# IONIZATION CHAMBER RADON MONITOR WITH PULSE COUNTING MODE

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## INTRODUCTION

There is a special need for continuous radon meters in studying radon entry and possible countermeasures against high radon concentrations in existing houses. In these studies, a wide concentration range and a fast response are required, as is a movable sampling probe for active sampling. In addition, the meters have to be portable to be suited for field use.

Traditional methods for radon measurement are the two-filter method (9), the electrostatic method (1), the scintillation chamber (5) and the ionization chamber (2). All of these methods can be applied to continuous measurement and relatively fast responses can be achieved using alpha spectroscopy or correction circuitry/computing (3,6,8). The sensitivity of these instruments is in general proportional to the chamber volume. A large measurement chamber, however, is not desirable from the viewpoint of portability. The volume is also limited by demands set by daughter collection and alpha detection in the electrostatic method and the scintillation chamber method, respectively. In the ionization chamber the benefit of using a larger chamber is decreased by the increase in the background current. The background affects also the other methods at a low concentration. A problem common for all active sampling devices is the variation in the diffusion coefficient and the neutralization rate of radon decay products (specially $^{218}$Po) caused by changes in the gaseous composition and the humidity of the air. This causes variation in the attachment of the daughters in the measuring chamber and hence affects the instrument output.

To meet the conditions and to solve the problems described we have designed a smaller ionization chamber used both in alpha pulse mode and total current mode. Using an ionization chamber in pulse mode with normal air introduces difficulties: the long and low pulses are hard to process and mechanical vibrations are ready to cause spurious pulses in the frequency range of the pulses. The pulse length causes the coincidence error to become significant at a relatively low pulse rate. Recently, Katase et al. (4) presented a new instrument based on the use of plane multiwire-electrode ionization chamber used in pulse counting mode. A good sensitivity and a fast response time was reported. Shimo et al. (7) reported the performance of an ionization chamber meter used in both pulse and total current mode. Unfortunately, the construction of their instrument is not known by the authors.

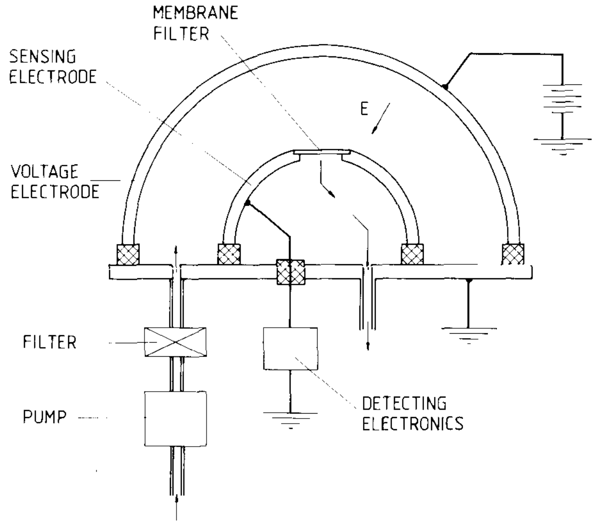


Figure 1. Schematic diagram of the instrument.

## CONSTRUCTION

A schematic diagram of the present instrument is shown in figure 1. The hemispherical ionization chamber has a volume of 1.7 litres. The volume is selected as a compromise between portability and sensitivity — the chamber can easily be replaced with a larger one. To achieve an adequate pulse rise time, a 2 kV voltage is used between the electrodes. A switching-generator-module is used with an additional RC-network for reducing the voltage ripple. The edge deformation of the electric field is minimized by a resistive voltage division chain on the supporting plane between the electrodes.

To eliminate the problem caused by the variation in the attachment of the daughters in the chamber, a membrane filter is installed at the air outlet (on the inner electrode) to ensure 100 % attachment of the decay products. The electrodes are constructed using plastic hemispheres coated with highly conductive ($< 3\Omega/\square$) paint in order to minimize the microfonic noise. The outer surface of the outer electrode is painted for electric shielding. The electrode-preamplifier unit is rubber band mounted inside a rigid metal box and connected to the pump unit with a flexible tubing.

The charge sensitive electrometer is constructed using a modern operational amplifier fulfilling the conditions for low noise and high input impedance. The output integrates the input signal without damping, and the electrometer is zeroed externally before saturation. The output signal of the electrometer is further processed and digitalized to satisfy the needs of the pulse counting and the total current mode measurements.

## DISCUSSION

Figure 2 shows results of a calibration measurement with different radon concentrations. This preliminary measurement has been performed using a larger prototype chamber. The pulse mode gives more reliable results when the radon concentration is low.

The signal processing in current mode is straightforward, whereas the operation in pulse mode still causes problems. At the moment the signal processing is performed using an external microcomputer. The program has still to be developed to be suited for a microprocessor based system to be built in the instrument. This system is also to deside whether pulse mode is used or the total current measured, as well as the length of the counting period. Alternatively, these can be selected manually.

Although at a prototype stage, the processing system has shown promising features: The pulses are recognized also by their shape rather than their height only. This is important because a large part of the alpha particles hit the electrodes before losing all the kinetic energy. The system is able to cope with some pulse pile-up before changing to total current mode. The spurious pulses caused by vibrations can be recognized and ignored — or the counting halted for a period. In highly vibrating conditions a warning is given and the total current mode used. The background current level can be checked on the field by introducing air with a relatively low radon concentration into the chamber (or rather performing this check before starting the sampling in a new location).

In general, the instrument has a relatively simple and inexpensive construction. On the other hand, the pulse processing and control are somewhat complicated. The micro program is still to be developed. Further development is also needed to have a construction less sensitive to vibrations.

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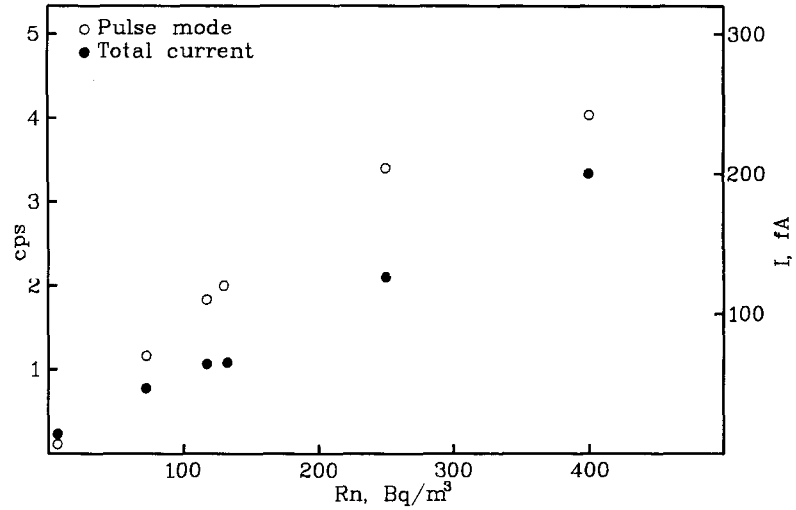


Figure 2. A comparison of the pulse and total current output of the prototype instrument at low radon concentrations.