A CALIBRATED DOSE DISPENSER FOR GASEOUS ^{133}Xe

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A device that permits accurate dispensing of individual doses of ^{133}Xe from multicurie ampuls is described. The advantages include economy, flexibility in dose selection, and radiologic safety.

The importance of pulmonary ventilation imaging with radioactive gases has been appreciated for many years. When used in conjunction with the traditional perfusion lung scan, the diagnosis of pulmonary embolism becomes considerably more reliable. Areas that are poorly perfused but adequately ventilated have a very high probability of being involved in the embolic process (*1–3*). In addition, studies of regional lung function and scintillation camera radiospirometry have grown in importance (*4*).

The cost of keeping ^{133}Xe on hand in individual doses has retarded the development of ventilation imaging. We describe here a dose dispenser for gaseous ^{133}Xe which, in a typical department, may reduce the cost of studies with radioxenon by a factor of 2–5. The ^{133}Xe gas can be purchased in less-expensive multicurie amounts and simply dispensed with simultaneous dose calibration for individual patient use.

The system is designed to dispense the required amount of ^{133}Xe gas from a shipping ampul through a metering valve into a serum vial. The dose of radioactivity deposited in the serum vial is measured by a calibrated G–M counter.

METHODS AND MATERIALS

Components. As indicated in Figs. 1 and 2, there are four components in the system: the ampul housing, metering valve assembly, serum-vial shield, and the G–M counter. The ampul housing is a steel cylinder with a $\frac{3}{32}$-in.-thick lead insert fabricated to accept the standard 5-cc Oak Ridge National Laboratory flame-sealed multicurie ^{133}Xe shipping ampul. A removable steel plug seals the left-hand end of the housing and is locked in place by a knurled thumb-screw. At the opposite end of this housing a hole permits the tubular end of the gas ampul to extend into the metering valve assembly.

A high-vacuum "O" ring disconnect, a needle valve, and a male Luer–lok adapter, all soldered in series, comprise the metering valve assembly. The "O" ring provides a demountable seal for the gas ampul. The needle valve regulates the flow of ^{133}Xe gas through the 26-gage-metal or plastic-hub hypodermic needle, mounted on the Luer–lok connector, and into an evacuated serum vial contained in the serum vial shield.

The serum vial shield is a steel cylinder with a sliding lock on one end to provide access for a 2-cc serum vial. An opening on the opposite end permits the septum of the serum vial to be exposed and punctured by the needle on the metering valve assembly. A 2-mm hole in the side of the cylinder allows the radiation from the contents of the vial to be monitored by a shielded collimated G–M tube connected to a conventional laboratory rate meter. The position of the counter assembly can be adjusted to obtain a reading on the rate meter appropriate to the activity of the vial.

All components are mounted on a steel plate equipped with a pivot to permit the system to rotate 360 deg. All connections must be vacuum-tight in order to maintain a safe, economical, and accurate operation. A floating steel rod is used to break the delicate seal on the tubular end of the gas ampul.

Operations: *Loading.* The system is loaded with the "O" ring seal loosened, the metering valve closed, the ampul housing plug removed, and the mounting plate rotated with the open end of the housing in a slightly elevated position. The steel ampul breaker is inserted through the open end of the ampul housing and located in the "O" ring assembly. The ^{133}Xe

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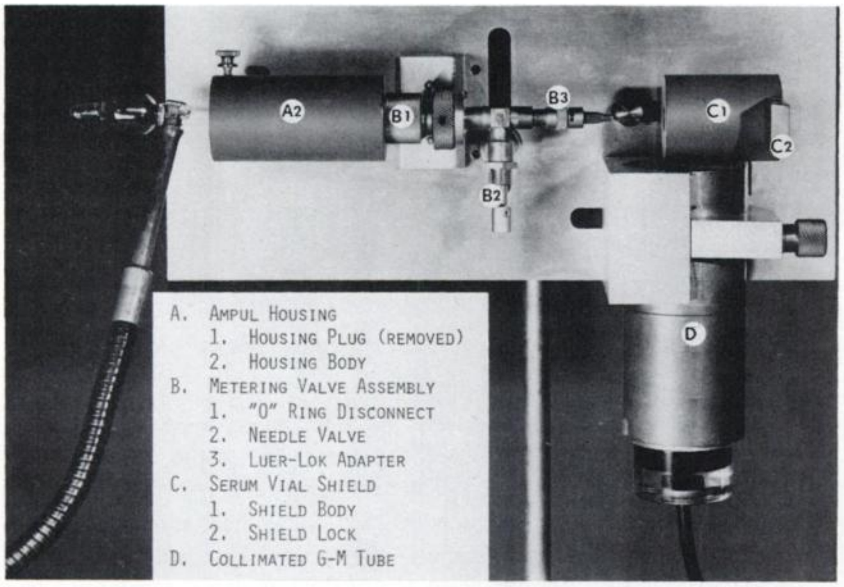

FIG. 1. Xenon-133 ampul is loaded into shielded housing with remote handling device. Seal breaker (not shown) is positioned in metering valve assembly. See text.

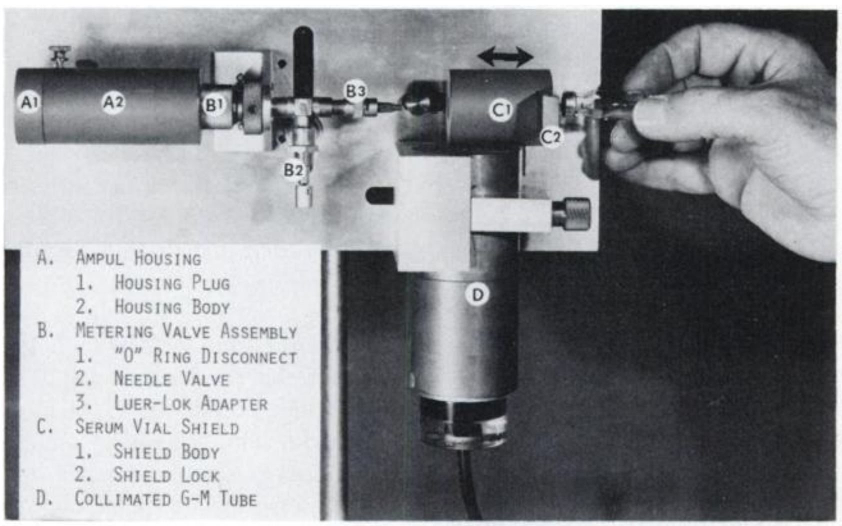

FIG. 2. Evacuated vial is inserted past sliding lock into serum vial shield (shown in retracted position). Note that ampul housing plug is in place. See text.

gas ampul (Fig. 1) is loaded, using remote handling devices and radiation shielding, so that the tubular end slides over the steel ampul breaker and rests in the "O" ring. The housing plug is locked into position and the "O" ring's compression ring is tightened to seal the ampul in the system. The mounting plate is rotated sharply to allow the steel ampul breaker to fall and break the flame seal in the tubular end of the gas ampul.

Dose dispensing. Individual doses of ^{133}Xe gas are dispensed in sealed evacuated Wheaton No. 223713 2-ml serum vials. A vacuum pump with a hose adapted to a 25-gage hypodermic needle is used to evacuate the sealed serum vials. Adequate evacuation is indicated by a slight depression of the rubber stopper.

An evacuated vial is loaded and locked into the serum vial shield (Fig. 2). The latter is then moved along the slot in the mounting plate so that the needle of the metering valve assembly punctures the septum and enters the vial. The metering valve is carefully opened. When an appropriate reading is obtained on the precalibrated laboratory monitor, the valve is closed. (The monitor is calibrated using a known activity of ^{133}Xe gas in this same orientation.) The serum vial shield is moved back along the slot in the mounting plate to disengage the vial from the needle. The vial is transferred to a lead shield and the calibration is confirmed with a dose calibrator. The system is stored under an exhaust hood with an empty serum vial in the dispensing position as a precaution against gas leaks.

RESULTS

The system provides up to twenty-four 10-mCi doses from a 1-Ci ^{133}Xe gas ampul over a 3-week period. It has been in regular use for about a year. The ^{133}Xe is obtained from Oak Ridge National Laboratories for $95.00 per Ci. (This includes all handling and delivery charges.) The dispensing vials are compatible with New England Nuclear's "Calidose" system, which we find convenient for the administration of the dose to the patient.

The loading operation takes less than 2 min from unpacking the gas ampul to compressing the "O" ring. The ^{133}Xe gas ampul is unshielded for less than 30 sec during this time. Radiation readings were obtained with a Victoreen Model 444 ion chamber at the surface of the ampul housing, when the ampul contained 532 mCi of ^{133}Xe. They were 6 mR/hr with the flame seal intact and 10 mR/hr with the seal broken. The dose indicated on the rate meter agrees with the dose calibrator to within $\pm 5\%$.

The "O" ring and Luer–lok seals have been effective in maintaining a gas-tight system. The xenon gas is maintained at or below atmospheric pressure at all times, thus minimizing the possibility of leakage of xenon to the outside.

DISCUSSION

The ^{133}Xe-dispensing system combines the advantages of unit-dose and multiple-dose dispensing systems. Preparing doses in 2-ml serum vials permits accurate calibration of the individual doses and simplified radiation-shielding techniques. Individual doses can be dispensed on an "as needed" basis or, if desired, doses can be prepared to precalibrated vials several days prior to use. With this system the average cost for a 10-mCi patient dose is $5. The system is stored and used in a vented fume hood, which minimizes personnel exposure in the event of leakage of ^{133}Xe gas.

The authors will provide working drawings to individuals wishing to construct this system.

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