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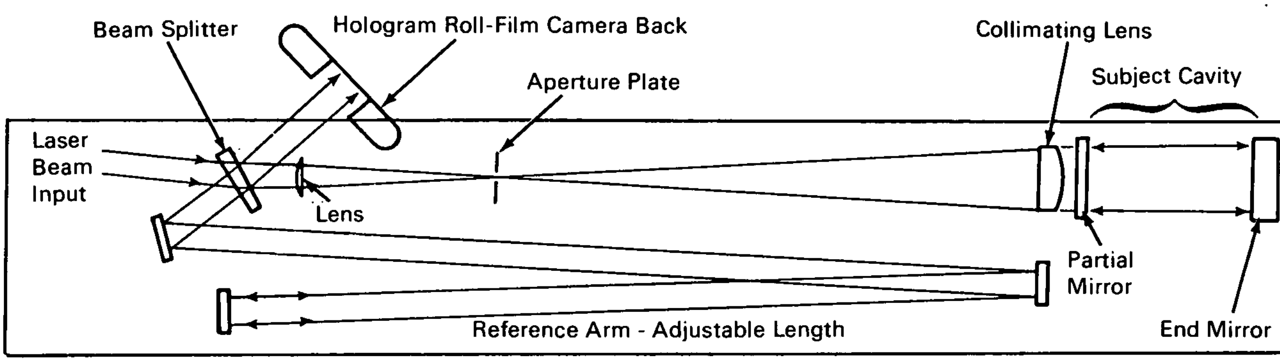
Multipass Holographic Interferometer Improves Image Resolution



An interferometer which measures small phase differences of light is a valuable instrument used in the study of physical phenomena occurring in gases, such as shock waves and combustion fronts of ignited mixtures. The ability of the instrument to measure extremely small phase differences, such as those associated with low pressure phenomena, is greatly increased by passing the light through the gas a number of times. The cumulative phase changes caused by the phenomena build up with the number of passes.

The effectiveness of conventional multipass techniques is highly dependent on the quality of the optical elements used. Holography is well suited to multipass interferometry since it is essentially independent of the quality of the optics. A novel multipass holographic interferometer, shown in the figure, has been used with 10 passes and represents a significant improvement over conventional techniques.

To achieve multipass operation, the subject is placed between two plane mirrors (forming a reflecting cavity) and the light is introduced at right angles to the mirror so that it is repeatedly reflected through the subject. If one of the mirrors is partially transparent, a portion of the light will be transmitted through it with each round trip in the cavity. In order to separate the beams corresponding to different numbers of passes, a slight angle exists between the two mirrors so that each beam will emerge at a slightly different angle. By focusing the emerging beam and placing a narrow slit in the focal plane, the desired beam can be selected and those not desired rejected.

In order to form a hologram of high diffraction efficiency, and hence to provide a bright and high contrast interferogram, the reference beam is attenuated so that it matches the intensity of the desired subject beam. Image resolution is degraded by three effects which tend to cause a smearing of each point of the subject. One is "beam walking," which is due to the slight angle between the mirrors of the subject cavity. A second is multiple imaging due to the successive reflection of the subject in the cavity. A third effect is the (one-dimensional) low-pass spatial filtering associated with the angle-selecting slit. Through means of analysis and experimentation, criteria have been developed for selecting system parameters in the instrument that will minimize the total image smear.

(continued overleaf)

Alternate means for selecting the subject beam involve a time or coherence gating of the light. These can be used independently or in combination with the angle-selecting aperture and promise greatly increased numbers of subject passes without serious loss in subject resolution. Time gating is accomplished with the use of electro-optic shutters or an electronically gated image tube instead of the standard hologram recording film. Coherence gating uses a laser source with a coherence length less than twice the subject cavity separation so that only one subject beam is coherent with the reference beam and, therefore, useful in forming the hologram.

Note:

The multipass holographic interferometer can be used to study any effect which changes the index of refraction (including water studies). It can also be used to study the surface deformations of a flat reflecting surface which constitutes the end mirror of the subject cavity.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [43 U.S.C. 2457 (f)], to the TRW Systems Group, One Space Park, Redondo Beach, California 90278.

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