Lenticular printing

From Wikipedia, the free encyclopedia

Lenticular printing is a technology in which a lenticular lens is used to produce images with an illusion of depth, or the ability to change or move as the image is viewed from different angles. Examples of lenticular printing include prizes given in Cracker Jack snack boxes that showed flip and animation effects such as winking eyes, and modern airport advertising graphics that change their message depending on the viewing angle. This technology was created in the 1940s but has evolved in recent years to show more motion and increased depth. Originally used mostly in novelty items, lenticular prints are now being used as a marketing tool to show products in motion. Recent advances in large-format presses have allowed for oversized lenses to be used in lithographic lenticular printing.[1]

Contents

Process

Lenticular printing is a multi-step process consisting of creating a lenticular image from at least two existing images, and combining it with a lenticular lens. This process can be used to create various frames of animation (for a motion effect), offsetting the various layers at different increments (for a 3d effect), or simply to show a set of alternate images which may appear to transform into each other. Once the various images are collected, they are flattened into individual, different frame files, and then digitally combined into a single final file in a process called interlacing.

Lenticular printing has been used to produce movie posters, such as this one which morphs.

From there the interlaced image can be printed directly to the back (smooth side) of the lens or it can be printed to a substrate (ideally a synthetic paper) and laminated to the lens. When printing to the backside of the lens, the critical registration of the fine "slices" of interlaced images must be absolutely correct during the lithographic or screen printing process or "ghosting" and poor imagery might result.

The combined lenticular print will show two or more different images simply by changing the angle from which the print is viewed. If more (30+) images are used, taken in a sequence, one can even show a short video of about one second. Though normally produced in sheet form, by interlacing simple images or different colors throughout the artwork, lenticular images can also be created in roll form with 3D effects or multi-color changes. Alternatively, one can use several images of the same object, taken from slightly different angles, and then create a lenticular print which shows a stereoscopic 3D effect. 3D effects can only be achieved in a side to side (left to right) direction, as the viewer's left eye needs to be seeing from a slightly different angle than the right to achieve the stereoscopic effect. Other effects, like morphs, motion, and zooms work better (less ghosting or latent effects) as top-to-bottom effects, but can be achieved in both directions.

There are several film processors that will take two or more pictures and create lenticular prints for hobbyists, at a reasonable cost. For slightly more money one can buy the equipment to make lenticular prints at home. This is in addition to the many corporate services that provide high volume lenticular printing.

There are many commercial end uses for lenticular images, which can made from PVC, APET, acrylic, and PETG, as well as other materials. While PETG and APET are the most common, other materials are becoming popular to accommodate outdoor use and special forming due to the increasing use of lenticular images on cups and gift cards. Lithographic lenticular printing allows for the flat side of the lenticular sheet to have ink placed directly onto the lens, while high-resolution photographic lenticulars typically have the image laminated to the lens.

Recently, large format (over 2 m) lenticular images have been used in bus shelters and movie theaters.

These are printed using an oversized lithographic press. Many advances have been made to the extrusion of lenticular lens and the way it is printed which has led to a decrease in cost and an increase in quality. Lenticular images have recently seen a surge in activity, from gracing the cover of the May 2006 issue of *Rolling Stone* to trading cards, sports posters and signs in stores that help to attract buyers.

How it works

Each image is sliced into strips, which are then interlaced with one or more other images. These are printed on the back of a piece of plastic, with a series of long, thin lenses molded into the other side. The lenses are lined up with each image interlace, so that light reflected off each strip is refracted in a slightly different direction, but the light from all strips of a given image are sent in the same direction (parallel).

The end result is that a single eye or camera looking at the print sees a single whole image, but an eye or camera with a different angle of view will see a different image.

Types of lenticular prints

Typically three different types of lenticular prints are used:

Transforming prints
: Here two or more very different pictures are used, and the lenses are designed to require a relatively large change in angle of view to switch from one image to another. This allows viewers to easily see the original images, since small movements cause no change. Larger movement of the viewers or the print causes the image to flip from one image to another.

Motion-capturing prints
: Here the distance between different angles of view is "medium", so that while both eyes usually see the same picture, moving a little bit switches to the next picture in the series, creating a motion effect. Usually many sequential images would be used, with only small differences between each image and the next.

Stereoscopic effects
: Here the change in viewing angle needed to change images is small: 6–7 centimeters (2–2.5 inches). This causes each eye to see a slightly different view, creating a 3D effect without the use of special glasses.

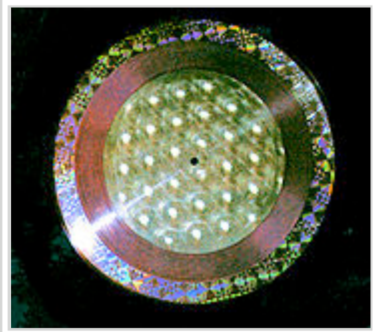
History of lenticular image technology

Images that change when viewed from different angles predate the development of lenticular lenses. In 1692 G. A. Bois-Clair, a French painter, created paintings containing two distinct images, with a grid of vertical laths in front.[2] Different images were visible when the work was viewed from the left and right sides.

Lenticular images were popularized from the late 1940s to the mid 1980's by the Vari-Vue company.[3] Early products included animated political campaign badges with the slogan "I Like Ike!" and animated cards that were stuck on boxes of Cheerios.[3] By the late sixties the company marketed about two thousand stock products including twelve inch square moving pattern and color sheets, large images (many religious), and a huge range of novelties including badges. The badge products included the Rolling Stones' tongue logo and an early Beatles badge with pictures of the 'fab four' on a red background.

Saturnalia record with lenticular label that switches from "Magical love" to a logo.

Some notable lenticular prints from this time include the limited-edition cover of the Rolling Stones' *Their Satanic Majesties Request*, and Saturnalia's *Magical Love*, a picture disk with a lenticular center. Several magazines including *Look* and *Venture* published issues in the 1960s that contained lenticular images. Many of the magazine images were produced by Crowle Communications (also known as Visual Panographics). Images produced by the company ranged from just a few millimeters to 28 by 19.5 inches.



Han-O-Disc record with diffraction grating 'Rainbow' film (outside ring), color shifting Rowlux (middle ring) and "silver balls" Rowlux film (center of record).

The panoramic cameras used for most of the early lenticular prints were French-made and weighed about 300 pounds. In the 1930s they were known as "auto-stereo cameras". These wood and brass cameras had a motorized lens that moved in a semicircle around the lens's nodal point. Sheet transparency film with the lenticular lens overlay was loaded into special dark slides (about 10×15 inches) and these were then inserted into the camera. The exposure time was several seconds long, giving time for the motor drive to power the lens around in an arc.

A related product produced by a small company in New Jersey was Rowlux. Unlike the Vari-Vue product, Rowlux used a microprismatic lens structure made by a process they patented in 1972,[4] and no paper print. Instead the plastic (Polycarbonate, flexible PVC and later PETG) was dyed with translucent colors and the film was usually thin and flexible (from 0.002" in thickness).

Han-O-Disc manufactured for Light Fantastic with metal flake outside and Dufex process print within.

While not a true lenticular, the Dufex Process (Manufactured by F.J. Warren Ltd.)[5] does use a form of lens structure to animate the image. The process consists of a metallic foil imprinted by litho printing with the image. The foil is than laminated to a thin sheet of card stock that has had a thick layer of wax coated upon it. The heated lamination press has the Dufex embossing plate on its upper platen. The plate has been engraved with angled 'lenses' at different angles so designed as to match the artwork and reflect light at different intensities depending on angle of view.

Manufacturing process

Designing and manufacturing a lenticular product requires a sound knowledge of optics, binocular vision, computing, the graphic chain, and also stringency in work and precision throughout the manufacturing process.

Printing

Creation of lenticular images in volume requires printing presses that are adapted to print on sensitive thermoplastic materials. Lithographic offset printing is typically used, to ensure the images are good quality. Printing presses for lenticulars must be capable of adjusting image placement in 10 μm steps, to allow good alignment of the image to the lens array.

Typically, ultraviolet-cured inks are used. These dry very quickly by direct conversion of the liquid ink to a solid form, rather than by evaporation of liquid solvents from a mixture. Powerful (400W per sq. in) ultraviolet (UV) lamps are used to rapidly cure the ink. This allows lenticular images to be printed at high speed.

In some cases, electron beam lithography is used instead. The curing of the ink is then initiated directly by an electron beam scanned across the surface.

Ink composition

Pigments

The choice of pigments in the formulation of UV inks was difficult in the early years because many useful pigments absorbed some UV radiation. The result was slow curing, and incomplete curing of the interior of the film. In addition, some pigments (particularly dark colors) can react with photoinitiators, which inhibits the process of drying. Better pigments have since been developed, however, which are resistant to these problems.

Prepolymers

The prepolymers are the equivalent of the resins used in non-UV inks. These are molecules that contain reactive centers and which are not completely polymerized. Two types of polymerization process are commonly used: radical polymerization, for example based on acrylate / methacrylate or unsaturated polyester resins; and cationic mechanisms, such as epoxy resins, phenoxides, and vinyl ethers. As of 2007, 90% of the formulations in use are based on radical mechanisms and 10% on cationic mechanisms.

Free radicals from photoinitiators initiate the reaction of polymerization of monomers and prepolymers. The polymerization reaction then spreads, gradually increasing the size of the macromolecules and therefore the viscosity, which solidifies the ink film.

Photoinitiators

The photoinitiators are compounds which, when exposed to UV radiation, provide reactive species (free radicals or cations) that can initiate the polymerization chain reaction. In electron beam lithography inks, photoinitiators are not necessary. The electrons provide enough energy to initiate polymerization reactions between different prepolymers and monomers or oligomers. Thus, the formula of these inks is generally the same as that of a UV ink, but without photoinitiators.

Monomers (diluents)

The monomers are sometimes called "reactive diluents". They play several roles: adjustment of rheological properties, solubilization of solid prepolymers, increasing pigment wetting, and improving the properties of the final dry film. They also participate in the polymerization reaction.

Relatively few compounds are suitable for use in printing inks, because many suitable candidates are toxic, volatile, or smell bad. A working group consisting of HSE (Health and Safety Executive —England), BG (Berufsgenossenschaften-Germany) and the CNAMTS (Caisse Nationale d'Assurance Maladie des Travailleurs Salariés) is studying UV printing and working on the classification of components not yet included in the European directives.

Additives and inhibitors

The additives are added in small quantities to adjust the ink's rheology, to increase the stability of the ink, or to give a particular feature (slipperiness, and so on). Inhibitors are needed to prevent premature gelling of the ink.

Water wetting

The chemistry of the water used to wet the lithographic printing plate is important for controlling the print quality. The water must not be too hard—no more than 250 mg of calcium carbonate per litre of water. The acidity of the water must also be controlled, with pH between 4.9 and 5.4. Excessively hard water can also cause changes in pH.

Lithographic printing relies on the surface tension of the water and interfacial tension. The repulsion between the oil-based ink and the water ensures that the ink ends up where it should on the plate. The greater the interfacial tension, the less the ink and water mix and the less chance there is of forming an emulsion (mixture of ink and water). Increased surface tension of the solution causes water to run well on the plate, forming a continuous thin film.

The electrical conductivity of the solution is measured to determine the amount of additives required.

UV curing

Ultraviolet light with wavelengths between 100 and 380 nm is used to cure the ink. Different portions of the UV spectrum play distinct roles in the curing process:

- UV-C radiation (100–280 nm) causes cross-linking of ink or varnish on the surface and ensures a fast and complete final reaction.

- UV-B radiation (280–315 nm) is essential for cross-linking deep within the ink film.
- UV-A radiation (315–380 nm), the rays closest to the visible light, ensures the hardening of the thick ink film.

There are many types of UV curing systems, but mercury vapor lamps are the most common. These lamps emit UV radiation in a broad spectrum and provide optimum curing. The UV sources typically generate 160–200 W/cm of radiation.[6]

Defects

Design defects

Double images on the relief and in depth

Double images are usually caused by an exaggeration of the 3-D effect from angles of view or an insufficient number of frames. Poor design can lead to doubling, small jumps, or a fuzzy image, especially on objects in relief or in depth. For some visuals, where the foreground and background are fuzzy or shaded, this exaggeration can prove to be an advantage. In most cases, the detail and precision required do not allow this.

Image ghosting

Ghosting occurs due to poor treatment of the source images, and also due to transitions where demand for an effect goes beyond the limits and technical possibilities of the system. This causes some of the images to remain visible when they should disappear. These effects can depend on the lighting of the lenticular print.

Prepress defects

Synchronisation of the print (master) with the pitch

Also known as "Banding". Poor calibration of the material can cause the passage from one image to another to not be simultaneous over the entire print. The image transition progresses from one side of the print to the other, giving the impression of a veil or curtain crossing the visual. This phenomenon is felt less for the 3-D effects, but is manifested by a jump of the transverse image. In some cases, the transition starts in several places and progresses from each starting point towards the next, giving the impression of several curtains crossing the visual, as described above.

Discordant harmonics

This phenomenon is unfortunately very common, and is explained either by incorrect calibration of the support or by incorrect parametrisation of the prepress operations. It is manifested in particular by streaks that appear parallel to the lenticules during transitions from one visual to the other.

Printing defects

Colour synchronisation

One of the main difficulties in lenticular printing is colour synchronisation. The causes are varied, they may come from a malleable material, incorrect printing conditions and adjustments, or again a dimensional differential of the engraving of the offset plates in each colour.

This poor marking is shown by doubling of the visual; a lack of clarity; a streak of colour or wavy colours (especially for four-colour shades) during a change of phase by inclination of the visual.

Synchronisation of parallelism of the printing to the lenticules

The origin of this problem is a fault in the printing and forcibly generates a phase defect. The passage from one visual to another must be simultaneous over the entire format. But when this problem occurs, there is a lag in the effects on the diagonals. At the end of one diagonal of the visual, we have one effect, and at the other end we have another.

Phasing

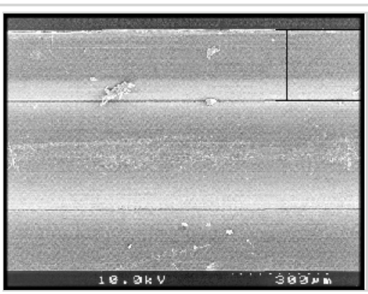
In most cases, the problem comes from imprecise cutting of the material, as explained below. Nevertheless, poor printing and rectification conditions may also be behind it.

In theory, for a given angle of observation, one and the same visual must appear, for the entire batch. As a general rule, the angle of vision is around 45°, and this angle must be in agreement with the sequence provided by the master. If the images have a tendency to double perpendicularly (for 3-D) or if the images provided for observation to the left appear to the right (top/bottom), there is a phasing problem.

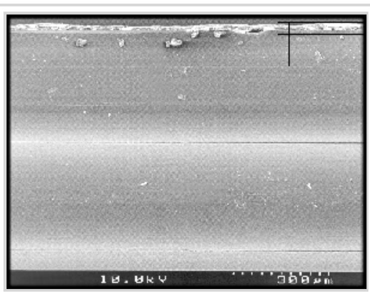
Cutting defects

Defects in the way the lenticular lens is cut lead to phase errors between the lens and the image.

Two examples, taken from the same production batch:



First image



Second image

The first image shows a cut which removed about 150 μm of the first lens, and which shows irregular cutting of the lenticular lenses. The second image shows a cut which removed about 30 μm of the first lens. Defects in cutting such as these lead to a serious phase problem. In the printing press the image being printed is aligned relative to the edges of the sheet of material. If the sheet is not always cut in the same place relative to the first lenticule, a phase error is introduced between the lenses and the image slices.

See also

- Integral imaging, the precursor of lenticular imaging
- Autostereoscopy

Notes and references

1. ^ O'Brien, Katherine (2006). "As big as all outdoors". *American Printer* (August 1, 2006). http://americanprinter.com/mag/printing_big_outdoors/. Retrieved on 4 June 2008.
2. ^ Oster, Gerald (1965). "Optical Art" (subscription required). *Applied Optics* **4** (11): 1359–69. http://www.opticsinfobase.org/abstract.cfm?URI=ao-4-11-1359.
3. ^ [a] [b] Lake, Matt (1999-05-20). "An art form that's precise but friendly enough to wink (http://query.nytimes.com/gst/fullpage.html?res=9C05E5DC1E3EF933A15756C0A96F958260) ", *New York Times*. Retrieved on 4 June 2008.
4. ^ US patent 3689346, "*Method for producing retroreflective material*", granted 1972-09-05, assigned to Rowland Development Corp.
5. ^ "F.J. Warren Ltd". *Kompass UK*. http://www.kompass.co.uk/frameset.asp?_Mycharset=iso-8859-1&_Lang=en&_Version=&_KProv=GB010&_Choix=CN&_Region=&_Locality=&_URL=search&_Keyword=F.J.+Warren&_Zone=GB. Retrieved on 2008-06-04.
6. ^ Prudent, Guillaume (2005-04-10). "Impression UV: les constructeurs de sécheurs améliorent la production de chaleur" (in French). *Caractère*. http://www.caractere.net/editorial/290880/impression-uv-les-constructeurs-de-secheurs-ameliorent-la-production-de-chaleur/. Retrieved on 2008-01-03.

- *Bordas Encyclopedia*: Organic Chemistry (French).
- Sirost, Jean-Claude (2007) (in French). *L'Offset : Principes, Technologies, Pratiques* (2nd edition ed.). Dunod. ISBN 2100513664.

External links

- Lecture slides by John Canny, covering lenticular lenses (http://www.cs.berkeley.edu/~jfc/DR/F03/lectures/lec27/lec27.ppt) (PowerPoint)
- Guide to design good lenticular effects (http://www.immaginilenticolari.com/Default.aspx?tabid=80&language=en-US)