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Underwater Laser Viewing System

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ABSTRACT

The difficulty of viewing through turbid water — due to obstruction from backscattered rays — is overcome by adopting the range gate camera, which is actuated only during the interval when useful laser pulsed laser beam. Experiments are performed to seek the dependence of laser ray attenuation in water on wavelength, on water turbidity and on suspended particle size. Results of trial runs prove appreciable improvement of image quality to be obtainable with the laser viewing system. Simulation is applied to fill the gaps between discrete points determined by experiment to obtain optimum values for the parameters governing the viewing system.

INTRODUCTION

Recent technological advances have led to the realization of submersible vehicles capable of navigating at great depths, and the combination of such vehicles with high-performance cameras has come to permit televising underwater scenes featuring colorful fishes and enchanting deep-sea waterscape. In practice, however, remote viewing involves fairly severe technical difficulties when it requires viewing through turbid water; yet it is precisely such a capability that is eagerly awaited by those engaged in port and harbor works and similar domains.

The laser — invented already 30 years ago — has been widely developed for applications in communication, surveying, material processing and other fields. Studies in laser applications to underwater environment at one time centered around communication, viewing and range-finding, but the difficulties caused by laser beam attenuation and by scattering of the illuminating light were such as to lead many to despair of successful long-distance underwater transmission. This applies particularly in the case of turbid water, which however is precisely the domain where means of clear viewing are the most strongly needed.

Viewing through turbid water has hitherto been tried by applying various expedients (e.g. Myers, 1969). One such expedient — proposed by T. Keil Jr. et al. (1968) — is what is known as a range gate camera, to prevent the viewing capability from being impaired by backscattering. At the time of Keil, however, the key elements constituting this viewing system — the ultra-short-pulse high-output illuminating light and the high-sensitivity camera with ultra-high-speed shutter — were not sufficiently developed to promise successful application of the system. For this reason, studies in this direction have declined since the 1980s, and reports have become less frequent.

At the 1st District Port Construction Bureau (Niigata), Ministry of Transport, the need came to be felt for a safer and surer means of underwater viewing in connection with the installation of caissons for the West Niigata Port Underwater Tunnel and of constructing a submerged wave dissipating breakwater off the western beach. In order to answer such needs in marine civil engineering, a study project on underwater viewing was started in 1992 jointly between the Port and Harbor Research Institute of the Ministry of Transport and the Ishikawajima-Harima Heavy Industries Co., Ltd.

Developments of recent years related to the range gate camera have led to the realization of an ultra-short-pulse high output illuminating system that can produce a pulsating light of intensity exceeding 100 mJ repeated at a rate of around 50 Hz and with a duration of several nanoseconds. This was brought about by Q-switching a YAG laser that emits secondary harmonic waves of 532 nm. As regards the high-sensitivity camera with ultra-high-speed shutter, a high-performance imaging system has been obtained by actuating at high speed a multi-channel plate type image intensifier and combining it with SIT tube television camera. We are at present experimenting with the use of such newly available elements in developing a range gate type of underwater viewing system, and we are planning to try the system on actual

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