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AUTOMATIC SCAN SYSTEM FOR REACTOR-FUEL ASSAY

by

Thomas H. Busse and Norman S. Beyer

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Special Materials and Services Division

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INTRODUCTION

The Automatic Fuel Scan System is basically an auto-gamma spectrometer¹ with automatic sample changer,² automatic X-Y scanner,³ and digital printer.⁴ The X-Y fuel-plate scanner has been developed and integrated with the commercial equipment, thus expanding the total system capability. Total system physical and electrical relationships are presented in the block diagram of Fig. 1.

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Fig. 1. Automatic Fuel Scan System Block Diagram

¹Packard Instrument Company, Inc., Single Channel Analyzer Model 410A.

²Packard Instrument Company, Inc., Sample Changer and Model 500D Controller.

³Quality Evaluation Section, Special Materials Division, Argonne National Laboratory.

⁴Monroe-Packard, Model 510D Digital Printer.

DESCRIPTION AND OPERATION

The scanner is primarily a machinist's lathe,⁵ modified to function as an automatic X-Y scanning device. The chuck, toolholder, tailstock, etc., were removed and additional equipment necessary to our purpose installed. This consisted of an electrically controlled, pneumatic, gear-shifting mechanism to control the carriage for X scanning. The installation of this mechanism is shown in the lower portion of Fig. 2. The carriage cross-feed is positioned by a reversible motor, driving the lead screw to provide Y scanning. The photomultiplier support replaces the toolholder and positions the detector over the fuel-plate table, which was also attached to the lathe. Figure 3 shows the overall scanner in operation, including the scanner control (Scan Control) box.

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Fig. 2. Pneumatic Controls and Gear-shifting Mechanism

⁵ LeBlond Lathe (10 ft).

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Fig. 3. Scanner Portion of Automatic Fuel Scan System

The scanner control box shown in Fig. 4 is located on the carriage and controls all scanning functions. These include the POWER switch, LEFT-RIGHT and STOP functions, choice of X or X-Y scanning modes, the option to select a preset number of scans before the system automatically shuts down, X and Y scan counters (TOTAL X SCANS and TOTAL Y SCANS) and a TOTAL SCAN TIME indicator. These controls, when manually operated, instantly override the automatic operation and are duplicated at the operator console.

The console assembly consists of a desk console and two additional cabinets which house all the electronic equipment. The console arrangement is shown in Fig. 5. The cabinet to the right of the desk contains the single-channel analyzer, a high-voltage stabilizing device,⁶ and the automatic controller that operates the sample changer and digital printer. The cabinet to the left of the desk contains a recording ratemeter⁷ and additional space for future expansion of the system. The printer is located on the desk in front of the operator.

In operation, the fuel plate and detector are positioned by the operator. The number of scans is preselected, and the automatic operation is initiated manually. After each X scan, the detector comes to rest and the

⁶ Cosmic Radiation Inc., Spectrostat Model 1001.

⁷ Packard Instrument Company, Inc., Model 380.

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Fig. 4. Scanner Control Box
Mounted on Lathe
Carriage

150-366

Fig. 5. Console Assembly Portion of Fuel Scan System

scan number, scan-time duration, and total accumulated count is printed on a paper tape. Upon completion of the print-out, the detector makes a second pass in the opposite direction. Scanning and printing continue until the preselected number of scans is completed, at which time the system shuts down automatically.

The system also incorporates a number of safety back-up devices, which take over or shut down the system should there be a component failure, power failure, or loss of pressure for the pneumatic system. A portion of the pneumatic safety system is shown in the upper part of Fig. 2. The push-button controls on the Scan Control box are also illuminated indicators, which show the operating state of the scanner at all times. Scanning speeds and dimensions are adjustable, allowing for a versatile scanning pattern with the basic form indicated in Fig. 6.

NOTE: THE ANGLE α IS GREATLY EXAGGERATED FOR THE PURPOSE OF ILLUSTRATION.
THE ACTUAL ANGLE WOULD BE IN THE AREA OF FROM 1° TO 4° .

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Fig. 6. Scanning Pattern Produced by Scanner

In addition to being a fine production tool, the Automatic Fuel Scan System also serves as a developmental system for improving many aspects of the scanning technique. It is anticipated, therefore, that periodic changes both in the equipment and its use will occur in order to keep its production and experimental usefulness at its peak. Significant changes will subsequently be reported in detail as their importance dictates.

RESULTS

During the 6-month period since the system became operational, several minor discrepancies were corrected. Pneumatic-pressure adjustments, relay-contact cleaning and adjustment, and final mechanical alignments were the areas in which debugging was required. On several

occasions, the compressed-air-supply pressure fell below acceptable limits and the automatic reserve supply switched in normally, thus providing continuous operation.

The electrical safety system, which includes a fail-safe device that automatically disengages the lathe drive in the event of a power failure, also functioned normally on several occasions. The audible alarm associated with this device failed after an abnormally long "on" period. It is being replaced with a more substantial unit.

The scanning system has been successfully used for fuel analysis on two occasions utilizing only the X mode of operation and is presently undergoing set-up adjustments for scanning in the X-Y mode. The first real test of the system was realized when approximately 1,300 2-in.-sq

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Fig. 7. Positioning Jig for ZPR-6 and ZPR-9 Fuel Plates

plates for the ZPR-6 and ZPR-9 reactors⁸ were scanned and counted. These plates were arranged on the fuel-plate table with the aid of a positioning jig as illustrated in Fig. 7. Spacing between the fuel plates, the detector velocity, and the counting-time duration before print-out, were all selected so that several plates were being scanned during one pass of the detector, data being printed after each plate was passed. The ability to adjust the system parameters in this manner proved to be extremely useful in this application. A second positioning jig was employed for setting up fuel plates for the next pass while the

first set of plates was being scanned. This greatly sped up the entire operation. The data accumulated and printed by the single-channel analyzer for each plate was typical and requires no further discussion at this time.

The second application of the scanning system was the analysis of approximately 240 fuel-rod assemblies associated with the PURE⁹ Project. Each rod was approximately 52 in. long and 1/2 in. in diam and contained 96 uranium pellets. The pellets were normal in some of the rods and 6% enriched in the others. Detector motion was also as shown in Fig. 7, the detector being conveyed along the entire length of the rod. To facilitate a more complete analytical inspection, additional equipment, in the form of a 400-channel analyzer¹⁰ and an X-Y plotter,¹¹ was employed. After the detector passed over a complete rod, the single-channel analyzer provided a total rod count while the multi-channel analyzer provided four

⁸ Zero Power Reactors-6 and -9, Argonne National Laboratory.

⁹ Plutonium-Uranium Recycle Experiment, Argonne National Laboratory.

¹⁰ R.C.L. 400-channel Analyzer and Display Scope.

¹¹ Moseley Autograf X-Y Recorder, Model 2D-2.

channels of its total capacity for each of the 96 pellets. The X-Y plotter then printed a permanent comprehensive picture of the fuel rod's level of activity. The plotted results from a typical rod are illustrated in Fig. 8A. The pellets are normally held against each other by means of spring tension at the end of the rod. Several of the rods inspected had gaps between the pellets due to spring-tension failure. Figure 8B illustrates the results from the inspection in which a gap of approximately $3/4$ in. had occurred between two of the pellets. Here again, system versatility provided a relatively straightforward method of analyzing another of the infinite variety in fuel-assembly configurations.

The most recent fuel plates submitted for analysis require X-Y scanning as illustrated in Fig. 6. Preliminary set-up for these plates has revealed the problem of intermittent noise pulses prematurely triggering the analyzer print-out. These pulses are being generated by the Y motor-reversing circuitry. An improved reversing circuit is presently under design to correct this problem.

CONCLUSION

The Automatic Fuel Scan System has evolved out of the ever-growing need for instrumentation of this type. The adaptation of existing equipment for automatic operation, such as the machinist lathe, has presented some unique and chal-

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Fig. 8. Plotted Results of Two Fuel Rods

lenging problems. Based on the results of several months of continued successful operation, most of these problems have been adequately solved. It is naturally expected that other minor difficulties will be encountered as the system continues to be used. However, we are rapidly nearing the point at which routine periodic maintenance is all that will be required to sustain operation.

Use of the system to date has indicated definite areas in which future scanning systems could provide considerably improved operation. The ability to program automatic operation would be very useful. Although this system was designed for automatic operation with preset scanning parameters, automatic operation with programmed parameter changes would vastly improve the versatility of the system.