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PNEUMATIC SYSTEM FOR TRANSFERRING RADIOACTIVE SAMPLES

by

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DISCLAIMER

Proposed running head:

PNEUMATIC SAMPLE TRANSFER SYSTEM

PNEUMATIC SYSTEM FOR TRANSFERRING RADIOACTIVE SAMPLES*

ABSTRACT

A pneumatic sample transfer system has been installed at the Savannah River Laboratory. Radioactive liquid samples are transferred from inside a shielded research cell to a shielded analytical chemistry cell 125 meters away. Samples are drawn into 4-mL glass vials which are sealed in polyethylene capsules. The capsules are propelled by compressed air at high speed through a 1-inch polyethylene tube. Equipment is provided for sealing and opening the polyethylene transfer capsules. The system has operated for 12 months, and 500 samples have been transferred successfully.

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INTRODUCTION

The Savannah River Laboratory has shielded research cells in which chemical process studies are made using highly radioactive materials. Cells are viewed through 3-ft-thick lead-glass windows, and operations are performed with master-slave manipulators. As the cells were originally constructed, analytical samples were loaded into a transfer cask, removed from the cells, and manually transported to a separate analytical facility 125 meters away. These operations were very time consuming because of the care needed to avoid spreading radioactive contamination and exposing personnel to excessive radiation.

This paper describes a recently installed pneumatic transfer system for conveying radioactive analytical samples between two highly contaminated facilities. Compressed air propels a sealed capsule through a flexible plastic tube connecting the research cells to the remote analytical cell. The system comprises (1) a capsule sealer, (2) an air supply, (3) a loader, (4) a diverter, (5) a control system that monitors the location of the capsule and operates air valves, (6) a receiving station, and (7) a capsule opener. These components and their operation are described below.

DESCRIPTION

Sample Preparation

Liquid radioactive samples are contained in 4-mL glass vials with Bakelite® (Union Carbide) caps and polyethylene sealing gaskets. The vials are inserted in high-density polyethylene capsules (Figure 1). The capsules are 7.11 cm long by 2.25 cm in diameter. The capsule cap snaps into a groove in the capsule body. A foam rubber cushion prevents movement of the vial inside the capsule. Capsules are numbered to aid in identifying samples and weigh approximately 40 g when loaded.

A capsule holder (Figure 2) is provided to minimize surface contamination of the capsules during sampling operations in the research cells. A wire bail is provided for handling. The holder is made in two pieces, an upper and a lower section, which are taped together after empty capsules are placed in the lower section. A plastic sheath is taped to the holder to keep the bottom and sides clean. In the research cells, sample vials are inserted into the capsules through holes in the upper section of the holder. When the holder is full of samples, it is transferred to the sending cell. In the sending cell, the plastic sheath and upper holder section are removed before the holder is placed on a clean piece of plastic. Clean tongs (held by the manipulator) are used to handle the capsules.

A capsule sealer (Figure 3) is installed in each of two sending cells. The sealer presses the cap into the capsule, heats the polyethylene seal area to flow temperature, then press-seals the cap to the capsule body.

Pneumatic Transfer System

The pneumatic transfer system is shown schematically in Figure 4. (The sending cells referred to above are shown in the schematic as HLC Cells 6 and 7.) Each of the two sending cells contains a sample loader. A loader is a slotted stainless steel tube with a movable sleeve which can be positioned to either expose or cover the slot. O-ring seals are provided between the tube and sleeve. Capsules are loaded by inserting them into the tube slot. When a capsule is loaded, it drops past a photoelectric cell (PC) that signals the control circuit that a capsule is loaded. A limit switch signals the position of the loader closure sleeve. If the loader is open, the system cannot be operated.

One side of the loader is piped to a compressed air storage tank. Storage tank pressure is regulated at 20 psig. A pressure switch on the tank prevents operation of the transfer system if the pressure is below 15 psig. (A tank pressure of 10 psig would be sufficient to make a pneumatic sample transfer.) The tank is sized to allow completion of a transfer even if the tank air supply system fails. Check valves prevent tank pressure bleed-back into the supply system. Electrically operated send valves control the flow of air from the storage tank to the sample transfer tube.

A 1-inch (2.54 cm) ID heavy-walled polyethylene tube connects the two sample loaders at the research facility with the analytical cell 125 meters away. An electromechanical diverter is installed to connect either of the loading stations to the transfer tube. Limit switches prevent operation of the system unless the diverter is in its proper position. Photoelectric cells are installed strategically along the transfer tube to monitor the progress of a capsule during a transfer. The progress is shown on a graphic display panel on the master control console.

The transfer tube was installed with long radius (0.5 meter) bends and smooth surface connectors and fittings to ensure the free, rapid movement of the capsule. All joints were leak-tested at 38 psig air pressure using leak detector solution to ensure that they were leak free.

The pneumatic transfer tube terminates at the dilution cell sample receiving station. A cushion of air, trapped in the transfer tube between a motor-driven ball valve (drop valve) and an air vent line, decelerates the sample capsule through the last 4 meters of travel so that it comes to rest gently at the drop valve. A photoelectric cell signals that the capsule is at the drop valve. The vent line is equipped with an electrically operated vent valve and a pressure switch (PS) and discharges into a glove box. The vent valve is closed except during transfers. The pressure switch is wired into the logic control system to prevent operation unless adequate negative pressure exists in the vent line and the glove box to accommodate the transfer air vent volume.

When a pneumatic sample transfer is completed, the drop valve can be opened to allow the sample capsule to drop by gravity into the dilution cell. The drop valve can be operated manually if the motorized operator fails.

The capsule opener (Figure 5) is located in the dilution cell. The capsule is held between two rotating jaws. A heated knife edge is held against the center of the capsule by spring pressure. The hot blade melts the polyethylene in a line around the capsule. When a cut is complete, the upper jaws, which are counterweighted, raise the upper part of the capsule and expose the upper part of the sample vial.

The main control console (Figure 6) is located at the dilution cell and contains the logic circuits that control the sample transfer operation. The logic circuits prevent a transfer unless the following conditions are met: (1) proper storage tank air pressure, (2) capsule is in the loader, (3) loader is closed, (4) drop valve is closed, (5) adequate negative pressure in the vent line, (6) the diverter valve is in the selected position, and (7) the vent valve opens. The main console has a graphic display panel that shows system conditions and the relative sample location as it passes through the transfer tube. Emergency override switches are provided to operate the send valve and vent valve. Sound-powered phones are installed for communication between the console and the sending station panels at the research facility. Sample transfers can be initiated only from the main control console.

The sending station panels contain a selector switch to control the diverter position. The panels also have a call button for the sound-powered phone and indicator lights to show when the power is on, send valve is open, capsule is loaded, and loader is closed. An audible alarm sounds if the loader is open while a capsule is loaded.

PERFORMANCE

The pneumatic sample transfer system allows radioactive samples to be transferred rapidly with insignificant radiation exposure to personnel or hazard of a radioactive spill. Less than one man-hour is required to seal the sample in a polyethylene transfer capsule, make the pneumatic transfer, and cut open the capsule. Radiation exposure is insignificant even though the transfer tube is unshielded and passes through personnel-occupied areas, because the sample travels through the transfer tube at 18 m/sec and exposes personnel to radiation for only a very short time.

The safe operation of the pneumatic transfer system is enhanced by the integrated logic control system that prevents a sample transfer unless preselected conditions controlling the transfer are satisfied.

The pneumatic transfer facility has been in operation for a year, and over 500 analytical samples have been successfully transferred. Routine inspection, pressure tests, and radiation smear surveys have shown that the system has remained leak free. A smear survey inside the transfer tube showed transferable contamination of less than 10^3 d/m alpha per 100 cm^2.

ACKNOWLEDGMENTS

B. M. Allen, Jr., Savannah River Laboratory, for design of the capsule opener.

V. W. Walker, Savannah River Laboratory, for design of the capsule sealer, the sample diverter, and the pneumatic transfer equipment.

W. J. Woodward, Jr., Savannah River Laboratory, for design of the logic control system and graphic display panel.

LIST OF FIGURES

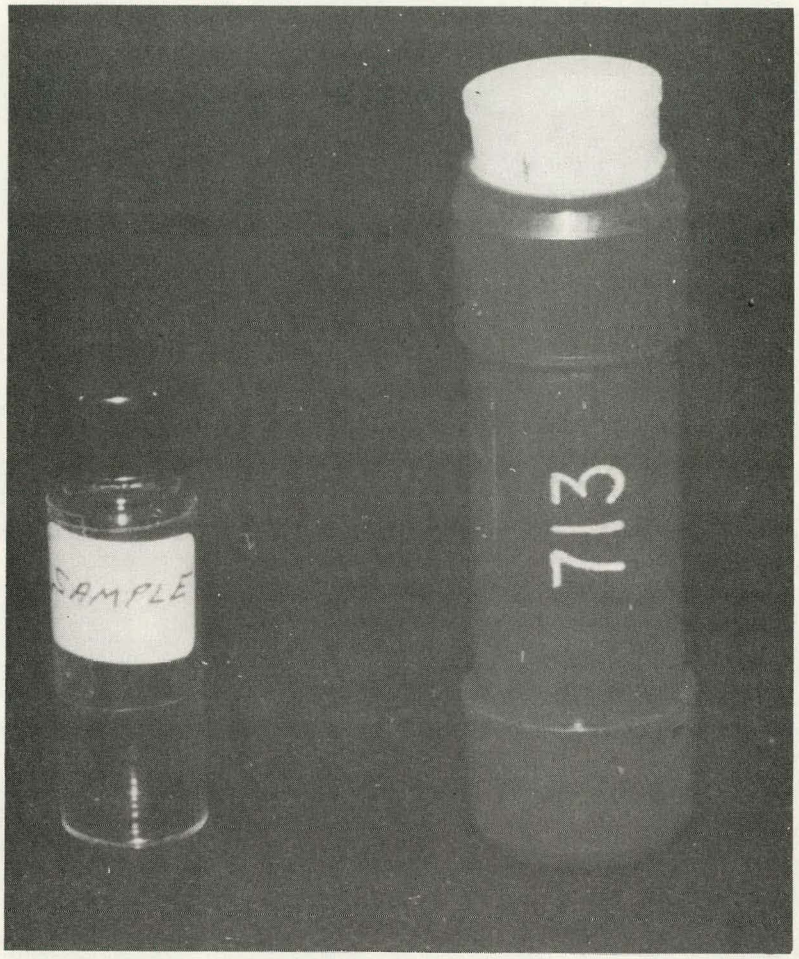

FIGURE 1. Capsule and Glass Vial

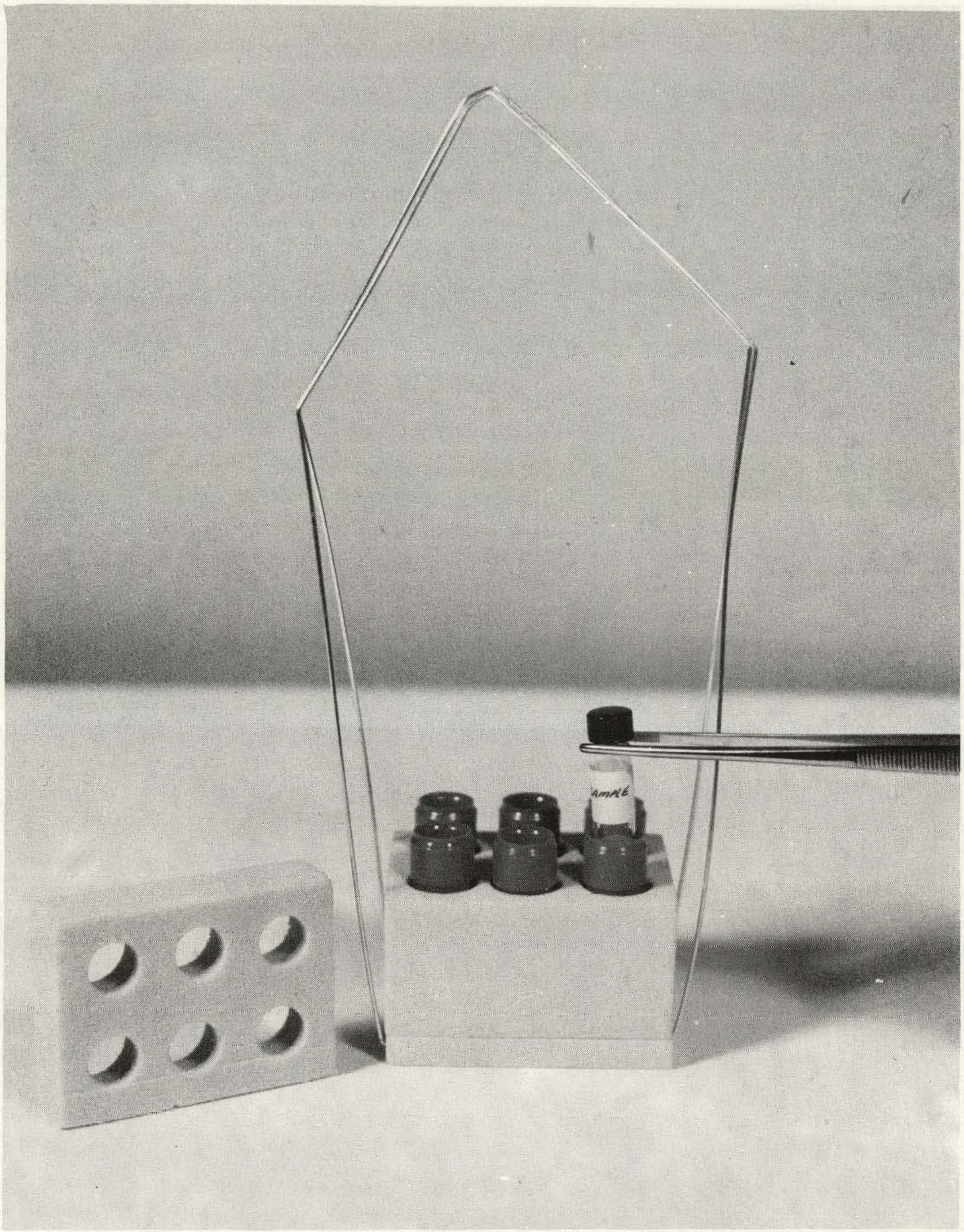

FIGURE 2. Capsule Holder

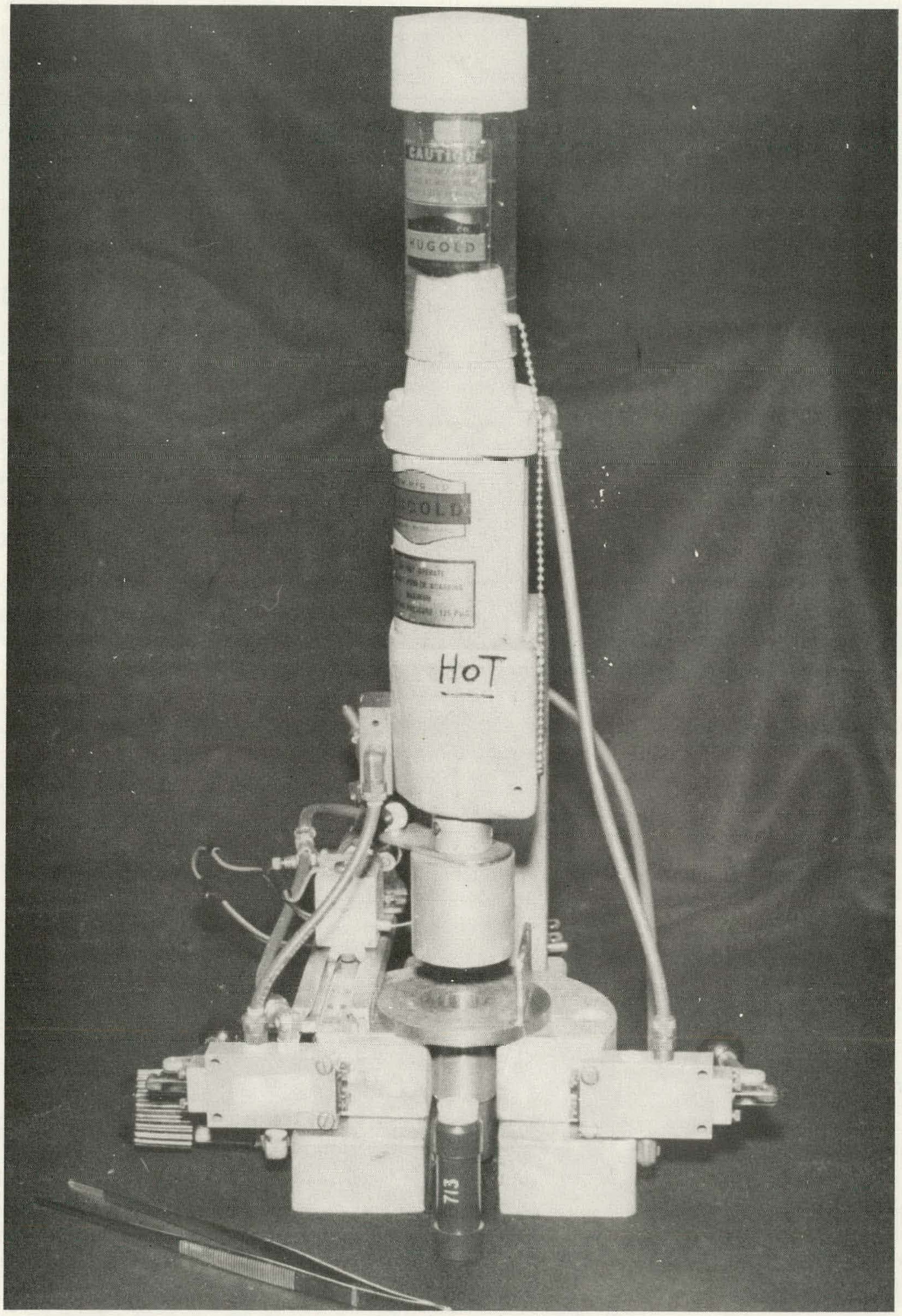

FIGURE 3. Capsule Sealer

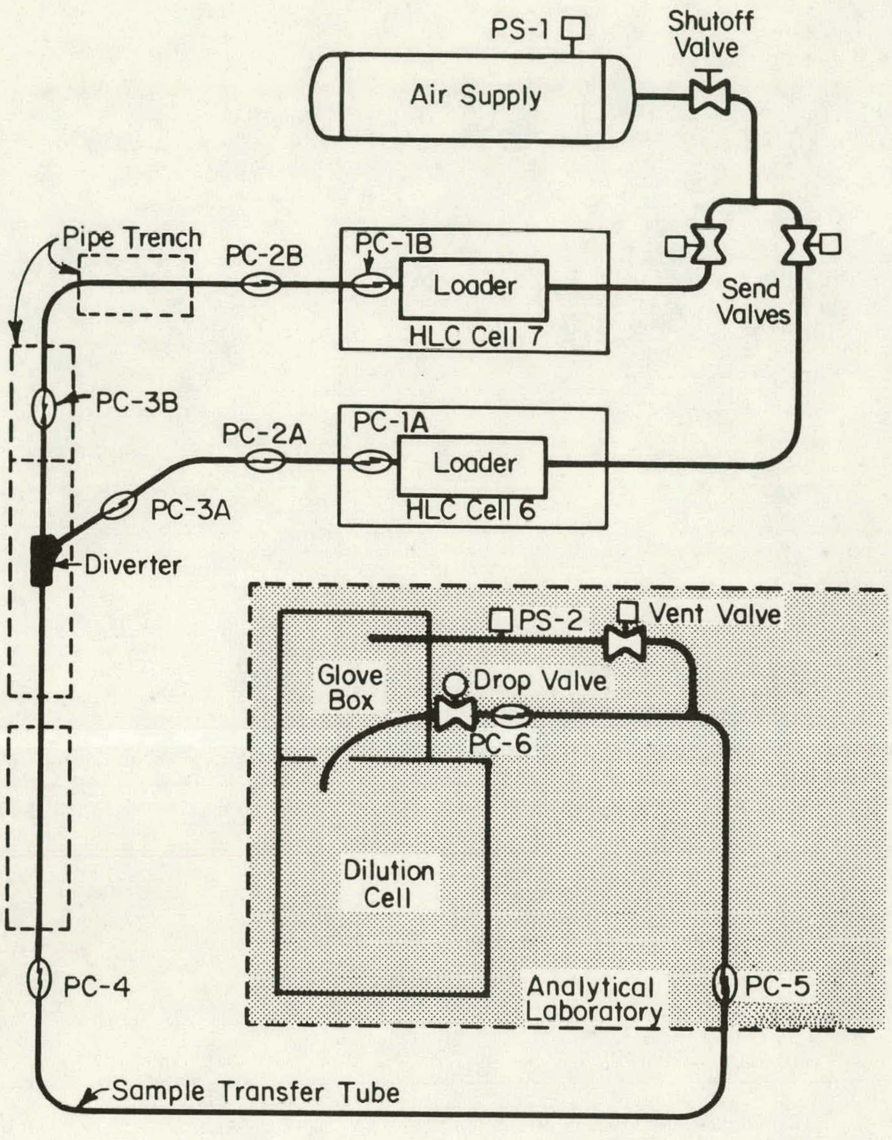

FIGURE 4. Pneumatic Transfer System Schematic

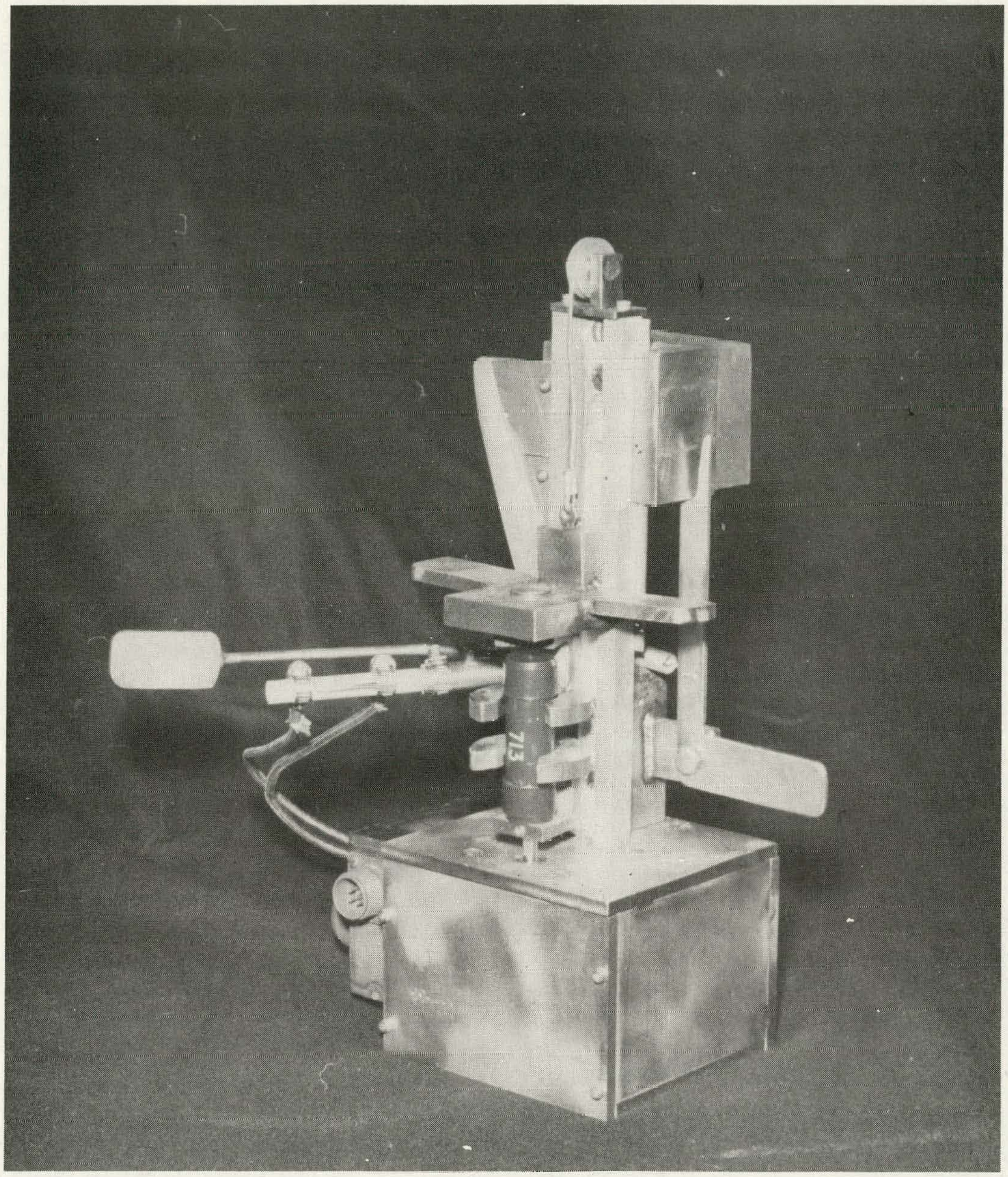

FIGURE 5. Capsule Opener

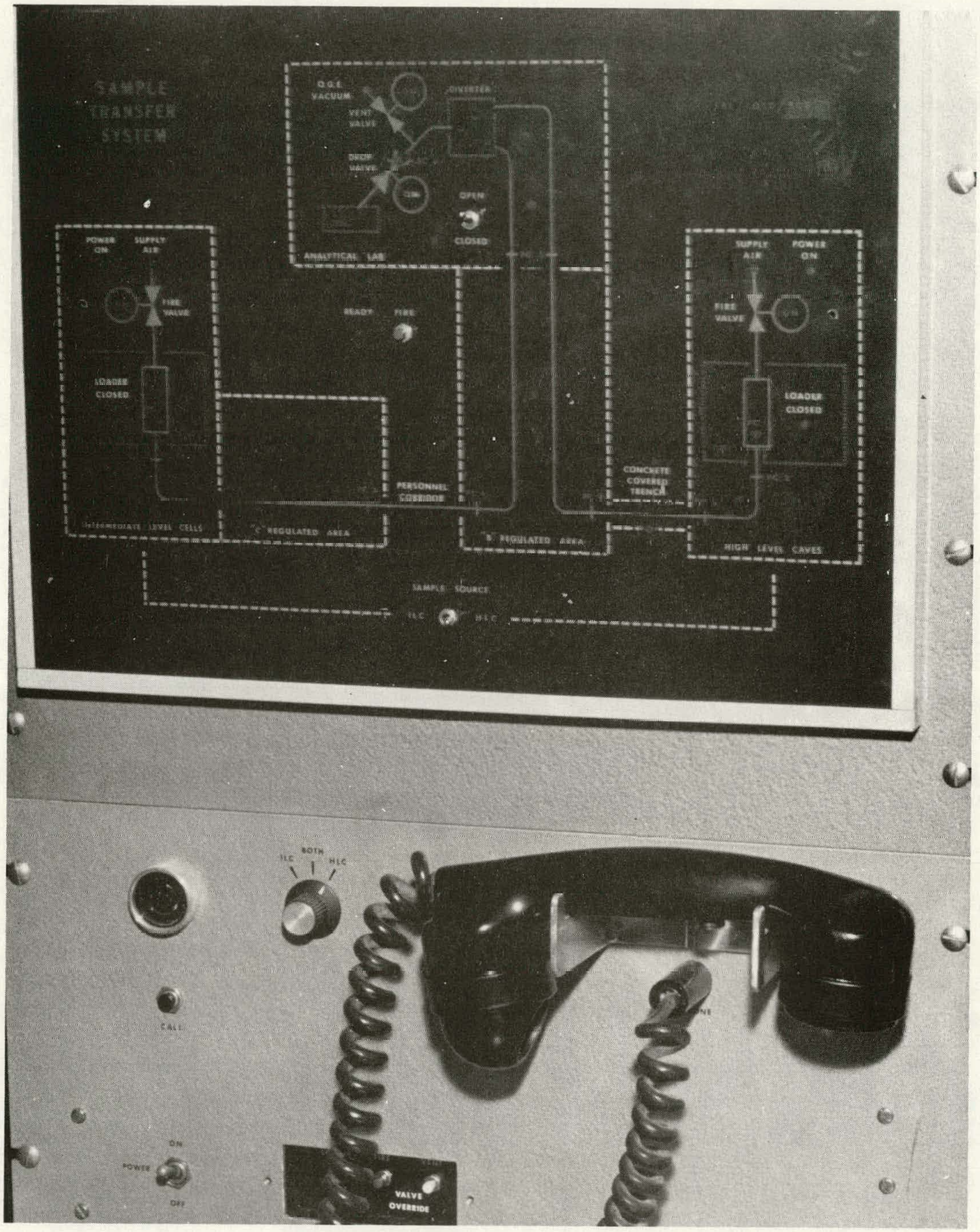

FIGURE 6. Main Control Console