Optical Short Course International

6679 N. Calle de Calipso, Tucson, AZ http://www.oscintl.com 520-797-9744

What's "In The Box"?

Optics of Digital Projectors Weekly Newsletter

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Holographic Projection Screen Technology Digital Projectors

By Michael Pate, President, OSCI

Holographic projection screens are used in many dynamic retail and corporate advertising and branding displays. Holographic screens get their name from the optical technology that is used in their specialized fabrication process. The holographic screens are used in transmission with the digital projector either on the ceiling or on the floor. The image often appears to hang in air as the holographic screen appears to be a clear transparent substrate. In this version of In The Box we are going to discuss holographic projection

screen technology to understand how they work and how they help deliver a high quality image for our eyes to view.

Figure 1. Holographic Screen in Retail and Office Uses
Figures Courtsey of ProScreen www. Prescreeninc.com

Function of a Holographic Projection Screen

Holographic screens are most often used in a rear projection scenario which means the viewer and projector are on opposite sides of the screen. We can see this scenario in Figure 1 above where the screen is very close to the front window of a retail store. There is essentially no room to have a front projection scenario in this case. A retail store can use this digital display to have some dynamic advertising 24x7 to communicate more information to potential customers about their products and services.

Holographic screens are popular in many of the progressive communities in Europe because of strict signage and neon laws. Quite a few municipalities in Europe have laws against large obtrusive signs along the roadway of shops. Merchants are keen to capture the attention of customers while maintaining the architectural beauty of their storefronts and this technology solution is perfect. They are also elegant in appearance with their simple frameless modern clean look.

What is a hologram?

A hologram is a recording of an interference pattern of two beams or wave fronts from the same coherent optical source. The coherent optical source is often a laser where the beam is split by amplitude into two beams called a reference beam and an object beam. The object beam as its name implies travels to the object and is reflected off the object to the recording plane. The reference beam goes directly to the recording plane. In the

recording plane the interference pattern is setup in space because of the constructive and destructive interference between these two coherent beams. A photo sensitive recording medium is located at this interference plane and a permanent record of the interference pattern can be captured. The record of the interference of the two beams is called a hologram.

The photosensitive medium can be silver halide film, dichromate gelatin, and photo polymers. The interference pattern can be recorded by several optical phenomena such as amplitude, phase, absorption constant, or refractive index change. Each of these optical phenomena have different optical efficiencies when the hologram is played back. When the light from a digital projector is incident upon these holograms or recorded interference patterns, in the volume of the hologram, the light is diffracted from these patterns towards the viewers' eyes.

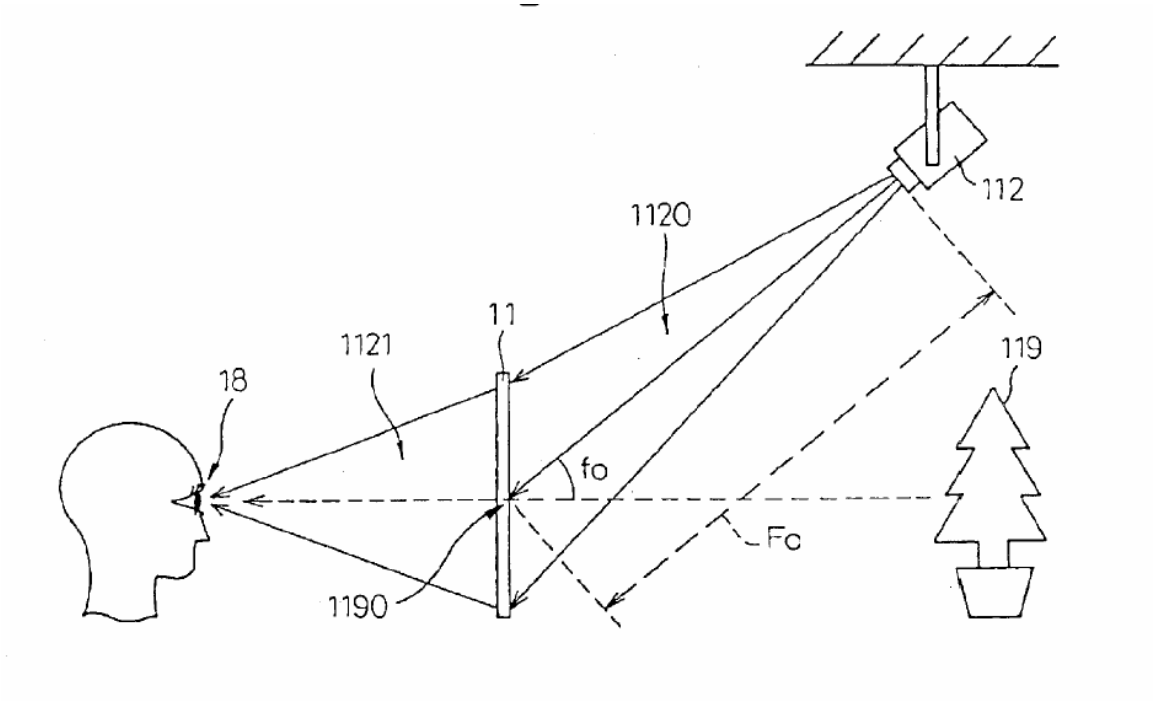

Figure 2. Diffraction of Light by Holographic Screen (11)
Illustration from US Patent 6,885,483 Kenichiro Takada, Denso Corporation

Diffraction
Diffraction is the deviation of light rays from rectilinear paths and is caused by confining the height of an electromagnetic wave by and aperture or boundary. The recorded interference patterns in a recorded hologram can be thought of a transmission diffraction grating. The interference patterns of changed refractive index in the photopolymer material act like Bragg gratings and diffract the light from the projector with high efficiency into the eye of the viewer.

This diffraction can be seen in Figure 3 below and is known to be highly efficient method of diffraction of light of the proper color into the proper diffraction order. This should be

a clue that different colors will diffract at a different angle or with different efficiency than the design wavelength. If we recall the diffraction equation it is:

$$Sin\Theta = \frac{m\lambda}{d}$$

The diffraction angle theta is dependent upon the diffraction order m, and the grating spacing d, as well as the wavelength lambda.

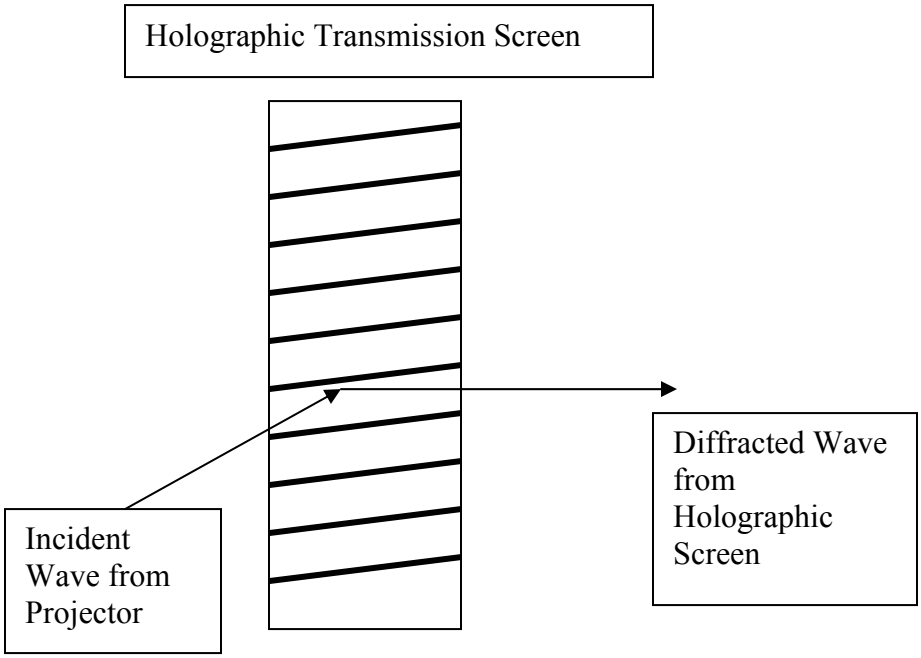

Figure 3 Transmission Holographic Screen Diffraction

Because digital projectors work over the full visible region color spectrum we will need several different holographic screens. In fact it is a common practice to have one holographic screen for each of the primary red, green, and blue colors and then laminate them together as a sandwich of transmission holograms.

Diffraction and Diffusion or Scattered Light

A projection screen must serve as a diffuse surface that will accept a specular incident image from a projector and diffusely reflect or transmit this energy into a directional pattern towards the viewer with high efficiency and color accuracy. In rear screen projection situations the light source is incident from behind the screen so the screen substrate must be optically transparent with a high optical transmission. The screen must also scatter light from this plane so our eyes can view the image located on this plane.

The different holographic projection screens have different amounts of scatter depending primarily if they are being touted as transparent screens. One of the benefits of transparent screens in a retail or commercial use is that when the light from the projector is not delivering an image to the screen, the screen substrate is transparent and an item or object is visible behind the transparent holographic screen, as shown in Figure 2 above with the Christmas tree behind the screen.

Recording the Holographic Screen

In Figure 4 below we can see a generic recording setup for a holographic screen. The laser source 730, will be split at 740 into object 734 and reference beams 51 and they will be interfered and recorded at the recording medium 6. The object beam 734 is expanded by the microscope objective 736 and illuminates a diffuser surface which scatters light 41 onto the recording plane 6. The reference beam is also expanded by the microscope objective 735 and is incident on the recording plane 6.

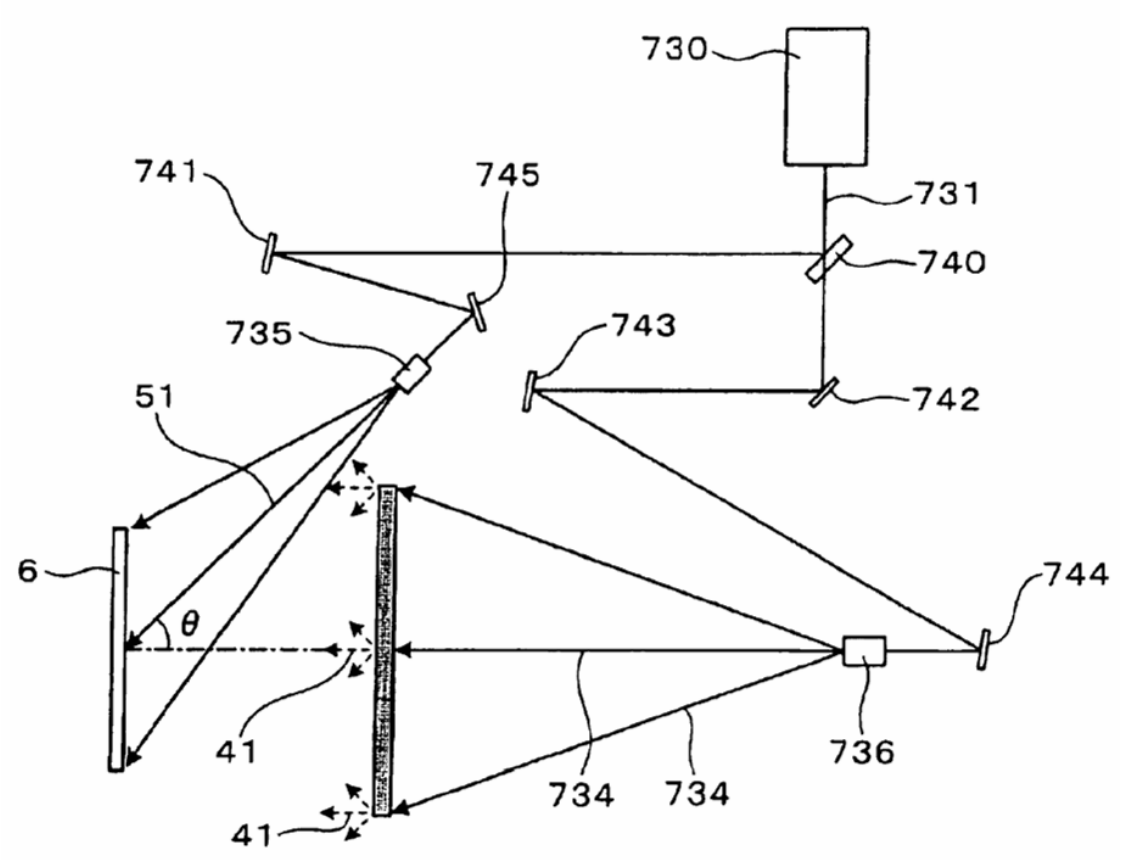

Figure 4 Holographic Projection Screen Recording Setup
Illustration from US Patent 6,836,348 Kenichiro Takada, Denso Corporation

A different color or wavelength laser is used for each of the three primary colors red, green, and blue holographic screens. These three screens are then laminated together to form a full spectrum holographic screen. Figure 5 below illustrates the three different

wavelengths being used to record different screens and then the lamination of the three into one holographic substrate.

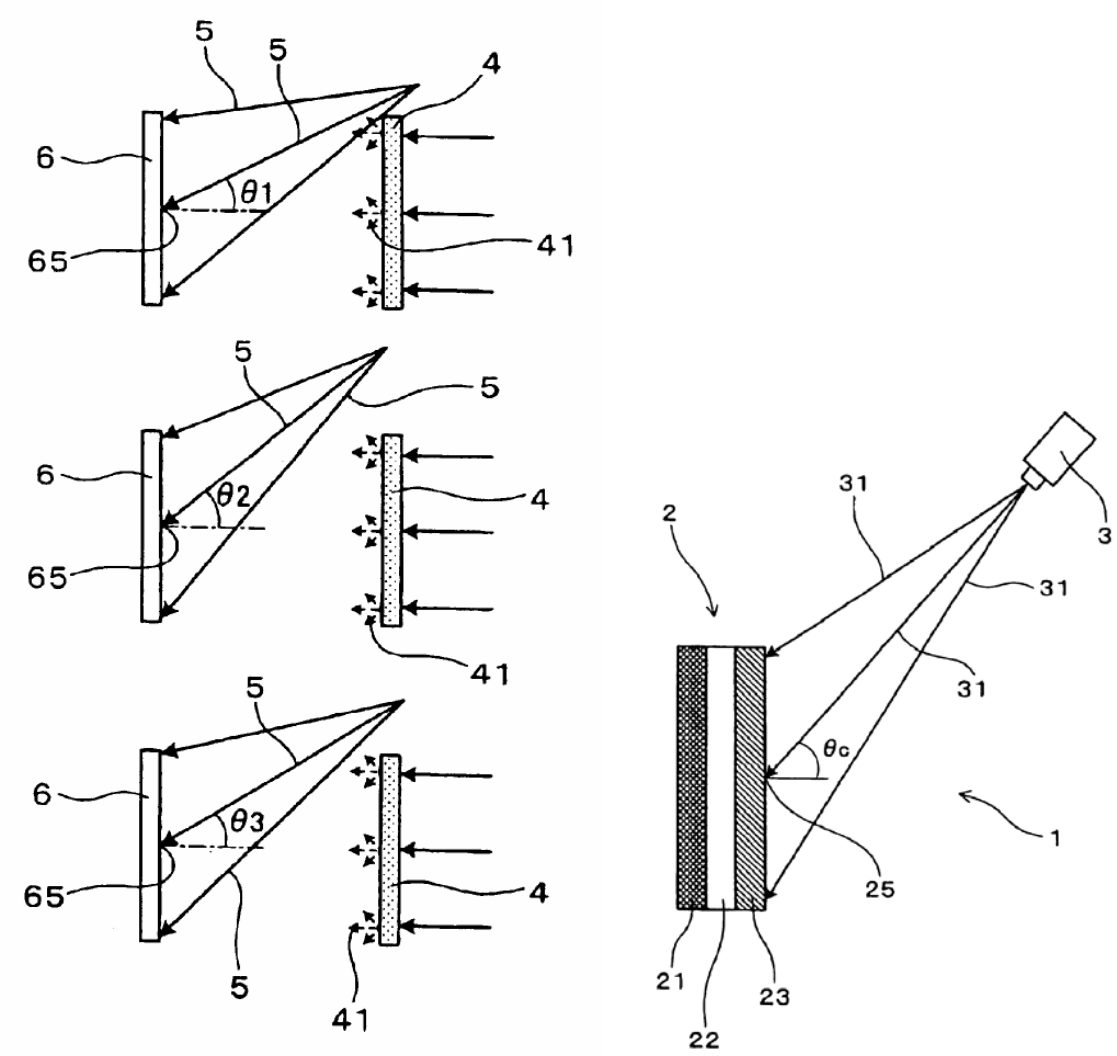

Figure 5 Three Wavelength Holographic Projection Screen Recording Setup
Illustration from US Patent 6,836,348 Kenichiro Takada, Denso Corporation

Denso teaches using a 514nm laser and recording their holograms in a DuPont photopolymer HRF600X in the 800 x 600mm size screens. They report an exposure of 30mJ/cm^2 and afterward it is also irradiated by a 365nm source at 0.1 J/cm^2 and then thermally processed for 30 minutes at 140 degrees C. They have also developed some innovative and inexpensive methods to produce working copies and second masters from which to produce production quantity holographic screens. They have also developed methods to copy the three level holograms onto a single level for even greater production and process efficiency. Somebody has been thinking about process and innovation at Denso.

Summary

Holographic projection screens are very useful as rear projection screens in certain applications and in some applications are the only solutions. Retailers have found holographic screens useful in dynamic storefront window displays to meet local building signage laws. Holographic projection screens are made similar to optical holograms with a laser and an object and reference beam. These two beams are interfered and create an interference pattern in the photosensitive material to record the hologram. The hologram is laminated to a diffuser surface and when illuminated by a digital projector diffracts and diffuses the light into the viewer's eyes.

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