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UNDERWATER ENGINEERING PHOTOGRAPHIC DOCUMENTATION

John P. Jones, President
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For years now the number of underwater structures has been increasing almost as a geometric progression. The complexity of design and construction has increased at an equally impressive rate. Today we are no longer just concerning ourselves with simple towers, pipelines, outfalls, etc., but rather with complex systems such as the Dubai storage tank, sophisticated deep water drilling and production platforms, subsea wellhead completions, undersea collection and separator systems and complex pipeline systems. The engineering design and construction of such structures is rapidly evolving from "brute force", "cut and try" to the science of ocean engineering. Inspection and preventive maintenance of our underwater construction however, have remained in the dark ages. For the most part our inspection programs have been little more than attempts to find and solve problems after the fact and our preventive maintenance programs have been more often than not exemplified by the philosophy of "once it's under water, forget it". Neither of these programs can continue in their present mode.

Our awareness of the sensitive ecological balances, the effects of major oil spills, the financial risks involved and the requirement for better use of the ocean, all dictate that disasters occasioned by failure of underwater structures can not be tolerated. Just as is the case with any air, ground or space structure an effective periodic inspection program and the proper preventive maintenance procedure are keys to the prevention of major disaster Very few people would feel safe aboard a ship or aircraft that was never inspected. Even homes, factories, office buildings, refineries, bridges, etc., all have inspection and preventive maintenance programs. Oddly enough however, until very recently there have been no programs for the inspection of bridge structures underwater. It took several instances of bridge failure and loss of life to develop interest in the condition of submerged bridge structures.

Until recently the primary source and in most instances the only source of data on underwater structures has been the diver. Even though most generally not a trained engineer or construction specialist and always working in an unfriendly environment, the diver has been the eyes of the construction manager. The diver has to inspect with limited vision and many times with only the sense of touch, portions of a structure, integrate and combine the information gathered and then relate it to an engineer or technician topside. Lack of familiarity or understanding, being unable to view the structure in an overall sense, working in a hazardous environment and having to relate or transmit his data to another, all tend to make the diver a questionable source at best. Just how questionable may be demonstrated by recent U.S. Navy tests when divers have been sent under the hulls of ships to inspect specified areas and after reporting turn on underwater television cameras and cover the same areas. In many cases the TV has shown the diver to be inspecting the wrong area, and more often incorrect in his estimate of the situation. This is no reflection on the diver, it merely demonstrates the severity of the condition under which the diver must function and the problem with viewing only small portions of a structure at a time. We must then employ a better information source if we are to solve the problem of underwater inspection and preventive maintenance. There's little doubt of the requirement to provide a solution.

Developments of recent years have produced equipment which can assist the engineer in evaluating the conditions of underwater structures and help establish preventive maintenance programs. Underwater television and photographic systems are the basic tools and must be capable of producing clear undistorted pictures.

The requirement to produce clear undistorted pictures is perhaps the most important reason for these underwater tools not being employed more frequently. Most often visibility in the water is poor and there are major distortions caused by light transmission through the water-glass-air interfaces between the subject and the film plane or video tube. Added to these problems is the one of lighting. Here the physics of the underwater world again require that the appropriate lighting design, placement, intensity and temperature be selected to obtain usable results. Along with the problems of the sensors there is one of a satisfactory system concept and design. Without solutions to these problems photographic and video results obtained cannot satisfy the requirements for engineering documentation underwater.

The problem of distortion may be solved by underwater correctors which are placed in front of the primary lens of the sensor and the lighting problem may be solved by modern design, trial and error placement, and the selection of the proper illumination source. Popular correctors which may be used are the dome, the Lietz and the Rebikoff-Ivanoff. Of these, the Rebikoff-Ivanoff is the most satisfactory in that it provides a more distortion-free picture and does not require focusing of the primary lens. There are several illumination sources: Tungston, Mercury Vapor, Thallium Iodide, etc., which may be used to advantage when selected to meet conditions. For example, the blue-green thallium iodide light provides excellent illumination for black and white TV under poor water visibility conditions. The final problem is that of a proper systems concept for the task at hand. A corrected camera and the correct light properly placed can obtain a photo or TV picture of a small area. The area covered is limited in two ways. One, in poor water visibility, the camera and light must be close to the object to obtain a picture and under good visibility the high intensity light required to obtain a picture at a significant distance from an object make such pictures impractical. The size of the area may be increased by using a wide angle lens and this is normally done but a 100° field of view is about the practical limit for lens and light. Although there are wider angle of view lenses available and camera systems which can obtain 365° field of view photographs they have not proved practical for our purposes here.

What is desired is a capability to produce a series of controlled photographs which may be used to construct a mosaic or in certain instances a photogrammetric presentation. In other words an underwater photographic reconnaissance system; a self-propelled mobile platform capable of moving rapidly, being easily and accurately controlled and which carries its own cameras and lighting system and is capable of automatically sequencing the camera. With such a system a series of photographs covering an entire structure may be obtained, the structure then reconstructed in a mosaic and if desired viewed in three dimension stero, or the photograph normalized and three dimensional maps prepared through photogrammetric techniques. In fact, with the proper selection of equipment one may obtain a mosaic of an extremely large structure under conditions where diver visibility is zero. These mosaic may be viewed at leisure by trained engineers, used for evaluation of the condition of the structure, have engineering measurements made from them and retained for comparisons with subsequent photographs. Properly equipped television systems, like the hand-held camera may be used to obtain coverage of a small area or "panned" across a structure and magnetic tapes made for future reference. However, there is considerable loss in resolution and there is no means of shall we say, "building the structure in air" as can be done with photographs. TV does offer the advantage of immediate viewing and topside direction. Perhaps the ultimate system will be a photographic camera system with a TV viewer, which with the exception of the water transmission problem, is feasible today. Cables to the surface would severely limit the systems mobility.

Many years ago Dimitri Rebikoff and others began a program to develop the components of an underwater photographic system. The corrector lens system, the camera and housing, the lighting, and the all important mobile platform. In recent years the Real Eight Co., Inc. has continued these developments and conducted many operations proving the concept and the system. Missions have been successfully completed in the North Sea, the Adriatic, the Persian Gulf and the Pacific as well as the local waters of the Carribbean and Atlantic. Water conditions have varied from absolute zero diver visibility to the unlimited visibility of the Bahamas. In every instance clear undistorted photographs have been obtained. In most instances structural conditions have been determined not to be as previously believed and many times the photographs have shown that the structure was not built according to specifications, without exception valuable data was gathered. There is little doubt that the system can be used to provide necessary data as desired earlier and move underwater inspection and preventive maintenance out of the dark ages.

Now I would like to show a short film which demonstrates some of the points I've been discussing. As I mentioned earlier, for actual engineering documentation sequence photography would be used but the motion picture provides a means of showing a view of the system and its uses.