

## Liquid Crystals

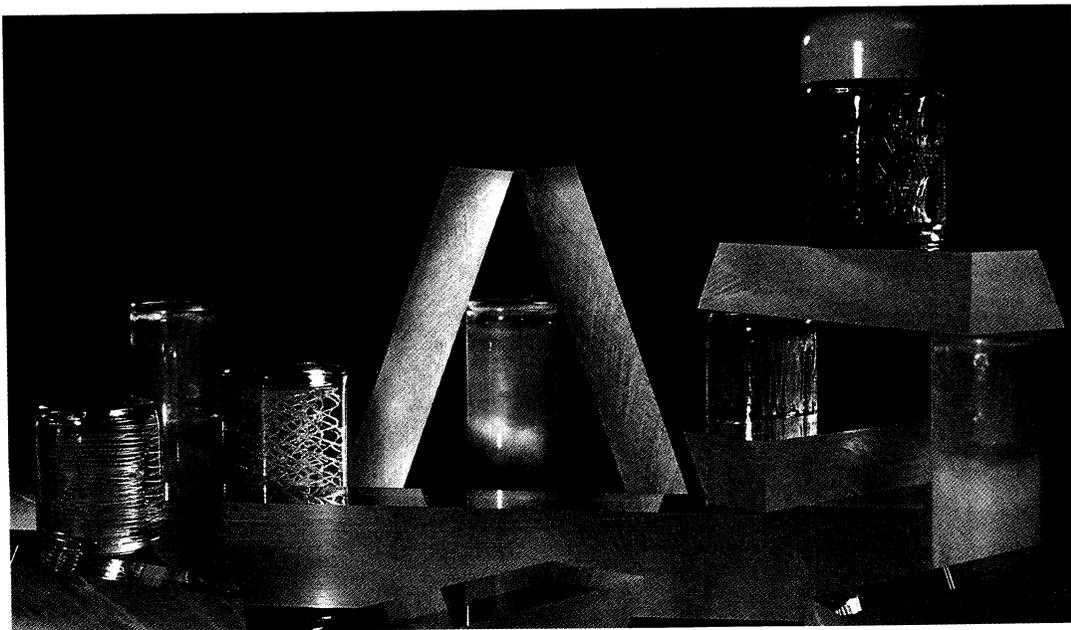
Liquid crystals are a form of matter in between solids and liquids. They appear as oily liquids, but they have certain properties of solid crystals; they also possess their own unique properties not found in either solids or liquids. They have familiar applications in everyday life, for example, in the displays of digital watches or pocket calculators and in a wide range of novelty products.

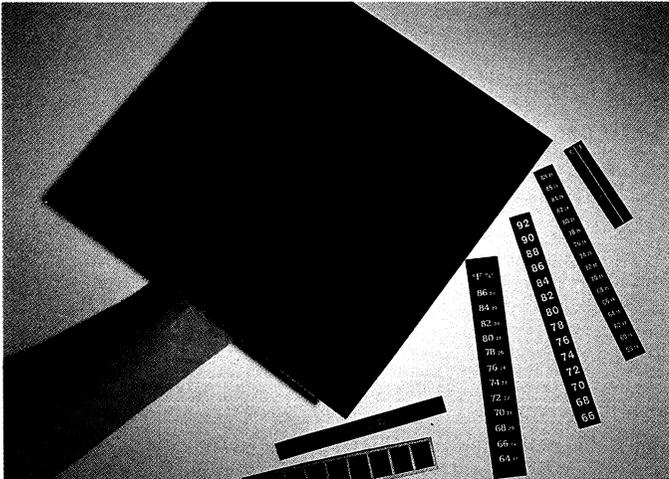
Thermochromic liquid crystals (below), or TLCs, are a type of liquid crystals that react to changes in temperature by changing color. Most TLC mixtures turn from colorless to red at a low temperature, then pass through other colors of the visible spectrum as temperatures increase. This color change characteristic offers a wide range of applications for TLC as temperature indicators, to mention just a few, digital thermometers, hot/cold warning indicators, disease diagnosis, industrial non-destructive testing, thermal imaging, chemical and gas detectors and advertising specialties.

Hallcrest, Glenview, Illinois has pioneered TLC technology since the beginning of the industry in 1973 and is now one of the world's leading manufacturers of temperature indicating devices.

Hallcrest is continually seeking to expand existing markets and generate new markets through an aggressive program of research and development. Toward that end, Hallcrest collaborated with Langley Research Center in a mid-1980s R&D effort whose success provided NASA with an improved aerodynamic testing capability and allowed Hallcrest to develop a new market.

The Hallcrest/NASA collaboration involved development of a new way to visualize boundary layer transition in flight and in wind tunnel testing of aircraft wing and body surfaces. The boundary layer is the layer of air immediately adjacent to the aircraft skin (or, in hydrodynamics, the flow of water immediately adjacent to a vessel's hull). In flight, when the boundary layer is laminar—smooth—it yields very low skin friction drag, but when it becomes turbulent with increased speed, drag is similarly increased. In aerodynamic research, it is important to determine exactly where the boundary layer transition from laminar to turbulent flow occurs on a particular aircraft. Since air turbulence increases skin friction and also raises the temperature of the boundary layer at the transition point, the color change characteristic of



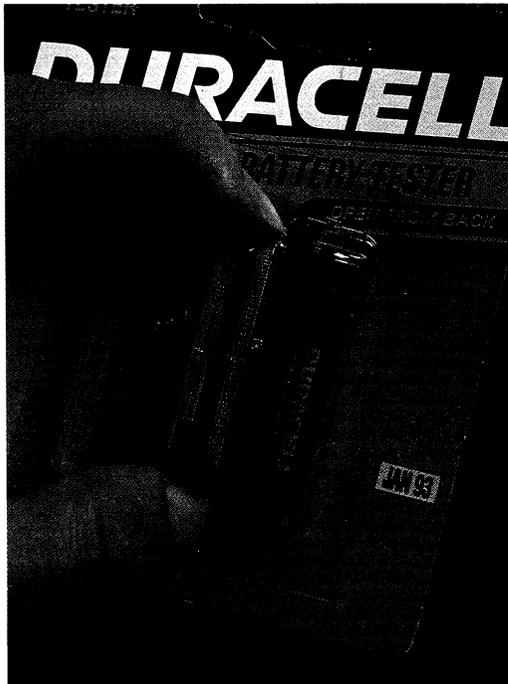


the surfaces of a test aircraft and the resulting color changes photographed in flight. TLC successfully indicated the transition points and the test results correlated closely with transitions indicated by other methods.

"Liquid crystal flow visualization provides a unique new testing capability for providing boundary layer transition data in some cases previously unavailable by practical means in wind or water tunnels and in flight test," said Dr. Bruce J. Holmes, who led the Langley test group. "The method is of great use to industry, government and universities for aerodynamic and hydrodynamic testing, saving significant cost and time."

This work enabled Hallcrest's establishment of a broad new market for TLC products in government/industrial aeronautical research, flow visualization and heat transfer studies, and for consulting or contract services on such programs. Hallcrest also supplies training kits designed to educate potential TLC users in the new technique, which is finding wide acceptance.

Among other subdivisions of Hallcrest's workload, the company's principal line is temperature indicating devices for industrial use, such as non-destructive testing and flaw detection in electric/electronic systems; for medical application, such as diagnostic systems; for retail sale, such as room, refrigerator, baby bath and aquarium thermometers (In the top photo are a sampling of thermometers with an illustration of the TLC's ability to display the temperatures of a human hand resulting from the thermal radiation of the hand); and for advertising and promotion specialties, decorations, jewelry, badges, etc. Additionally, Hallcrest manufactures TLC mixtures for cosmetic applications; at top left is Hallcrest technical marketing director Dr. Michael Parsley with a selection of liquid crystals used in a preparation manufactured by Estée Lauder Cosmetics. At lower left is a new Duracell battery that comes complete with a liquid crystal battery tester whose color change indicates the battery's condition.



TLCs offered a new and potentially better method of visualizing the boundary layer transition in flight.

Hallcrest provided a liquid crystal formulation technique that afforded great control over the sensitivity of the liquid crystals to varying conditions. For flight research, for example, the Hallcrest/Langley team used a TLC formulation that would change color over a wide temperature range because the air temperature varies at different altitudes and the researchers wanted a technique that would allow transition measurement over a broad range of altitudes in a single flight. The solution was applied like paint over