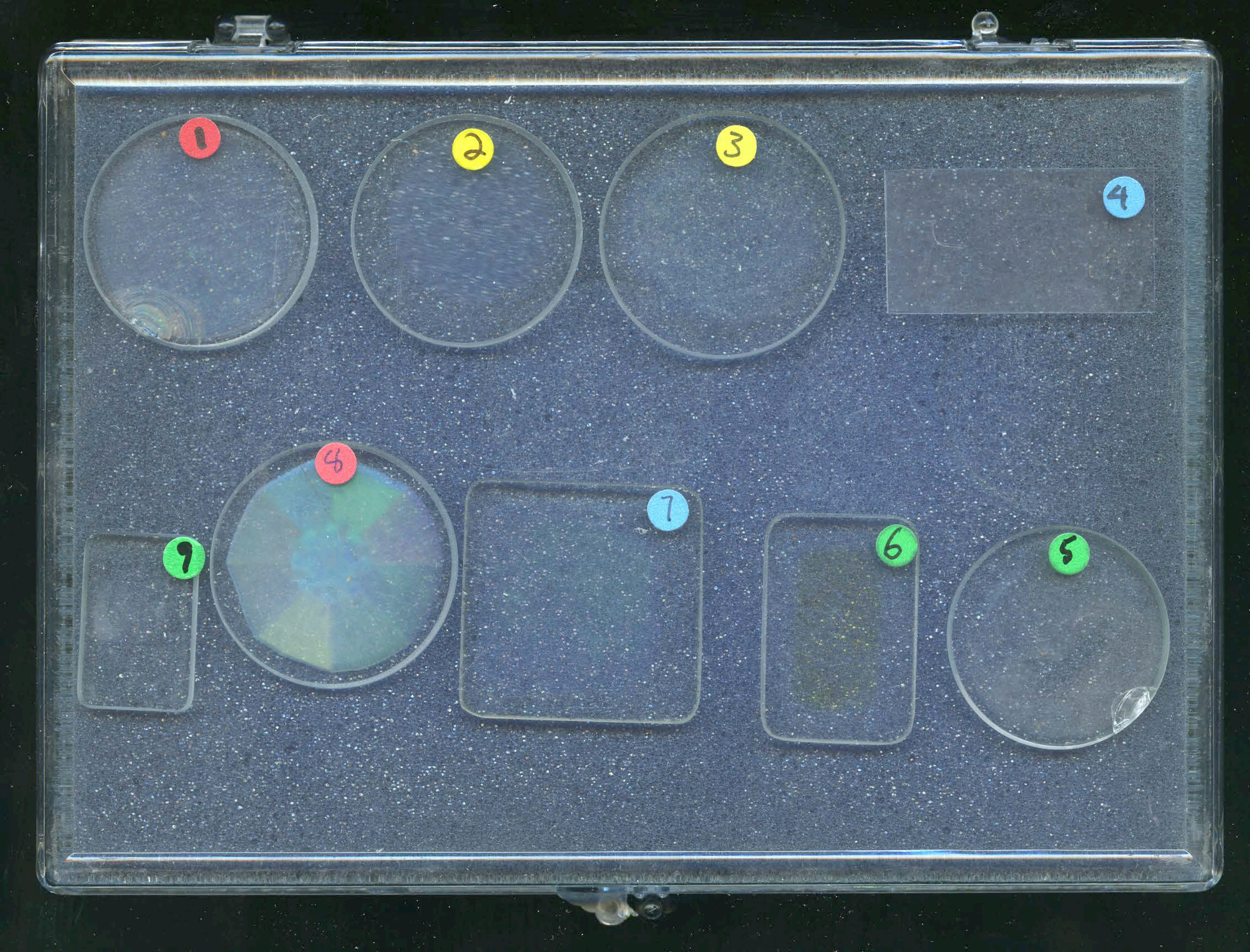
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RALCON
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8501 So. 400 W., Box 142
Paradise, Utah 84328

HOE KIT # RK8

Description, use and construction of the HOEs in this kit.

1. Off Axis Interferometric Zone Plate (IZP) – This unit has a focal length of 25 cm @ 633nm and reconstructs with a collimated wave introduced 20 degrees off axis. The focused spot will appear 20 degrees off axis also for a total diffraction angle of 40 degrees. It was made @ 488 nm but has few aberrations because it was contact copied from a master that was made at 633 nm. The master was made in a silver grain film that was cleared and processed like dichromated gelatin (DCG) to reduce scatter at the copy wavelength. The copy is in 8 microns of DCG sandwiched between two pieces of thin glass.

2. Planer Gratings, Low Spatial Frequency - These units are made by interfering two collimated waves at small angles. The small angle low spatial frequency samples, (approx 100 l/mm) diffract with many orders present over a few degrees. They are similar to sinusoidal surface phase gratings in power spectrum and exhibit only a small Bragg selectivity. The power distribution is a function of the phase modulation which is in turn dependent on the available index modulation. As the spatial frequency goes above 500 l/mm the Bragg selectivity becomes strong and a single order dominates. These gratings are made in DCG in the range of 12 to 20 microns and each one is an original or first generation grating exposed at 488nm.

3. Planar Gratings, High Spatial Frequency- A spatial frequency is considered high when the grating spacing is about equal to the wavelength being used. In the visible region this is around 2000 lines/mm. Higher orders are either not possible or are very weak in this range and diffraction efficiency is dependant on polarization as well as modulation, thickness, wavelength and angle. Volume phase gratings can also suppress higher orders even at low spatial frequencies if the thickness is many times the grating spacing. If it is thick in this sense it is said to have a high Q. The sample in this kit would be considered medium thick at 5 to 8 microns and of moderately high frequency at 2234 l/mm.

4. Blazed Binary Optic Array - This is a set of six small blazed zone plates. Two of them are negative with focal lengths of 25 cm and two are positive with the same focal length. The other two are positive with focal lengths of about 75 cm. These were computer generated using a custom program written in POSTSCRIPT language which we call ZONE. The program writes a geometric zone plate pattern and fills the region between zones with up to 20 shades of grey which are printed as variations in dot density at 300 or 600 dots per inch.

The output on paper was photoreduced in a common 35 mm NIKON camera using KODAK 5052 TMX negative print film. The next step was to expose a 3 micron layer of photo resist with a mercury arc lamp through the negative master which produced the desired positive blazed phase pattern. The resist master was then replicated in epoxy and the embossed copies in this kit were made by chemically softening a piece of cellulose acetate and pressing it against the epoxy master to cast a positive impression. The originals were 8 inches in diameter but were reduced about 30 times in the camera. The 25 cm focal length was generated by plotting 45 zones with 10 shades of grey and the long focal length came from a print of 15 zones with 20 shades of grey. The surface roughness is from contamination on the photo resist and will unfortunately scatter some of the input light and some moire artifacts are visible indicating that we should print the originals at a higher resolution than 300 dpi.

The dispersion is low due to the small number of zones copied so white light may be used with these optics. Blazed zone plates exhibit good first order efficiency when the blaze depth produces a full wavelength of phase shift. These samples are close to correct and have very weak second orders at shorter focal lengths as well as fairly low minus first order. Outputs are easily observed on a white card by imaging a clear light bulb at a distance greater than 2 meters.

5. Powered Holographic Reflector – These optics are produced by interfering a plane wave on one side of the film with a spherical wave from the other side. They are convex mirrors on one side and concave on the other. The micro structure resembles a layered reflective zone plate, the layers give it wavelength selectivity in the same fashion as a multilayer dielectric laser mirror and the zones give it angular dispersion. If there are many uniform layers or planes then a narrow spectral band is reflected and dispersion is only observed as an artifact in the transmitted light.

The unit found in this kit is one of fairly short focal length and is easy to use in white light to observe off axis aberrations. It is not very narrow band and will show both longitudinal and lateral dispersion. The DCG is about 8 microns thick and has been processed to have a chirp in the spacing of the planes as well as a gradient in the index of modulation. The processing makes it behave as if it were thinner than it is.

6. Conformal Holographic Reflector – These devices have no dispersion but can be made to have bandwidths of from 8 to 200 nm by choosing the appropriate thickness and process. They are in every way nearly identical to multilayer dielectric coatings. As the angle of incidence goes off normal the reflected wave goes toward the blue.

The unit in this kit is a medium bandwidth reflector made in an 8 micron layer of DCG by the "air gate" method. It was held in laser light by hand in such a way that some of the light passing through would reflect back on itself at an angle and produce planes conformal to the film surface. The unstable hand holding is sufficient to spoil the spatial coherence of the laser resulting in a stable interference pattern only in a small volume near the film surface. This effectively suppresses the formation of diffracting structures that would otherwise result from multiple surface reflections. These devices are sometimes called notch filters.

7. High Gain Holographic Diffusing Screen – These are projection screens that have precisely defined energy windows. The projected image is only visible and bright

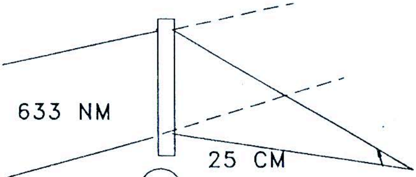
when it is originating from the correct angle and is of the correct wavelength. Even then it can only be seen when the eyes are positioned in the energy box or output pupil of the system. Otherwise it is a slightly hazy piece of clear glass. These units are made by projecting a diffuser through an aperture onto the film from one side and then introducing an appropriate reference wave on the other side. The reference wave for this sample was converging to a point about half a meter away. At arms length it should produce a bright eye box when illuminated with a white light diverging from a point just out from the right shoulder.

This is an effective screen for stacking visual inputs since it is nearly invisible when not illuminated correctly. It also concentrates the projected light in a small area making possible the use of lower power projection sources. The sample in this kit is made in 8 microns of DCG at 488nm and processed to reflect green light.

8. Holographic Scanner, 'One Shot'– This is a small 8 facet deflector intended for use in a hand held Bar Code Scanner. At 633 nm it accepts an input beam 5 degrees off normal and diffracts at 30 degrees off axis where it focuses at 4 different ranges between 200 and 400 mm from the deflector. It is unique in that it can be copied at 488 nm with a single on axis exposure. The master was made one facet at a time at 633 nm in Agfa film and converted to a clean gelatin hologram. Copies are made in DCG of about 5 micron thickness. The thin film and low spatial frequency results in low angular and polarization sensitivity over the scanned angle but also causes losses to a negative order. It can be glued to the end of a stick or mounted on a motor to demonstrate how a section of a zone plate can deflect light.

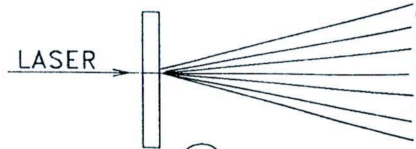
9. Optical Interconnect HOE, –Any optical device that connects a source of photons with one or more detectors is an optical interconnect. In electronic circuits, clock pulses are sometimes made to modulate a diode laser which in turn broadcasts the pulse through free space to other parts of the device or circuit. The optical interconnect included in this kit is of appropriate dimensions to connect circuit boards or components on a board with each other. It is of a general design, made up of individual gratings or zone plates arranged side by side or "spatially multiplexed". It could connect a clock laser with 40 detectors, however it was originally designed to address angularly multiplexed pages in a photorefractive Holographic memory.

Again this HOE has been fabricated from 10 microns of gelatin, in a sandwich of two pieces of glass. The method of construction was simple step and repeat, the machinery used to change angles between exposures is made from precision rotary tables and a single mode fiber optic system. The fiber is easily positioned any where in space to serve as a point source and it carries blue–green light from an Argon laser which is necessary to generate fringes in the gelatin. Plane Gratings have been formed in the sample but plane or powered reflectors are also possible to form with the same hardware. The gelatin is thick enough to allow volume multiplexing of each individual cell. As many as 25 individual overlapping exposures have been made in this film with only a small change in angle between exposures.



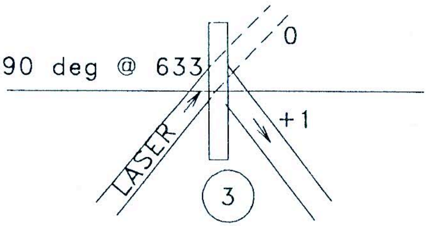
633 NM
25 CM

1



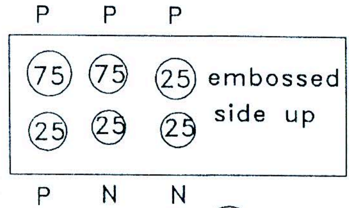
LASER

2



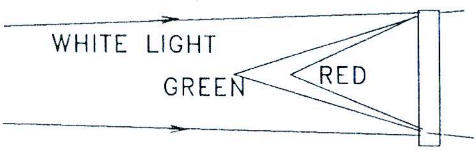
90 deg @ 633
0
+1
LASER

3



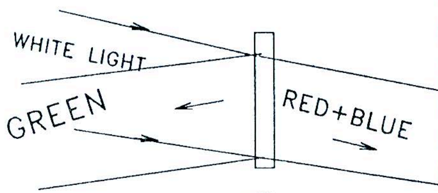
P P P
75 75 25
embossed side up
25 25 25
P N N

4



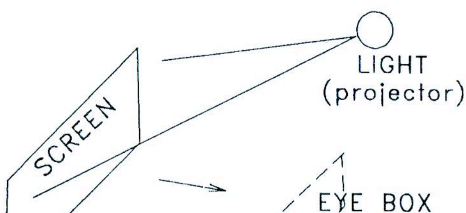
WHITE LIGHT
GREEN
RED

5



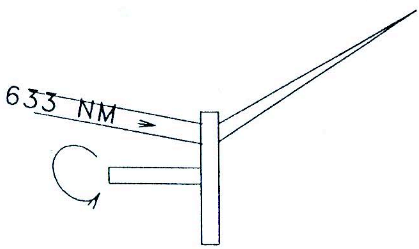
WHITE LIGHT
GREEN
RED+BLUE

6



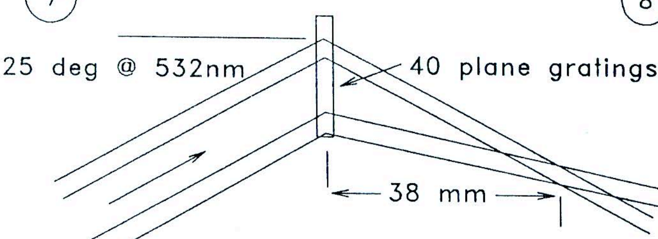
LIGHT
(projector)
SCREEN
EYE BOX

7



633 NM

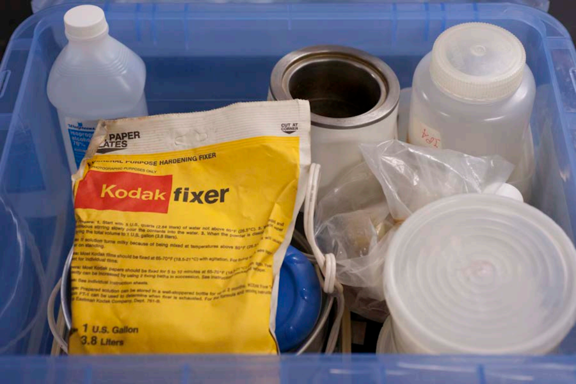
8



25 deg @ 532nm
40 plane gratings
38 mm

9

Rallison
stuff
for class


CUT AT
CORNER
Kodak
fixer
1 U.S. Gallon
3.8 Liters
IPA


Kodak fixer
Osco
91% Isopropyl
Alcohol
Isopropyl
alcohol
70%