

Dr. James Fergason

A Pioneer of Liquid Crystal Technology

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Advancing the Understanding of Liquid Crystal Technology

Dr. James L. Fergason was recognized around the world as a pioneer of modern liquid crystal technology. Starting in November of 1957 when he saw his first liquid crystal, he sustained a continuous commitment to research and invention in liquid crystal materials and displays

Dr. Fergason received more than 150 U.S. patents on liquid crystal technology, leading to scientific advancements and commercial products that improved the lives of millions of individuals. His research resulted in the introduction of many new products that leveraged liquid crystal technology including optical, medical, and safety devices, quartz watches, LCD displays, and much more.

Context

Today, the liquid crystal display (LCD), like its predecessor the cathode ray tube (CRT) is taken for granted. No one even notices the millions of tiny displays in watches and calculators any more. And while a 60-inch LCD flat screen TV may get a few oohs and ahs from the neighbors, smaller color TVs, flat screen desktop monitors and notebook displays, as well as the billions of LCD screens in mobile phones are simply part of the modern landscape, worldwide.

During the first half of the 20th century the invention, development, and commercialization of CRT technology brought the world the miracle of broadcast full color video imagery in our homes. In the past 50 years, the invention, development, and commercialization of liquid crystal displays has not only extended the range of full color video imagery to mobile handsets and notebooks, but also actually displaced the venerable CRT from the office and home.

Today the LCD module (component) industry generates nearly \$100 billion in revenue worldwide. But more importantly the LCD is a critical component of even larger industries. Without the LCD, the cellular phone would be simply a telephone, and not a personal mobile tele-computing tool. There would be no notebook or portable computer. Anytime access to communications and entertainment would still be a dream. The multiplier effect of the LCD on the IT, entertainment, software, and communications industries has been estimated to be at least a factor of 10. The LCD has been called one of the most important inventions and developments of the electronics era.

It is hard to believe that in the 1960s the modern LCD architecture had not been conceived. Yes, inventors and scientists worldwide saw the potential for a flat panel display, but a practical display architecture with adequate imaging capability, lifetime, and low cost and power had not been discovered.

Liquid Crystal – Any of various liquids whose component particles, atoms or molecules, tend to arrange themselves with a degree of order far exceeding that found in ordinary liquids and approaching that of solid crystals. As a result, liquid crystals have many of the optical properties of solid crystals. Moreover, since the order is not as firmly fixed as that of a solid crystal, it can be easily modified with corresponding changes in the optical properties; typically, a small electrical impulse darkens the crystal so that it is clearly visible against the lighter background of neutral crystals.

A Nematic Liquid

Crystal is a transparent or translucent liquid that causes the polarization (that is, the focusing in a plane) of light waves to change as the waves pass through the liquid. The extent of the change in polarization depends on the intensity of an applied electric field. Nematic comes from a Greek prefix *nemato* meaning threadlike and is used here because the molecules in the liquid align themselves into a threadlike shape. Nematic liquid crystals are used in twisted nematic displays, the most common form of liquid crystal display.

James L. Fergason, was but one of many researchers in the United States and around the world seeking the solution, but he is one of three researchers to be acknowledged by IEEE to have independently conceived of the workable architecture and design of the LCD and he is also credited with laying out a vision and plan for overcoming the materials, processing, and manufacturing hurdles that stood in the way of low cost mass production.

Early Years

Dr. Fergason is a product of Middle America, born and raised in a rural area of Missouri where he attended a one-room school and later a small high school. Dr. Fergason graduated from the University of Missouri in 1956, with a degree in Physics. After proudly serving in the Army, he launched his career in the field of liquid crystal science.

A Pioneer Researcher

Dr. Fergason began his career as a researcher, first at Westinghouse Corporation for ten years and later at the Liquid Crystal Institute of Kent State University. He immediately became intrigued by liquid crystals and increasingly focused on finding commercial applications for these unique materials.

In 1958 he invented the first practical use of liquid crystals. They were temperature-sensitive cholesteric liquid crystals that show dramatic color changes that can be used for accurate temperature measurement. These inventions are still sold in retail stores as well as hospital supply companies. Some common products are forehead thermometers and mood rings. His first patent was issued in 1963 for his work in the application of cholesteric liquid crystals to temperature-sensing applications.

From 1966 to 1970 he was Associate Director of the Liquid Crystal Institute at Kent State University. Dr. Fergason was part of an effort to use liquid crystals for thermal mapping to screen for breast cancer. Fergason was also an early pioneer in developing electronic display applications and increasingly focused his attention on nematic materials.

James was a leading force in research that was pursued in parallel by an international group of researchers, and Fergason's ideas and inventions have been recognized as critical to moving the research forward. In 1970 he published a paper that broadly defined approaches for making nematic LCDs. His paper has been cited by hundreds of inventors who did research after him, providing a springboard for others to continue to evolve the technology.

Inventor and Entrepreneur

Jim made the decision to leave Kent State to establish his own company to pursue his research and commercialize displays in 1970. He founded International Liquid Crystal Company (Ilixco) to

commercialize LCDs, serving as President. Here he led the effort to refine his concepts about nematic field effect displays.

During an incredibly creative and productive decade, Jim published a series of technical papers and filed a family of patents that became not only the foundation of the initial LCD watch and calculator products, but the roadmap for industry development. His vision was so broad that many of his early designs were not realized commercially for more than 20 years. His inventions and technical contributions related to the core LCD industry are many and well documented. His accomplishments during this era include:

- Invented the first room temperature liquid crystal material, a formulation still used today, more than 50 years later, in LC thermometers. His formulation approach was widely followed to greatly expand the range of commercially viable LC mixtures.
- Conceived and invented the architecture of the commercial LCD in 1971. The “twisted nematic” design that uses an electric field to control the twist orientation of the LC molecules to create a high contrast image in polarized light is still the basis of operation for most LCDs today.
- Described and patented a range of materials and process solutions to configure display electrodes, surface align liquid crystal molecules on glass surfaces, construct and seal flat glass cells, and fabricate LCDs.
- Conceived of and described a range of longer term directions for LCD development to improve the switching speed, viewing angle, and general performance of the display as well as processes to enable fabrication of larger size panels to significantly reduce manufacturing costs.

Liquid Crystal Display (LCD) is the technology used for displays in notebook and other smaller computers. Like light-emitting diode (LED) and gas-plasma technologies, LCDs allow displays to be much thinner than cathode ray tube (CRT) technology. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it.

Technology Incubation

During the 1980s and 1990s, Ferguson led a succession of self-funded research and technology incubation programs. Over a period spanning more than two decades, Ferguson chose projects that addressed a succession of hurdles in liquid crystal and display technology. He also led a focused intellectual property (IP) program that patented his inventions. Many of his inventions were licensed and successfully commercialized.

Plastic LCDs. During the 1980s Jim invented and licensed material and process technology related to plastic LCDs. Called Polymer Dispersed Liquid Crystal (PDLC) displays, the devices used a suspension of LC droplets in a polymer sandwiched between plastic films.

Eye Protection. Jim and his sons pioneered the market for automatic switching welding helmets based on high-speed LC

Polymer-Dispersed Liquid Crystals (PDLs)

consist of liquid crystal droplets that are dispersed in a solid polymer matrix. The resulting material is a polymer with liquid crystal droplets filling in the holes. These tiny droplets are responsible for the unique behavior of the material. By changing the orientation of the liquid crystal molecules with an electric field, it is possible to vary the intensity of transmitted light.

shutters. Jim also completed DOD research contracts to refine eye protection devices against laser weapons and nuclear blasts

Personal Viewers. During the 1990s, Fergason filed a family of patents for technology and devices to overcome the commercial hurdles of personal viewers, sometimes called head-mounted displays, or near-to-eye displays. The inventions disclosed included optical dithering devices to increase imager resolution, the Retro-Vue™ head-mounted projector currently be evaluated as a military training device, and a range of viewer optics to enable multiple optical channels.

IP Licensing

Dr. James Fergason began a new phase in his career in 2001 with the founding of Fergason Patent Properties (FPP) and the assignment to the company of more than 35 issued patents. FPP's goal is to broadly license all of Fergason's IP on a non-exclusive basis and to support licensees in integrating the inventions into new and improved products that provide value to users. FPP is also actively acquiring related IP to provide increased value to licensees.

During the past few years, FPP has successfully licensed several families of IP to companies who are bringing the inventions to market in unique and improved products. These technologies include:

Dynamic Contrast Ratio and High Dynamic Range LCDs.

Introduced in 2002, the System Synchronized Brightness Control (SSBC™) technology has been widely adopted by the leading LCD module and TV companies. The patented LCD video control system optimizes the backlight brightness and video signal to display a high contrast image with the intended brightness. The current list of licensees includes Sony, Sharp, Samsung, LG Display, JVC, Seiko, and others.

Stereo 3D Monitors. The StereoMirror™ desktop 3D monitor offers bright and high definition viewing of stereo images. Planar Systems, an FPP licensee, is currently developing applications in medical and geophysical markets.

In summary, Dr. Fergason's technology contributions include product architectures, designs, materials, processes and concepts and qualify him as worthy for consideration for the National Medal.

Economic Contribution

As noted above the LCD component business is approaching \$100 billion in annual revenues and the multiplier effect in system hardware and software as well as services is estimated to be a factor of ten times.

But by far the biggest contribution of the LCD industry to the US economy comes from the enabling of new communications, information, and entertainment services. Mobile handsets with

StereoMirror™ 3D Displays incorporate a new FPP technology that dramatically improves the brightness, sharpness, and definition of stereographic desktop monitors. StereoMirror monitors present stable and flicker free stereographic 3D graphic and video images with a clarity that has never before been demonstrated.

Current FPP demonstrators use two off the shelf AMLCD desktop monitors or TVs. In stereographic 3D mode, the monitors are stacked vertically and a StereoMirror beamsplitter is interposed between the monitors. The user, wearing passive polarized glasses, sees a stereographic 3D image by viewing the vertical monitor through the StereoMirror beamsplitter.

integrated LCDs are the consumer portal to cellular phones and services, MP3 entertainment, anywhere-anytime information. Companies like Motorola, Qualcomm, AT&T, Verizon, Apple, HP, Dell and the movie and television industry have all prospered as a result of the dramatic improvement in the imaging capability, low power consumption, and low price of the LCD.

Environmental Contributions

Much of the success of the LCD can be traced to the low power and lightweight, flat form factor of the device. While to date, these value propositions have mainly been used to expand the use of electronic displays into mobile applications, during the next decade, further improvements will result in substantial power savings for televisions and desktop monitors. Already current generation LCDs use a fraction of the power consumed by the CRT. The industry is currently introducing new lower power TVs that integrate Ferguson's SSBC technology that require half of the power of conventional models.

The weight of the LCD also attests to another fact. There are substantially less materials in an LCD than in a CRT. Total lifecycle cost will decline since there are fewer materials per display, LCDs have a longer lifetime, and there are no dangerous metals left to deal with.

Social Well-being

Some of Dr Ferguson's inventions have directly contributed to eye safety, defense and security, and education and training as mentioned above.

Jim has also been a long time supporter of the SPIE and OSA Optics Suitcase Program led by Dr. Stephen Jacobs of the University of Rochester. Jim has donated liquid crystal materials and films and provided funding to support the distribution of teaching tools to schools throughout the country.

Jim has also been a supporter of inventors and the invention process. In 2000 he served on the first USPTO Patent Advisory Committee, working to implement patent quality improvement programs that are still in place today. He also volunteered to participate in the patent office's Independent Inventor Conferences, mentoring his fellow independent inventors and inspiring them with his life story.

I leave it to a future generation to judge the ultimate impact of the latest generation of consumer telecommunications, entertainment, and information devices and services on human welfare. But many analysts have commented that ubiquitous information and communication, especially in the third world cannot help but improve social well-being. Note that the interface in all consumer interfaces is an LCD.

Challenges Overcome by Dr. Fergason

Certainly Dr. Fergason had to overcome a lifetime of challenges and hurdles to make his contributions. Jim is the product of a rural Missouri farm family whose father was the local postmaster. With a degree in physics from the University of Missouri and a discharge from the army, he arrived in Pittsburgh to begin his career in research and invention.

He quickly decided that LCDs were the right field for him and devoted his decade of work at Westinghouse to gaining sufficient budget and support from management to allow him to take on the whole challenge. Acting as a one-man band, Jim took on the physics, chemistry, materials, and processing problems of establishing the base LCD technology components necessary for progress. Jim became a well-known researcher in the field, a prolific producer of technical papers, and he filed his first patents.

Success at Westinghouse led to his position as Associate Director of the Liquid Crystal Institute at Kent State University, and it was here that he was confronted with a different kind of hurdle. Jim had to rise above the academic prejudices against a researcher without a PhD. Over his years there, his influence was handicapped by his lack of a doctorate, despite his contributions, publications, and research. Finally, his frustration led to him leaving academia to pursue his LCD vision on his own in a start up company.

But here again, it was a struggle to sell the dream of the LCD to the financial community. While he was able to attract one veteran investor, his company was always underfunded and running on a shoestring, threatening his family and home. So at the very time he conceived of and patented the twisted nematic LCD, he was struggling to fund his company and commercialize his inventions.

And then came a major legal challenge from Hoffman LaRoche regarding the TN patents. After a long negotiation, his company made a deal and settled for a piece of the worldwide royalty stream, but ultimately the deal resulted in a protracted lawsuit, Fergason vs. Hoffman LaRoche. The mouse vs. the elephant.

At about the time the suit was finally settled Jim suffered a heart attack. So after more than 20 years of fighting to make the LCD a reality, the industry was launched, but Jim's company and his health were suffering. The Japanese quickly established dominance in LCD production.

Suffice to say, Jim managed to recover from all of his early disappointments and build a new life. But it is only in the past few years that the world has come to give him the credit he deserved as an inventor of the LCD (See Lemelson and IEEE Awards). During the intervening 30 years he managed to continue to focus on a series of display challenges and invent solutions to address problems. Again all of this work was done through self-funding. He is truly a self made man.

Finally in the sunset of his career, he has achieved financial security. But he now faces the hurdles of a cancer survivor.

Family and Community

Throughout his life one value of his life has been constant: the primary importance of his marriage and family. He and his wife Dora celebrated their 50th wedding anniversary in 2006 and they always enjoyed each other's company and their four children and ten grandchildren.

The Fergusons have also established a program of charitable giving and over the years have generously supported many causes, including medical foundations and symphony orchestras. They have been especially focused on giving to Silicon Valley.

Summary of Awards and Honors

James Ferguson has been widely recognized for his contributions to LCD technology and for his success as an independent inventor. Among the awards are:

- In September 2008 Dr. Ferguson was the co-recipient of the IEEE Jun-Ichi Nishizawa Medal recognizing him for his independent conception of the twisted nematic mode liquid crystal display that enabled the development of the flat panel display industry.
- The Optical Society of America (OSA) awarded the 2007 David Richardson Medal to Dr. Ferguson for his outstanding contributions to the understanding of the physics and optics of liquid crystals, and particularly for his pioneering contributions to liquid crystal display technology.
- The Lemelson Foundation awarded him the 2006 Lemelson-MIT Prize to recognize his inventions that are "directly responsible for the creation of a multi-billion dollar liquid crystal display industry that employs millions of people around the world."
- His alma mater, the University of Missouri, recognized him as a distinguished alumnus and awarded him the Honorary Degree of Doctor of Science in 2001.
- The Intellectual Property Owners Association, Smithsonian Institute, National Inventors Hall of Fame, and the US Department of Commerce have recognized his accomplishments as an inventor with a series of awards over the past two decades. Further, the US Patent and Trademark Office selected him to serve on the civilian advisory panel in 2000.
- In 1996, James Ferguson was recognized for his inventions, which led to the development of the quartz watch by the American History Museum of the Smithsonian Institution.
- In September of 1998 he was inducted into the National Inventors Hall of Fame in Akron, Ohio followed in November by

the U.S. Department of Commerce Ron Brown technology award.

- Two awards from the Society for Information Display: The 1986 Francis Rice Darne Memorial Award for outstanding technical achievements and contributions to the display field, and in 1997, the society made Ferguson a fellow.
- In 1965, he was the recipient of the IR 100 Award from Industrial Research Magazine for one of the 100 most significant inventions of the year.
- In 1989, he was recognized as Distinguished Inventor for his nonlinear optical eye protection with sub-nanosecond response by the Intellectual Property Owners, Inc and was the
- 1989 Laurels Award Recipient from Aviation Week & Space Technology.
- Then in 1990, Dr. Ferguson received the Quiet Hero Award from Application Design.

About Fergason Patent Properties

Fergason Patent Properties was founded in 2001 by the inventor, Dr. James L. Fergason, who assigned a portfolio of more than 35 issued U.S. patents and foreign counterparts to the company. The company maximizes the value of the FPP patent portfolio to licensees by providing technical support services and creating or acquiring related and synergistic intellectual property including Trademarks and Copyrights. In addition to the SSBC program, FPP is actively developing licensees for its StereoMirror(TM) 3D monitors and RetroVue(TM) out-the-window-view head mounted projector for use in simulators. For more information, see www.fergasonpatents.com.

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