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New Small Devices for Radiation Detection: the Wee Pocket Chirper and the Portable Multichannel Analyzer

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TWO NEW INSTRUMENTS

Recent events have demonstrated the need for improved capability to monitor the exposure of workers to radiation and, in general, to identify and measure the many forms of radioactive materials found throughout the nuclear industry. Filling such a need often requires sophisticated instruments that are portable and battery-powered. Recently, scientists and engineers at the Los Alamos Scientific Laboratory (LASL) have developed two radiation monitoring devices that are much smaller than existing instruments, yet exhibit superior performance and a longer battery life.

The first instrument, the Wee Pocket Chirper, is a tiny, battery-powered warning device that "chirps" when exposed to radiation. It was developed by LASL's Health, Electronics, and Chemistry-Materials Science Divisions. The second instrument is a portable battery-powered, computer-based, multichannel analyzer that allows the user to examine radiation fields and to identify the types and amounts of radioactive materials present. It was developed by LASL's Health and Electronics Divisions and Nuclear Safeguards Program. M. A. Wolf of the Health Division designed the electronics and developed the prototypes for both instruments.

THE WEE POCKET CHIRPER

Radiation workers need to know the levels of radiation exposure in their work places. Ideally, a worker always has a monitoring instrument nearby to measure the radiation level. Fixed-base ac-powered monitoring instruments are frequently used to provide this information, but portable battery-powered instruments are often more cost effective and convenient to use. Also, unusual places of work sometimes require the use of portable instruments. Because a small instrument with adequate sensitivity is more convenient than a large instrument, it is more likely to be carried by a radiation worker. Therefore, smaller portable instruments are preferred.

At present, film badges and thermoluminescence dosimeter (TLD) badges are used to record and document worker exposures. They are small enough to be clipped to a worker's shirt collar or pocket. Although they are sensitive, such devices only record the total accumulated exposure, and they must be read later on special machines. Another small instrument used to record radiation exposures, called a quartz fiber dosimeter, can be read immediately by the worker. However, neither the badges nor the dosimeters will give the wearer an automatic and immediate warning of a high-radiation exposure condition.

Active electronic instruments that warn of radiation exposure are called "chirpers" and give workers continuous indication of radiation exposure. Intended to supplement the radiation monitoring instruments described above, chirpers usually fit in a pocket or clip to a belt and give off sonic chirps at a rate proportional to the exposure. In other words, the chirper indicates radiation exposure by the number of chirps given off per minute. The number of chirps increases as the exposure level goes higher. They also can be made to sum the exposure for later record keeping. Existing chirpers are comparatively large—about the size of a pack of cigarettes—and weigh 4 ounces or more. In contrast, the Wee Pocket Chirper, recently developed at LASL, weighs only 1.2 ounces and is similar in size to the film and TLD badges. It also can be clipped to a shirt collar. The new chirper and a TLD badge are shown in Fig. 1, both clipped to the worker's collar. The chirper is orange; the TLD badge is turquoise.

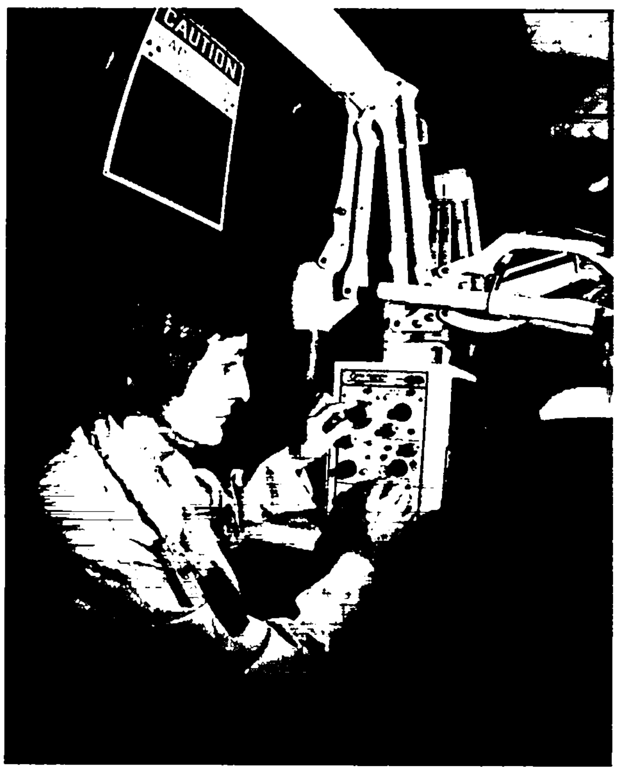

Fig. 1.

The secret of the new chirper's small size depends on two things: its radiation detector and its electronic design. Most chirpers contain a gas-filled Geiger counter to detect radiation. In the new chirper, LASL designers used a much smaller, but more dense (and thus more sensitive) counter made from a small chip of cadmium telluride (CdTe), purchased commercially. The chip, a cube measuring less than 1/10 of an inch on a side and weighing only 1/5000 of a pound, gives off a small electrical signal when it is struck by radiation. The signal is amplified by the associated electronics package, which produces a chirp (like the sound made by an alarm wristwatch) for each unit of radiation exposure. Figure 2 shows two chirpers. The one on the right (orange) has its battery compartment opened. The chirper on the left has its body made of clear plastic to show its electronic circuitry. All of the electronic components, including the tiny CdTe cube, are attached to a single card and make up a "hybrid circuit." Including the 2 integrated circuits on the hybrid, this one card contains 52 resistors, 20 capacitors, 25 diodes, and 62 transistors. The card is only slightly larger than the nickel coin shown in the figure. Because of its circuit design, the chirper will operate continuously for 40 days on the two small batteries seen in the open battery compartment of the orange chirper.

THE PORTABLE MULTICHANNEL ANALYZER

Although the chirper can determine the presence or absence of radiation, it cannot determine the amount of radioactive material present or identify material types. Many applications in the areas of health physics, nuclear waste management, environmental monitoring, nuclear safeguards, nuclear medicine, uranium prospecting, and others require more sophisticated analysis. Laboratory-based instruments are adequate for these applications if radioactive samples can be brought into the laboratory for analysis. Sometimes, however, samples must be measured in the field. Instruments for field use must be battery-powered and as small and lightweight as possible, and complete measurements often require a small computer to perform the complicated analysis.

To determine the type and amount of radioactive material present in a sample, a radiation "spectrum" must be acquired. This means that the different gamma rays and x rays emitted by the material must be sorted and identified according to amount and energy. The

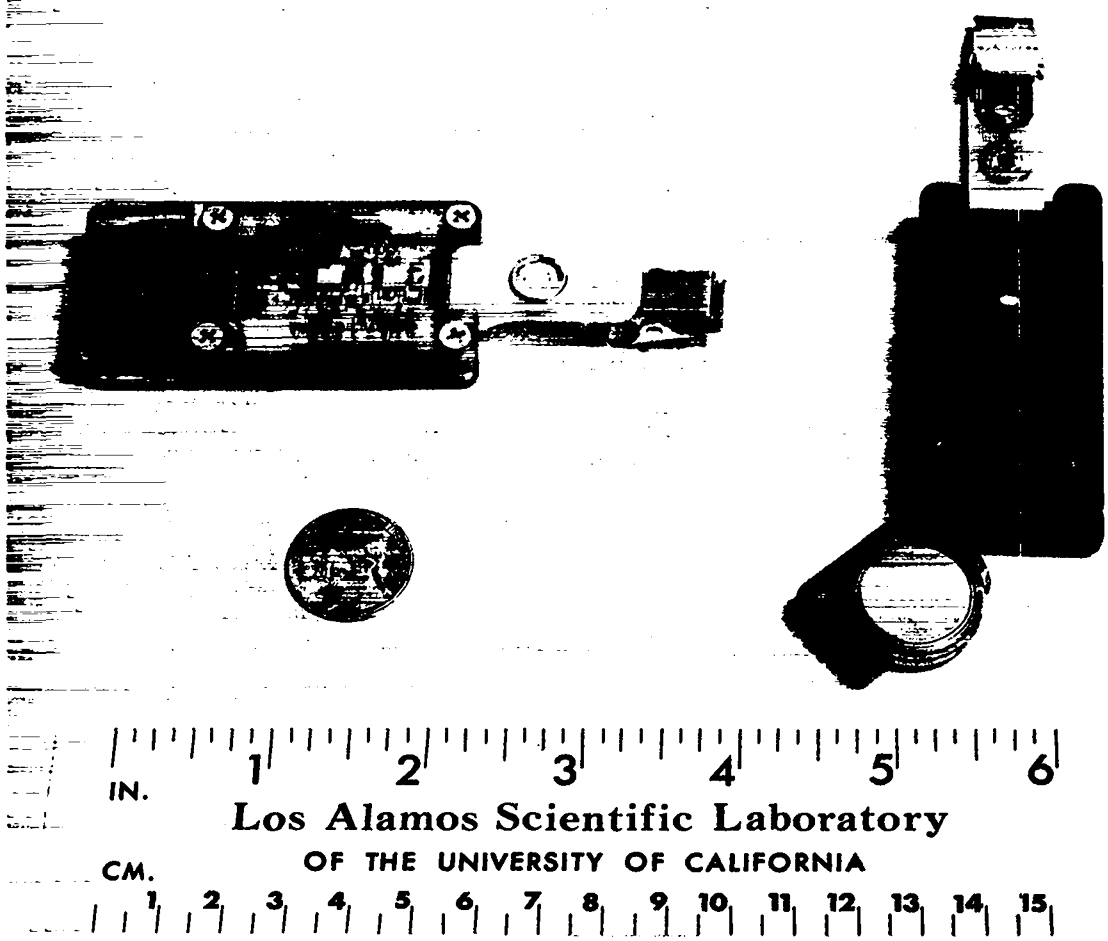

Fig. 2.

information then allows identification of the radioactive material. Figure 3 shows a gamma and x-ray spectrum collected from the radioisotope ^{241}Am, a decay product of plutonium. The spectrum is a characteristic signature or "fingerprint" of ^{241}Am and specifically identifies its presence.

An instrument that acquires and analyzes a radiation spectrum is called a multichannel analyzer; its many channels (often a thousand or more; 1024 in this case) allow the simultaneous analysis of many gamma rays and x rays. When the multichannel analyzer is connected to an appropriate radiation detector, it provides a complete radiation analysis package.

The portable multichannel analyzer recently developed at LASL (used to acquire the spectrum in Fig. 3) is about one-third the size and weight of previous systems and, unlike those systems, incorporates a microcomputer that controls the instrument and performs the analysis. Figure 4 shows the multichannel analyzer connected to a gamma-ray detector. On its face are a key pad for information entry and two displays for data analysis and read-out. Many measurements can be stored on the tiny digital cassette recorder located just to the left of the key pad. The orange custom computer memory card at upper right (called a ROM or "read only memory") allows the analyzer to perform certain extra tasks preprogrammed for the operator. The instrument weighs only 12 pounds and will run for 8 hours on a single battery charge.

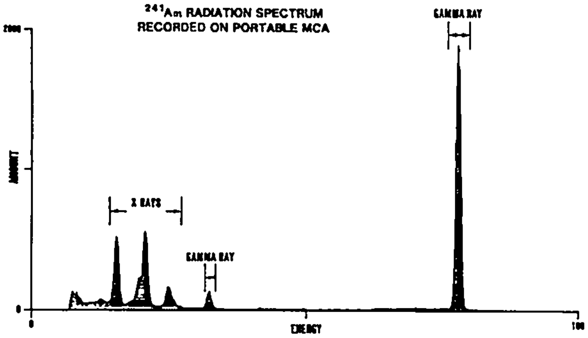

Fig. 3.

TECHNOLOGY TRANSFER

The technology for producing both of these newly developed radiation-detection instruments has been transferred to the commercial instrumentation industry. The instruments are now being manufactured for world-wide sale.

Fig. 4.

Mini-Review
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