Reflection Spectrum of Lippman Holograms

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Synopsis

Two types of Lippman hologram were made by Denisyuk method. The first type was fixed after development, the second type was not fixed. The image reconstructed of the first type looked greenish and that of the second type looked reddish. The reflection spectrum of them was measured. The first type had a smooth peak between 470 nm and 530 nm, and the second type had a smooth peak between 570 nm and 620 nm.

KEYWORDS: Lippman hologram, Denisyuk hologram, Reflection spectrum

Introduction

There are two kinds of holograms depending on the direction of the object light beam and the reference light beam. When both beams come from the same side of the hologram, the interference fringes are made vertically to the hologram plane, which is the Fresnel hologram. When each beam comes from the opposite side of the hologram, the interference fringes are made parallel to the hologram plane, which is the Lippman hologram. To reconstruct the image of Fresnel hologram, laser light source is necessary. On the other hand, in Lippman hologram, the reflection occurs when the light satisfies the Brag condition, so the white light can reconstruct the image.

It is well known that the image reconstructed from the Lippman hologram looks greenish in spite that the hologram is made by a red He-Ne laser. This is because the emulsion of the dry plate shrinks during the fixing process. If the fixing process is omitted the image looks reddish. Two types of Lippman hologram with and without fixing were made and the reflection spectrum from them was measured.

Experimental Setup

A Lippman hologram was made by the Denisyuk method[1] as shown in Fig.1. He-Ne laser beam was expanded by a microscope objective lens and illuminates a dry plate (Agfa-Gevaert: 8E75HD).

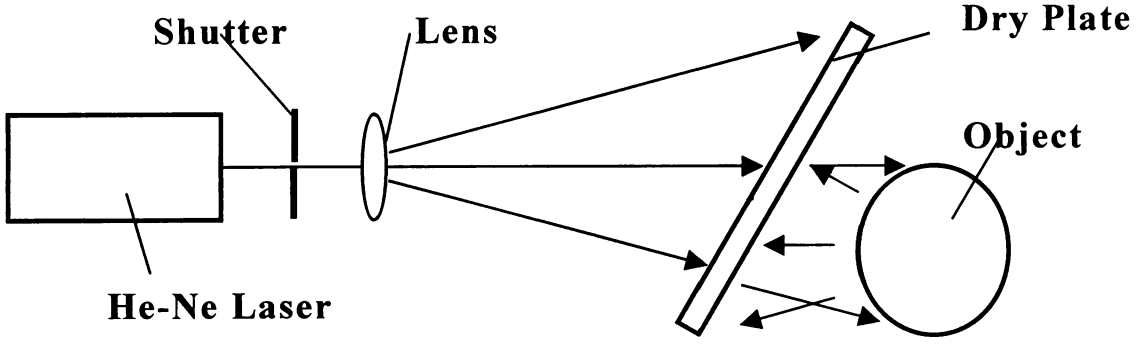

Fig.1 Schematic drawing of the system to make a Lippman hologram

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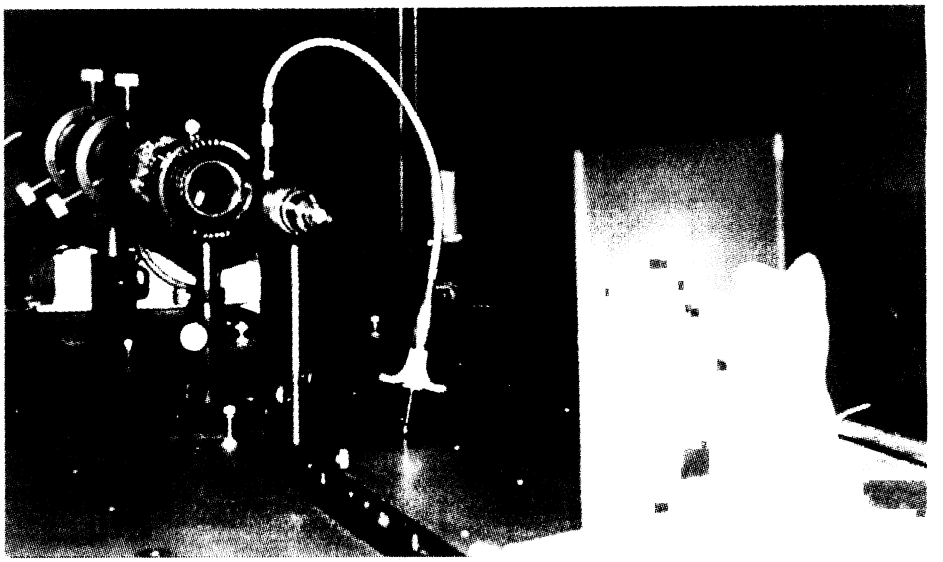

Fig.2 Picture of the Lippman holography system

The light also illuminates an object behind the dry plate, which is a small ornament of a dog in this case. The light reflected by the object interferes with the original laser light and produces the interference pattern in the emulsion layer of the dry plate. After 2 second exposure, the dry plate is developed by Kodak D-19 for 1 minute at the temperature of 20 ℃. The development is stopped in 3% acetic acid for 30 seconds. Then it is fixed with Fuji-Fix for 10 minutes at the temperature of 20 ℃, then rinsed with water for 2minutes. Bleach is made by Ilford Fe-Na EDTA solution for 5 minutes. Then again rinsed with water for 2 minutes, with alcohol for 2 minutes, then dried.

Another Lippman hologram is made for the same object in the same procedure except fixing process. The second type hologram is not fixed after the development.

Reconstructed Image

When the hologram is illuminated by a tungsten lamp, a greenish image of the dog is observed. Four images from slightly different direction are taken by a digital-camera as shown in Fig.2. When the viewing angle is moved, different part of the dog is seen, which is the main characteristics of holography.

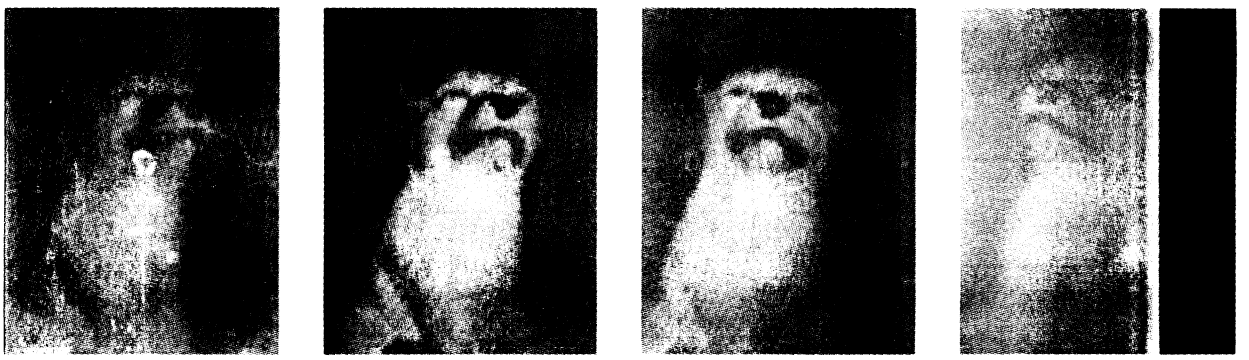

Fig.3 Holographic mages of the dog viewed from different direction

When the second type hologram, which is not fixed after development, is illuminated in the same way, a reddish image of the dog is observed. The difference of the color of the dog image has been explained by the thickness of the emulsion of the dry plate. When the hologram is developed and fixed, the unexposed silver particles are removed, which makes the emulsion thinner. This causes the reflection with a shorter wavelength. Then the image looks greenish. When the hologram is not fixed, the thickness of the emulsion does not change and the reflection is in the wavelength of He-Ne laser. Then the image looks reddish.

Reflection Spectrum

The reflection spectrum from the two types of hologram is measured using the spectroscopy system as shown in Fig. 4. The light from a tungsten lamp light source enters a monochromator and becomes monochromatic light. The monochromatic light illuminates the hologram.

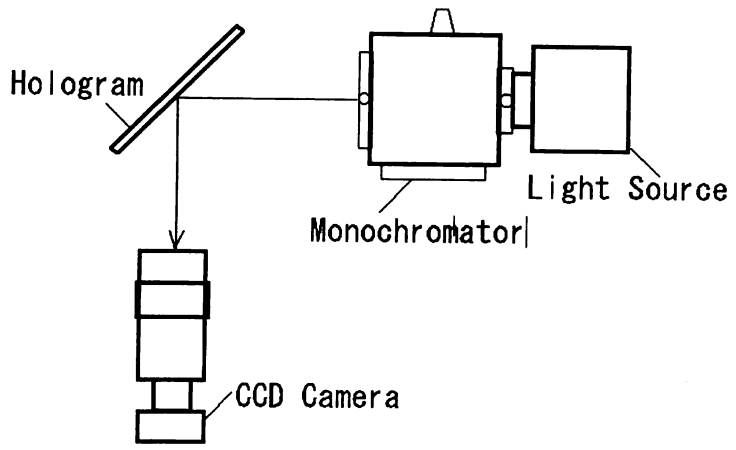

Fig.4. Experimental set-up for reflection spectrum measurement

At first the reflection light was measured by a photo diode. In this case any peak was not observed in the reflection spectrum. Various reflected light from the surface of the dry plate is mixed and the greenish light from the dog image would be hidden by them.

To measure the reflection spectrum of the dog image, a CCD camera is used as the detection device. The signal from the CCD camera is captured and processed by a image-memory system.[2)]

The reflection spectrum of the first type hologram is shown in Fig. 5. This is the plot of the reflection light of the forehead part of the dog. A smooth peak on the background light is observed between 470 nm and 530 nm which corresponds green color. The background light is considered to be the direct reflection by the dry plate glass.

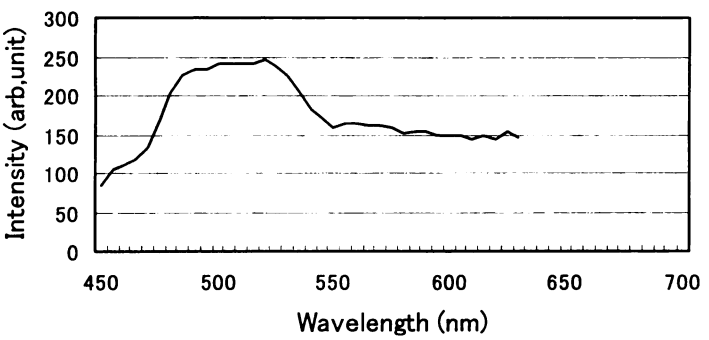

Fig.5. Reflection spectrum of the first type hologram

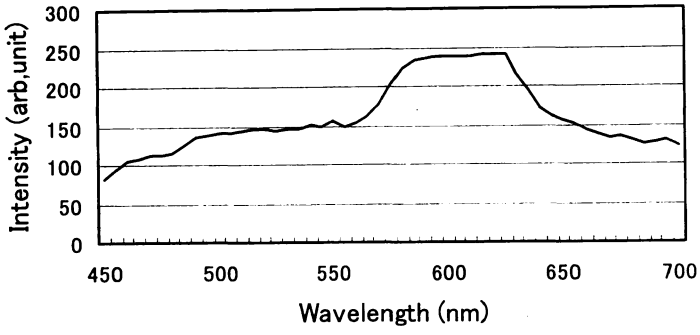

Fig.6. Reflection spectrum from the second type hologram

The reflection spectrum of the second type hologram is shown in Fig.6. It is also the light from the forehead part of the dog. A smooth peak is observed between 570 nm and 620 nm, which corresponds to red color.

Conclusion

By use of a CCD camera which enables to measure the light from local point, the reflection spectrum of two type of Lippman hologram is measured. The fixed hologram shows a smooth peak in the green region and the nonfixed hologram shows a smooth peak in red region. These spectrum explains the greenish and reddish color of the two type Lippsman hologram.

Acknowledgment

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References

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2} M.Mimura, M.Miyagi, T.Okumichi, *Mem. Fac. Eng. Osaka City University*, **34**(1993)165-169.