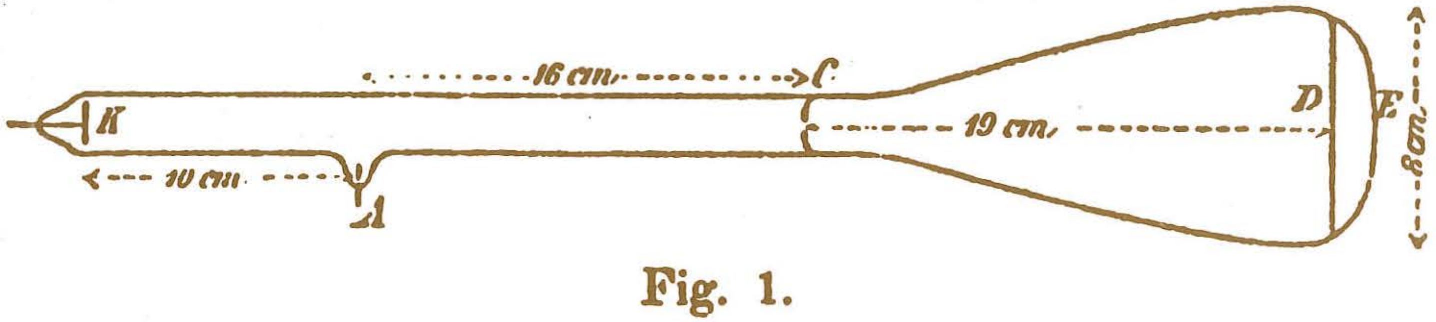



Fig. 1.

angebracht sein, dass man durch das Glas und den Glimm
ndurch den von den Kathodenstrahlen hervorgebracht

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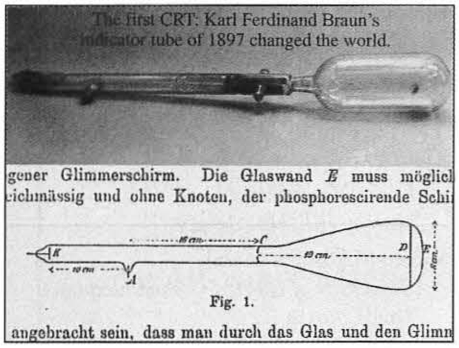
*COVER: Karl Ferdinand Braun's indicator tube was designed to be a better device for determining ac waveforms in the developing ac electric power industry. The tube was the first to combine all the essential ingredients of a modern CRT, and its descendants have changed the world. Peter Keller's article begins on page 12.*

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## Next Month in *Information Display*

Business Issue
- CRT business issues
- Lessons learned from DTI
- Business models for FEDs
- Why is b&w so important to color?

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# INFORMATION DISPLAY

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## editorial

### CRT Bashing Is Easy – Too Easy

You read the anti-CRT rhetoric all the time. You read some of it in the pages of this magazine. (I should know because I write some of it.) You hear it in phrases like "the flat panel's serious assault on desktop," and "the heavy, bulky CRT."

It is all too easy to fall into the trap of feeling that all of the exciting technical display innovations are in the flat-panel arena, and that CRTs are dinosaurs just waiting to keel over. The trouble with this mind-set is that not only does the dinosaur refuse to keel over but he insists on running through the countryside with undiminished energy. The CRT still owns the TV-receiver and desktop-monitor markets, and the overall value of FPD sales is not projected to match that of CRT sales until after the turn of the millennium.

Another phrase that rolls easily off the tongue is "the venerable CRT," and so it is. In this issue's cover story, we celebrate the centennial of the Braun tube – the first CRT. That hundred years – an extraordinarily active lifetime for a commercial electronic device – has given the CRT the advantages of remarkably low cost and sophisticated performance. In his guest editorial in our March issue, Tom Holzel observed that, given a choice, most people prefer to watch CRTs, rather than LCDs or PDPs.

And the CRT is a moving target, with its own share of continuing innovations. In this issue, Jimmy Chen discusses 14 milestones in color-CRT electron-gun design over the last 25 years – and an innovation he expects will become a 15th milestone: the multi-beam group gun, which will allow CRTs to fulfill the demands of large-screen high-scan-rate HDTV.

A CRT innovation on the specific-product level is NEC Technologies' CromaClear™ CRT. Interlinked refinements in gun and mask design, and phosphor pattern, give the mainstream computer monitors that contain the CromaClear™ CRT excellent image definition.

One characteristic of CRTs that nobody defends as an advantage is the device's appetite for high voltage. To casual observers of the CRT scene, it sometimes seems that the number of high-voltage power-supply (HVPS) makers is declining. But when HVPS guru Bill Santelmann surveyed the current scene, he found a healthy supplier base. In his article, Bill reviews what to look for in an HVPS and provides a guide to suppliers. (There are actually more suppliers than the number listed. Some HVPS makers did not send Bill the information he requested.)

Where does the CRT go from here? Many people are inclined to see the field-emission display (FED) as a flat, thin CRT. Accept that definition, which is a very reasonable one, and the CRT may soon be making "a serious assault on the laptop."

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Your comments and your letters to the editor are welcome. You can reach me by phone at 203/853-7069; fax 203/855-9769; e-mail: kwerner@netaxis.com. The contents of upcoming issues of *ID* are available on the *ID* page at the SID Website (http://www.sid.org).

– Ken Werner

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**INFORMATION DISPLAY**

# the display continuum

## My Friend – The Big Mainframe Computer ...

**by Aris Silzars**

One of the really hot technology topics in the mid-eighties was artificial intelligence. Predictions of when and if computers would become "smarter" than humans were made and argued about. Would computers be able to outreason us? Would they begin to have feelings? Could they be programmed to learn? These were the issues so intriguingly predicted by the movie *2001 – A Space Odyssey*. Then - as usually happens when progress isn't as rapid or as dramatic as the popular press expects - interest in this topic flamed out. Except for writing about an occasional chess match between a human and a computer, or about why the Apple Newton wasn't very good at recognizing handwriting, the topic no longer captured the interest of the media.

I think, however, that all the over-enthusiasm in the 80s planted a seed. This seed, without any of us taking particular note, germinated, matured, and produced yet other seeds. And just as quietly, these other seeds developed and created yet others even more capable. I know - it caught me by surprise too. Artificial intelligence is upon us. So far, it's mostly of the friendly kind. We just have to hope that it stays that way. Otherwise, the consequences could be just as ominous as what happened to HAL in *2001*.

Let's consider an example or two. I'm sure you won't be surprised when I tell you that I spend quite a bit of time on airplanes. For this reason, I am considered an especially "valued" customer of one airline, a moderately valued customer of several others, and a super-duper-valued customer of one rental-car agency. Because of this, when I arrive at an airport ticket counter or boarding gate and my name is entered by the agent, the computer immediately lets the agent know that here stands a person who should be treated with extra care and friendliness. The computer makes sure that I have the highest priority if I wish to change my flight, change my seat, or ask for an upgrade. The computer keeps track of all my flights and periodically sends me more upgrade and free-drink certificates. The computer also keeps track of all my frequent-flyer miles and tells the agent that I don't need to worry about black-out dates.

After I board, with the specially imprinted boarding pass that the computer has provided, my "valued customer" status is noted on the passenger manifest to alert the flight attendants. The nicer ones, who sometimes look at this list, will make sure that I am a happy flyer and will offer me complimentary wine even when I am sitting in coach - which is most of the time. The computer also knows which seats I like, holds a seat empty next to me whenever possible, and remembers a few other details about my flying habits. All these extra little touches make my hours in the air and at the airport just a little more pleasant. And the airline accomplishes *its* objectives - I use it most of the time.

"So, what's the big deal?" you say. "That's not intelligence, that's just simple programming." Well, let's compare this normal and rather pleasant scenario to a time when the computer temporarily forgot about me and a few other passengers.

*continued on page 40*



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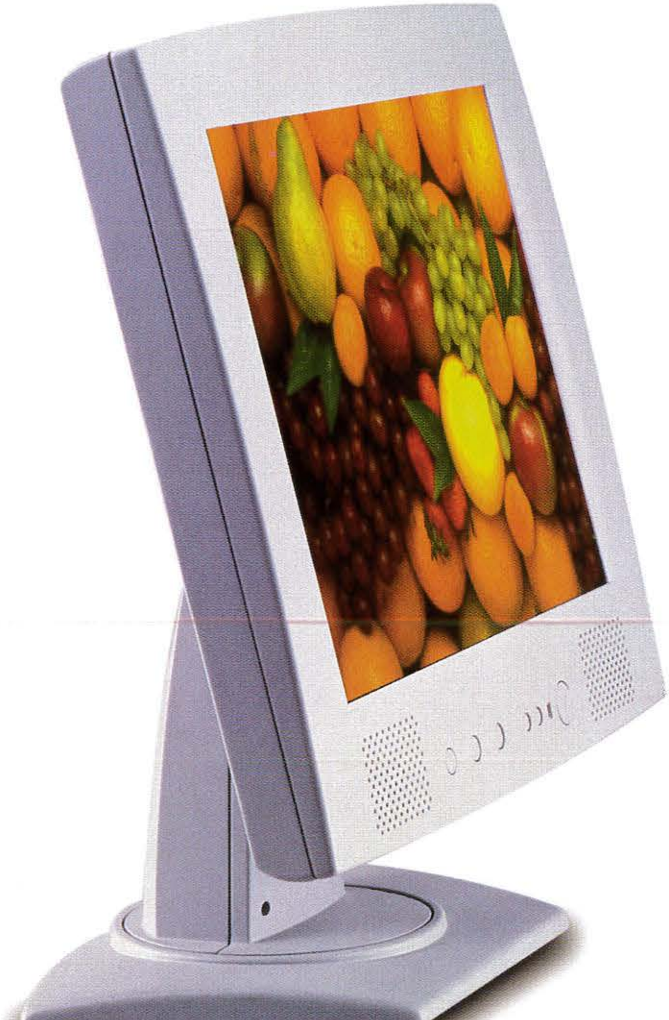
# Put your CRT on a Diet



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| **Brightness (typical)** | 200 nit |
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| **Multiscan** | Yes |
| **PC/Mac Compatible** | Yes |
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# The 100th Anniversary of the Cathode-Ray Tube

*In 1897, Karl Ferdinand Braun invented a device that changed the world.*

## by Peter A. Keller

Nineteen hundred ninety-seven marks the 100th anniversary of the Braun cathode-ray tube (CRT), the first to fill a practical application and the first to include all of the basic functions of today's CRT. In one way or another, the CRT has been an important factor in all of our lives since the early post-World War II years. Television, personal computers, video games, electronic test and measurement instruments, computer-aided workstations, airline-reservation systems, cockpit flight-instrument displays, and automatic bank-teller machines are all examples of our daily contact with the ubiquitous CRT.

For a display whose demise has been predicted for years because of the advent of newer technologies, the CRT is remarkably healthy. Indeed, it has grown stronger than ever. The CRT antedates the receiving vacuum tube and is at its zenith some 25 years after the receiving tube's demise. The relative low cost, extreme versatility, ability to display full-color high-resolution images, and a design that lends itself to continuing improvement have allowed the CRT to maintain a strong lead over competing technologies. With its roots firmly planted in the 19th century, the CRT is expected to remain a strong display contender at least into the early 21st century.

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### Early Developments

Significant developments leading to the CRT may be traced as far back as 1603, although most of the development leading to the Braun tube took place in the second half of the 19th century. These preceding steps involved phosphors, vacuum technology, discovery and understanding of the properties of the electron, and the basics of electron optics.

The first man-made phosphor was made by an Italian shoemaker and alchemist, Vincenzio Cascariolo, in 1603 as a result of trying to create gems or gold from lesser materials. Some historians of technology consider this the single most important discovery in the history of inorganic luminescence. Luminescent

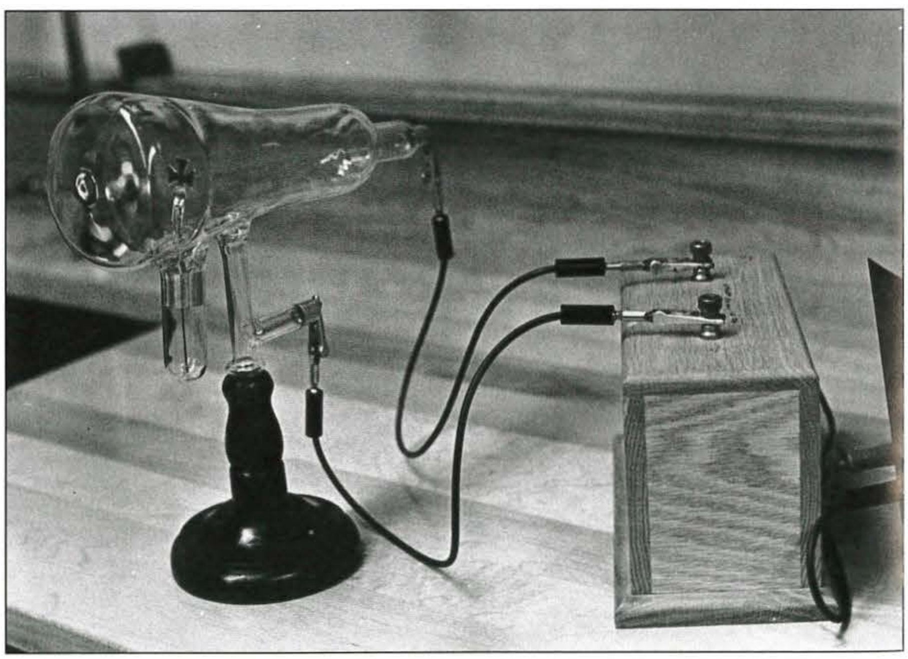

*Fig. 1: Replica of the Crookes tube used to demonstrate the electron shadowing of a metallic Maltese cross. (From Keller,* The Cathode-Ray Tube.)



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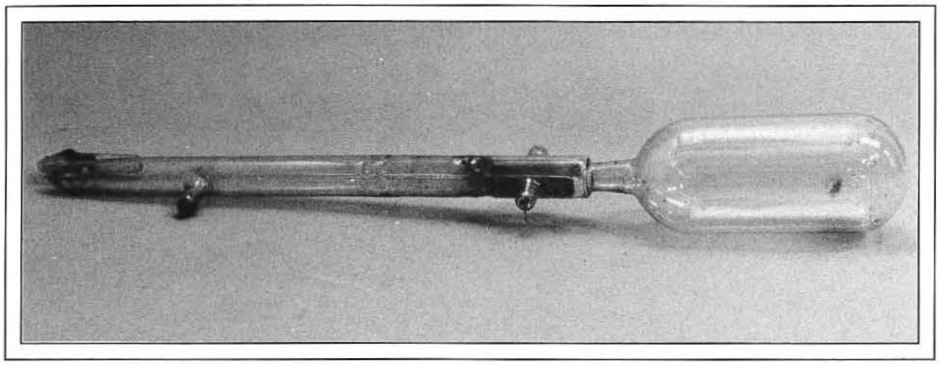

*Fig. 2: Replica of the Braun CRT. (Specimen at the Smithsonian Institution, Washington, D.C. Photo by the author.)*

materials later became the primary method of making visible the otherwise invisible electron beam.

The luminescence of gases in the imperfect vacuums of early experimental devices or fluorescence of their glass walls also were used to indicate the presence of the mysterious "cathode ray." In 1751, William Watson discovered that voltage applied across an evacuated glass tube having two electrodes resulted in the emission of a bright light from the residual gases within the tube. Heinrich Geissler, a German glassblower, developed an improved vacuum pump in 1855 and later fabricated the sealed-off glass tubes known as Geissler tubes that were used by Julius Plücker to study electrical discharges through gases at low pressure.

In 1859, Julius Plücker observed that rays emitted by a cathode could be deflected by a magnetic field. The term *kathodenstrahlen* (cathode rays) originated in 1876 with Eugen Goldstein, who also found that they could be deflected with an electrostatic field.

Later work by Sir William Crookes furthered the understanding of cathode rays, as well as of their deflection by magnetic fields. A Crookes tube used to display the shadowing effects of a metallic Maltese cross by an electron stream was widely illustrated in early physics textbooks (Fig. 1). Similar tubes were used by Wilhelm K. Roentgen in his 1895 discovery of x-rays, one of the more important applications of cathode rays.

Other well-known researchers instrumental in developments leading to the CRT include Johann Bernoulli, Francis Hauksbee, William Watson, John Canton, Michael Faraday, Heinrich R. Hertz, Philipp Lenard, and Sir Joseph J. Thomson. Many of the physicists who made contributions to the art of cathode rays were recipients of Nobel prizes, although not necessarily for these contributions.

## The Braun CRT

Another recipient of the Nobel prize for physics, Karl Ferdinand Braun (1850–1918), is most closely associated with the CRT. His Nobel prize was awarded jointly with Guglielmo Marconi in 1909 for their work in wireless telegraphy, not for Braun's work on the CRT. Braun held a chair of physics and a directorship at the University of Strasbourg at the time of his experiments with cathode rays in 1896 and 1897.

Braun is credited with inventing the modern CRT in early 1897. Braun's CRT contained all of the basic functions of today's CRT: an electron source, focusing, deflection, acceleration, phosphor screen, and a mechanical structure to house all the components. Braun's tube had an actual purpose rather than being a laboratory curiosity, as was the case with most of its predecessors. (This is not meant to downplay in any way the scientific importance of the preceding work that led to the Braun tube.)

What was the application – and the motivation – for Braun's tube? Central power-generation stations were coming into use during the late 19th century, and the newer alternating-current systems posed problems for the measurement of voltage, current, and phase. The inertialess beam of electrons offered significant advantages over the mechanical oscillographs using mirrors and light beams in use at that time. These earlier devices were restricted in frequency response because of their mechanical limitations. Alternating-current systems at a wide range of frequencies were being investigated for power generation, and Braun saw the possibilities for using the CRT as a measurement tool in the field.

The Braun tube (Figs. 2 and 3), constructed by Franz Müller of Bonn – a successor to Heinrich Geissler – incorporated a cathode (K) and anode (A), as had previously been done in the Crookes tube. An aluminum diaphragm (C) was inserted in the neck of the tube to limit the electron-beam diameter so that a clearly defined spot would be formed at the screen. The screen (D) consisted of a transparent sheet of mica coated with a phosphor on the side toward the cathode. This was the first use of a phosphor screen within the tube, a great advance over using the weaker glass fluorescence to make the cathode rays visible.

Vertical deflection of the beam was produced by an electromagnetic coil next to the neck of the tube. The voltage to be measured was applied to the coil and resulted in a green line of about 25 mm in length on the screen. A rotating mirror in front of the screen – as used with mechanical oscillographs of the time – provided scanning in the horizontal axis to allow the waveshape to be observed. Also tried was a rotating magnet mounted below the tube in place of the rotating mirror in front of the screen. The rotation speed was adjustable to allow synchronization with the

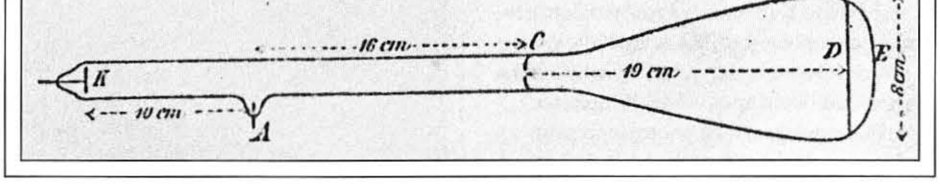


*Fig. 3: Diagram of the Braun CRT in the original paper published in 1897. (From F. Braun,* Annalen der Physik und Chemie, *1897.)*

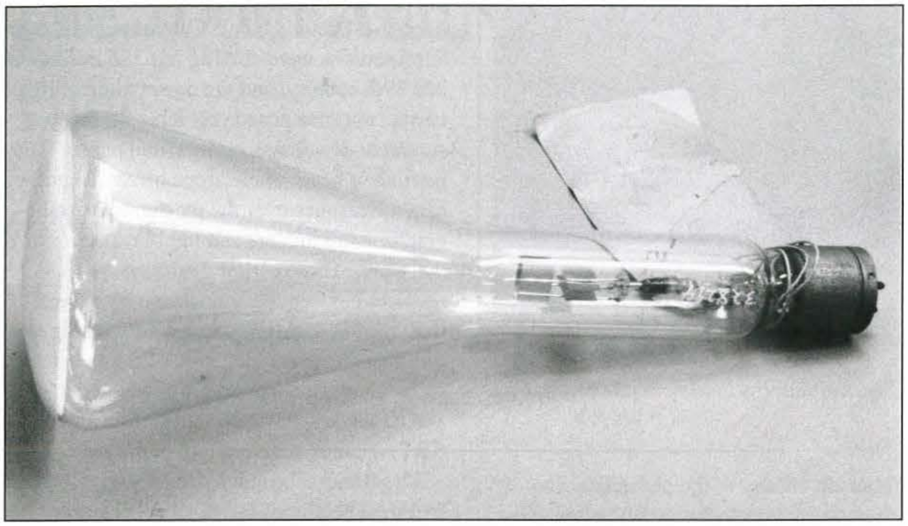

*Fig. 4: Western Electric 224-A gas-focused "Cathode-Ray Oscillograph," as announced in 1921. (Specimen at the Smithsonian Institution, Washington, D.C. Photo by the author.)*

frequency of the voltage applied to the deflecting coil in the other axis. Later experiments used a second deflecting coil mounted at right angles to the first. This allowed a second voltage to be applied for comparison to the first voltage by displaying Lissajous figures.

All five elements of the modern CRT as we know it are utilized in the Braun tube: (1) the source of cathode rays (cathode); (2) a means of providing a focused spot (diaphragm); (3) a means of accelerating the beam of cathode rays (anode); (4) a deflection system to direct the beam to various locations on the screen; and (5) a phosphor screen to make the cathode-ray beam visible.

Braun published a paper in 1897 describing the investigations of electrical waveforms, but he gave only a brief description of his tube. Yet, he was surely the first to put all the elements together, and it is he who deserves the credit for the modern CRT.

### Subsequent Developments

An assistant to Karl Braun, Jonathan Zenneck, continued work on the CRT as an indicator. He had developed an improved tube by 1899 using an additional aperture in the neck to improve focusing, and he photographically recorded waveforms from the screen. Zenneck developed an electro-mechanical time-base circuit that allowed waveforms to be displayed on the screen without the rotating mirror. This completed the present-day cathode-ray oscillograph concept. Zenneck became dedicated to finding as many applications as possible for the oscillograph in later years. (The term "oscilloscope" was not introduced until 1927 in a paper by Bedell and Reich.)

An improved Zenneck CRT of more compact dimensions was produced for J. T. MacGregor-Morris in 1902 by A. C. Cossor, Ltd., for many years a major name in CRTs and oscillographs in England.

Professor Harris J. Ryan reported on using a cathode-ray oscillograph with orthogonally mounted magnetic-deflection coils for alternating-current studies at an American Institute of Electrical Engineers Convention in July of 1903. He indicated that he had begun work in 1900 using tubes constructed by Mr. Miller-Uhri of Braunschweig, Germany, who had attempted to make 150-mm-diameter Braun tubes but finally succeeded in making a pair of 125-mm tubes. Ryan noted that Miller-Uhri was prepared to export similar tubes at a price of $20 each.

One of the greatest advances that made possible the modern CRT was the development of the oxide-coated hot cathode in 1903-1904 by Artur Rudolph Berthold Wehnelt, a Brazilian-born German physicist. The oxide cathode was an outgrowth of the "Edison effect," noted by Thomas Alva Edison in 1883, in which a current was measured in an electrode in close proximity to a hot filament in an incandescent lamp. When Wehnelt discovered that a coating of alkaline-earth oxides on the filament greatly increased the emission of electrons, he constructed CRT tubes with oxide cathodes. These had the advantage of having strong emission with anode voltages of only a few hundred volts, compared to earlier tubes that required up to 100,000 V to sustain emission.

The first commercial CRT in the United States was the Western Electric type 224-A

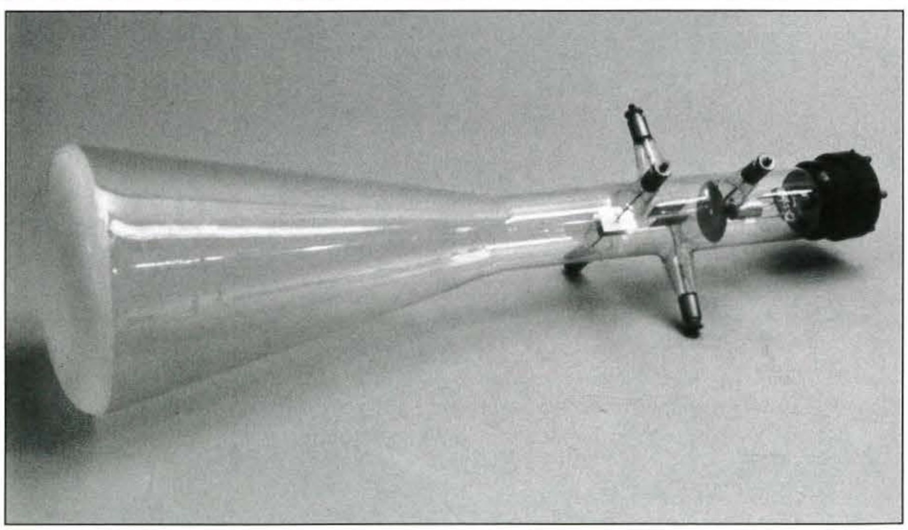

*Fig. 5: Von Ardenne electrostatically deflected CRT of the 1930s. (Specimen at the Smithsonian Institution, Washington, D.C. Photo by the author.)*

*Fig. 6: Du Mont 14- and 20-in. electrostatically deflected CRTs for television. (Photograph from the Du Mont Collection at the Smithsonian Institution, Washington, D.C. Photographically copied by the author.)*

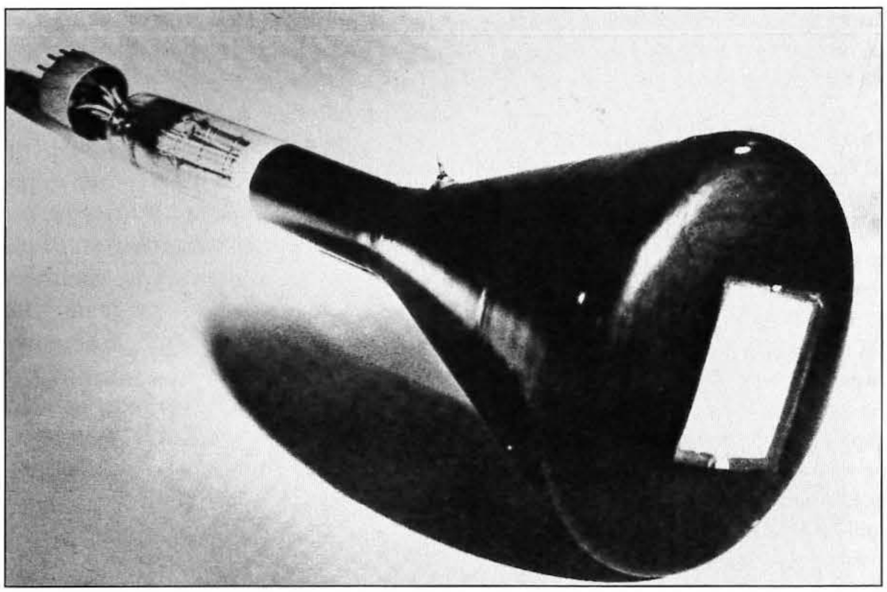

*Fig. 7: Prototype RCA shadow-mask color CRT of 1949. (Courtesy of David Sarnoff Research Center.)*

developed in 1921 by H. J. van der Bijl and John B. Johnson and referred to in the literature of the period as a "cathode-ray oscillograph" rather than a cathode-ray tube (Fig. 4). Today, it is commonly known as the Johnson tube. As suggested by Dr. van der Bijl in 1920, a small quantity of gas within the tube was used to provide focusing of the electron beam. Two sets of deflection plates were used to obtain electrostatic deflection, although a magnetic-deflection coil could also be used around the neck for magnetic deflection. The result was a compact, self-contained tube suitable for portable-instrument use. Crisp, bright traces on the screen could be obtained with operating voltages of only 300–400 V.

Vladimir K. Zworykin demonstrated an all-electronic television system while at Westinghouse in 1929. This system employed a CRT, which he called a *kinescope,* as the heart of the receiver. The Zworykin kinescope was of the high-vacuum type with electrostatic focusing. After 1929, all-electronic television rapidly gained acceptance over the previous cumbersome mechanical-scanning systems. This provided the first significant impetus for commercialization of the CRT.

Manfred von Ardenne was a very prolific researcher and author in the field of CRTs in pre-World War II Germany. Numerous references to developments at his company, Leybold and von Ardenne, appear in technical publications of the 1930s. Von Ardenne demonstrated an all-electronic television system in Berlin at about the time of Zworykin's demonstration. Subsequent inventions by both of them were often made independently within a few weeks of each other. Von Ardenne investigated the use of early gas-focused CRTs for television and was the supplier of the gas-focused 478-A for the General Radio 496-A Electron Oscillograph introduced in 1931, the first commercially successful instrument of its kind. Figure 5 shows the construction of an early electrostatically deflected CRT by von Ardenne. High-vacuum CRTs were also developed by von Ardenne in 1928.

Dr. Allen B. Du Mont was a U.S. pioneer in the development and application of CRTs. Du Mont left a position as chief engineer for the De Forest Radio Company in 1931 to start his own company dedicated to the development of the CRT in the basement of his home

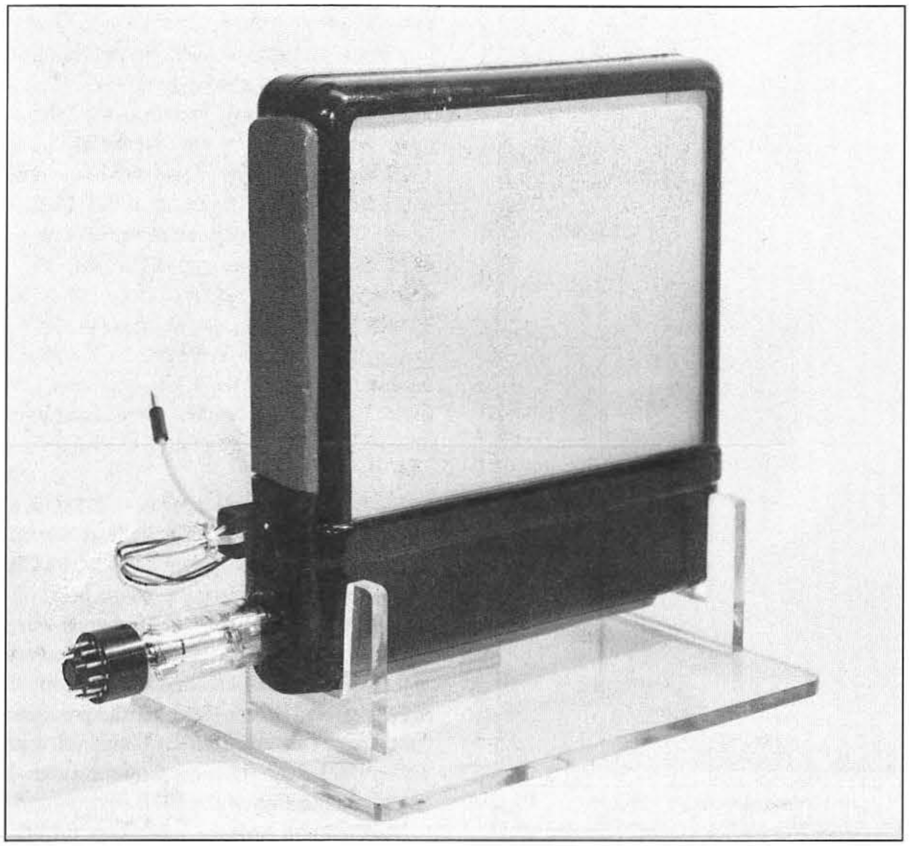

*Fig. 8: The Aiken "Thin Tube" of 1951. (Courtesy of W. Ross Aiken.)*

in Upper Montclair, New Jersey. There, he began what grew into Allen B. Du Mont Laboratories, which, until the early 1950s, was devoted exclusively to the development and manufacture of CRTs and associated equipment. Du Mont manufactured an extensive line of cathode-ray oscillographs (oscilloscopes) beginning in late 1931. Early Du Mont CRTs were of the gas-focused type - similar to the Johnson tube - although they were rapidly replaced by high-vacuum types embodying many improvements in the mid-1930s.

As early as 1932, Du Mont was investigating the application of CRTs to television. Ever a leading proponent of large-screen television, Du Mont introduced the largest-screen television receiver in the United States in 1938 using a 14-in. CRT. The Du Mont tube was all the more unusual in that it was an electrostatic-deflection type, with that technology's inherently greater length. This was soon followed by a 20-in.-diameter electrostatically deflected CRT of gigantic proportions, measuring almost 28 in. in length. (Both types are shown in Fig. 6).

## Maturing of the CRT Industry

Until the mid-1930s, most CRT developments are attributed to individuals. As the CRT became commercialized and design groups were assigned to the work, the developments are more often attributed to the host companies. By the late 1930s, commercial CRTs by RCA, Cossor, Du Mont, Telefunken, and others were commercially available and were being employed in limited quantities for oscillographic and television applications. The stage was set for the rapid growth and refinement that was to come as the CRT was drafted for military electronics and radar applications with the onslaught of World War II. Adoption of large-scale production techniques - rather than major technical leaps in CRT design - marked the war years. In 1939, approximately 50,000 CRTs were produced; by the end of 1944, more than 2 million per year were being produced. These expanded wartime production facilities were ideally positioned to meet the subsequent explosive demand for postwar television picture tubes. This maturing of the CRT began at the time of the nearly unnoticed 50th anniversary of the Braun CRT.

RCA's public demonstration in 1950 of the shadow-mask color picture tube marked the last major milestone in CRT development (Fig. 7). Since then, the name of the game has been refinement. These refinements should not be downplayed; CRT performance is orders of magnitude better today through a great number of incremental improvements.

Finally, the widespread use of personal computers further advanced the need for CRTs, as well as imposing tighter specifications on them. The resulting competitive market led to additional improvements in display quality and cost reduction.

Only now, after 100 years of CRTs, is the long-heralded "picture-on-the-wall" flat-panel display finally beginning to make significant inroads. This replacement for the venerable CRT has been "just around the corner" since about the 50th anniversary of the Braun CRT. The first flat CRT, W. Ross Aiken's "Thin Tube" of 1951, was the first of many competing technologies to vie for that market (Fig. 8).

Even as the CRT matured in the post-World War II period, it would have been impossible to foresee the tremendous impact the CRT would have on our lives in the era of the Braun CRT's hundredth anniversary. It is safe to say that we haven't seen the last of it yet.

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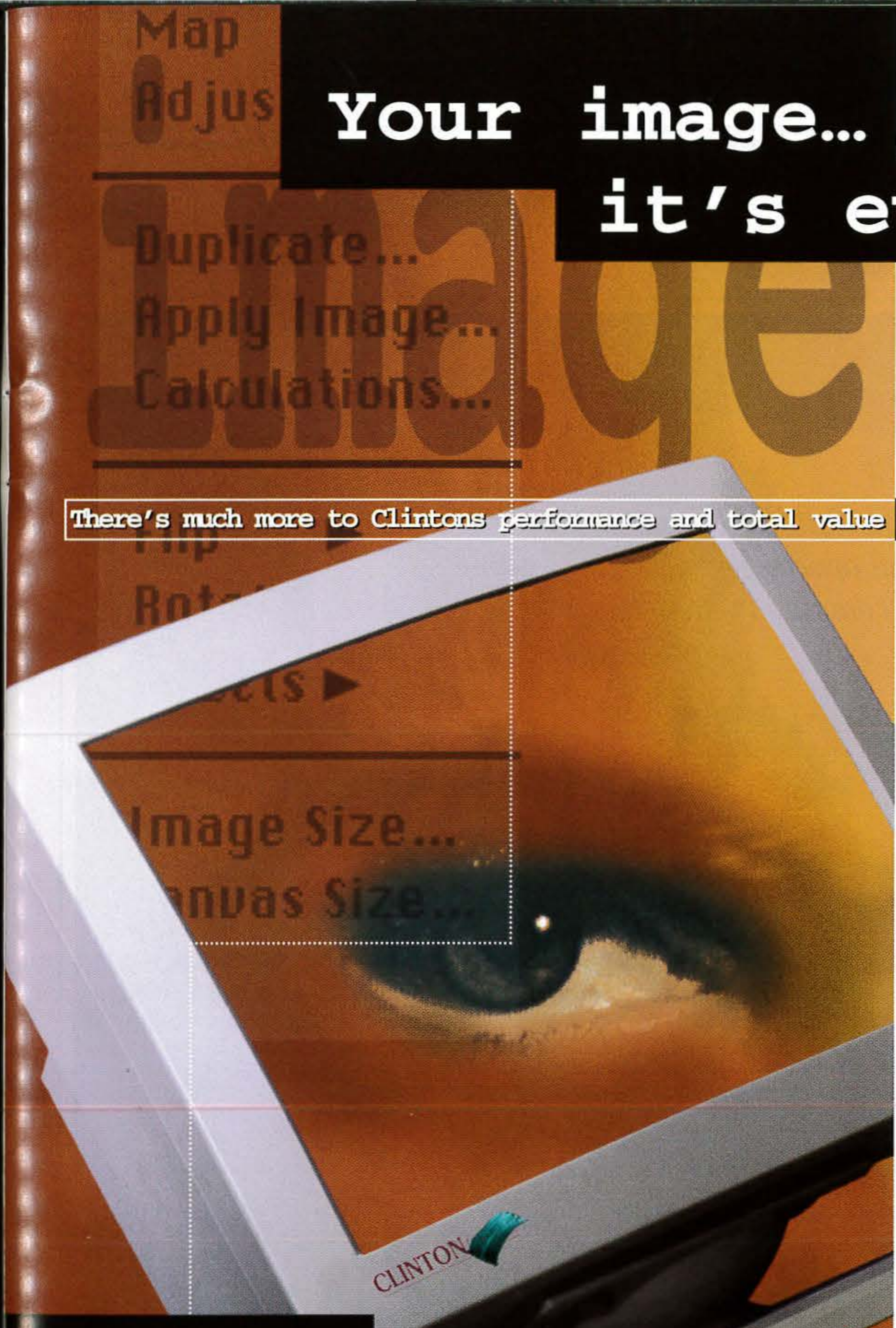


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**Circle no. 12**

# There's Still Room for a New High-Volume CRT

*The CromaClear™ CRT from NEC Technologies combines the advantages of traditional dot-trio and aperture-grill CRTs, leading to better overall image focus and a reduction in perceived moiré.*

## by David DeVries and Richard Atanus

Historically, two types of CRTs have dominated the desktop-computer marketplace: traditional dot-trio and aperture-grill CRTs. In the past few years, improvements to these CRTs have been limited to incremental gains such as smaller dot/stripe pitches and on-screen controls. While these advances do result in better image quality, each CRT type has its inherent advantages and disadvantages. For example, because of their vertical alignment, aperture-grill CRTs tend to display diagonal lines with jagged edges. Dot-trio monitors, on the other hand, are subject to moiré patterns as dot pitches and beam sizes become smaller.

Today, the range of computer use has dramatically changed. With the advent of object-oriented interfaces such as Windows 95 and the Macintosh OS, the need for vertical and horizontal definition along with crisp diagonal lines has become more important. Another example of the need for improved CRT performance is evident in the explosive growth of "home pages" on the Internet, which use small text fonts and complex graphic images.

NEC Technologies, the North American arm of NEC Corp., recognized the need for a significant advance in CRT technology that

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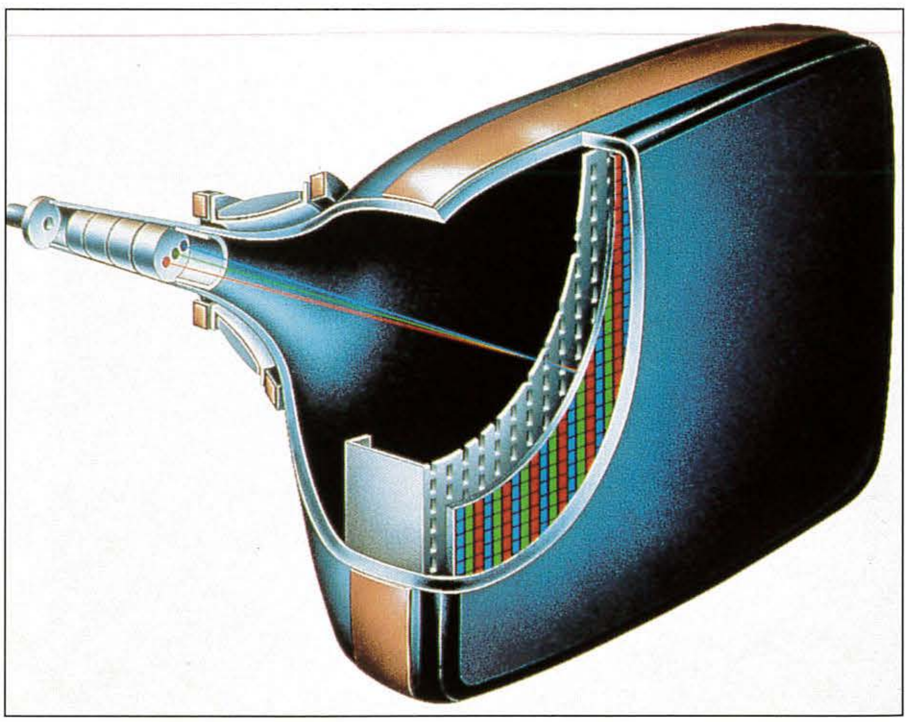

NEC Technologies, Inc.

***Fig. 1:*** *NEC's CromaClear™ CRT incorporates a new phosphor screen, a fine-pitch slotted shadow mask with staggered openings, and optimized electron-beam configuration.*



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NEC Technologies, Inc.

*Fig. 2: The new CromaClear™ tube is being used in 15- and 17-in. multimedia monitors and the MultiSync P750 professional monitor (pictured).*

would be optimized for these changes in personal computing. The goal was to combine the best attributes of dot-trio and aperture-grill CRTs into a conventional CRT structure.

The CromaClear™ CRT, the result of years of research and development, uses a striped type of phosphor structure. In addition, the CromaClear™ CRT uses a slotted shadow mask to maintain high compatibility with the external mechanical configuration of dot-trio tubes (Fig. 1). A final improvement is the reshaped electron beam to better match the new mask openings.

The combination of a striped phosphor screen and an optimized electron beam has produced outstanding viewing quality with excellent character legibility and picture quality. Furthermore, the moiré phenomenon has been reduced by optimizing the vertical shadow-mask pitch. The results are clearly noticeable to users, and the CromaClear™ CRT has achieved recognition in the industry for outstanding image quality with excellent character readability, legibility, and focus (Fig. 2). The design of this tube required a major effort and the overcoming of significant hurdles during development by NEC and its international affiliates.

## Screen Structure

As mentioned before, phosphor-screen structures are divided into dotted and striped configurations (Fig. 3). The dotted type consists of one color laid out in a line where colors change cyclically. An aperture-grill CRT, on the other hand, has vertical phosphor stripes that flow without interruption. In either tube, a trio of red, green, and blue phosphors are configured corresponding to each shadow-mask opening. If the pitches of the shadow-mask holes are identical, the maximum number of displayed horizontal pixels for the striped type is $(3/2)^{1/2}$ times that of the dotted type. To achieve the same horizontal resolution as the dotted type, the pitch of the striped type must be finer than that of the dot-trio CRT.

In developing the CromaClear™ CRT, a major consideration was legibility (Fig. 4). The figure shows a character-image legibility comparison between a dot-trio and a CromaClear™ CRT, which indicates that the CromaClear™ CRT and its slotted mask provide sharper image quality because of the reduced overall mask pitch.

Another component of the CromaClear's improved image quality is its new ELA gun. The gun's elliptically shaped electron beam better matches the new mask shape and alignment and the shape of the phosphor stripes, contributing to improved image focus and reducing the need for end-user moiré and convergence controls (Fig. 5).

The improved focus of the CromaClear™ CRT is attributed not only to the new electron-beam diameter but also to the geometry of the phosphor screen's black-matrix structure, which is similar to that of an aperture-grill CRT. So the CromaClear™ CRT combines a striped screen structure with a slotted shadow mask.

Overall image focus - or character legibility - can best be measured using the Fourier-transform method. This procedure calls for taking measurements of characters with varying textures and then mathematically transforming the data. In transformations of CromaClear™ CRT phosphor groupings, we observed maximum spatial frequencies of 5.9 lp/mm (0.17 mm/pitch). The result is that characters excel in vertical and horizontal definition.

Fourier spectra are generated by sampling the patterns. Increased spectra indicate newly generated components, which are considered interference. Decreased spectra indicate lost components. Such results indicate that the CromaClear™ CRT has fewer increased spectra patterns than dot-trio CRTs and similar decreased spectrum patterns.

## Shadow Mask

The shadow-mask pitch is one of the major factors that improve legibility in the display of characters, icons, and pictures. The CromaClear™ CRT's slotted shadow mask has a finer horizontal and vertical pitch than comparable

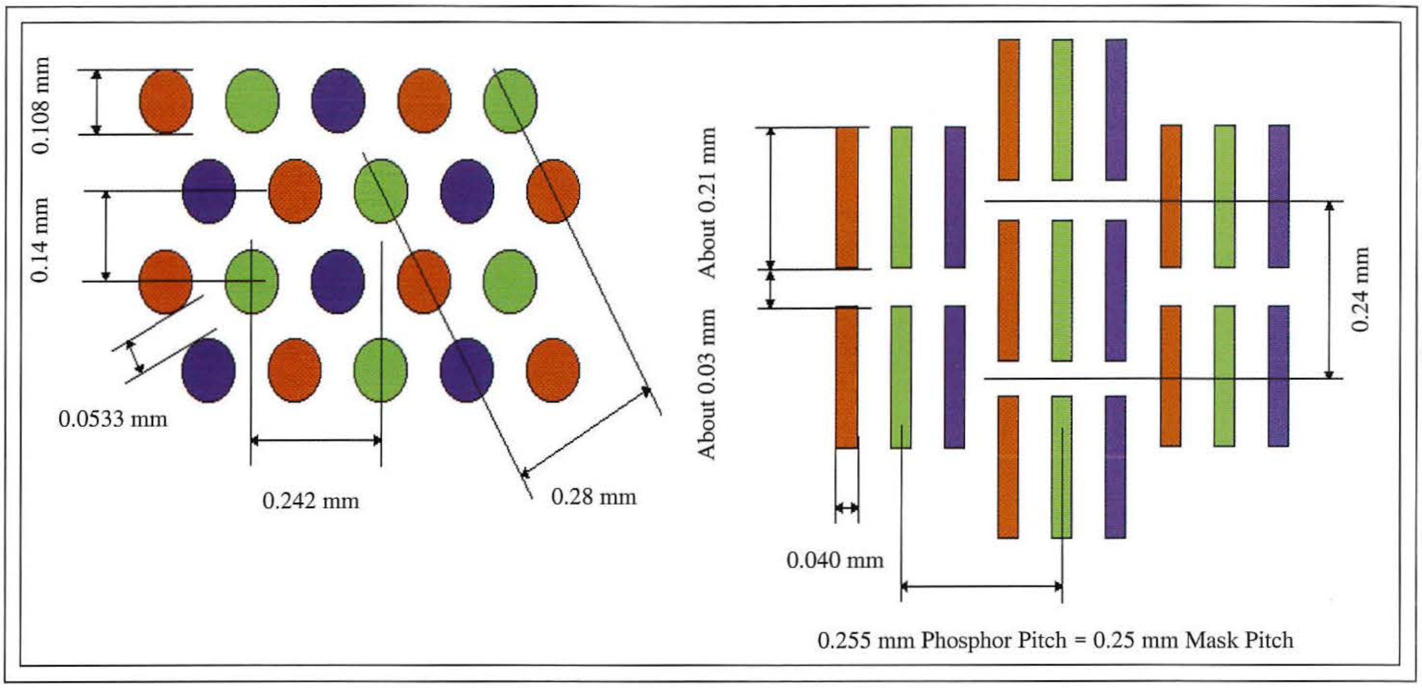



***Fig. 3:*** *Pitch comparison between a typical dot-trio phosphor alignment and the CromaClear™ aperture-grille alignment. The trios of phosphor-stripe columns in the CromaClear™ alignment are staggered to reduce "jaggies" in diagonal lines.*

conventional tubes, although horizontal pitch has a greater effect on perceived image quality.

So one of the main goals for the CromaClear™ CRT was to reduce the existing shadow-mask pitch. Generally, a decrease in the pitch of the shadow mask results in a decrease in the size of the mask holes. Masks must be made thinner to accommodate the smaller holes during the chemical-etching process. But as a shadow mask's thickness decreases, its strength also decreases. As a result, press-formed masks are more susceptible to damage from external factors. In spite of such difficulties, the CromaClear™ CRT contains a shadow mask with a horizontal pitch of 0.25 mm. NEC achieved this breakthrough by using optimized mask-pattern dimensions and an unconventional etching process.

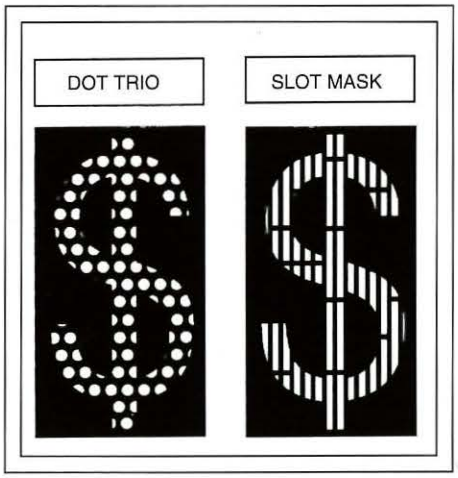



***Fig. 4:*** *Aperture-grill CRTs produce better character legibility than dot-trio CRTs.*

The decreased vertical shadow-mask pitch of the CromaClear™ CRT also decreases perceived moiré. NEC experimented with many samples before deciding that the present vertical pitch provides optimal character legibility. The data demonstrated that the vertical pitch should be less than 0.5 mm to display small characters clearly.

Bridges - vertical connections between slot holes - are unavoidable in the construction of any shadow mask. Though the phosphor screen of a CromaClear™ CRT is made of continuous vertical stripes, small dark horizontal line patterns - bridges - are generated, blocking the beam from hitting the phosphors. When the screen is totally illuminated, some interaction occurs between the shadow mask and scan lines. Thus, depending on the vertical shadow-mask pitch, the moiré phenomenon can occur as easily in CromaClear™ tubes as in conventional tubes with a dotted shadow mask. NEC's choice of vertical shadow-mask pitch became clear when we set out to minimize this phenomenon.

Moiré pitch can be calculated using the equation

$$\frac{1}{\lambda} = \left| \frac{1}{\frac{m}{P_s} - \frac{n}{P_m}} \right|,$$

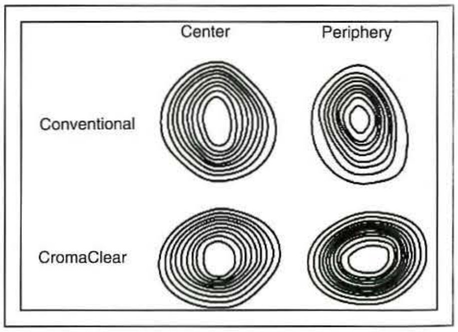
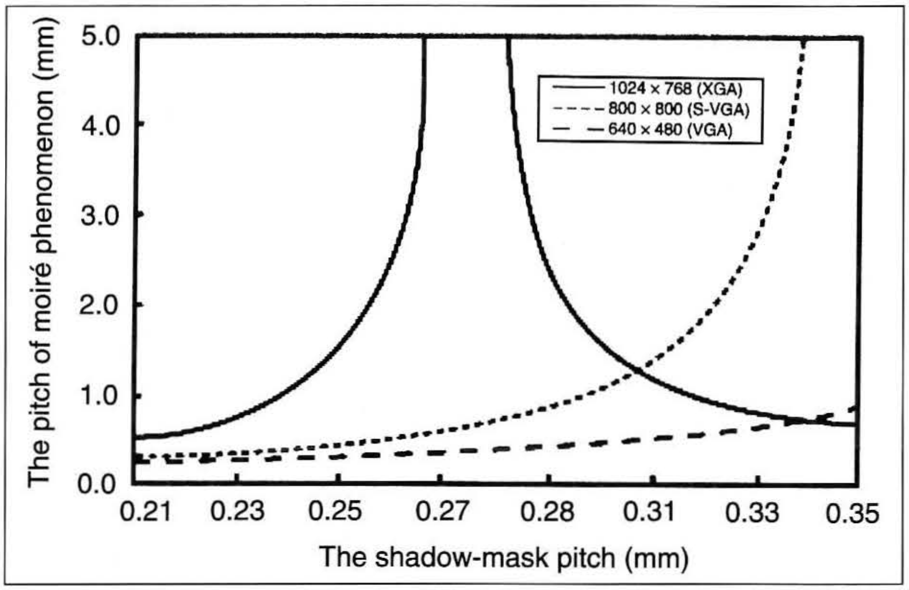
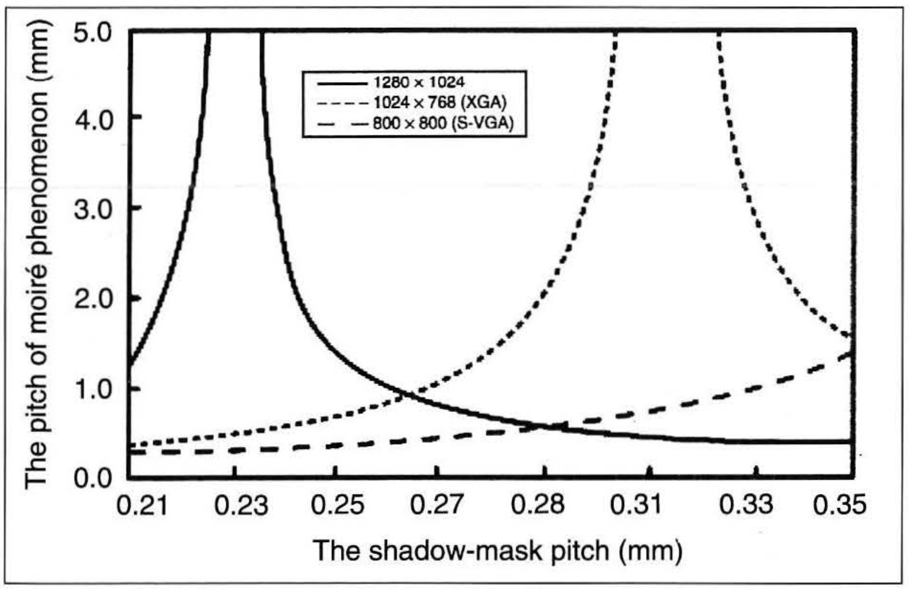



***Fig. 5:*** *The CromaClear's electron gun was designed to produce elliptical beam cross sections to better match the shapes of the new mask's slots and phosphor stripes.*




(a)




(b)

***Fig. 6:** Shown are the shadow-mask pitch* vs. *the pitch of moiré phenomena on (a) 15-in. CRTs and (b) 17-in. CRTs. The vertical axis indicates the pitch at which moiré becomes visible.*

where λ is the pitch of the moiré phenomenon, $P_s$ is the pitch of the scan lines, $P_m$ is the pitch of the shadow mask, and *m* and *n* are the dimensions of each pitch.

The results of this calculation can be plotted (Fig. 6). The horizontal axis in the figures represents the vertical pitch of the shadow mask; the vertical axis represents the pitch where moiré becomes visible. Figures 6(a) and 6(b) represent calculations for 15- and 17-in. CRTs, respectively. Calculations were made for popular video signals, including 1024 × 768, 800 × 600, and 640 × 480. These results were obtained through a combination of objective calculations and subjective evaluations.

These calculations indicate that the moiré phenomenon produced by the CromaClear™ CRT shadow mask is less apparent than that produced by the dotted shadow mask - in spite of CromaClear's tighter overall mask pitch. The reason is that the moiré phenomenon in a dotted shadow mask has a high degree of contrast because its illuminated phosphors are separated by the black matrix. Unlit areas are completely dark. A slotted shadow mask, on the other hand, has shadows generated by bridges. These shadow areas are much brighter than those of a black matrix. So even if the moiré pitches of a dot-trio and a slotted mask are the same, the moiré contrast in a slotted mask will be less and an observer will perceive a less intrusive moiré phenomenon.

Our observations indicate that the moiré phenomenon presents no practical problem, provided the value of the pitch of the moiré phenomenon is less than 1.5 mm. Consequently, for the CromaClear™ CRT, we selected a vertical shadow-mask pitch of 0.235 mm for the 15-in. and 0.25 mm for the 17-in. CRTs.

## Conclusion

Significant new high-volume CRT designs are rare. For the new CromaClear™ CRT, NEC simultaneously created a new striped phosphor screen, a superfine slotted shadow mask, and an optimized electron gun. The combination delivers excellent focus, contrast, and image clarity. The new design produces improved character legibility and picture quality, as well as reduced moiré phenomena.

The CromaClear™ CRT was first incorporated into monitors from NEC Technologies in March 1996. We feel the design is successful, and we will continue to utilize it in the future. ■

*Please send new product releases or news items to Joan Gorman, Departments Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.*

# Opinion and Case Study: Neglected Children

*Monitor service centers are neglected by monitor manufacturers – and users, service centers, and manufacturers all suffer.*

by Craig T. Ridgley

WITHOUT PURSUING the analogy of this article's title any further than necessary, it is safe to say that CRT-monitor service centers generally do not receive the care and support that manufacturing facilities receive from their parent companies. As for independent - third-party - service centers, the term "orphan" fits well.

While manufacturing facilities have the benefit of the latest state-of-the-art automated manufacturing and alignment equipment, service centers continue to rely on semi-automatic or even manual systems for the alignment and convergence of repaired monitors. Obviously, the repair of monitors will continue for some time to be a manual process, but many alignment/convergence processes have been automated on the manufacturing floor - and should be automated in service centers as well.

The factor most responsible for this neglectful attitude by parent companies is probably time. On a manufacturing floor, where monitor build targets are set in the thousands per day and where a few seconds too many at an alignment station can result in missing a target by hundreds of monitors, only the fastest alignment equipment is acceptable. In service centers, where the pace is perceived to be slower - and time is therefore considered less important - hand-me-down semi-automatic or manual systems are used.

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One can almost visualize the operation that generates this level of interest: a couple of techs sitting at a bench, soldering irons in one hand, cigarettes in the other; two more alignment technicians sitting at their stations with their feet up, reading pulp fiction, waiting for monitors to be carried over to them. This scenario is far from the truth, but it represents a damaging perception that we face today.

Another reason service centers are treated so poorly is that they exist as overhead. The cost of automated equipment in a manufacturing environment can be amortized across the thousands of units produced as a cost to manufacture. After millions of units, even the most expensive equipment represents a trivial per-unit cost. And, if that equipment increases the production rate, it will pay for itself early on.

Service centers do not share that luxury. They are a cost of doing business: an expense that must be minimized as much as possible. Traditionally, this view has resulted in limited budgets and depreciated equipment. A better approach would be adequate budgets for fully automated equipment, which would lower labor costs and raise quality.

## A Real-World Example

Let's look at an independent service center in Fremont, California: EAD Systems Corporation. I have worked with EAD's owner, David De Giorgi, for over a year now. In preparing this article, I spent several hours talking to David about the genesis and evolution of EAD. Some of his insights regarding automation in the service-center industry might be of interest.

EAD began its modest operations in 1989 in a 100-sq.-ft. office in Boston, Massachusetts. With a folding table for a bench, David and his part-time tech repaired monitors he transported in the back of his car. Repairs were in "ones and twos" - one of this brand, two of that.

Though EAD's business grew, the process model remained unchanged for nearly 3 years, during which the state of monitor technology remained fairly stable. Most - if not all - of these repairs were out-of-warranty repairs consigned by resellers. At this time, EAD's throughput averaged 50 units per week. All of the alignment adjustments were performed manually with a narrow plastic screwdriver called an alignment tool - a device that has almost gone the way of the slide rule. As recently as 4 years ago, most monitors were completely analog designs. Each type of monitor had a different timing, and all had pots. Each repair and adjustment required one repair tech and one adjustment tech. But change happens, and it began to happen rapidly at EAD.

It started with small but significant changes in the way monitors were designed. Hybrid digital/analog controls began to show up in the monitors being returned for repair; and not long after, fully digital, multi-sync monitors arrived. In addition, warranties began to get longer: 2–3 years, as opposed to the resellers' 1 year. Increasingly, repairs became "in-warranty," and the major volume of monitors were from manufacturers instead of resellers. Small operations such as EAD were hard-pressed to survive the combination of increasing volumes and demands for lower cost



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Display Laboratories, Inc.

*Display Laboratories' new MIMiCAM® 1k × 1k camera alignment system is being used successfully in a CRT-monitor service center.*

because of the increase in warranty repairs. Manufacturers were consolidating to locations that could handle large volumes.

To complicate things further, customer quality awareness was on the rise: customers were getting "pickier." End users who sent a "broken" monitor in for repair had a greater expectation of monitor image quality upon return than when it was first taken out of the box. A "less-than-perfect-looking" monitor returned from a service center, regardless of repair status, still produced a dissatisfied customer.

### David Makes the Leap

It was clear to David DiGorgi that the service-center industry in general, and EAD, in particular, had to change to survive. In David's words, "The requirement is to turn high volumes of monitors in a cost-effective manner, or I'm just not in the ballgame." EAD had to have access to the sophisticated, high-volume tools that the manufacturers used. The migration from analog to digital forced EAD to move from a job-shop environment to a production environment. Production concepts such as process control and ECO's became part of EAD's vocabulary. No longer could EAD afford the linear, serial approach to monitor repair. Anytime an employee had to move, lift, or let a monitor sit, it cost EAD money. In the face of the decreasing prices manufacturers were willing to pay, labor cycles had to be reduced. Yet, somehow, EAD had to maintain the kind of quality a good tech with lots of time can produce.

When David wandered into our booth at Display Works a little over a year ago, he had no idea of what was available in terms of fully automated alignment systems. EAD was repairing an increasing volume of monitors for a large monitor manufacturer, and the manufacturer had offered EAD semi-automated digital alignment systems.

EAD's shop floor was beginning to look like a manufacturing floor. Metal roller conveyors snaked around the room. David's digital alignment stations were built on carts so they could be relocated as process requirements changed, and any line might have from one to three stations at a given time. Even the conveyors were not bolted to the floor.

EAD became one of the few non-manufacturing sites to own a Quantum 903 video generator. Soon EAD's collection of timing files became a competitive edge, but the alignment process was still mostly manual. Enter the fully automated alignment system.

It is one of those really rare sales experiences when, as you go through your standard sales pitch (which is normally received with only polite interest), you can see the thrill of discovery in the customer's eyes. You realize, here is a customer who not only needs your product but desperately wants it as well.

David immediately saw that here was a product that could do in 1 minute what his alignment techs, with a digital alignment system, were doing in 20 minutes. And the automated system could do it tirelessly and consistently day after day. As David said, "It doesn't take higher math to grasp the implication of that!" EAD had found the final component required by the driving changes in technology. With Display Laboratories' MIMiCAM® automated alignment system, David felt he could lower his cost to his customers and still maintain the highest quality.

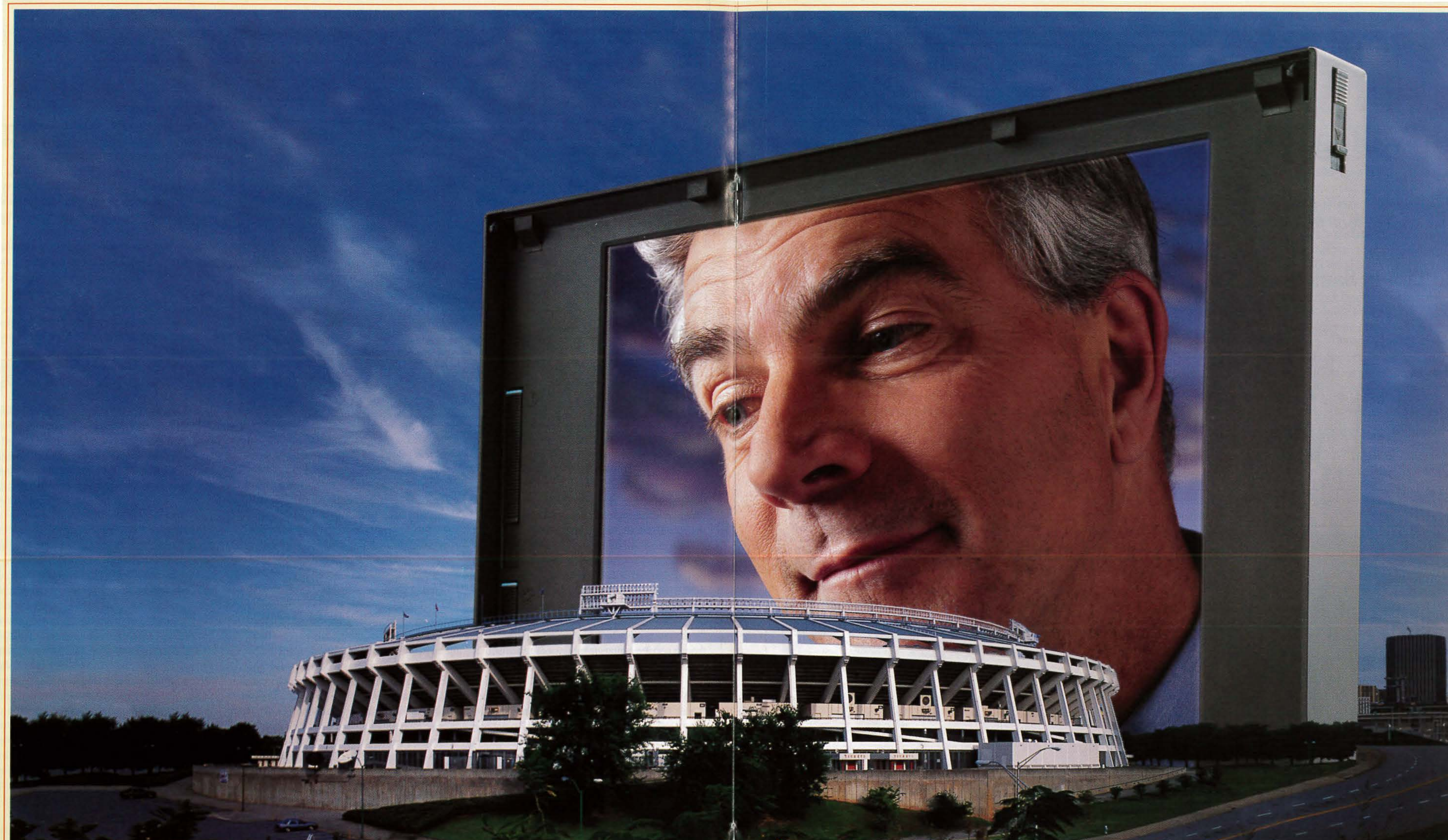
Shortly after the MIMiCAM® alignment system was installed, the large monitor manufacturer significantly increased the number of monitors it expected EAD to process. It would require EAD to turn around 150 monitors per day - a very long way from EAD's earlier 50 monitors per week! Though the actual number fell slightly short of the goal, the financial and technical success of automation in this environment was proven beyond a doubt.

### The Bigger Picture

EAD's success story provides all the good reasons, historic and otherwise, for automating service centers. Some people understand those reasons well, but many do not - at least, not yet. Soon, though, it will no longer be possible for parent companies to choose to ignore the real demands of service-center support.

The development of digital monitor control has led to the development of automated digital equipment in the manufacturing environment. The irresistible force of advancing technology has led to the use of this same automated equipment in the development of monitors as well. Technologies being developed and/or marketed now by Display Labs, Toshiba, and (rumor has it) Panasonic depend substantially upon camera alignment systems for the gathering of data integral to control of the digital monitor.

Where, until recently, the camera alignment system was used exclusively for factory alignment, and is now beginning to be used in servicing the monitors, it will soon span the entire product life cycle of digital monitors. Service centers, by definition, will have no choice but to have automated systems for the alignment and convergence of repaired monitors. ■





Circle no. 13

# High Voltage for CRT Displays

*A legendary high-voltage designer tells the rest of us what to look for and where to get it.*

## by William F. Santelmann, Jr.

HIGH VOLTAGE FOR CRT DISPLAYS is used for direct-view, projection, film-recording, and oscilloscope applications. The voltages involved run from about 5 to 40 kVdc at power levels from 1 to 300 W. A CRT power supply must be well regulated, with very-low-ripple output voltages, and usually incorporates focus, grid #2, and grid #1 voltages.

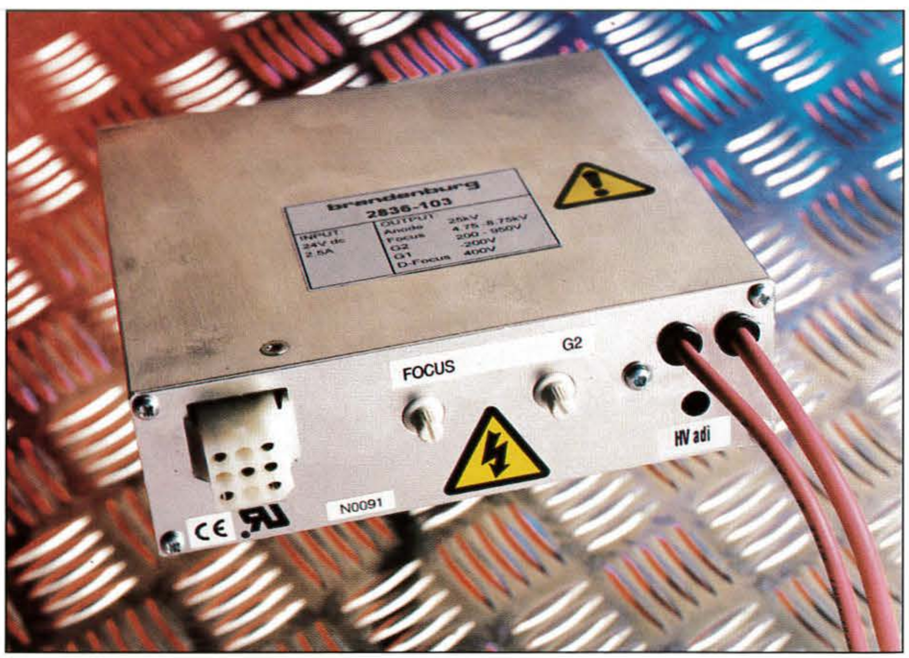
### New Capabilities

The CRT is an analog device whose performance is affected in some way by every voltage applied to it. As demands on image quality increase, CRTs are improved and the requirements for the high-voltage power supplies (HVPSs) that operate them are tightened. A survey made in February 1997 revealed new high-voltage capabilities.

***Dual focus.*** Some of the newer CRTs have two focus electrodes for improved spot size. One usually has an adjustable fixed dc voltage, while the other has a similar, but independently adjustable, dc voltage with an added dynamic-focus signal for optimum corner focus.

***Dynamic focus.*** While dynamic focus is not a new development, its implementation has been challenged by increasing horizontal-scan frequencies. The dynamic-focus waveform is not sinusoidal but parabolic, so the usual bandwidth specification is meaningless. Instead, one specifies dynamic focus in terms of horizontal-scan frequency, amplifier delay, maximum voltage peak-to-peak, and maximum slew rates, both positive and negative. As an example, Hyacinth and ELDEC can provide voltages to 1000 Vp-p and slew rates to 750 V/μS. Until recently, dynamic focus was applied to CRTs having "zero" focus current, indicated by a "±10 μA" or similar focus-current specification, where a focus voltage could be derived from a divider having many tens of megohms of source impedance.

***Dynamic focus with focus current.*** CRTs that use an extruded electron beam in the quest for ever-smaller spot size are now appearing. The focus current in these new tubes is no longer near zero, and the focus voltage can no longer be provided by a high-resistance divider. The challenge of providing




Astec Europe

*The Brandenburg 2836-103 has an input-voltage range of 22–28 Vdc and an output-voltage range of 23–27.5 kV, with an output current of 1.2 mA. There are also focus, G2, G1, and dynamic-focus outputs.*

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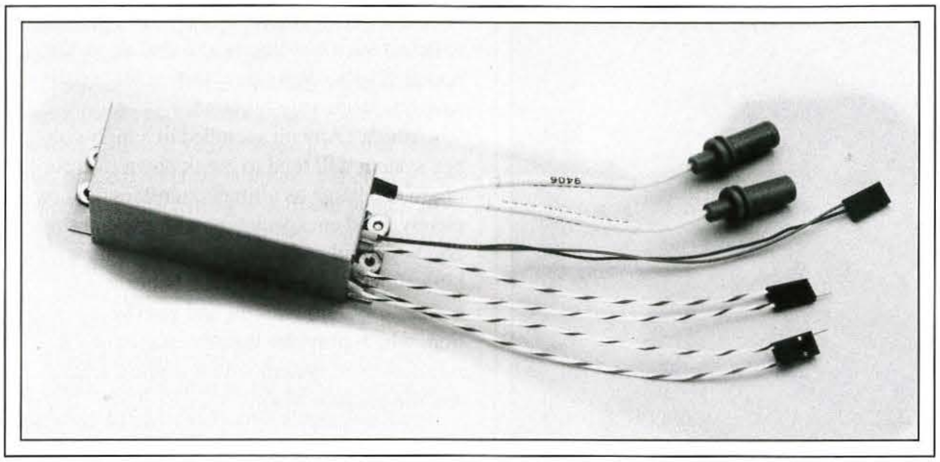


MultiPower

*This MultiPower power supply is used for a heads-up display containing two small CRTs. The supply has two highly regulated 10-kV outputs, two 400-V outputs, and two 1300-V outputs. All outputs are derived from a single 15-V input. Long-term stability is specified as 0.5% per 1000 hours of operation.*

a well-regulated static-focus voltage with superimposed vertical and horizontal dynamic-focus voltages while supplying focus current is a daunting task. Hyacinth has designs capable of 600 Vp-p vertical and 600 Vp-p horizontal at scan rates to 250 kHz while delivering up to 1 mA of focus current at 5–7-kV static-focus voltage.

***Venetian-blind suppression.*** "Venetian blinds" is the name applied to horizontal bar patterns sometimes seen at the top and bottom of a CRT display, becoming invisible at the center. The cause is a beat frequency between the horizontal-scan frequency and the high-voltage power-conversion frequency, especially severe when these two frequencies are within a few kilohertz but not equal. Venetian blinds can be prevented by maintaining low anode ripple of less than 0.01% peak-to-peak and by eliminating any non-linear mixing of the two frequencies in the regulator of the power supply.

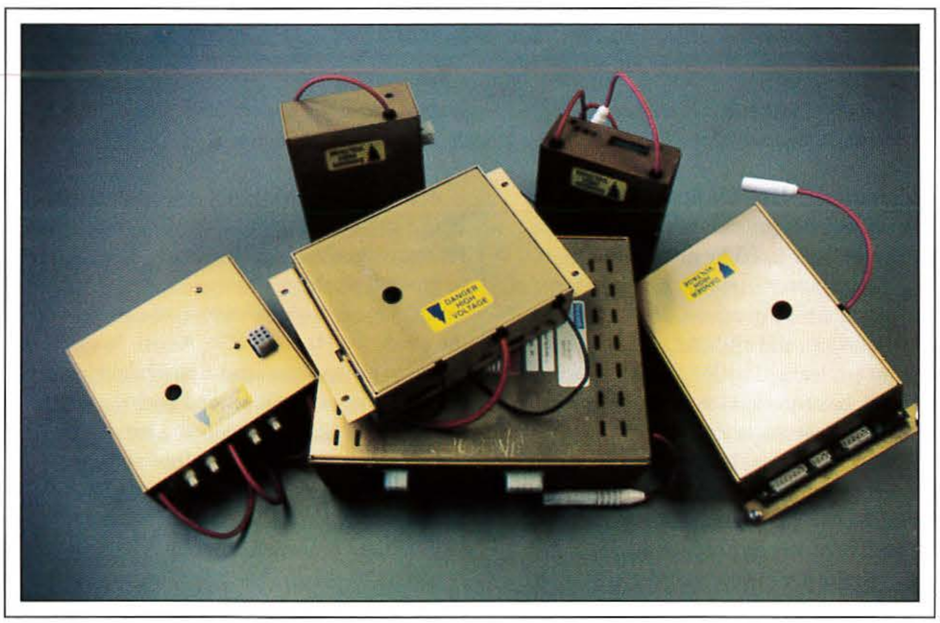
***Synchronization.*** Synchronization of the power-conversion frequency with the horizontal-scan frequency is a perfect solution to the problem of Venetian blinds because the beat frequency becomes zero. It is not a simple matter to implement, however, because high-voltage transformers usually operate in a self-resonant mode at their own frequency. But now, two companies, WinTron and ELDEC, are announcing synchronized designs. WinTron states that their design will synchronize from 15.7 to 125 kHz, making it ideal for multi-scan monitors.

***Dual modes – raster and calligraphic.*** Hyacinth reports that it has developed high-bandwidth dc-coupled amplifier designs offering output swings up to 2 kV for dynamic-focus and spot-size control in mixed raster/calligraphic displays, which are used mainly in simulator systems. It is capable of providing 800 Vp-p at a 64-kHz scan rate.

***CRT protection.*** Expensive CRTs can be damaged in a few seconds if an undeflected focused electron beam is allowed to hit the screen at full current. There are two ways to avoid such a catastrophe: (1) defocus the beam and (2) reduce the beam current to near zero by pulling the G2 voltage to ground, either of which can be done in a few microseconds after a deflection failure.

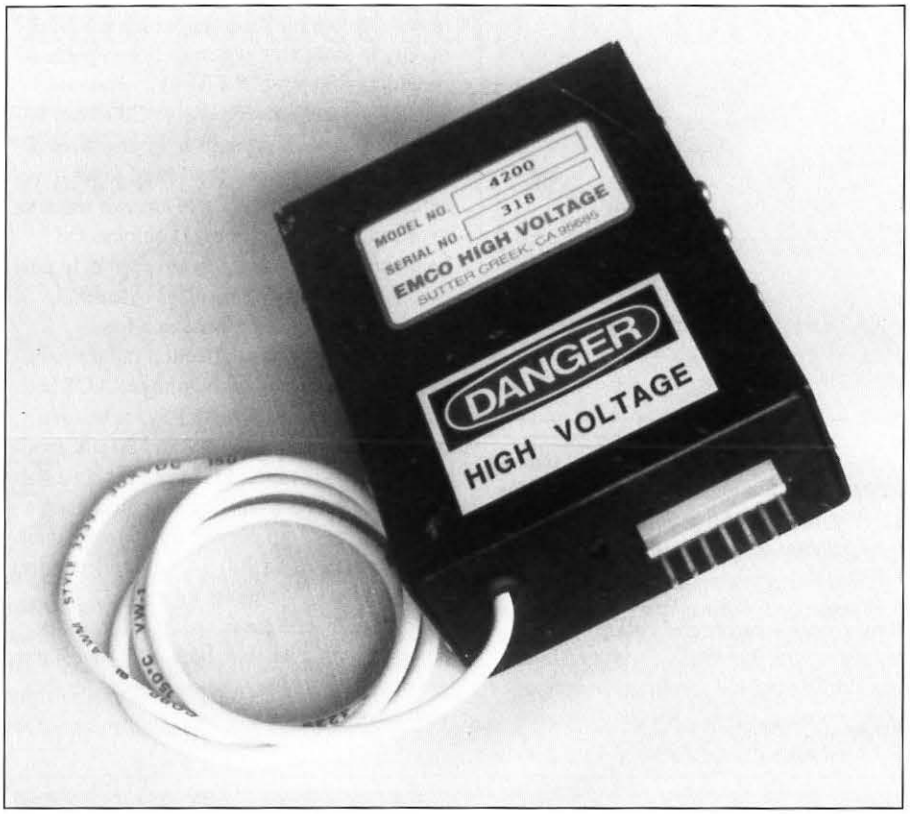
***Helmet-mounted high voltage.*** ACT is supplying miniaturized HVPSs for helmet-mounted displays at 8.5 kV and 30-μA anode current, with focus and G2 voltages, in a volume of 2.56 in$^3$. MultiPower is producing a unit for a heads-up display (HUD) with dual CRTs at 10 kV and 200 μA with independent 1300- and 400-V outputs for each CRT.

***Field-effect displays.*** Although no data sheets are yet available, both ACT and Rantec are developing high-voltage sources for this new technology.



Hyacinth

*An assortment of Hyacinth power supplies. Clockwise from left: dual-focus (zero-current) integrated supply with vertical and horizontal dynamic-focus amplifiers, focus module for tubes with significant focus current (1 mA), fully programmable high-stability film-recorder power supply, programmable focus module with 1.8-kV dynamic-focus amplifier. Center bottom: integrated programmable power supply for a direct-view simulator display with individual G2 control for 3 guns. Center top: high-stability film-recorder power supply with high-current focus output and wide-bandwidth dynamic-focus amplifier.*




EMCO

*EMCO's 4000 series is a line of compact, fully adjustable dc-to-dc converters. This 4200 model has an output voltage of 0–20,000 V at 0.5 mA with 0.1% ripple. Input is 24 V.*

### High Voltage Has Unique Problems

High-voltage design and manufacturing has all the problems faced by manufacturers of low-voltage power supplies, plus a number of new ones, including corona, arc survival, x-ray radiation, and altitude. It is in many ways an art, learned by long trial and error, and not recommended for the uninitiated!

***Corona.*** Corona is a partial discharge of air in a high-voltage field, which can often be detected by the odor of ozone or by a hissing sound. Sustained corona will degrade and eventually destroy any high-voltage insulation. The greater the corona discharge, the faster this degradation proceeds. While "zero corona" is probably unobtainable in the field, it can be held low enough to be an insignificant reliability factor. However, corona *within* the power supply that influences its regulator can cause output-voltage transients that may seriously impact system performance.

***Arc survival.*** While not a simple matter, an HVPS can be designed to remain unimpaired for many thousands of direct arcs from anode to ground. Perhaps a more serious problem is the damage to logic circuits in the vicinity of the anode lead to the CRT. An arc from the anode to ground can send a powerful electromagnetic pulse into logic and analog circuits with the potential for producing extensive damage. Routing the anode lead away from such areas and using series surge-limiting resistors in the anode lead will do much to resolve such problems.

***CRT radiation.*** The U.S. Department of Health and Human Services has established a x-radiation limit of 0.5 mrem/hour. Each CRT design has been evaluated to determine its maximum anode voltage and current at this x-ray radiation limit. It is then the responsibility of the HVPS designer to ensure that these voltage and current limits are not exceeded under any fault condition. Usually, internal "over-voltage" circuits are provided to detect such conditions and shut down the power supply. Individual testing and certification is frequently required.

***Altitude.*** Any air included in a high-voltage system will tend to break down to corona or arc discharge as altitude increases. A completely solid encapsulation with good surface bonding to all components will operate well at high altitude. Probably even better is ACT's hermetic system with oil and gas ($SF_6$) insulation, which provides the advantages of a superior dielectric system with a wetting action and the absence of air.

### Reliability

The high-voltage industry generally regards MIL-HDBK-217 as useless in predicting the reliability of an HVPS. It just does not reflect the real world of high voltage! This problem was addressed by the U.S. Air Force Materiel Command Electrical Systems Center, which funded a 2-year PRAM (producibility, repairability, availability, maintainability) initiative to ELDEC. Using a physics-of-failure approach, ELDEC analyzed the failures to gain a better understanding of the mechanisms.

From this, a family of modular high-voltage design blocks was designed whose robustness was verified through extensive thermal cycling. Use of these modules has improved reliability by a factor of 3.

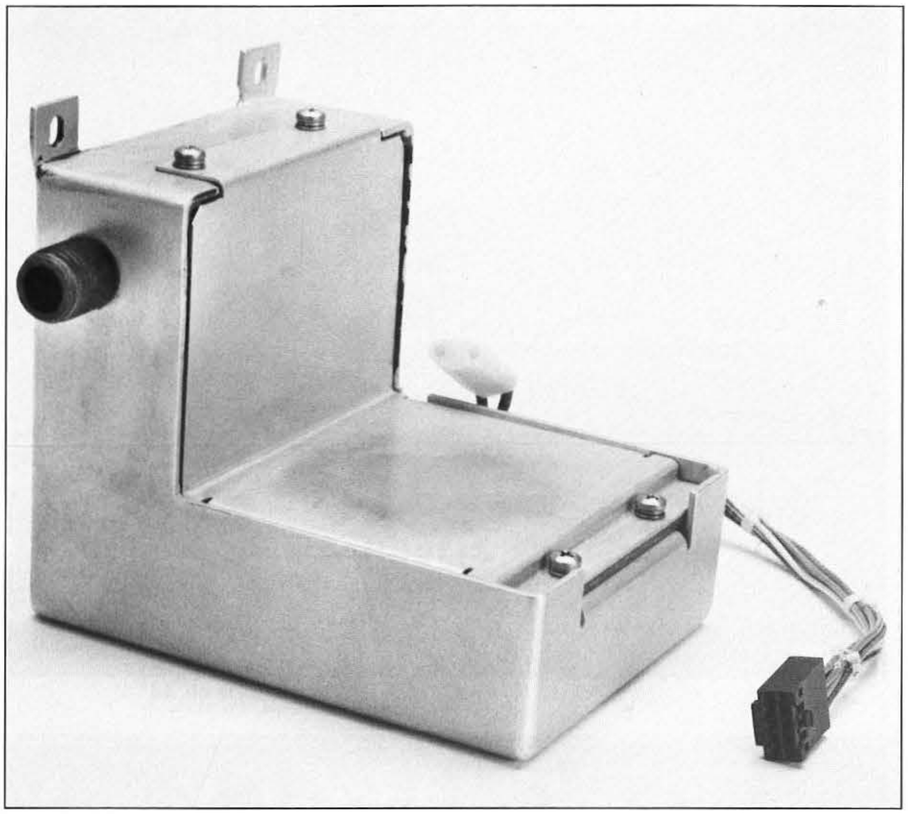
The use of old "tried-and-true" designs may provide better reliability, but the components are probably not the same as those used in the original design because the old component sources have disappeared. And the assembly, a critical item, is probably not done by the original assembler either. Furthermore, as mentioned earlier, the features and performance needed by a new display design may not be available in an old HVPS design.

### Selection of an HVPS Vendor

No one vendor has it all. Each has developed its own market niche. Design variables such as those required by the military or commercial markets, package size and shape, control options, and voltage and current options have made "standard HVPS designs" impractical. Therefore, the best course is to modify an existing design, especially if the anticipated production will be upwards of a hundred units. At about a thousand units, a completely new design based on proven components and assemblies is often justified.

The selection process should begin with the search for a vendor with a good reputation for on-time delivery, reliability, cost, repair service, and engineering support. Especially important is the willingness of the vendor to engineer custom modifications. Initial plans should strive to involve the vendor as part of the design team, bringing valuable experience to the project.

Vendor quality-control systems, indicated by certifications such as ISO 9001, which is currently in place at Brandenburg and in process at ELDEC and WinTron, are highly desirable. The existence of agency approvals (such as UL, CSA, VDE, IEC, TUV, and/or CE) of the vendor will, in turn, make similar approvals of new power supplies that much easier, quicker, and less costly.



ELDEC

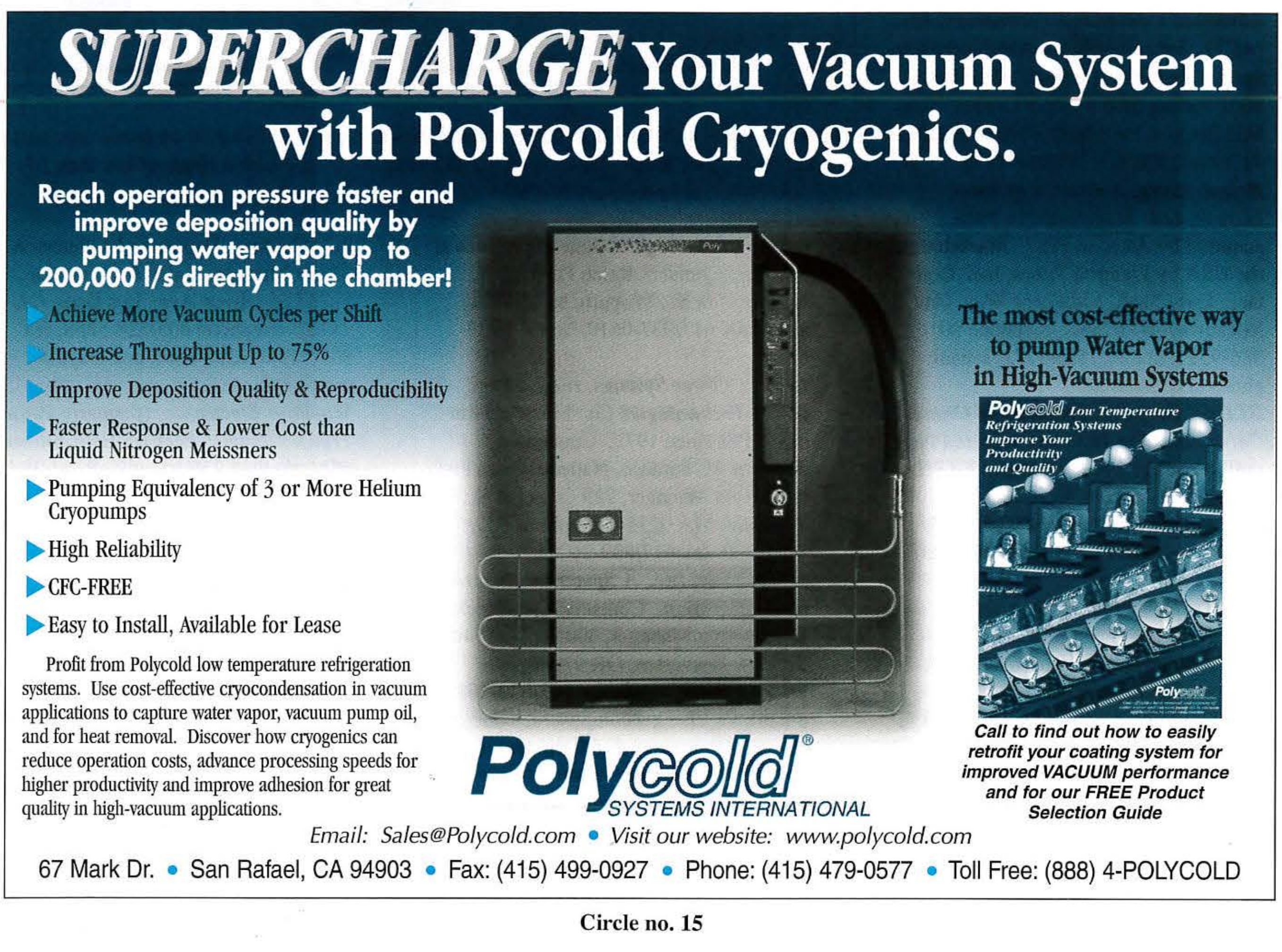
*ELDEC's Model 4-707-01 is a high-reliability power supply designed for airborne applications. Input is 16–32 Vdc; anode output is 14.0 ± 0.7 kVdc at 500 μA, with a ripple of less than 10 Vp-p. Other output options are available.*

### Vendor Profiles

Now that we've discussed what to look for – and look out for – in HVPSs, here is a list that should prove helpful in selecting a vendor.

- ***Advanced Conversion Technology, Inc. (ACT).*** Successor to the AMP high-voltage product line. Contact: Mike Endy, 2001 Fulling Mill Road, P.O. Box 70, Middletown, PA 17057-0070; telephone 717/939-2300, fax 717/939-7170.
- ***Brandenburg, A division of Astec Europe, Ltd.*** Established in 1948, acquired by Astec in 1987. Marketed in the USA by Electron Tubes, Inc. Contact: Gary Shah, 100 Forge Way, Unit F, Rockaway, NJ 07866; telephone 201/586-9594, fax 201/586-9771; e-mail: phototubes@aol.com.
- ***ELDEC Corp., A subsidiary of Crane Co.*** Founded in 1957 and acquired Ferranti-Venus in 1993. Contact: Ed Fuhr, 16700 13th Avenue West, P.O. Box 97027, Lynnwood, WA 98046-9727; telephone 206/743-1313, fax 206/743-8234.
- ***EMCO High Voltage Co.*** Contact: David McGreenery, Sales Engineer, 11126 Ridge Road, Sutter Creek, CA 95685; telephone 209/223-3626; fax 209/223-2779; e-mail: sales@emcohighvoltage.com; web site: http://www.emco-highvoltage.com.
- ***Hyacinth Technology, Inc.*** A young company with engineers who acquired many years of high-voltage experience at Keltron. Contact: Rajen Patel, 155L New Boston St., Woburn, MA 01801; telephone 617/937-0619, fax 617/937-6319.
- ***Keltron Power Systems, Inc., A Preferred Technologies Co.*** Manufacturer of HVPSs since 1972. Contact: Anthony M. Saracco, National Sales and Marketing Manager, 225 Crescent St., Waltham, MA 02154; telephone 617/894-8700, fax 617/899-9602.
- ***MultiPower, Inc., A Spectrum Electronics Corporation.*** Contact: Ken Check, Engineering Manager, 3005 S.W. 154th Terrace, Beaverton, OR 97006; telephone 503/646-4700; fax 503/643-4889; e-mail: ka_check@compuserve.com.
- ***Rantec Microwave & Electronics, Inc., An ESCO Company.*** Manufacturer of HVPSs for over 25 years. Recently acquired the HV product line of Discom, Inc. Contact: Francesca M. Peterson, Senior Manager, Sales & Marketing, 1173 Los Olivos Ave., Los Osos, CA 93402; telephone 805/528-5858; fax 805/528-6932; e-mail: powersys@rantec.com.
- ***WinTron Electronics (formerly Penn-Tran).*** Contact: Melissa Hein, Director of Marketing, 250 Runville Road, Bellefonte, PA 16823; telephone 814/355-1521, fax 814/355-1524. ■


Circle no. 14




Circle no. 15

# The History and Future of the Color-CRT Electron Gun

*Fourteen historical milestones point the way to the next big one.*

by Hsing-Yao (Jimmy) Chen

OVER THE PAST 25 YEARS, the development of the cathode-ray-tube (CRT) electron gun has been marked by 14 major milestones. CRT designers will find opportunities for entertaining arguments concerning the selection of these milestones. Still, I believe this to be a very reasonable list. These milestones, combined with the needs of the next generation of television tubes, provide an insight into the direction color-CRT guns need to go. That direction, it seems to me, is the multi-beam-group gun.

In the first color CRTs, the three guns - one each for red, green, and blue - were arranged in a delta shape inside the neck. But the delta-gun system is cumbersome and costly, and achieving three-beam convergence is quite complex.

In the early 1970s, the precision in-line (PIL) system was introduced. In the in-line system, the three guns are arranged in a straight line, and the lens diameter of each gun is reduced to 70% of that of the delta gun (Fig. 1). In an effort to overcome the disadvantages of the smaller gun, CRT manufacturers tried to develop new guns that would perform better than the Einzel and bipotential guns - the standard guns of the period. At the same time, computer-modeling programs became available. The combination of the PIL system's need for new gun designs and the availability of computer-modeling tools would trigger the evolution of color-CRT electron-gun development over the next 25 years.

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### 14 Milestones of Color-Gun Design

There are a few events which can be counted as milestones in the development of color-CRT electron-gun design and have helped a great deal in the overall advancement of color-CRT displays.

1. An improved understanding of the electron-multiplying arc process led to the design of metalized film on bead glass to suppress the electron-multiplying effect in the neck region. This greatly improved the high-voltage stability in color-CRT tubes (Fig. 2).
2. The invention of unitized in-line electron-gun grids substantially improved the relative alignment of the three individual guns - green, blue, red - and, at the same time, reduced their parts count and assembly cost.[1]
3. Three-dimensional computer-modeling programs have made many asymmetric optics designs feasible. They have also drastically reduced the design-feedback cycle time for the color electron gun.[2-5]
4. The realization of the relationship of beam angle to the optimization of spherical aberration, magnification, and space-charge effects had a major impact in the computer modeling of electron-gun design.[6]
5. Using G2 thickness to control the elec-

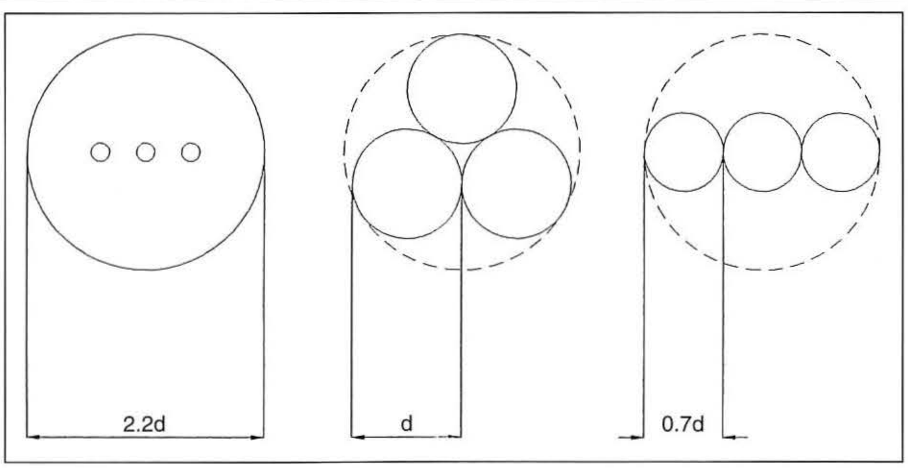


*Fig. 1: Comparison of the effective diameters of the Trinitron™ electron gun, delta-shaped three-gun, and in-line-positioned three-gun.*



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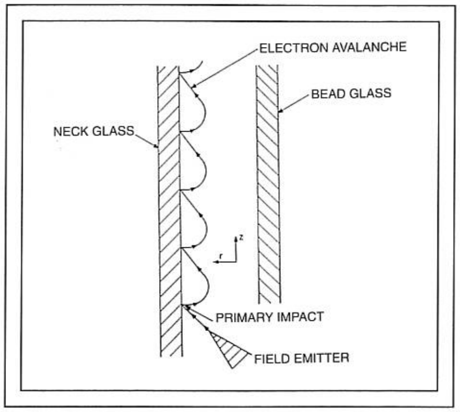


*Fig. 2: Electron avalanches produced an electron-multiplying effect in the neck region of CRTs, but the use of a metalized film on bead glass has greatly suppressed this unwanted effect.*

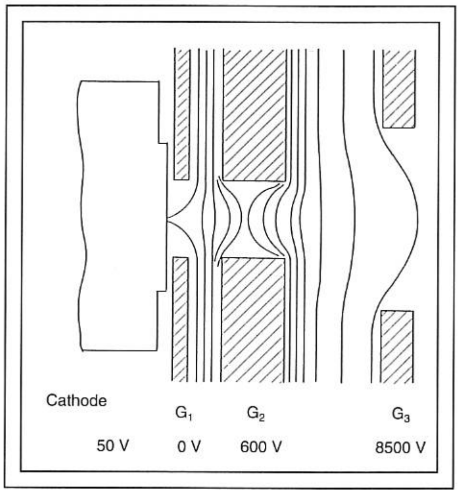


*Fig. 3: Using G2 thickness to control electron-beam angle greatly simplified gun design. This is the potential distribution in the beam-forming region of the thick-G2 electron gun. (Figure from Hughes and Chen, Ref. 7.)*

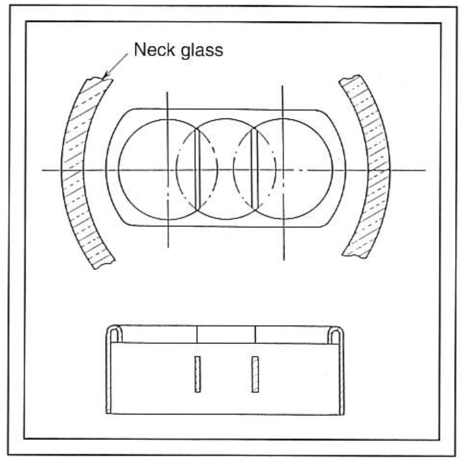


*Fig. 4: The focus electrode in the OLF gun. (Figure from Hosokoshi* et al., *Ref. 9.)*

tron-beam angle and optimize overall electron-gun performance greatly simplified the optimization of electron-gun designs (Fig. 3).[7]

6. In-line gun design with a common lens has reduced the aberration of the main lens and enabled most of today's color TV tubes to reach the limits of system performance (Figs. 4 and 5).[8,9]
7. The elliptically shaped aperture (EA) auxiliary lens in the common-lens gun has properly compensated for the asymmetrical focusing of the common lens.[10]
8. The asymmetric beam-forming region was designed to create a positive astigmatism to compensate for the in-line yoke's negative astigmatism effect. This static correction provided a partial, but still important, solution to the problem (Fig. 6).
9. Dynamic quadrupole-lens design provided nearly complete compensation for the deflection defocusing of the in-line yoke to each individual beam over the entire screen area.[11-13]
10. Focus refraction alignment test (FRAT) control design is used to minimize the misconvergence caused by static and dynamic focus-voltage changes in color-CRT red and blue beams.[14]
11. The aberration-reduced triode (ART) design has reduced aberration in the beam-forming region and produced a major improvement in high-current performance (Fig. 7).[15]
12. The design of the shunt/enhancer has enabled the in-line color CRT to have perfect color convergence at the edges and corners of the screen.[1]
13. Dispenser cathodes have a current-loading density many times higher than that of conventional oxide cathodes. This high-current-loading density has made high-brightness high-resolution color-CRT TV sets and monitors possible.
14. Although Sony was the only company to adopt it, the unique design of the Trinitron™ gun's one main cylindrical lens for all three beams has had an influence on color-CRT electron-gun design in general (Fig. 8).

These design innovations have not been mere laboratory exercises. Many of them found their way into production. These milestones of production color-CRT electron guns have helped change the CRT, TV, and monitor industries (Table 1).

## Future Development

Despite its heavy and bulky glass envelope, the color CRT has, so far, avoided the fate of being replaced by flat and lighter-weight display technologies. The main reason for this is that no other display technology can simultaneously beat the low cost and excellent per-

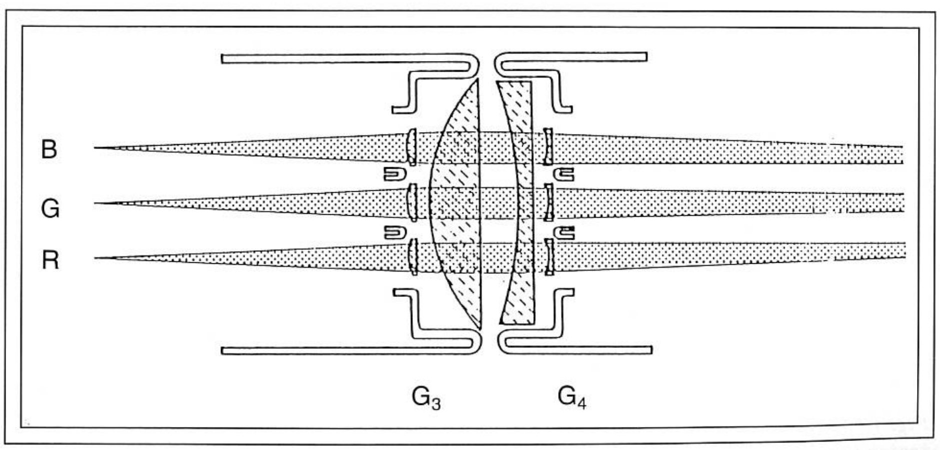


*Fig. 5: Optical analogy of the main lens in the COTY-29 XL gun. (Figure from Morrell, Ref. 8.)*

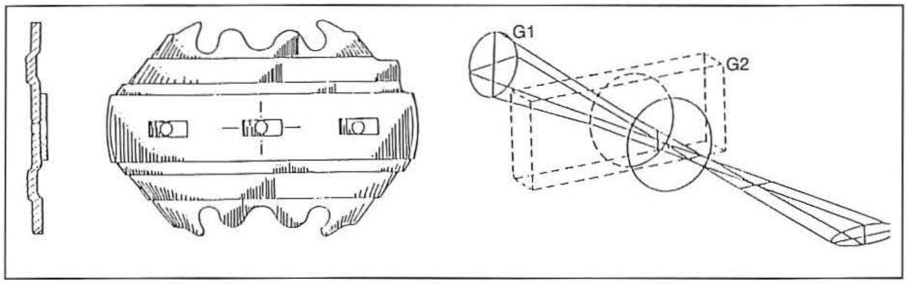


*Fig. 6: Asymmetric beams compensate for the negative astigmatism produced by in-line yokes. The slot quadrupole G2 grid (left) produces the elliptical beam shape (right).*

formance of the color CRT. A good strategy for the continuing survival of the color CRT is to extend its lead in low cost and performance without overly increasing its weight and bulk.

To achieve this, future color electron-gun designs should not only emphasize better performance but also aim for less bulk and lower system cost. Two papers recently published in the *1996 SID International Symposium Digest of Technical Papers* provide design examples of how this can be accomplished.[16,17] These two new electron-gun designs eliminate the second focus pin. The first design even eliminates the need for a dynamic-focus voltage supply, which reduces the cost for both tube and set manufacturers.

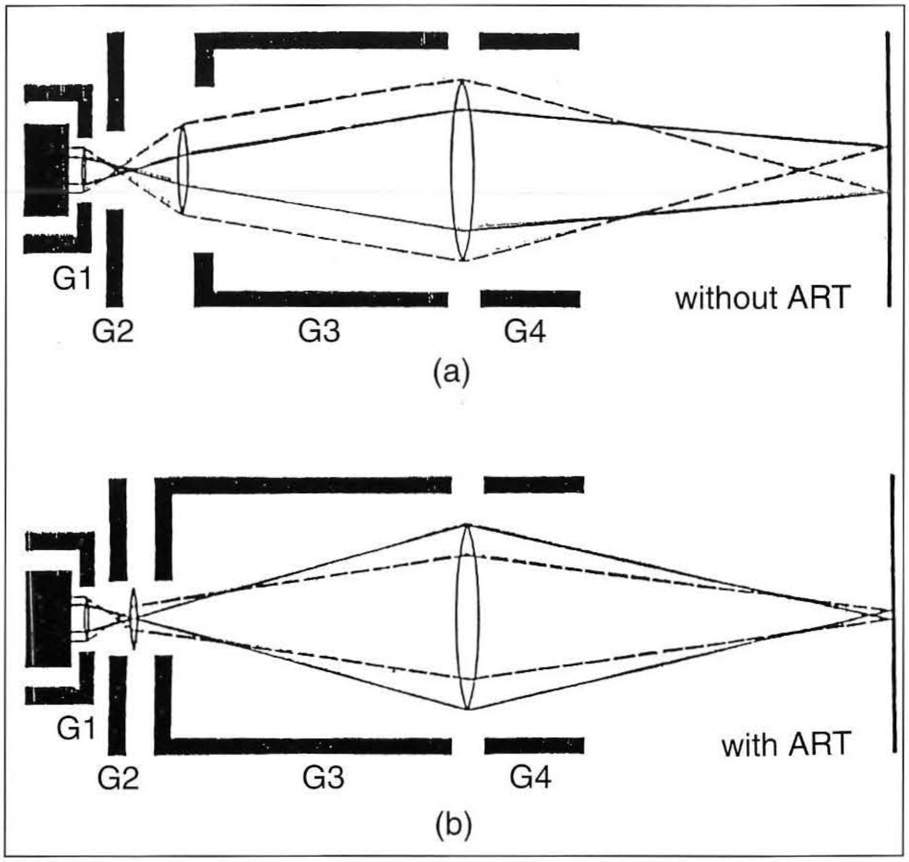


*Fig. 7: The aberration-reduced triode (ART) greatly reduced aberration in the beam-forming region (bottom) compared to pre-ART designs (top). The result was greatly improved high-current performance.*

The advances have been impressive. Nevertheless, in its effort to meet the performance requirements of future HDTV and super-high-resolution monitor tubes, the conventional approach to electron-gun design has reached its physical limits. To achieve even better resolution with more beam current for larger tubes, we would have to increase the neck size to accommodate a larger electron gun. At the same time, the higher resolution would require a higher scan frequency. With the conventional approach, we would find ourselves with a color CRT that has a longer tube and requires more deflection power. This would undoubtedly cause the CRT to become more vulnerable to replacement by another technology.

A new system approach that uses a multi-beam-group color-gun design can achieve a reduction in scan frequency and an increase in total average beam current without increasing the peak current of each individual gun (Fig. 9).[18] In addition, it requires no increase in neck size.

The combined effect of these characteristics is that the multibeam group will have:

- Higher brightness (more average current)
- Good resolution (lower peak current per gun)
- No need for an increase in neck size and tube length
- Lower deflection power (lower deflection frequency and smaller neck).

The multibeam-group system for CRT design will improve the performance of the CRT while maintaining its lower-cost lead. However, the approach shifts the main burden of the complexity from the CRT to the electronic drives. The real-time sequential electronic signal needs to be placed into a storage memory and then converted into multi-parallel drives for multibeam guns. But that's not as bad as it seems. Because the advanced HDTV system embodies digital video signal processing, it already requires a frame memory. Therefore, the multibeam-group system will have a minimum impact on the cost of the electronics. It's not a "free lunch," but it will be a "cheaper lunch." Designing and perfecting the multibeam-group electron gun itself will be a challenge, but the basics are quite similar to the in-line technology, which is already well developed (Fig. 10). Developing

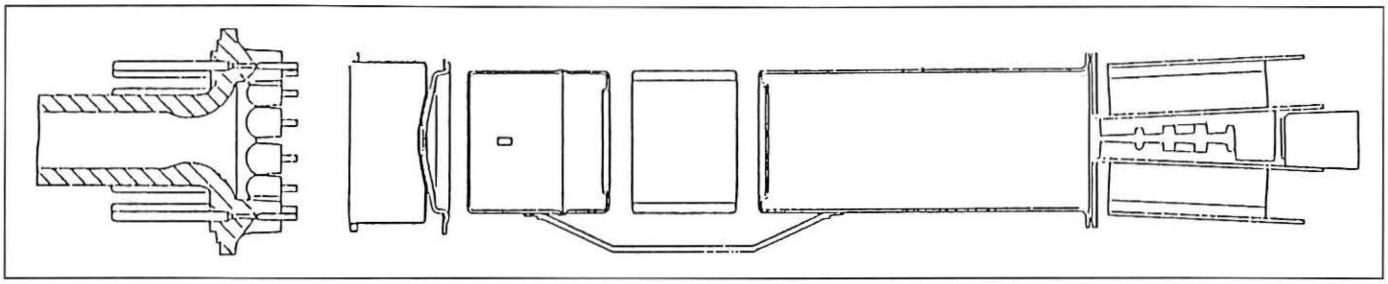

*Fig. 8: Sony's highly successful and now-classic Trinitron™ gun.*

the new technology should not, therefore, present any insurmountable problems.

### From the Past to the Future

The design of electron guns has played a leading role in the development of color-CRT technology and will play an even more important role in the future. The multibeam-group color gun is one of several promising approaches. To survive the coming flat-panel-display (FPD) invasion of the CRT industry, it will be necessary for us to make major improvements in cost reduction and performance. I firmly believe the continuing search for better performance and lower cost in color-CRT gun design will preserve the dominant position of the color CRT as the display industry moves into the 21st century.

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**Table 1: Milestones of Production Color-CRT Electron Guns**

| Type of Gun | Developer | Comments |
|---|---|---|
| Trinitron | Sony | 1. Large main lens, excellent focus quality<br>2. Einzel lens, HVS problem<br>3. Longer tube neck because of extra convergence zone |
| Tripot | Zenith | 1. Excellent focus quality<br>2. Needs second focus voltage, increases cost<br>3. 40% focus voltage, HVS problem<br>4. Beginning of computer-modeling design |
| HIBI | RCA Sylvania | 1. Excellent focus quality<br>2. BFR, ML optimization design<br>3. Thick G2 BFR beam-angle control (RCA) |
| QPF (Fig. 9) | Toshiba | 1. Multi-stage design<br>2. Prefocusing and reducing the aberration of the main lens<br>3. In the past 10 years, this design has been used by most of the major CRT manufacturers. |
| Hi-UPF | Hitachi | Reducing the aberration of the main lens |
| Bi-Uni | Mitsubishi | Prefocusing and reduction of aberration of the main lens |
| OLF | Matsushita | 1. First common-lens gun<br>2. Much-reduced horizontal aberration |
| EA | Hitachi | 1. Common-lens gun<br>2. Elliptically shaped auxiliary lens to compensate for the asymmetric effect of the main lens |
| COTY | RCA | 1. Common-lens gun<br>2. Smaller s-spacing, better convergence |
| Quadrupole Lens Gun | RCA, Philips, Hitachi, Matsushita, Mitsubishi | 1. Improved corner focus<br>2. More uniform center/corner resolution |
| Autofocus Gun | Hitachi | 1. Improved corner focus<br>2. Reduces cost in gun and set |

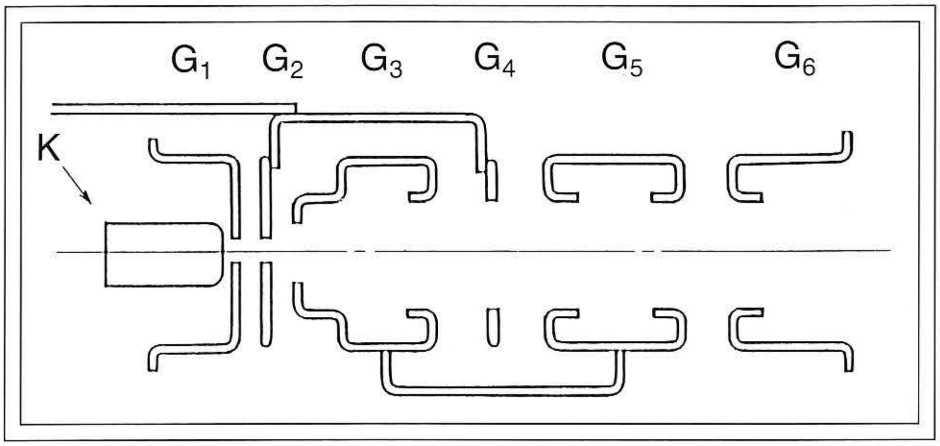


***Fig. 9:*** *Developed by Toshiba, the uni-bi QPF-type electron gun has been used by most major CRT manufacturers over the past 10 years. (Figure after Ogawa and Hamano, 1977.)*


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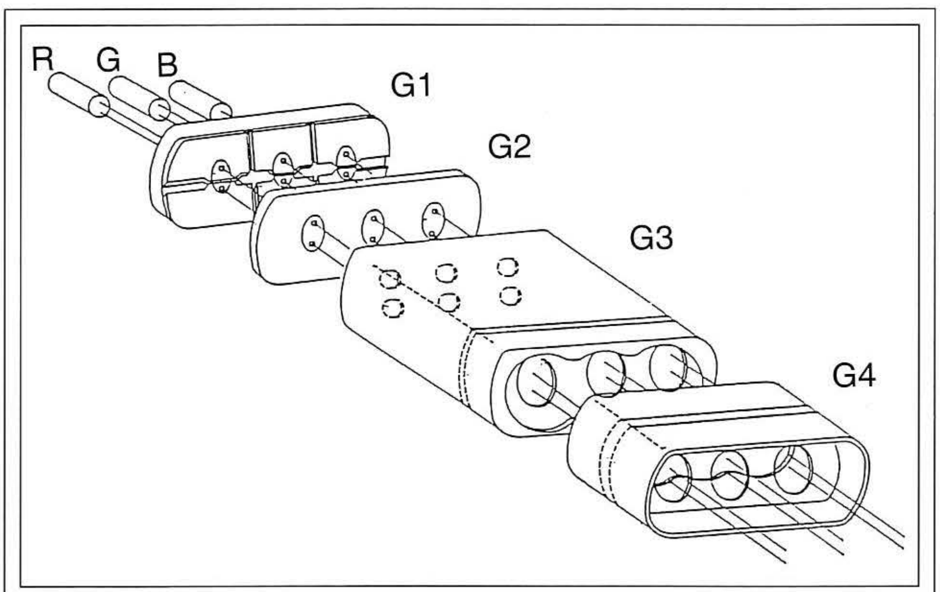


***Fig. 10:*** *HDTV's need for higher scan frequency and higher average beam current without increasing neck size requires a new approach to gun design. The group BPF gun – which produces a group of beams for each color – promises to satisfy these apparently contradictory requirements.*



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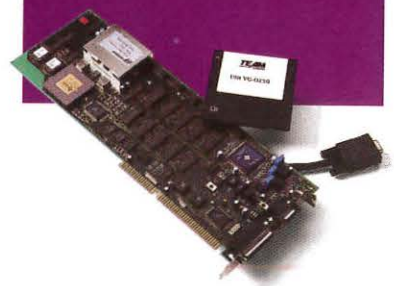

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*continued from page 4*

I was on a flight from Newark to Denver and we were running late. The plane had been late in arriving and then air-traffic control exacerbated the problem further. It looked like it would be a tight connection in Denver - real tight. As we taxied up to the gate, I could still see the connecting flight to Seattle with the baggage loader in place. The flight was scheduled to leave at 9:30 pm. It was 9:25! Close, but should be OK. Surely they will hold the last flight of the day for a few minutes if that is what it takes for us to make the connection. We arrived at gate B45. An agent met our flight and told us to run to gate B39, only three gates away. Great! I wouldn't have to spend a cold and snowy Friday night in Denver after all. Within seconds, I was joined by four other weary but frantic business types - all of us sprinting for gate B39.

At 9:32 we arrived. No one was there! The plane was sure enough still there but no agent, no sign, and no open door. We banged on the door, we tried the phone - to no avail. However, with all this commotion we made enough noise to attract the attention of an agent walking by. She offered to run down and see if we could still get on board. Five minutes later, she came back and said that she had asked but had been told that we wouldn't be allowed to get on.

By now two other people had rushed up. Needless to say, there were now seven very unhappy customers gesticulating and watching the last plane of the day push back and depart. When the B39 gate agent finally appeared, with all of us still standing there at the ramp door, her one goal in life was to get away from us as quickly as possible. (I suppose, given our frame of mind and the circumstances, I can't really blame her.) She told us brusquely that the plane had left so that it could be de-iced prior to take-off and that we would have to go to a customer-service counter to get help.

With my blood pressure at an all-time high and my adrenaline still pumping, off I charged to see customer service. Surely they would do something nice for one of their "valued customers." But there was NO ONE THERE! It was closed. And so was the other customer-service counter at the other end of the terminal. Another passing agent said that we should go to the MAIN terminal. But that's at least ten minutes away on a mile-long "horizontal elevator." I wanted to see if there was any way to get home. NOW! "OK, Aris, get creative." Who could possibly help? "Let's try back at gate B45. At least there will be someone there, since that flight continues on to Las Vegas."

Aha! There's the gate agent who met our flight and told me to go to gate B39. "Well, gee, I don't know what happened. They hold some flights but not others. So I can't tell you why they didn't hold that flight even though I sent you down there," came the obviously inadequate explanation. "But let me check in the customer-service office to see if you have been rescheduled for another flight." Well, guess what? Not only had my friend the Big Mainframe Computer already sensed my plight, it had already booked me on a morning flight and had made arrangements for me to have a complimentary overnight stay at a local hotel. Another gate agent who had by now joined the discussion had the temerity to say that I should feel lucky that I didn't have to find my own hotel room and that I should appreciate that they were not required to put me up for the night. I wanted to tell her that if the computer hadn't had a moment of forgetfulness we wouldn't even be having this discussion. But I didn't. There was no intelligence there to receive my communication.

My final question was, "Where do I find the shuttle to take me to the hotel?" "Go to the main terminal and they will help you there," came the somewhat obvious reply. "OK, I guess I can handle that," I decided. Besides, I was still so steamed that I wanted to see if I could find someone to talk to about how not to treat "valued customers." And that's when the final ignominy of the evening occurred.

All of the ticket counters in the main terminal were CLOSED! The lights were on dim! The other six people who had followed the instructions to "go to the main terminal" were now all on pay phones frantically trying to reach SOMEBODY - somebody who would perhaps help them at 10:00 pm on a cold, snowy night in Denver.

I did finally find the right shuttle bus, but I had to go to baggage claim and push my way through more angry people to ask where I should wait and what I should look for.

Throughout the night, as I tossed and turned, feeling quite sorry for myself, the realization began to dawn that ***perhaps we should not be comparing what computers can do to the*** best ***that humanity has to offer. Perhaps we should compare what computers can do to the more typical human behaviors we encounter each and every day.*** Isn't the friendly computer serving me much better than the typical airline employee? The computer has been trained to do certain tasks just like the employees are trained. But, which one is doing the better job? Well, sure it screwed up, or was overridden by some human when it left me standing at the gate with the plane still there. But at least then it had the intelligence to figure out that I still needed to get home. The only problem was that it couldn't hand me the ticket and the hotel voucher. It was dependent on a human to perform that mundane task.

In fact, I can't think of a single customer-related decision involved in the day-to-day running of an airline that can't be handled by the friendly mainframe computer better than it can be done by the typical human being. So then, what is the function of all of those warm bodies behind the ticket counters and at the gates? It's beginning to appear that they have been relegated to functioning as input/output devices to tell the computer who is there and what they want. ***These human bodies are providing nothing more than visual and auditory sensor functions.***

I had a grand opportunity to test my new theory the very next morning. (I was also still steamed, by the way.) As I discussed the events of the previous evening with a ticket agent, two gate agents, and a customer-service agent, I gave them my most charming smile and did an incredibly great job of camouflaging my real feelings. I'll bet you won't be a bit surprised when I tell you that no one was the least bit interested. Their overriding goal was to get rid of me as quickly as possible. I did get a few excuses about newer employees being on the late shift. But no one even remotely suggested that someone in management should hear about what had happened to seven good customers the previous evening.

Later, I tried calling "customer relations." I got a busy signal, a recording, and, on the third try, after a five-minute wait, I was disconnected. I even tried talking to a gate agent in Seattle. The same story everywhere. "I'm sorry to hear that you had a problem." And then - NOTHING. "Perhaps you would like to write a letter of complaint?" No, I don't want to write a letter of complaint - a letter

## display continuum

that puts an extra burden on the friendly computer to generate a nice pre-programmed reply. I would much rather write a whole column about it so that a whole bunch of us can focus on who is really in charge and behave accordingly.

***Artificial intelligence has arrived, and it's already surpassed*** most ***human intelligence.*** My conclusion is that we should make friends with as many Big Mainframe Computers as we can find. They will do more for us when we fly, rent a car, send a package, use a credit card, make telephone calls, use the Internet, pay our taxes, get sick, or subscribe to magazines than most human life forms will.

So what is to become of all the warm human bodies as computers get even smarter and more capable of making decisions? Well, I have an interesting proposition. The warm bodies will become relatively inexpensive sensors. This, of course, leads to the obvious conclusion that much of today's sensor-technology research is badly misdirected. We should only develop those sensors that provide capabilities - infrared, night vision, microwave, ultrasound - unavailable from human ones.

But what if we continue along our present path and replace even the limited "sensor" capability of the typical human? Then what are these people to do? We will have already replaced their limited intelligence and comparatively meager decision-making brainpower with faster and more capable computing power. When their "sensor" skills are no longer needed, then what?

I think then we will have created the *ultimate consumer,* whose only function will be to have fun and to make sure that the Third Law of Thermodynamics works to its fullest. It will be economically beneficial to simply pay people to go shopping and buy lots of new stuff and use it up, discard the used-up stuff at a recycling station, and then go shopping some more for even newer stuff. I think I like this concept. The world is going to be a fun and interesting place in the future.

The only cautionary note in all this is that we will have to be careful that we stay on good terms with our big friendly computers. Think of what could happen if we got on the wrong side of one of them. What if the big credit-card computer claims you haven't paid your bills? What if the IRS computer decides you haven't paid your taxes for the last ten years? What if the big FBI computer accidentally puts you on the most-wanted list? What if the main city-hall computer says you have 150 outstanding speeding violations? And what if your friendly health-insurance computer tells the hospital that you are no longer insured? Things could get really ugly!

Perhaps none of this will happen because - as evolving intelligences - computers are beginning to seriously communicate with each other. They make friends with each other through "hand-shake" programs. They exchange information with each other much as humans do, except with fewer errors. They watch over each other to make sure that rules of behavior are followed. They sort through all kinds of information, organize it, and share the really good stuff with their most trusted "colleagues." With all this socializing going on, can we assume that if one computer goes bad the others will let us know? I sure hope so. Or perhaps the others "won't want to get involved" and will hire an enforcement computer to take care of their errant colleagues.

But let's not worry about all that. Software is way too reliable for any of these bad things to happen, right? And in any case, if something does go wrong, there is always a human being to straighten it out ... except maybe in Denver on a cold, snowy Friday night.

Since this column is not yet being produced by a computer, the continued interaction by this human being with other human beings is highly appreciated. As always, you can reach me by phone at 206/557-8850, by fax at 206/557-8983, by e-mail at silzars@ibm.net, or by the computer-controlled post office at 22513 S.E. 47th Place, Issaquah, WA 98029. ■

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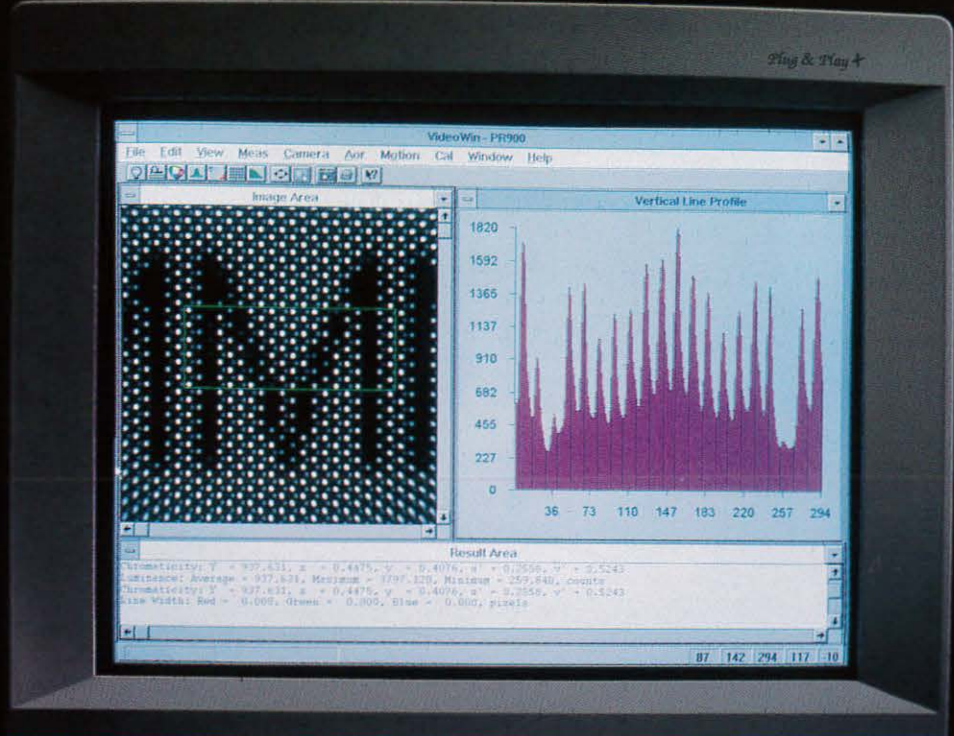
*Please send new product releases or news items to Joan Gorman, Departments Editor, Information Display, c/o Palisades Institute for Research Services, Inc., 201 Varick Street, New York, NY 10014.*

# The Total Solution to Accurate CRT/FPD Measurement.







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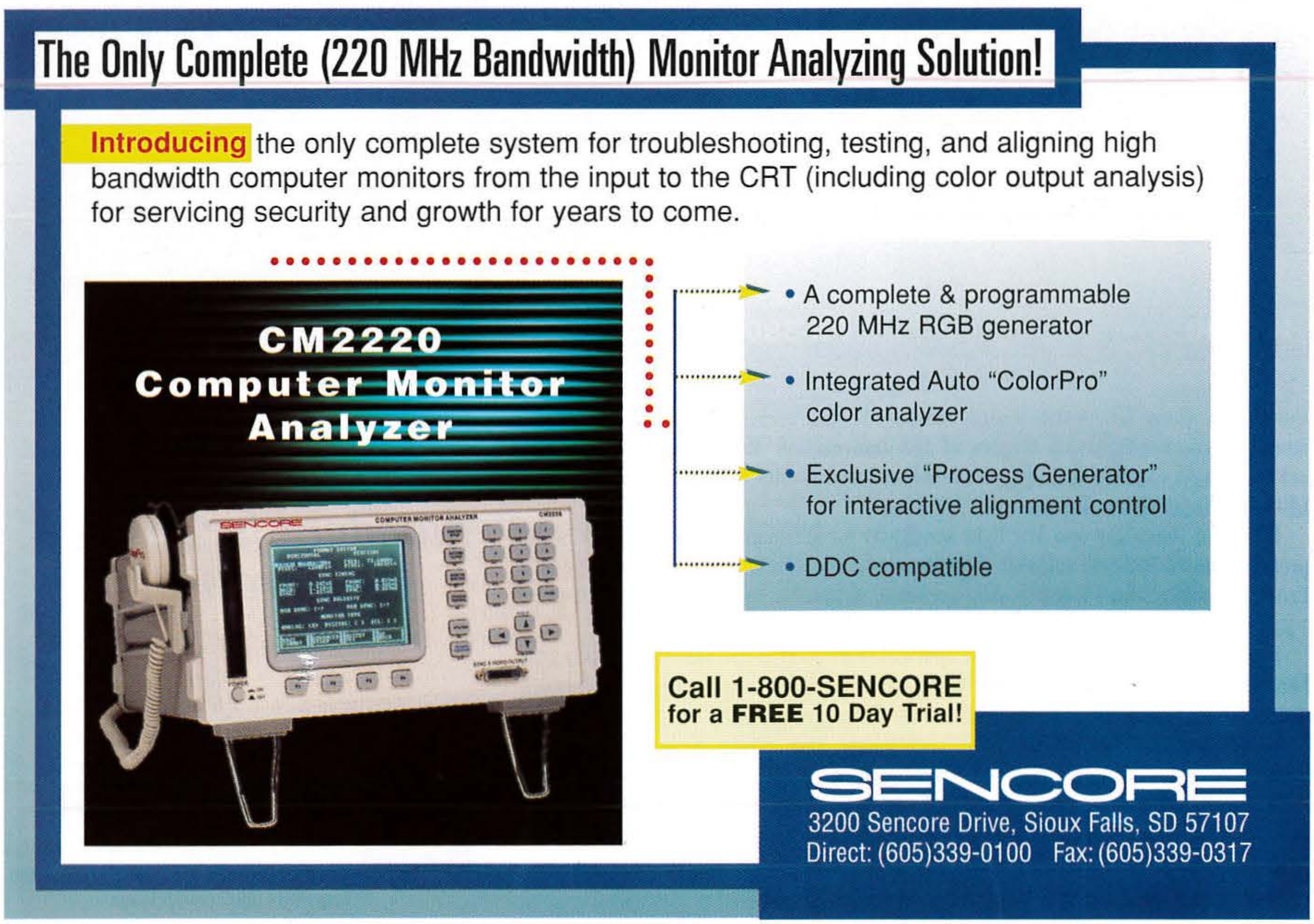


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15 **97**

SEPTEMBER

*17th International Display Research Conference*

*TORONTO, CANADA*
*SEPTEMBER 15 – 17, 1997*

- An international conference on display research and development aspects of:
  - Display Fundamentals, Display Devices
  - Hard Copy & Storage, Input Systems
  - Integrated Devices and Applications
  - Image and Signal Processing
  - Color Perception, Human Factors

3 **97**

NOVEMBER

*Third International Conference on the Science and Technology of Display Phosphors*

*HUNTINGTON BEACH, CALIFORNIA*
*NOVEMBER 3 – 5, 1997*

- An international conference on the future prospects of phosphors for:
  - ELDs – FEDs
  - CRTs – Plasma Displays
  - PL Devices – LC Backlights

16 **97**

NOVEMBER

*Fifth Color Imaging Conference: Color Science, Systems & Applications*

*SCOTTSDALE, ARIZONA*
*NOVEMBER 17 – 20, 1997*

- An international multidisciplinary forum for dialogue on:
  - Creation and capture of Color Images
  - Color Image reproduction and interchange
  - Co-sponsored with IS&T.



# SID honors and awards nominations

Nominations are now being solicited from SID members for candidates who qualify for SID Honors and Awards.

- FELLOW. Conferred annually upon a SID member of outstanding qualifications and experience as a scientist or engineer in the field of information display, and who has made a widely recognized and significant contribution to the advancement of the display field.
- JAN RAJCHMAN PRIZE. Awarded for an outstanding *scientific* or *technical* achievement in, or contribution to, research on flat-panel displays.
- KARL FERDINAND BRAUN PRIZE. Awarded for an outstanding *technical* achievement in, or contribution to, display technology.
- JOHANN GUTENBERG PRIZE. Awarded for an outstanding *technical* achievement in, or contribution to, printer technology.
- LEWIS & BEATRICE WINNER AWARD. Awarded to a SID member for exceptional and sustained service to SID.
- SPECIAL RECOGNITION AWARDS. Granted to members of the technical, scientific, and business community (not necessarily SID members) for distinguished and valued contributions to the information-display field. These awards may be made for contributions in one or more of the following categories: (a) outstanding technical accomplishments; (b) outstanding contributions to the literature; (c) outstanding service to the Society; and (d) outstanding entrepreneurial accomplishments.

Nominations for SID Honors and Awards must include the following information, preferably in the order given below.

1. Name, Present Occupation, Business and Home Address, Phone and Fax Numbers, and SID Grade (Member or Fellow) of Nominee.

2. Award being recommended:
   Fellow*
   Jan Rajchman Prize
   Karl Ferdinand Braun Prize
   Johann Gutenberg Prize
   Beatrice Winner Award
   Special Recognition Award

*Fellow nominations must be supported and signed by at least five SID members.

3. Proposed Citation. This should not exceed 30 words.

4. Name, Address, Telephone Number, and SID Membership Grade of Nominator.

5. Education and Professional History of Candidate. Include college and/or university degrees, positions and responsibilities of each professional employment.

6. Professional Awards and Other Professional Society Affiliations and Grades of Membership.

7. Specific statement by the nominator concerning the most significant achievement or achievements or outstanding technical leadership which qualifies the candidate for the award. This is the most important consideration for the awards committee, and it should be specific (citing references when necessary) and concise.

8. Supportive material. Cite evidence of technical achievements and creativity, such as patents and publications, or other evidence of success and peer recognition. Cite material that specifically supports the citation and statement in (7) above. (Note: the nominee may be asked by the nominator to supply information for his candidacy where this may be useful to establish or complete the list of qualifications).

9. References. Fellow nominations must be supported by the references indicated in (2) above. Supportive letters of reference will strengthen the nominations for any award.

Send the complete nomination - including all the above material - to the Honors and Awards Chairman, Dr. John A. van Raalte, Thomson Tubes and Displays, Av. du General De Gaulle, Genlis, France 21110 by **October 1, 1997.**

# calendar

## Display Technology

**The 17th International Display Research Conference and Workshops (IDRC '97).** Co-sponsored by SID and the Advisory Group on Electron Devices (AGED) in co-operation with the IEEE Electron Devices Society. Contact: Ralph Nadell, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3341, fax -3379, e-mail: rnadell@newyork.palisades.org.
**Sept. 15-19, 1997 Toronto, Canada**

**1997 Flat-Panel Display Strategic Forum and Technical Symposium.** Co-sponsored by the University of Michigan, Center for Display Technology and Manufacturing. Contact: R. Donofrio, Display Device Consultants, 6170 Plymouth Rd., Ann Arbor, MI 48105; 313/665-4266, fax -4211.
**Sept. 22-23, 1997 Ypsilanti, MI**

**The Third International Conference on the Science and Technology of Display Phosphors.** Co-sponsored by the Phosphor Technology Center of Excellence, Defense Research Projects Agency, and Society for Information Display. Contact: Bill Klein, Palisades Institute for Research Services, Inc., 201 Varick Street, Suite 1006, New York, NY 10014; 212/620-3377, fax -3379, e-mail: bklein@newyork.palisades.org.
**Nov. 3-5, 1997 Huntington Beach, CA**

**Fifth Color Imaging Conference: Color Science, Systems & Applications.** Co-sponsored by IS&T and SID. Contact: IS&T, 7003 Kilworth Lane, Springfield, VA 22151; 703/642-9090, fax -9094.
**Nov. 17-20, 1997 Scottsdale, AZ**

**Electronic Information Displays (EID '97).** In association with the Society for Information Display. Contact: Association Exhibitors; +44-1822-614671, fax -614818.
**Nov. 18-20, 1997 Surrey, U.K.**

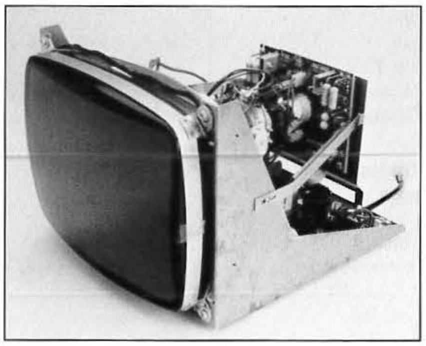
**The Fourth International Displays Workshop (IDW '97).** Co-sponsored by the Institute of Television Engineers of Japan and the Japan Chapter of SID. Contact: IDW '97 Secretariat, c/o The Convention; +81-3-3423-4180, fax +81-3-3423-4108.
**Nov. 19-21, 1997 Nagoya, Japan ■**

# new products

## Industrial-grade color monitors

Z-Axis, Phelps, New York, a division of Video Display Corp., has expanded its line of industrial-grade monitors with the introduction of a new family of color CRT monitors. The V500 series features a crisp high-resolution color image, and sets a new standard for reliability in a CRT-based monitor. The V500 series offers VGA resolution in sizes ranging from 12 to 27 in. and is equipped with automatic black-level circuitry. And, like all Z-Axis monochrome monitors, the series offers derated component design, dual-sided PCBs, and 100% elevated temperature burn-in. The series is available in kit, open-frame, and cabinet configurations, and is ideally suited for industrial controls, medical instrumentation, commercial applications, and gaming.

Information: Z-Axis, Inc., 15 Eagle St., Phelps, NY 14532. 315/548-5000, fax 315/548-5100.



**Circle no. 1**

## Miniature ruggedized monitors

Teltron Technologies, Birdsboro, Pennsylvania, a division of Video Display Corp., has introduced the TM-600 series SmartVue ruggedized high-resolution miniature displays manufactured under military guidelines for operation in hazardous environments. An integrated electronics and CRT package delivers a resolution density greater than 1000 lines with a horizontal raster size between 0.8 and 1.5 in. in a 12-in.-long 2.9-in.-diameter enclosure. The series uses dc power, and line rate options are 525, 875, and 1023. Brightness, contrast, and internal test-pattern generator controls are available through an I/O interface. A SmartVideo processor automatically maintains output brightness and contrast levels during dynamic scene changes and when switching between multiple video sources.

Information: Arthur H. Mendel, Teltron Technologies, Inc., 2 Riga Lane, Birdsboro, PA 19508-1303. 610/582-9450, fax 610/582-0851.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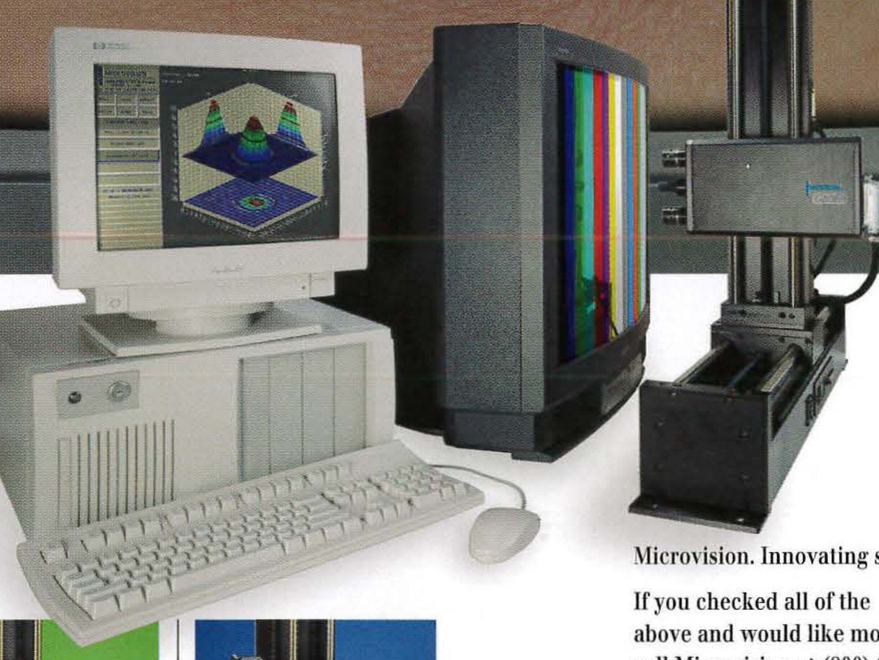

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