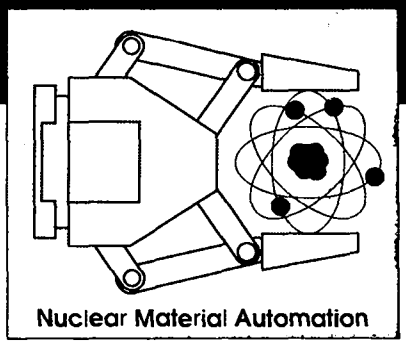
Applied Robotics and Automation



Robot for Dispensing Solutions of Underground Nuclear Test Samples

The Test Samples

Following the underground detonation of a nuclear device, core samples were taken from the subterranean area richest in radioactive debris. The analysis of these samples provides elemental and isotopic profiles used to evaluate the performance of the device. Traditionally, samples were ground [illegible] powder inside a glovebox, small quantities of the powder [illegible]e dissolved in various acids, and then outside the glovebox in a fume hood solutions were bottled for dispensing. Subsequently, referring to a ledger that prescribes the number and sizes of aliquots to be evaluated, researchers used pipettes to draw aliquots of the solutions.

An Automated Dispensing System

We developed a robotic system to automate the dispensing of aliquots. It was designed to dispense a hundred radioactive acid solutions with a range of volumes between 1 milliliter (mL) and 500 mL. The automated system reduces radiation exposure of the researchers, eliminates the incidence of spills and the possibility of cross-contamination of the aliquots, and performs more error-free record keeping than the human, hands-on system. Moreover, the aliquots can now be dispensed by weight rather than by volume, enabling researchers to perform a more precise analysis.

A Unique Design Feature

The robotic system was designed by Laboratory personnel so that no permanent components such as pumps and valves would become contaminated by the radioactive solutions the system dispenses. System designers were able to use off-the-shelf peristaltic pumps and three-way pinch valves and to isolate them from the solutions (Figures 1, 2). Flexible tubing that comes in contact with the solutions is replaced after each dispensing operation.

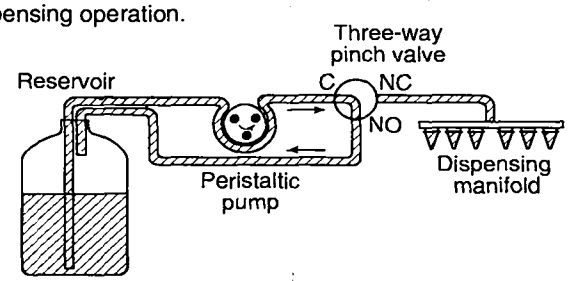


Figure 1. Diagram of the peristaltic pump station.

Information Management

A dedicated personal computer interfaces with the robot controller. The personal computer holds all the information from the ledger: the number and sizes of the aliquots to be dispensed, the container types, and the intended destination for each. These data are stored on floppy disks, and printouts

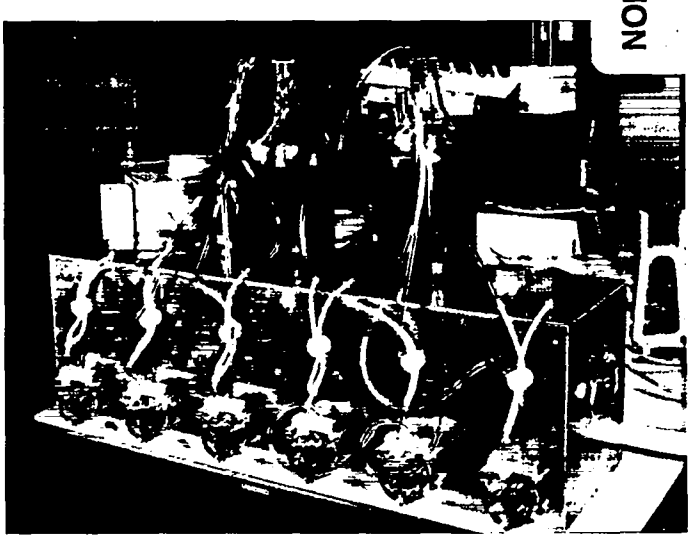


Figure 2. The noncontact pumping station developed for the dispensing task with the robotic system in the background.

are available. The personal computer also performs an error-checking function so that the correct container size can be verified before the dispensing operation begins. Once the aliquots are prepared, the computer stores their weights and provides a printout.

System Components

The system is based on the Zymate Laboratory Automation System (Figure 3). The robot arm swivels around a center point. Attached to the arm is a general purpose hand, which has a pair of fingers to lift the centrifuge tubes and Erlenmeyer flasks that hold the aliquots. The arm is surrounded by sample racks that are divided into grids for identifiable container locations.

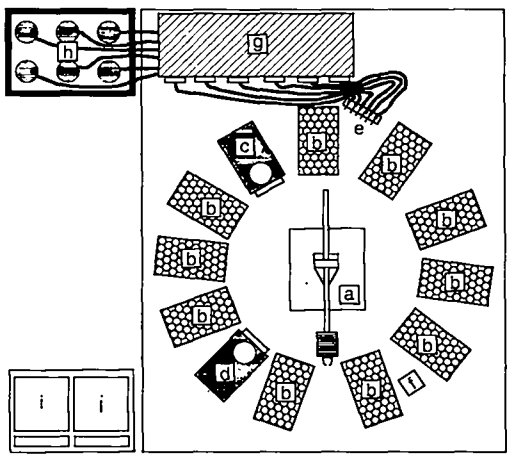


Figure 3. Zymate system showing (a) robot arm, (b) sample racks, (c) Mettler PE-600 balance, (d) Mettler AE-163 balance, (e) dispensing nozzles, (f) hand parking station, (g) peristaltic pump station, (h) debris solutions, (i) Zymate controller, (j) personal computer.

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The interchangeable racks each hold one type of container: 125-mL, 250-mL, and 500-mL flasks or 50-mL centrifuge tubes, depending on the requirements of the particular underground test. Also within reach of the arm are two analytical balances and a set of six solution-dispensing nozzles. Outside the robot work area are the pumping station, two Zymate power and event controllers (PECs), the Zymate controller, and the personal computer.

The personal computer provides input to the Zymate controller, which directs the robot arm, each PEC, and the two balances. The PECs control pumps and valves and the switches that supervise the opening and closing of the door on the AE-163 balance.

System Procedure

Using the information entered on the personal computer, the Zymate controller directs the robot to dispense the desired aliquots into tared containers and to weigh each one (Figures 4, 5). The robot stores the weighed samples in separate racks for each type of analysis (Figure 6). The controller sends the actual weights to the personal computer, where data are stored on a floppy disk and made available to researchers as printouts to accompany their samples. The system can deliver the aliquots (about fifty) for a typical underground test in approximately three hours. The system was used successfully for eight years, and system designers are studying the feasibility of expanding the system to include other steps in the process of preparing and analyzing any future core samples.

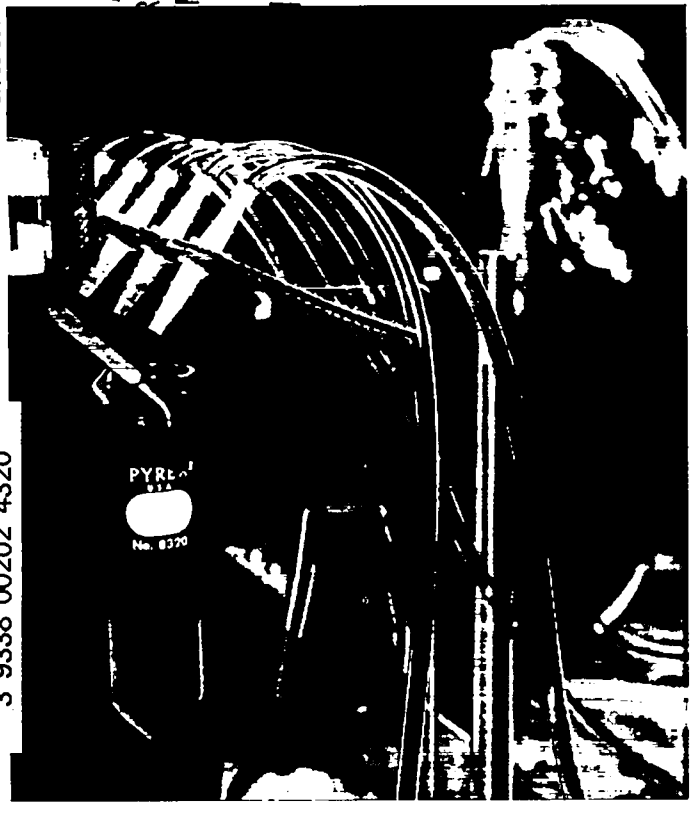

Figure 4. The robotic system in the prototype stage dispenses an aliquot of the dissolved core samples into a test tube.

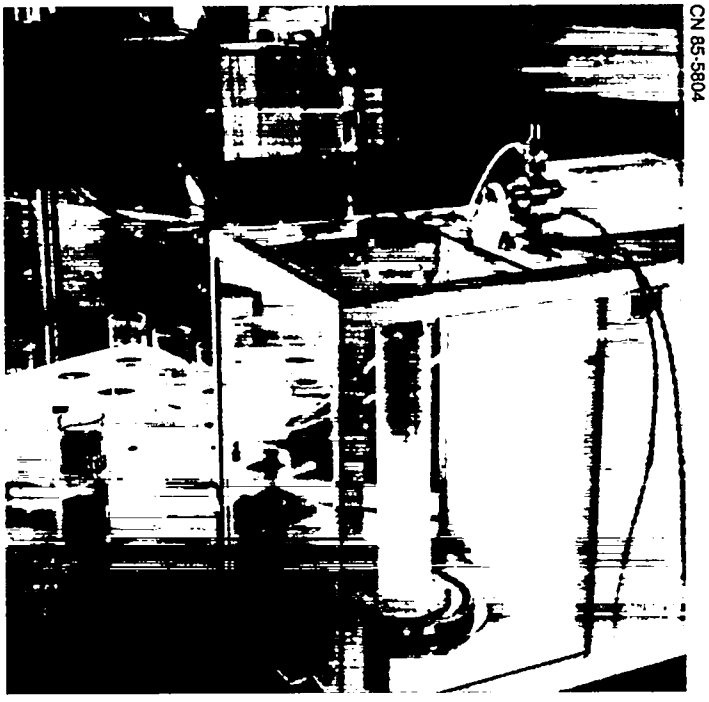

Figure 5. A just-filled test tube is weighed automatically, and the results are sent electronically to the system controller.

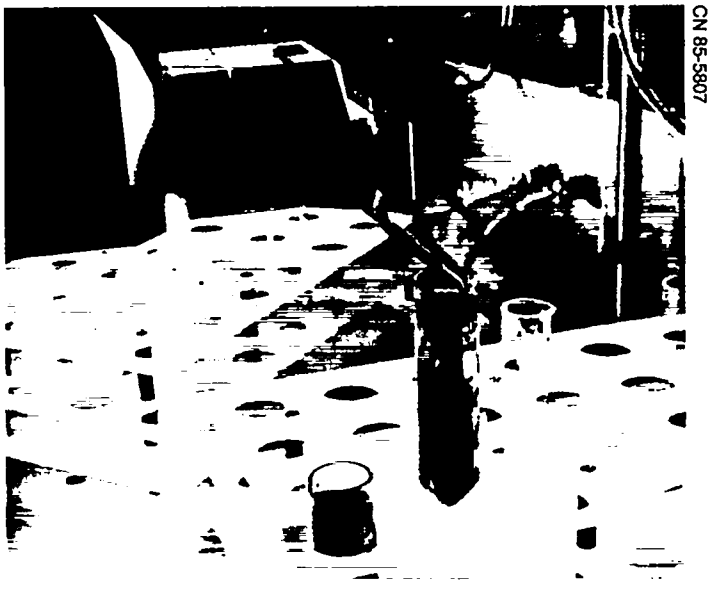

Figure 6. A filled and weighed test tube is sorted into a rack to be sent to the laboratory for analysis.

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