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FAST RABBIT AND RAPID CHEMISTRY:
A CONTROL SYSTEM FOR AUTOMATED CHEMICAL ANALYSIS

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1.0 INTRODUCTION

LLL's need to study the nuclear decay of short-lived radionuclides has resulted in the development of an automated, microcomputer-controlled system for controlling the movement of samples, and for performing the required chemical analysis. An automated system was needed because of:

- .The large numbers of samples to be analyzed.
- .The rapid analysis required for short-lived radionuclides.
- .A need for better repeatability in the analysis procedures.
- .Operator protection from the sample's sometimes high radiation fields.

A MCS-8 microcomputer was chosen as the nucleus of the system because the operations desired required an extensive multiple-sequential control which could be easily changed for new system configurations. Use of a microcomputer for system control reduced the sequencing problem to a computer program.

2.0 SYSTEM CONFIGURATION

The complete system, as shown in Figure 5, actually consists of two interrelated sub-systems: First, the Fast Rabbit system which moves the rabbit sample to the reactor and back to a preselected experiment, controls and monitors the pneumatic system, times the rabbit in and out of the reactor, displays the position and condition of the rabbit and system at all times, and allows interaction by the operator. Second, the receiving stations and in particular the Liquid-transfer/Rapid Chemistry system which: Receives an irradiated rabbit liquid sample, transfers the sample liquid to the chemistry, performs the chemistry program previously created on the system, disposes of the liquid and the spent rabbit container, initiates counting equipment, starts and stops clocks and reports status information.

2.1 The Fast Rabbit System (Figure 1)

The Fast Rabbit System is like the pneumatic-message, or money-sending systems that are used in some banks and department stores. The main function of the Fast Rabbit System is to send a rabbit sample from the launch station into the core of the reactor for a predetermined amount of time, then send it back to a preselected destination as fast as possible. It is operated on 60 lb./in² of dry nitrogen gas and the rabbit travels at an average velocity of about 100 mi/hr.

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A rabbit is a little cylindrical polyethylene container that is used in this system to transport the samples to be irradiated. The approximate outside dimension of a rabbit is three centimeters in diameter by six centimeters in length. For maximum safety, the rabbit consists of three containers that fit into one package, (see Figure 2).

The total Fast Rabbit system consists of 42 valves, five photodetectors, eight microswitches, 21 pushbutton switches, one main control panel and three display panels. Figure 3a is the control system block diagram and Figure 3b is the control system state diagram.

There are five possible home sites for the rabbit:

Station 1 is the Liquid Transfer Station;

Station 2 is the Germanium Detector experiment;

Station 3 is the Neutron Detection experiment;

Station 4 is the Emergency Dump Station;

Station 5 is the Store Station. It is a lead storage pig following the Neutron Detection station.

Some additional features are operator interaction through push buttons, visual status information, manual control, simulation control, hangup checking and recovery, remote clock stop and emergency return. Several radiation monitors have been added along the rabbit path. The detector's displays serve as additional visual feedback. A photograph of the actual panel with the MCS-8 microcomputer is shown in Figure 4.

The total memory for the Fast Rabbit computer control system requires three 256-word PROMs and one 256-word RAM.

2.2 Liquid Transfer/Rapid Chemistry System

The Liquid Transfer/Rapid Chemistry System is a computer-based fixed and programmable control system. (The Liquid Transfer program is fixed and the Rapid Chemistry system is programmable.) Figure 5 is a block diagram showing the relationship of the Liquid Transfer/Rapid Chemistry system with the Fast Rabbit system.

The main function of the Liquid Transfer/Rapid Chemistry system is to receive a rabbit containing an irradiated liquid sample from the Fast Rabbit system, detect it, extract the liquid, and perform automated chemistry upon the sample, where the chemistry procedure followed was prepared from a TTY using an interpretive language called LIL8.* Some additional features are: rapid understanding of how to program the Fast Chemistry, paper tape read and punch out of a program, ability to start the program at any logical point, remote and manual modes, operator interaction with the Fast Chemistry valves through pushbutton switches, and visual status information.

Figure 6 shows a photograph of the MCS-8 microcomputer, TTY and the manual control and status chassis. Figure 7 shows the liquid transfer mechanism and the automated chemistry.

2.3 Overall System Operation

The user begins with an idea for the chemistry. He configures the chemistry hardware, then sits down to the Rapid Chemistry TTY, and using ODT and LIL8, he programs the MCS-8. The program and chemistry are checked for accuracy and then readied.

The reactor operator is notified to select station one as the return station and the amount of time for irradiation. He can then make a dry run using the simulator on the control panel. When all is readied, the rabbit is placed in the launch station and the launch button is pressed. The rabbit goes into the core of the reactor and the timer begins to count down. When the timer reaches zero, the rabbit is sent back to station one. The rabbit is detected by both MCS-8 systems and the liquid transfer system moves the rabbit under a hypodermic needle which punctures the rabbit and extracts the liquid. Next, the automatic chemistry is started and when the analysis is completed, the spent rabbit and waste chemicals are automatically disposed of and the TTY gives a FINISHED message. Figure 8 gives a timing chart of the fast rabbit operation.

3.0 CONCLUDING REMARKS

The two control systems have closely similar hardware with 8-bit input and 8-bit output ports. The real design problem was defining the system as a state diagram and then writing a computer program to fit. A PDP8/I's editor and modified assembler was used to create the system programs; this contributed greatly to rapid program turnaround times.

*For details of LIL8, see UCRL Preprint 76608 "A List Interpretive Language for Process Control Applications of the MCS-8 Microcomputer."

The time saved by going to a microcomputer-based system, as opposed to a hardware-only system, was estimated to be on the order of half a man year since both computer systems could essentially have the same hardware. Time was also saved in the debugging stage because software changes are usually much cleaner and easier to make.

The time from the presentation of the problem until demonstration that the Fast Rabbit system would send a rabbit into the core of the reactor and send it back to one station, was roughly three and a half months. At this time the electronics was about 90% done for both systems. System additions and changes are now mostly a change in the system program.

A language for a programmable control system, as opposed to a fixed turnkey micro-coding system, was needed to allow easy changes in the chemistry process control program. The language was written to compete in simplicity of understanding with a rotating-cam programmer. The resulting language (already referenced in Section 2.2) was called LIL8 for "List Interpreter Language for MCS-8".

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Figure 1 Overall configuration of automated chemical analysis system.

Figure 2 Rabbit Nesting Sample Containers

Figure 3a Fast Rabbit control system
block diagram

Figure 3b Fast Rabbit system state diagram

Figure 4 Fast Rabbit Control Panel

Figure 5 Block diagram of relationship between the Fast Rabbit system and Liquid Transfer/Rapid Chemistry system

Figure 6 MCS-8 Microcomputer, Input-Output Teletype and control panel for Liquid Transfer/Rapid Chemistry system

Figure 7 Liquid-transfer mechanism and typical automated chemistry for Liquid Transfer/Rapid chemistry system

PUSHBUTTON OPERATIONS
TO SELECT CONTROL ACTIONS
OPERATOR

Figure 8 Time Chart for Fast Rabbit system

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