Liquid Crystal Display Development

By Dr. Kataoka Shoei

In April 1973, Sharp Corp. became the first company in the world to use a liquid crystal display in an electronic calculator. The thin, lightweight and low power liquid crystal display took its first stride toward becoming a key device supporting today's advanced information society. Sharp's LCD was a "segment" type, made up of a row of figure "8's" and could only display numbers, therefore, it was only useful in calculators and digital watches.

By 1979, just six years later, the display of characters and diagrams became possible with the development of the dot matrix LCD, in which an entire display is composed of tiny dots. (Today nearly all LCDs are of this type.) With this new development, LCDs moved into pocket computers and electronic games. Since 1983, when large-size LCD screens were developed, liquid crystals have been used in word processors and personal computers.

In 1986 a 3-inch color liquid crystal display television was developed that incorporated a thin film transistor (TFT) liquid crystal for every several tens of thousands of dots in the dot matrix as its drive control mechanism. Finally, with a technology that could compete with the Braun tube, the curtain lifted on the history of a new culture of screen images.

There has been no stopping the technological development of the LCD since then. The year 1988 saw the unveiling of an experimental 14-inch large screen TFT liquid crystal display. It was about one-thirteenth as thick and about one-quarter as heavy as a 14-inch Braun tube television. This large screen LCD television was a giant step forward towards the realization of what possibilities existed for large screen LCDs and had a far-reaching impact on the industry and consumers.

In 1992 a 16.5-inch wide screen TFT liquid crystal display and a 17-inch unit for engineering work stations (EWS) with a high density of 1.228 million dots were successfully developed. Mass-production of a 14-inch color TFT LCD for audiovisual and office automation use also began that same year.

The progress from numerals to diagrams, from monochrome to color, from still frames to motion and from small screens to large screens has truly been remarkable. The semiconductor has been called the "food staple of industry," but the liquid crystal display has advanced so far that it is now called the "paper of industry." With the advent of the multimedia age, the fiscal 1993 industry-wide production of liquid crystal display panels topped ¥429.4 billion. In the midst of the current stormy business environment, the liquid crystal display industry is a rarity—with growth exceeding a blistering 20% per year.

Liquid Crystal Display Applications Market Estimates Showing Expectations for Large Increases in Demand (Compiled by Sharp Corp.)

(fiscal year)	1992	1995	1997
Portable computers	440	950	1,650
Portable data terminals	0	850	2,100
Portable A/V equipment	180	350	750
Work stations	70	200	350
Navigation systems	17	162	320

(unit: 10,000)

Present and future applications

The more the arrival of the multimedia age is heralded, the more anticipation regarding liquid crystal display accelerates. As already stated, in 1993 the liquid crystal display market was worth ¥429.4 billion and this figure is expected to increase to ¥1 trillion by 1996 and ¥2 trillion by the year 2000. When the cost of products using liquid crystal display is considered, the market becomes immeasurably vast.

It is not difficult to image that applications of liquid crystal displays will continue to expand. Possible examples of uses in the home are wall-mount televisions and high definition large-screen televisions that use liquid crystal display images. In the business world, the range of possibilities is limitless: In computer terminals, liquid crystal displays can serve as "windows" through which individuals can share and manipulate information; they can be used in pen computers to create a paperless office, and in LCDs that promote space conservation.

There are limits to the demand for liquid crystal displays, however, if they are treated merely as a replacement for other display technologies currently in use. We must take the lead to develop new uses that will expand the market for liquid crystal display panels. The idea is to create next-generation products centered on LCDs as a key device that create their own demand. The unique characteristics of liquid crystal displays must be put to use to create products that did not exist up until now, products that will make the consumer say, "Ah, I've always wanted something like this."

There are five categories in which there are particularly high hopes for liquid crystal products: space-saving information devices (personal computers, word processors, etc.); new portable information tools (liquid crystal display pen computers, etc.); amusement devices (game devices, etc.); on-board devices (navigation systems, etc.); and audiovisual devices (liquid crystal display ViewCam camcorders with a LCD liquid crystal display television, liquid crystal display vision, etc.).

As has so far been the case, the information devices under the space-saving information device category seem to drive demand. With the wave of information accessible to the individual, the greatest progress is expected to be in new portable information tools. Sharp Corp.'s pen-based portable information tool Zaurus was put on the Japanese market in October 1993. As the first product in this new genre, it has been a huge hit, with 200,000 units sold during the first six months. In this age of information, "portable information" and "real time information management at the individual level" have become imperative. In this climate, liquid crystal displays have attracted great attention not only as small-sized, lightweight and low power displays, but also as "man-machine interfaces" that can read handwritten data.

Use of liquid crystal displays in on-board devices also has a promising outlook. A typical example would be navigation systems, which are more than simply a matter of convenience. A wide range of uses are currently being investigated as part of a move toward multi-media in automobiles, which is expected to be the trend in the future of on-board devices.

There are many examples of applications of liquid crystal displays in the audiovisual equipment category. The liquid crystal display video camera ViewCam (put on the market in October 1992), whereby the liquid crystal display technology created a new demand, is a primary example. It created an entirely new principle for video cameras by replacing the conventional viewfinder with a liquid crystal display monitor. As of March 31, 1993, 730,000 units had been sold worldwide, giving a much-needed shot in the arm to the sluggish video camera market. Other examples are the "Liquid Crystal Museum," heralded in the mass media as "the long-awaited wall-mount television" (put on the market in July 1990). Then there is the thin and portable "liquid crystal display television," mobile enough to be carried into a car, the kitchen or the bedroom. Finally, there is the "liquid crystal display projector," which will be indispensable in the coming "age of HDTV (High Definition TV)" due to its unprecedented lightness and convenience. The sphere of applications is expected to continue to expand in similar fields where interest is strong.

The multi-media trend, digitalization of information and the individualization of information will certainly heighten demand for liquid crystal displays. Liquid crystal display technology will advance with an eye toward staying one step ahead of product needs. Therefore, entirely new products impossible with the display technology currently available are sure to arise with further development of liquid crystal display technology.

Future prospects and technical issues

If the 20 years since the inception of the liquid crystal display industry can be called the first stage of its infancy, it is now entering the second stage. As the intensity of the competition steps up another notch, the development efforts of each company have become extraordinary.

As the dramatic shift in demand

Photo: Sharp Corporation

Quartz ViewCam, achieving multimedia communication through visual and phone capabilities.

towards TFT technology and the promotion of color continues to advance, the most pressing issue for development technology is the move to large screen and, for production technology, cost-reduction. Other issues are high resolution, brightness and thinness. Lower power consumption and wider angle of vision are also demanded. Accompanying these improvements are a mountain of other technical issues that must be resolved, including innovations in liquid crystal materials and innovations in key peripheral materials such as color filters and backlights as well as a wide range of improvements in manufacturing technology, particularly in the area of productivity.

The fact that the problems have been elucidated means that resolution cannot be too far behind. Based on the current level of technology, there are a number of innovations which are expected to reach the implementation stage within the next several years: large 30-inch screens; 1.3 million pixel high-definition television and applications for EWS level; thin display units of under 8 millimeters with backlighting and under 2 millimeters without backlighting; low power consumption of under 3 watts for 14-inch and under 10 milliwatts without backlighting; and 160-degree wide angle horizontal and vertical field of view. As for the most important issue—namely price—a 10-inch VGA panel that now sells for around ¥150,000 should be at the ¥50,000 level by 1996.

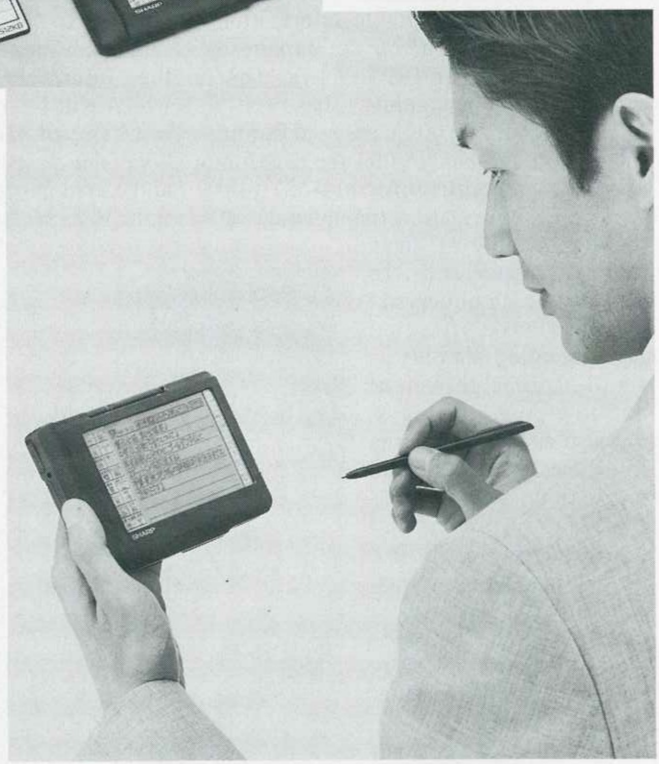
Still a newborn compared to the Braun tube technology, liquid crystal technology is in the position of the next generation of displays, but the road to that position has by no means been a smooth one. Now, however, there is no stopping this overwhelming trend. With Sharp Corp. taking the lead with planned plant and equipment investments equaling ¥120 billion in total during the three years between fiscal 1993 and fiscal 1995, other companies are making huge investments with an eye on participating in this market. With such ongoing competition, there is no telling what future trends will look like.

Furthermore, the winds of globalization are now blowing through this industry which up until now Japan has been leading. Some Asian countries, such as South Korea, are trending toward initiation of mass production of LCDs. Also in the U.S., of which industry is at the leading edge in understanding the function and design of LCDs but lags relatively behind the leading edge in mass production technology, there is a trend to nurture the LCD industry. With the coming accelerated competition on a global scale, further progress in technological innovations and development of products incorporating LCD technology are expected. The liquid crystal display industry should continue to expand.

Technological innovations are continuing unabated in countries around the world to come up with bigger, more beautiful and less expensive liquid crystals. Whether or not liquid crystals will become the next true pillar of industry will depend on unrelenting efforts of liquid crystal display makers the world over.

Photos: Sharp Corporation

Zaurus, a cellular data tool that shrinks data functions needed for business down to pocket size. A pen is all that is needed for anyone to learn to use it.



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