Chapter 16

ULTRASONIC HOLOGRAPHY VIA THE ULTRASONIC CAMERA

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Various ways of recording the interference patterns of ultrasonic waves have recently been described. These methods include real-time reconstructions obtained by the reflection of a laser beam from the interference patterns set on the interface between two materials, as well as the use of a delayed sonic hologram in which the ultrasonic interference pattern is recorded photographically after being obtained point by point by scanning techniques. We wish to report a new way of obtaining a hologram, by recording the interference pattern as displayed by a commercially available ultrasonic camera. A quartz crystal located at the front window of a cathode ray tube is irradiated by a sound beam scattered from an object and by a second unscattered reference beam. The interference pattern picked up by the scanning electron beam is amplified and displayed on a TV monitor and photographed conventionally. The processed photograph is viewed in laser light, and the two reconstructed images are thus obtained. Experimental results, as well as limitations of the method and possible real-time holographic viewing, are discussed.

INTRODUCTION

Several means of obtaining ultrasonic holograms have recently been reported in the literature (1–3). These include real-time reconstructions obtained by reflection of a laser beam from the interference pattern generated on the interface between two materials, as well as the use of delayed sonic holograms for which the interference pattern was recorded photographically after being obtained point by point from mechanical or laser scanning techniques. We wish to report a means of obtaining immediate displays of ultrasonic holograms by electronic scanning of a piezoelectric crystal on which two interfering sound beams impinge. Thus with a proper readout system the photographic process can be eliminated entirely, opening another way to real-time holographic displays and reconstructions.
Fig. 1. Experimental setup. Immersed in the water tank (1) are two ultrasonic transducers (2) fed by generator (3). The beams are impinging upon quartz target (5) after one of the beams was scattered by target (4). The electron beam in cathode ray tube (6) induces secondary emission multiplied by electron multiplier (7) and carrier amplifier (8) and finally displayed on TV monitor (10). Box (9) includes the electronic circuits for beam generation and deflection.

The apparatus used was an ultrasonic camera,* a schematic diagram of which is shown in Fig. 1. It is an improved version of the system described by Sokolov in 1930.† A quartz crystal located at the front window of a cathode ray tube is irradiated by a 7-MHz ultrasonic beam scattered from an object immersed in a water tank and by a second unscattered reference beam, both beams obtained from the same generator. The ultrasonic waves impinging on the piezoelectric crystal induce a voltage whose magnitude at any point varies linearly with the instantaneous ultrasonic amplitude of that point. This voltage distribution modulates the intensity of the secondary emission generated by the scanning electron beam. The resulting signal is then amplified by the electron multiplier and video amplifier and displayed on the television monitor after square-law detection in the electronics. The ultrasonic hologram displayed on the television screen is photographed and, as for conventional holograms, two reconstructed images are obtained by placing the processed photographic plate in a laser beam.

The ultrasonic object and reference beam were generated by two ¼-in.-diameter 7-MHz transducers apertured to ⅛ in. to obtain a uniform far-field pattern at the receiving crystal. To ensure angular separation of the reconstructed images from the zero-order diffracted light, the object and reference beam subtended an angle of 10°.

Figure 2 shows a photograph of a hologram of the letter “C” (right) placed 20 cm from the receiving crystal, as well as the original letter (left). The width of the lettering was 3 mm cut from a 1¼ × 1 cm brass plate. The reconstructions obtained for each of the two images together with their

†See, for instance, S. Sokolov, Means for Indicating Flaws in Materials, U.S. Patent 2,164,125.