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NASA TECH BRIEF

Long Range Holographic Contour Mapping Concept

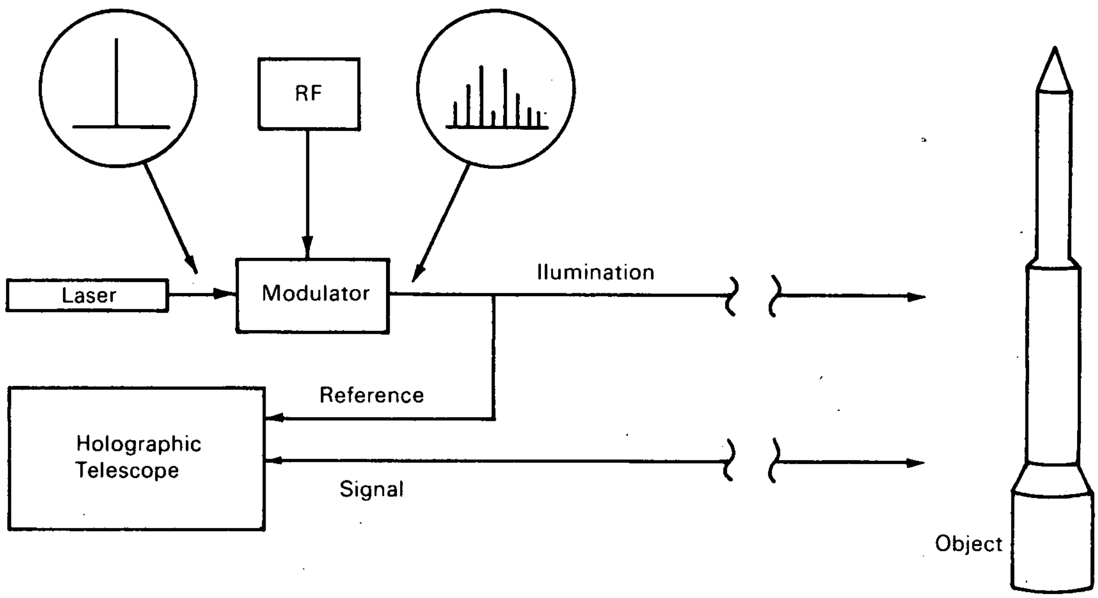

Figure 1

Holography is frequently used as a technique for recording objects at close ranges; therefore, it has often been erroneously identified as a technique which cannot be applied to large or distant objects. A scheme is proposed for generating a two-dimensional contour map of a distant object with range contour intervals of a few millimeters to a few inches. The basic scheme uses a laser light source which has a periodically varying coherence function to form a hologram of the object. Target ranges can be comparable to a conventional laser-illuminator/camera arrangement when a holographic telescope is used.

The method for generating the contours is based upon the theoretical considerations of a two-wavelength coherence relationship. It can be shown that the temporal coherence function of a radiation field in the direction of propagation is the Fourier transform of its power spectral density. Thus, if a laser emits light consisting of two sharp spectral lines, the coherence function in the direction of propagation varies sinusoidally with the distance between cycles. If such a source is used to make a hologram of a reflecting object, the object will appear striped with periodic contour intervals.

The proposed instrumentation could include an electro-optical phase modulator which would provide a simple and flexible means for obtaining a desired line profile with efficient use of the laser energy. If the laser beam is frequency modulated with a periodic waveform, then energy sidebands will appear on the

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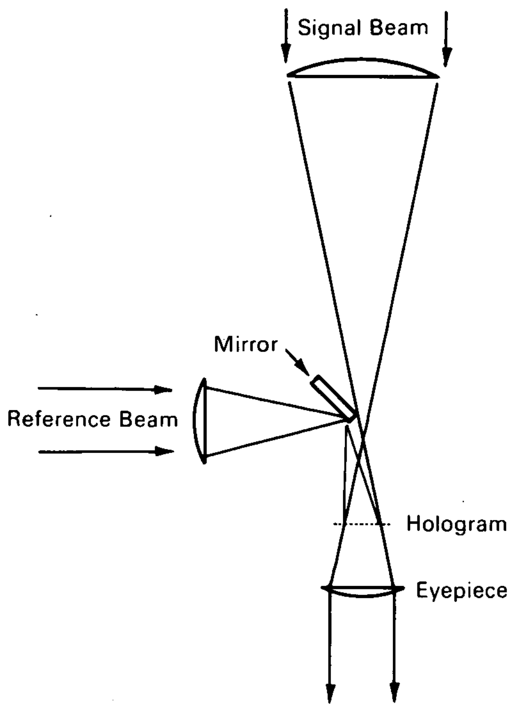

Figure 2

modulated beam. The contour interval will be one-half the wavelength of the modulation and the sharpness of the lines will depend on the depth of modulation. Because the modulation is periodic, a high-Q cavity modulator can be used with nominal power requirements. The use of a high modulation frequency permits large frequency differences which are necessary for the construction of quality holograms; the frequency difference is a point of interest when the coherence requirements of the laser are considered.

Figure 1 shows a block diagram of the contour mapper. The laser is phase modulated at a microwave frequency whose wavelength is twice the desired contour interval. The modulator might consist of a klystron driven, high-Q resonant cavity containing a KDP crystal. A small aperture at each end of the cavity would allow the laser beam to pass through the crystal, whose index of refraction is a function of the electric field. A small portion of the modulated beam is tapped to serve as the reference in the receiver, and the remainder is used to illuminate the target. Part of the signal light returned from the illuminated target is intercepted by the holographic telescope where it is combined with the reference beam to form the hologram. Because the received waves are nearly plane, the offset angle between the signal and reference beams can be made quite small and very sensitive film can be used to record the hologram.

The key to producing the hologram, of course, is the mixing of two laser signals with the proper phase and frequency relationships. Another technique for meeting this requirement relies on an optical arrangement shown in Figure 2. The reflected signal enters the telescope objective lens and forms a tiny image of the subject at its focus. The reference beam from the laser can be focused alongside the image and would illuminate the hologram at a small angle with respect to the reflected signal. By using a beam splitter, the reference beam can be injected at the desired position between the subject and hologram. To view the reconstructed image, the reference light is injected into the hologram and the telescope. Visual observation of the contour is achieved by adding an eyepiece at the viewer's side of the hologram.

Notes:

1. This development is in the conceptual stage only: as of the date of publication of this Tech Brief, neither a model nor a prototype has been constructed.
2. No further documentation is available. Inquiries may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics
   and Space Administration
   Washington, D.C. 20546
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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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