A Small Robot Submarine for Oceanographic Applications

**Abstract**

*A small computer controlled submarine capable of carrying out various underwater tasks has been designed and built. The vehicle continues to be developed and improved. It has operated for many hours under computer control and has made test runs where oceanographic data have been measured, stored, and eventually printed out. The vehicle is approximately 2.3 m long, -37 m diameter, and weighs 110 kg, in air.*

**Summary**

The authors begin by describing the contents of the paper, and the capabilities and specifications of the finished robot, before delving straight into details of various aspects of the vehicle. The device is designed to autonomously carry out pre-programed tasks, storing data as it goes for later retrieval.

First to be discussed is the hull and structure, in which the placement of the various internal electronics is described, along with the materials used in fabricating the hull. Further detail is added to describe methods used in the fabrication process, particularly with regards to ensuring the vehicle is hermetically sealed and retains enough structural integrity to allow depths of 60m to be achieved. Various diagrams and pictures give an impression of the structure, conveying a vehicle similar in shape to a torpedo.

Discussion then moves on to propulsion and control; as before the content is a straightforward description of the components used, with particular focus on the modifications made to ensure the components retain their functionality in a scenario beyond their design specifications. Various difficulties arose with the power source, consisting of a modified car battery – battery pressure had to be compensated by filling any open cavities with oil, and hydrogen emissions typical of such batteries needed to be vented. To avoid venting oil along with the gas, a novel new battery casing was designed with an in-built valve for gas release.

The computer controlling the vehicle is then described in detail, consisting of the expected memory, CPU and various interfaces. Of note are the specifications of the CPU and memory; a cycle time of 23 microseconds and a memory capacity of just 40kb, no doubt some severely limiting factors for this early example of an autonomous vehicle. A lengthy description of the programming process follows, in which commands are inputted before the specified ‘mission’, to be carried out in succession by the internal computer, communicating with the autopilot system whilst input data from various on-board sensors (salinity, temperature etc) is stored for later retrieval. All commands are input in assembly language, with a few modifications also to the machine language (seemingly for small adjustments of various parameters).

Interestingly, even in these early days of robotics, and computing generally, much of the software written for the internal computer were tested beforehand on simulations, a process that has become somewhat of a staple in modern robotics.

The autopilot operated on some remarkably archaic principles, with heading being obtained from a basic magnetic compass, the markings on which could be read by photo-potentiometers, whilst pitch was measured using a pendulum on a string, suspended in oil to dampen oscillations.