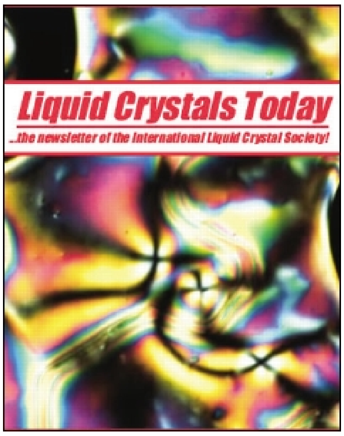

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LIQUID CRYSTAL DISPLAY APPLICATIONS: Past, Present & Future

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LIQUID CRYSTAL DISPLAY APPLICATIONS
Past, Present & Future

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Liquid crystallinity was first observed in 1888 but it was more than 30 years before Mauguin[1] discovered and described the twisted nematic structure which later became the basis for liquid crystal display (LCD) technology, now the major application for liquid crystal materials. During the 1920s and 1930s work on liquid crystal materials and the electro-optic effects which they produced was conducted in France, Germany, the USSR and Great Britain.

Perhaps the first patent on a light valve device which used liquid crystals was awarded to the Marconi Wireless Telegraph company (now part of GEC) in 1936[2]. Then in the mid-1950s, researchers at the Westinghouse Research Laboratories discovered that cholesteric liquid crystals could be used as temperature sensors. It was not until the 1960s, however, that serious studies of the materials and the effects of electric fields on them were carried out.

The early work on applications of liquid crystals was carried out in research laboratories in the USA, Eastern and Western Europe and Japan. The idea of using liquid crystal materials for display applications was probably first conceived by Richard Williams and George Heilmeier at the David Sarnoff Research Center (then the central research arm of RCA Corporation) in Princeton, New Jersey in 1963[3]. Later, a larger group, headed by G H Heilmeier and including Louis Zanoni, Joel Goldmacher, Lucian Barton and myself, spearheaded the work to develop liquid crystal displays for application to the fabled "TV on-a-wall" concept, a dream of the TV pioneer

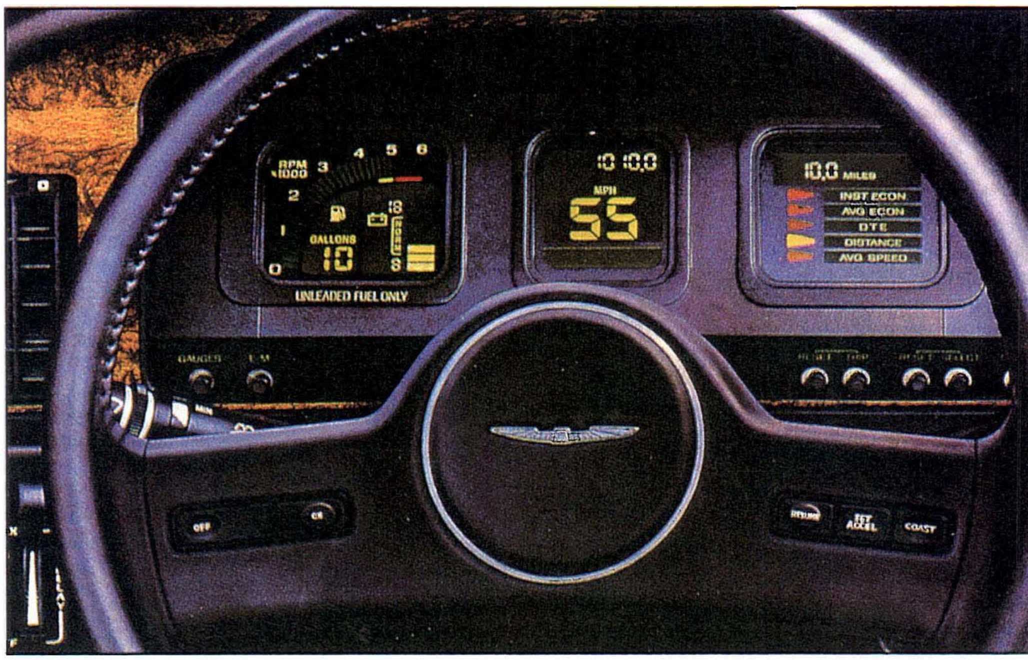

Figure 1: Primary LCD auto dashboard cluster. Reproduced from Molecular Crystals and Liquid Crystals, Vol 165, *by kind permission of the publisher, Gordon and Breach*

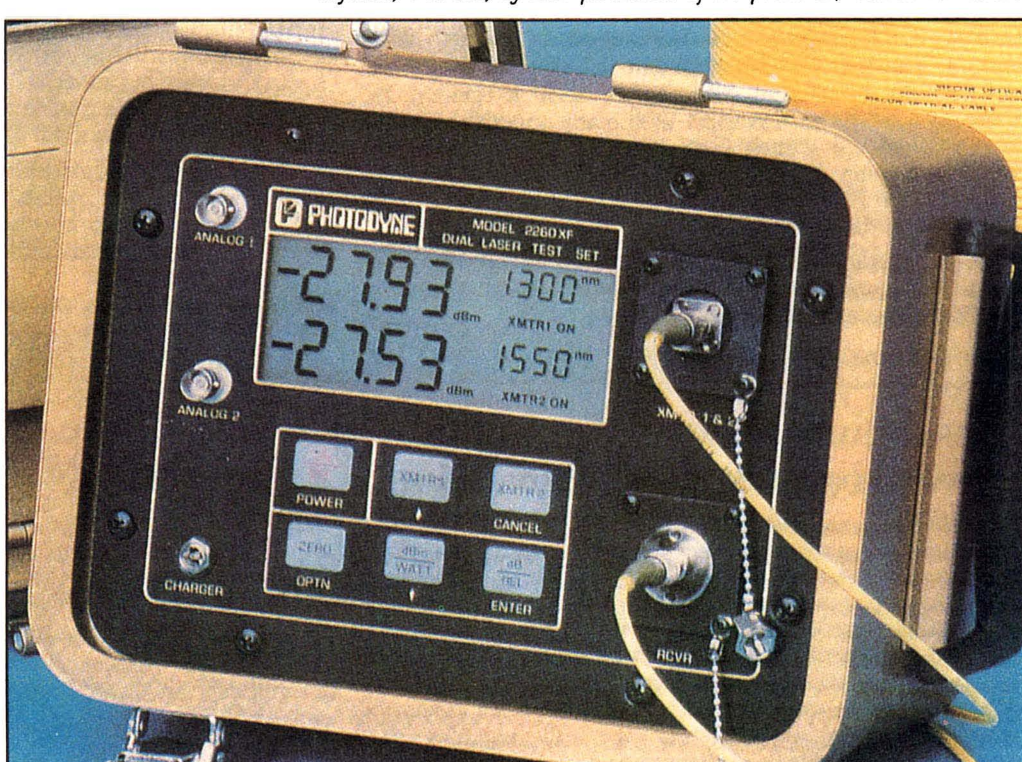

Figure 2: Multi-digit LCD in test instrument. Reproduced from Molecular Crystals and Liquid Crystals, Vol 165, *by kind permission of the publisher, Gordon and Breach*

the late David Sarnoff. During the period from 1964 to 1968, this group discovered many of the effects which were later to be commercialised including dynamic scattering[4], dichroic dye LCDs[5], and phase change displays[6]. One of the major breakthroughs was the group's discovery that by mixing various pure nematic liquid crystalline compounds together it was possible, for the first time, to produce stable, homogeneous liquid crystal mixtures which could operate over a broad temperature range including ordinary room temperature[7]. Later, cyano-biphenyl materials with improved properties and even broader temperature ranges were developed[8]; these compounds form the basis of most of the liquid crystal materials used today in commercial products.

Among the most important early applications were the wrist watch and portable calculator, made possible by the low power consumption of LCDs and the integrated circuit industry, then in its infancy. Later, numeric indicators for instruments, digital clocks, optically tuned colour filters, displays for auto dashboards, aircraft cockpits, score-boards, highway signs and computers were developed.

Today, manufacturing techniques and equipment for LCD production are readily available and highly reliable, low cost liquid crystal displays are being made by the hundreds of millions, primarily in Japan and the Far East. These displays are, for the most part, driven by a low level of multiplexing (30% to 50% duty cycle) or directly driven with each segment receiving full voltage.

The LCD technology became successful because of its "passive" (non-light emitting) nature which provided the combined characteristics of low power and viewability in bright light, factors that made miniaturisation and portability a reality.

Today we see more sophisticated LCDs appearing in industrial and consumer products. These second generation LCDs, driven by a high-level multiplexing scheme, or using a "Supertwisted" technique provide a higher level of information content and appear in the applications envisioned nearly 20 years earlier: automobile dashboards (Figure 1), electronic test equipment (Figure 2), aircraft cockpits (the Boeing 757 and 767 have LCDs), instruments, and hand-held colour TV sets (Figure 3).

The truly portable computer became a reality because of the advent of personal computers in the late 1970s

Figure 3: Hand-held TV with full colour LCD. Reproduced from Molecular Crystals and Liquid Crystals, Vol 165 *by kind permission of the publisher, Gordon and Breach.*

and 1980s. Today, portable computers and word processors with high information content LCDs are being sold by the million. Many of these products can be operated with a set of small batteries; others use a backlighting scheme to enhance viewability in dimly lit environments.

Displays for general desk-top computer use are about to emerge, although the cost of the displays is still too high compared with the traditional cathode ray tube. Several firms recently introduced desk-top computers with multi-colour, high information content LCD screens. A list of the existing applications for liquid crystal displays is presented in Table 1.

Clearly LCDs have come of age. But developments in this technology have continued and now we are beginning to see what I would call the third generation of LCDs. These are based on the use of thin-film electronic devices (such as the thin-film transistors or TFTs) to drive a large number of picture elements (pixels) without the loss of contrast or angle of view. Coupled with the use of colour filters, these full-colour displays now appear in large numbers of hand-held TV sets and soon will be used in table top TV sets, portable computers, automobile dashboards, instruments and many other applications.

Now that liquid crystal displays have become widely used in a whole variety of commercial products, what can we expect to see in the future? With more than $200 million per year being spent on LCD research and several billion dollars on the construction of manufacturing plants throughout the world, it is clear that the products of the next 20 years will be even more impressive than those of the past 20. Of course, colour TV will be one of the most important applications and we expect to see sets with diagonal screen sizes of 9-14" on the market by the mid-1990s. The first wall-mountable units will probably appear in 1995 with screen sizes of 14" or more, and by the late 1990s colour TVs with 20" diagonal LCD screens will appear on walls and tables in homes and offices; the 40" diagonal screen will certainly be a reality early in the 21st Century.

The other major application for LCDs will be portable personal computers. Within the next five years, we expect to see the truly "book-size" (8 x 10") computer become a reality. With an active matrix LCD screen of 10" (diagonal), this computer will have the power of many of today's desk-top

TABLE 1 Current Applications for Liquid Crystal Displays

Analytical Instruments	Household Appliances
Auto Dashboards, Radios & Clocks	Jewellery
Battlefield Computers	Marine Engine Indicators
Blood Pressure Indicators	Marine Speedometers & Depth Finders
Calculators	Overhead Projector Plates
Cameras	Pens
Cash Registers	Photocopy Machines
Clock Radios	Point-of-purchase/sale Displays
Digital Meters	Portable Radios
Electric Shavers	Portable Computers & Word Processors
Electronic Billboards	Portable Oscilloscopes
Exercise Equipment	Telephones
Gasoline Pump Indicators	Toys & Games
Hand-held TV & Terminals	TV & VCR Channel Indicators
Hand-held Data Collection	Typewriters, editing
Heart Monitoring Devices	Windometers
Highway Signs	Wristwatches

Liquid Crystal Display Applications
(continued from previous page)

units but will be about the size of a book (8" x10").

Replacement of the cathode ray tube in the desk-top computer will begin in earnest early in the 21st Century. In full colour, these computer screens will be extremely compact, freeing desk space for many of the other new, compact office automation products which will be available at that time.

Flexible LCDs will appear in primary auto dashboard instruments. The displays will be curved to the contour of the dashboard and be multicoloured. Other LCDs will be used for navigation, colour computer monitor, clock, etc.

Another major application for LCDs could be the electronic window shade, a concept which has been around for more than 20 years. Once incorporated into large panes of glass, these electronically controlled windows could become commonplace on the buildings and skyscrapers of the 21st Century. The polymer dispersed LCD technology appears to have the potential to fit this application.

In addition to these new applications, we expect to see LCDs continue to be used in all the applications listed in Table 1. However, the displays will have much greater information content, be available in colour and, in some cases, be flexible and have very large screens. The number and type of applications appear to be limited only by the imagination.

REFERENCES

1. C Mauguin, *Bull. Soc. fr. Min.*, **34**, 71 (1911)
2. Marconi Wireless Telegraph Company, *BRITISH PATENT 441,274* (1936)
3. R Williams, *J. Chem. Phys.*, **39**, 384 (1963); R Williams, G H Heilmeier, *J. Chem. Phys.*, **44**, 638 (1966)
4. G H Heilmeier, L A Barton & L A Zanoni, *Appl. Phys. Lett.*, **13**, 46 (1968)
5. G H Heilmeier, J A Castellano, L A Zanoni, *Mol. Cryst. & Liq. Cryst.*, **8**, 293 (1969)
6. G H Heilmeier, and J E Goldmacher, *Proc. IFEEE*, **57**, 34 (1969)
7. J A Castellano, J E Goldmacher, *US PATENT 3,540,796* (1970), applied for June 6, 1966; J A Castellano, *US PATENT 3,597,044* (1971), applied for September 1, 1968.
8. G W Gray, K J Harrison and J A Nash, *Electronic Letters*, **9**, 130 (1973)

SOCIETY NEWS

Membership Applications

Enclosed with this copy of Liquid Crystals Today is a membership application form. This should be completed and sent with the appropriate payment to THE TREASURER, Prof J W Doane, at Kent State University.

Following receipt and approval of the application, members will receive a copy of the Bylaws of the International Liquid Crystal Society, and a membership card.

Many liquid crystal scientists have already expressed interest in joining the ILCS, and have returned preliminary application forms. Their applications will be confirmed and they will receive membership cards on receipt of the appropriate dues.

The Officers of the ILCS are at present considering problems associated with the collection of dues from members in soft currency areas. It is hoped that arrangements can be made to collect dues through National or Regional liquid crystal organisations, but in the meantime members should return the application form and check the box labelled soft currency area.

News from Members

Professor G W Gray, FRS, formerly G F Grant Professor of Chemistry at the University of Hull, has now taken up a position as Advanced Materials Consultant with E Merck Ltd in their UK laboratories at Broom Road, Poole, Dorset. [Tel: (0202) 744520; ext 3584; Fax: (0202) 681497]. His links with universities still continue however through visiting professorships in his old University at Hull and also at the University of Southampton.

TREASURER'S REPORT

The Treasury of the ILCS currently stands at approximately $28,000. The loan of $10,000 to the 13th International Liquid Crystal Conference was repaid in full with a supplement of $2,000 to offset loss of interest as well as the $500 presented as the Glen Brown Award.

The bulk of the funds in the Treasury came from the 11th International Liquid Crystal Conference held at Berkeley in 1986. Because of the large amount generated at this Conference it was necessary to incorporate the Planning and Steering Committee which had existed since 1965. The necessary forms are now complete to change the name of the corporation to the International Liquid Crystal Society.

J W Doane, Treasurer to the ILCS