HOLOGRAPHY

Holography is a process of recording the intensity and phase information of light reflected from an object to produce its three dimensional image. It is a three dimensional *lens-less photography*. *Dennis Gabor* invented the holography in 1948 when he was attempting to increase the resolving power of electron microscopes. The word *holography* is the combination of two Greek words: *holos* and *graphein*. *Holos* stands for *whole* and *graphein* stands for *to write*. Thus holography means writing the complete image.

In an ordinary photograph, the film records the intensity of reflected light from an object. When the photograph is viewed, a two dimensional image is obtained. But, in holography a beam from a laser is split into two beams, a reference beam and an object beam. The object beam reflects or scatters light from the object to be photographed. The interference pattern produced by this light and the reference beam is photographed. Since the intensity at any point in the interference pattern also depends on the phase of the object, the resulting recording (**hologram**) contains information on the amplitude and phase of the object wave. When the hologram is illuminated with the original reference wave, it reconstructs the original object wave. An observer looking through the hologram sees a perfect three dimensional image. The image will change its appearance if you look at it from a different angle. A hologram does not bear any resemblance to the original object but possesses a spectracular property. It contains an encoded image of the object which is superior to ordinary photograph.

The basic difference between a hologram and an ordinary photograph is - In a photograph, the information is stored in an orderly fashion, i.e. each point in the object relates to a conjugate point in the image. Whereas in a hologram, there is no such relationship, i.e. the light from every point on the object goes to the entire hologram.

PRINCIPLE OF HOLOGRAPHY

The process involved in generating holograms consists of two stages:

- **Recording of the hologram:** Fig.13 shows the arrangement for recording a hologram. Light form the laser source is split into two components by a beam splitter. One of the components is directed towards the object and the other is directed to a suitable recording medium, usually a photographic emulsion. The wave that is directed to the recording medium is the reference wave. The beam that is directed to the object is reflected or scattered by the object. The scattered wave constitutes the object wave, which is also allowed to fall on the recording medium. Since the object wave and reference wave are mutually coherent, suitable interference patterns are formed when the two meet at the recording medium.

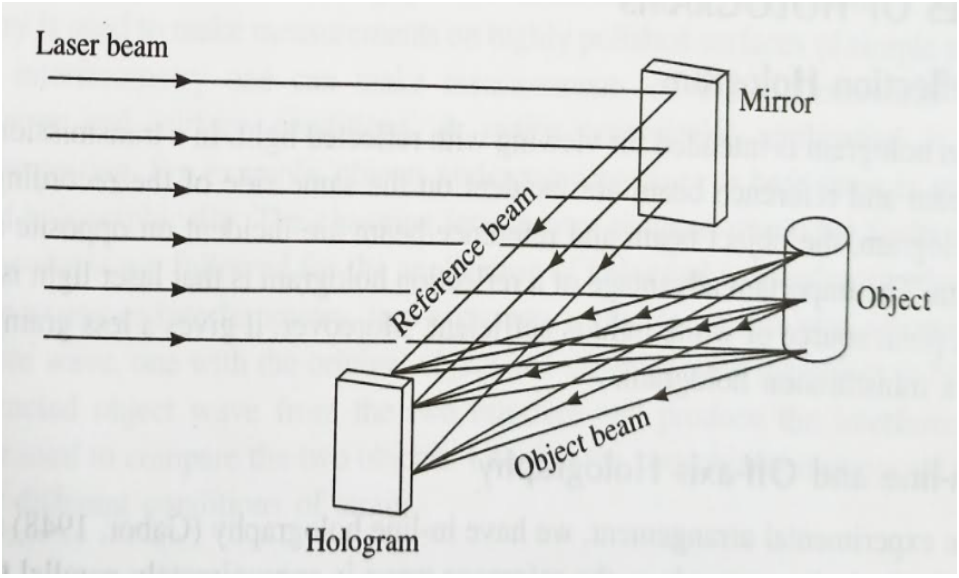

Fig.13 An arrangement for recording of a hologram

- **Reconstruction of the image:** In the reconstruction process, the hologram is illuminated by a beam of light similar to the reference wave used for recording the hologram. When the hologram is illuminated, light will only be transmitted through the clear portions. This results in a complex transmitted wave having three components as shown in the Fig.14. Of these, one is the reconstruction wave itself. Another one exactly duplicates the original object wave, called the reconstructed object wave, which gives an exact replica of the original object in its true three-dimensional form. By placing a lens on the path of the reconstructed object wave one can get an image of the object on the screen. The third wave is the complex conjugate of the object wave, which gives a real image that can be photographed by placing a photographic plate at that position. Thus, **holography is a two-step process by which images can be formed without lenses**.

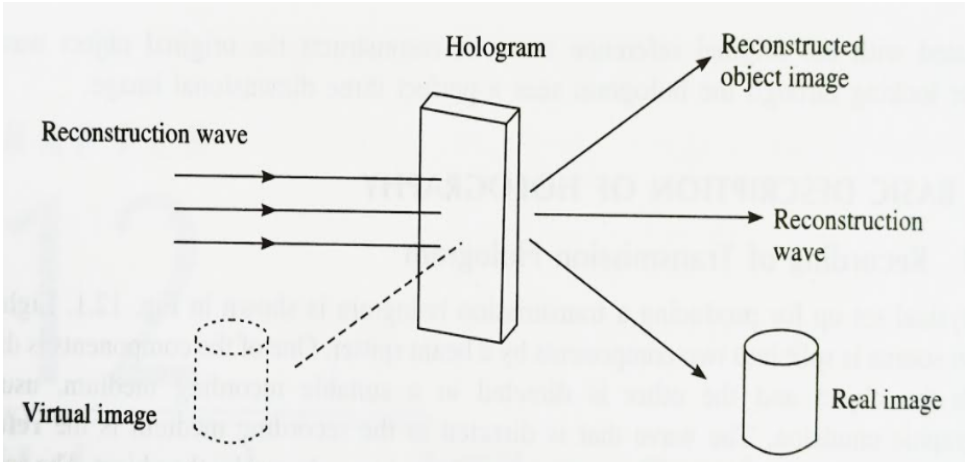

Fig.14 Reconstruction of hologram

IMPORTANT PROPERTIES OF A HOLOGRAM

Holograms have many unique properties; some of them are as follows:

- Each part of a hologram contains information about the entire object.
- Hologram is a reliable medium for data storage because a small part of hologram can reconstruct the entire image.
- On the hologram, information is recorded in the form of interference pattern. The type of the pattern obtained depends on the reference beam which is used to record the hologram.
- Information holding capacity of a hologram is extremely high. For example, the hologram of size 6 X 9 mm can hold the information of one printed page.
- If the wavelength of the reconstructing beam is greater than that of the original reference beam, the reconstructed image will be a magnified image. This magnification is proportional to the ratio of the two wavelengths.

APPLICATIONS OF HOLOGRAPHY

Holography has many fascinating applications and some of them are listed below:

- Holograms made with X-rays or ultraviolet rays are able to record images of particles smaller than visible light such as atoms or molecules. Microwave holography detects images deep in space by recording radio waves they emit.
- Holography is widely used in non-destructive testing to study distortions resulting from stresses, strain, heat and vibrations.
- Holographic lenses are used in supermarket scanners to read barcodes on merchandise for the store's computers.
- Three dimensional acoustical hologram of an opaque object is used to see the internal structure of an object. Such techniques are very useful in the fields of medicine and technology.
- Holograms are also used for data storage such as holographic hard devices. The entire contents of a library can be stored in the area having size of a sugar cube.
- A holographic lens is used in an aircraft "head-up-display" to allow a fighter pilot to see critical cockpit instruments while looking straight ahead through the wind screen.
- Dichromate holograms are used as jewellery pendants, watches etc.