AUTOMATIC SAMPLE CHANGER

BY

M. O. RANKIN AND R. A. HARVEY

HANFORD LABORATORIES OPERATION

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HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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Radiation Protection Instruments Research and Development
Physics and Instruments Research and Development Operation

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AUTOMATIC SAMPLE CHANGER

INTRODUCTION

Radiochemical control work at Hanford requires that samples containing trace amounts of radioactive isotopes be counted daily to determine the amount and kind of isotope present.

Each sample is prepared on a stainless steel sample dish, mounted on an aluminum holder, and manually placed under a mica-window GM tube for counting. The sample is counted for a fixed time, removed, and all data are recorded by hand.

Many samples require counting several times with fixed time intervals between each counting period to obtain necessary information for decay curve data. Background counts for various predetermined times are required periodically. To determine GM tube characteristics, a certain number of counts must be made on a known sample during a given period.

An automatic sample changer was developed to increase the number of samples that can be handled and eliminate many routine manual operations.

REQUIREMENTS

The automatic sample changer, to replace the present manual methods, must meet the following requirements: dependable continuous operation, smooth handling of each sample, capacity of fifty 2-1/2" x 3-1/2" x 1/16" sample holders, and versatile enough to obtain routine sample, decay curve, background, and tube characteristic data. The instrument must record all information from the scaler and the written material on the sample holder.

SUMMARY

An automatic sample changer was developed to increase the number of samples that can be handled daily by eliminating many of the operations now done manually. When the instrument is in operation, it will only be
necessary for the operator to load the samples into a rack and select the mode of operation desired. Background counts for various predetermined times and data for decay curves are obtained automatically. For each sample the count, duration of count, date, time, sample number, and other written data are recorded with a 35 mm camera to provide a permanent record.

EQUIPMENT DESCRIPTION

The overall system, completely mounted on a castored steel table, comprises three principal sections; namely, the electromechanical, the counting, and the recording sections.

The electromechanical system utilizes a servo system for indexing and a motor driven slide for handling the samples.

The counting section utilizes a commercial scaler(1) which provides for manual, pre-set count, pre-set time, and count-time operation.

The recording section employs a 35 mm, automatic camera(2) with a 36 mm, f/3.5, Wray "Supar" anastigmat lens in a calibrated mount, and a 24-volt power supply.

OPERATION

The sample changer was designed to be easily adaptable to the present methods used in the radiochemical control laboratory. It will handle the aluminum sample holders now used in the counting room.

Routine samples are delivered to the laboratory daily and are loaded into the sample rack of the automatic sample changer. Each sample is removed from the rack by the motor driven slide, pushed into the lead pig, counted for a predetermined time or count, and returned to the rack. Then the servo system indexes the rack one position and the next sample is inserted automatically into the pig for counting.

(1) Nuclear Instrument and Chemical Corporation; Model 192X Ultrascaler.
(2) D. Schackman and Sons; Mark III.
Selected samples are counted several times with fixed time intervals between each counting period to obtain decay rate data necessary for plotting decay curves. A maximum of 50 of these selected samples may be loaded into the sample changer. The rack of samples can be returned to the number one position after 10, 20, 30, or 50 samples have been counted, the number of which is determined by the position of the selector switch on the front panel. The length of time between the successive countings of a particular sample is determined by the number of samples to be counted and by the length of time of the counting period.

Background counts are required periodically and may be obtained by inserting blank plates which will be counted for the same length of time as each of the samples. To obtain longer background counts for improved accuracy, a special background plate which actuates a switch that interrupts current flow to the timer motor can be inserted into the rack. This plate must be manually removed to end the counting period.

After a new mica-window tube is installed, it is necessary that a known sample be counted several times to insure that the tube and associated counting equipment are operating satisfactorily. This operation may be accomplished automatically by inserting the known sample in the rack at the indexed position and turning off the power to the servo indexing unit.

The complete system, shown schematically in Figure 1 and pictorially in Figures 5 and 6, is comprised of three principal sections; namely, the electromechanical, the counting, and the recording sections.

The Electromechanical System

The electromechanical section includes the servo system, motor driven slide, gear box, associated switches and relays, and the drive motor. A complete circuit diagram is shown in Figure 3.
After fifty prepared samples are loaded into the rack, placed in the automatic sample changer and the instrument is energized, the motor driven slide pushes one sample into the lead pig for counting. As the sample is withdrawn, each of the sequentially operated shaft cam switches close. Switch number 4 (Figure 1) energizes the coil of the camera that records all data, number 3 closes and resets the scaler, and number 1 energizes the coil of the stepping relay. The rack of samples is indexed and another sample is pushed into the lead pig. Switch number 2 starts the counting cycle and is held closed by the cam until the counting of the sample is completed.

Indexing of the samples is accomplished with a servo system. The balancing potentiometer, balancing motor, and sample rack are connected through a gear train. When the stepping switch is advanced to the new position, the voltage difference between the trimming potentiometer for that position and the balancing potentiometer is amplified in the servo amplifier. The amplified signal drives the balancing motor until the voltage of the balancing potentiometer and the trimming potentiometer are equal. When these voltages are equal, the rack is indexed at the new position.

Safety Devices

Three safety devices are incorporated to protect different portions of the system. When the instrument is indexing, a portion of the signal to the servo motor operates a relay whose contacts open and de-energize the drive motor circuit. When the rack is returning to position 1, switch number 6 prevents the motor from operating until the rack is indexed. These features prevent the slide from being pushed into the rack except when it is in an indexed position.

A spring loaded clutch protects the drive motor against overloading. If the clutch becomes disengaged, a phosphor bronze clip which bridges the clutch is released and touches a brass stop. Using this stop and motor shaft as ground, a 6 volt relay is energized whose contacts stop the drive motor.
Two series cadmium sulfide photocells, one located on each side of the rack of samples, are shielded from the light when the motor driven slide moves into the lead pig. The resulting resistance increase in these cells causes a second relay to de-energize which has contacts in the signal lead of the servo motor and prevents the system from indexing.

**Counting Section**

The counting section consists of a mica-window GM tube and the scaler. The various modes of operations of the scaler which may be selected include predetermined time, predetermined count, and predetermined time-count.

The automatic timer, used to select the predetermined time, is continuously adjustable from 0 to 60 minutes in minimum increments of three seconds. The pre-set count selector knob is adjustable for 10, 100, or 1000 register counts. Scaling factors of 4, 10, 40, 100, 400, and 1000 are available in the scaler. By combining the operation of these switches a wide range of pre-set counts is available.

**Recording Section**

The recording section utilizes a 35 mm, 150 exposure, automatic camera with a 36 mm, f/3.5 lens, two 4 x 5 mirrors, and auxiliary lights. The film is advanced by a spring motor which is wound each time the camera is loaded and the shutter is triggered electrically with a 24 v d-c power supply. A wiring diagram is shown in Figure 4.

Data recorded on the film include the date, time of day, time of count, predetermined time or count setting, count, sample number, written information on the sample dish, and all switch positions on the face of the scaler. The written information on the sample dish is reflected into a vertical plane by two 4 x 5 mirrors. Data from a test sample are shown in Figure 2.
A 300-watt flood lamp and a 60-watt bulb are used for auxiliary lighting. An exposure time of $1/25$ second is used to photograph data on the moving sample plate clearly. An aperture opening of $f/3.5$ provides the correct amount of light and a sufficient depth of field to photograph all data.

Recorded data for any group of samples can be removed from the camera at any time. After developing the film by a standard photographic process, the results can be interpreted and read out by using a viewer. Each roll of film may be filed for future reference.

**Operating Sequence**

The operating sequence for a routine sample is as follows:

A. Manual

I. Load 50 samples in their aluminum holders into the rack.

II. Insert the rack into the Automatic Sample Changer. The rack will seat at an indexed position determined by the position of the stepping switch.

III. Energize the instrument.

IV. Advance the stepping switch to the number 1 position by moving the selector switch to 10 and manually operating Switch No. 1 until the stepping relay automatically moves to position 1.

B. Automatic

I. The slide and sample are pushed into the lead pig after the rack is indexed.

   A. Microswitch number 2 is held closed by cam.
      1. The timer is energized.
      2. The drive motor relay contacts open thus stopping the motor.
      3. The count cycle is started in scaler.
II. The Count Period ends as determined by the timer setting.
   A. The timer is timed out.
   B. The drive motor relay contacts close and start motor again.

III. The slide and sample are withdrawn from the lead pig.
   A. Switch number 2 opens.
      1. The timer is de-energized and reset.
   B. Switch number 4 is momentarily closed.
      1. The coil in the camera is energized.
   C. Switch number 3 is momentarily closed.
      1. The scaler is reset to zero.
   D. Switch number 1 is momentarily closed.
      1. The stepping switch is advanced one position.
         a. The unbalanced voltage between balancing potentiometer 
            and trimming potentiometer is used as input signal 
            to the balance unit.
         b. The amplified output signal from the balance unit 
            drives the balancing motor.
            1. The drive motor relay contacts open thus stopping 
               the motor.
         c. The balancing potentiometer is driven until it reaches 
            the same voltage as the trimming potentiometer.
            1. The drive motor relay contacts close and start the 
               motor again.

IV. Start for a new cycle automatically.
CONCLUSION

The chief function of the automatic sample changer is to count samples for a pre-set time automatically. However, the instrument is versatile and can be used in a variety of ways. Any group of samples may be counted for a predetermined time, a predetermined count, combination of predetermined time and count, or manually.

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M. O. Rankin

R. A. Harvey
FIGURE 1
SAMPLE CHANGER BLOCK DIAGRAM
FIGURE 2
PHOTOGRAPH SHOWING RECORDED DATA, USUALLY READ FROM NEGATIVES
FIGURE 4

WIRING DIAGRAM FOR AUTOMATIC CAMERA
FIGURE 5

COMPLETE SYSTEM IN OPERATION
FIGURE 6

RACK AND INDEXING MECHANISM