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A desire for small size, low cost, and flexibility in alpha instrumentation has prompted the formation of a "building block" method. This system is composed of several simple basic units that are easily combined into more complex ones. Such problems as air-borne alpha detection, detection and recording of fast or thermal neutrons, area alarms for alpha or beta-gamma radiation or neutrons, and large-area floor and hallway alpha survey devices have been satisfactorily solved by this method.

Motives Prompting System Formation. As radionuclear chemistry involving alpha and neutron emitters increases, cave and enclosure instrumentation problems become more involved, and the space allotments for solving them is generally at a premium.

As members of a service organization that is responsible for supplying many parts of these diverse systems, we felt that a "building block" approach would best meet the requirements. Our system features a group of relatively simple units that are easily united for more complex systems. Other important factors are small size, reliability, and moderate cost. These requirements have led to an unusual form of portable and semiportable instrumentation.

Primary Unit Selection. The "nucleus" chosen for the system was the Health Chemistry portable alpha survey instrument. (1) This instrument is of transistorized modular construction, featuring three scales extending to 10^5 counts/min. Both metered and aural indicators are provided. High voltage is regulated and adjustable. These units use five D-type cells with 500 to 1000 hours of life, depending on the duty cycle. The standard detector is of an air proportional type with 18 in.^{2} of active area. It consists of a 4 x 9 x 3/8-in. aluminum plate with a series of milled 1/8-in.-radius grooves running lengthwise in it, strung with 0.0005-in. tungsten wire supported with teflon insulators. Construction details are shown in Fig. 1. The small chamber and wire size produce a voltage gradient sufficient to allow alpha detection at 1710 volts. The 10% slope plateau extends from 1730 volts to 1780 volts, with 1750 volts as the optimum operational voltage at sea level. Electrical breakdown occurs above 1810 volts. Gamma discrimination at the operation voltage is excellent; fluxes as high as 500 r/h produce no appreciable increase in background. With the 0.00025-in. double aluminized Mylar covering over the face and the protective grid installed, the efficiency is 16%. This detector's usefulness is further extended by the fact that, as long as the individual groove radius is retained, the probe may be fabricated in almost any size. Successful detectors have been constructed running in size from 1 x 3 in. to 5 x 13 in.

Applying the System. How the unit is applied in systems can best be shown by reviewing several typical requests. The recent californium separation chemistry presented the following problems.

The first need was for a small-area alpha detector, capable of being remotely handled with manipulators, to be placed directly in the processing area. Expected gamma fluxes of 10^3/hr and neutron fluxes of 10^8/sec. should not interfere with alpha survey.

Secondly, a large-area detector was needed for a rapid surface survey of materials and containers coming from the interchange Berkeley box that functions as the link between the processing area and the general working area.

Thirdly, a continuous record of the fast-neutron flux in the area occupied by the operators was desired. In conjunction with this, several portable neutron-survey devices were needed to monitor passed-out materials and storage areas.

Severe space limitations dictated that all units be as small as possible.

The standard alpha survey unit with the 18-in.^{2} detector was chosen as the large-area instrument to be used in the interchange box. The air proportional probe may be used with 10 ft. of RG-58 AU coaxial cable without preamplifier. Because the unit was to function 18 to 20 hours per day the batteries were replaced with a line-operated power-supply module occupying the area that normally contains the batteries.

Figure 2 presents an interior view, showing the modular construction and the line-operated power supply in place. The unit occupies only 16 in.^{2} of shelf space and is 9 in. tall; it was placed on top of the interchange box.

A silicon detector was chosen to handle the small-area high-flux situation. A 3/4-in.-diam. 1000-ohm/cm unit was used with a gain-of-20 preamplifier. The complete unit was assembled in a 1-in.-diam tube, and 0.00025-in. double aluminized Mylar was used as a protective covering over the detector surface. A small tab was attached to facilitate handling by slave manipulators. Eighteen ft of shielded cable delivered the signal to the same instrument used by the large-area detector. By use of separate and isolated inputs both detectors may be used on one instrument. No switching is necessary, in fact both detectors may be used at the same time with additive results. Figure 3 shows the complete instrument with the detectors used.

The neutron recorder is essentially the same basic unit as the alpha device. It, too, was converted to line operation. The detector chosen was a small BF_3 tube with active volume 5/8 in. in diameter by 4 in. Its operational voltage is identical with the air proportional detector mentioned previously. A 4-in. cylinder of paraffin envelops the BF_3 tube, and it in turn is encased in cadmium. This produces 50 counts/min per neutron per cm^2/sec. The ranges used on the basic alpha instrument are 10^3, 10^4, and 10^5 counts/min.

With neutrons, the ranges become 1, 10, and 100 mrem/h (with a flux of 7.2 neutrons/cm^2/sec assumed equal to 1 mrem/h for 2-MeV neutrons). The detector was placed as near as possible to the area the operators occupied without interfering with their movements. A Rustrac miniature chart recorder with 100-uA sensitivity is inserted in the count-rate circuit via a small plug. The total package of recorder and neutron instruments occupies only 32 $in.^2$ of shelf space and has a maximum height of 9 in.

General neutron surveys were made with the battery-operated basic rate meter. The detector is the same as in the neutron recorder, but with the addition of a brass case and a handle to facilitate handling. Figure 4 shows the hand-held neutron detector and the miniature recording unit.

All instruments performed as required and have since been removed and used in other operations.

Air-Borne Alpha Alarm. A request was received from one of the accelerators for a temporary gross air-borne alpha detection-and-alarm system to monitor the beam bombardment area for target foil rupture or flaking. Again, space for placement of equipment was practically nil.

The standard alpha count-rate meter converted to line use and the air proportional detector were again chosen as the basic unit. Air is drawn directly from the target to a small 4 x 9-in. filter paper held in a special holder (shown in Fig. 5). Four $ft.^3$/min of air is drawn through the paper, and the detector is placed 1/8 in. away from the deposition side. The units are so arranged that the detector and filter paper are in a closed system. In conjunction with the basic alpha unit is an alarm module. This consists of a variable-contact rate meter, power supply, and necessary relays for alarm and power-failure contact. This unit is simply put into the rate meter circuit of the basic unit via a small plug. Depositions as low as 1000 counts/min are easily detectable. This "temporary" unit has now been in service 18 months without failure. Total space of the electronics is again 32 $in.^2$ of shelf space and 9 in. height.

The same configuration of basic unit and alarm module with suitable detectors may be used as alarms for beta-gamma radiation or neutrons.

Hallway and Floor Alpha Survey. A request for a large-area portable floor and hallway alpha survey device was again speedily handled by using the basic configuration. Five of the standard air proportional detectors were placed side by side and held by a wood clamp through their handles. This clamp was attached to a small three-wheel dolly and adjusted to bring the detecting surfaces as close to the area to be monitored as its texture permitted. A handle attached to the dolly permits the operator to push the unit across the floor much as one would a vacuum cleaner. The basic portable alpha meter is placed on the dolly's top surface. Because the unit features loud-speaker indication, the operator needs only to push the unit along at a moderate speed and listen for detected activity. Because of negligible loading by the detectors upon the survey device it is possible to use more than five. Actually one large area was surveyed by using ten tandem detectors, giving nearly 40-in.-wide coverage with one pass. As the unit is composed of standard-sized detectors the construction cost was very modest. Upon completion of a survey the detectors can be removed and used in normal fashion on hand-held survey units.

Other Factors Aiding the System. The effective use of the system as a whole is enhanced by a carefully planned servicing procedure. The modular construction of the basic nucleus unit permits rapid repair by direct replacement of any defective part with a working unit. Exotic or hard-to-replace components were not used in the construction. Only four different transistor types are used in any of the modules described above. These considerations, in conjunction with a documented monthly calibration, have permitted an excellent service record.

The flexibility of the systems allows rapid concentration of equipment when emergency decontamination and protective measures are called for and yet, normally, allows a multitude of different needs to be met.

The overall low cost, small size, and reliability have made the system well received both by users and by the service team that maintains it.

REFERENCES

(1) W. J. Roach and R. J. Walker, "Portable Alpha-Survey Instrument", Report #UCRL 9651, Lawrence Radiation Laboratory, University of California, Berkeley, California, (April 1961).

Fig. 1.

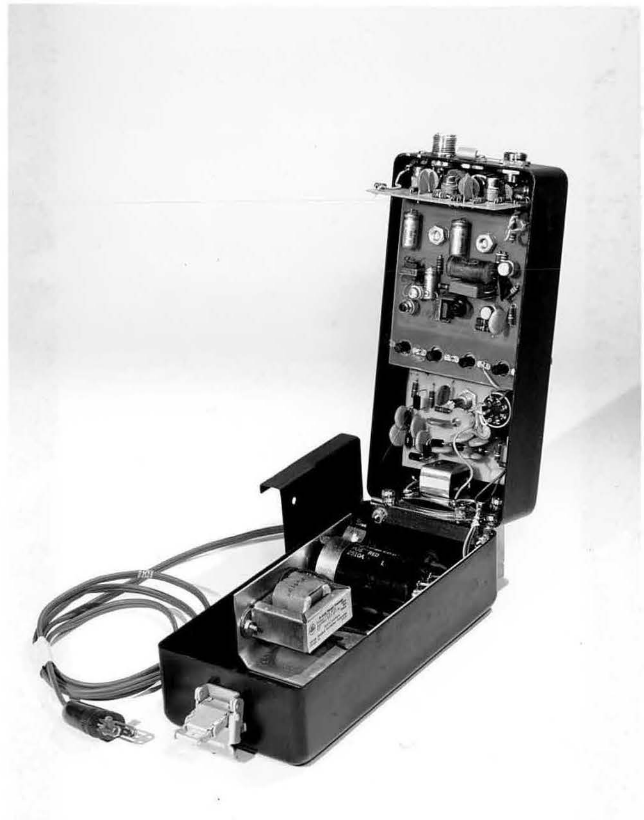

Fig. 2.

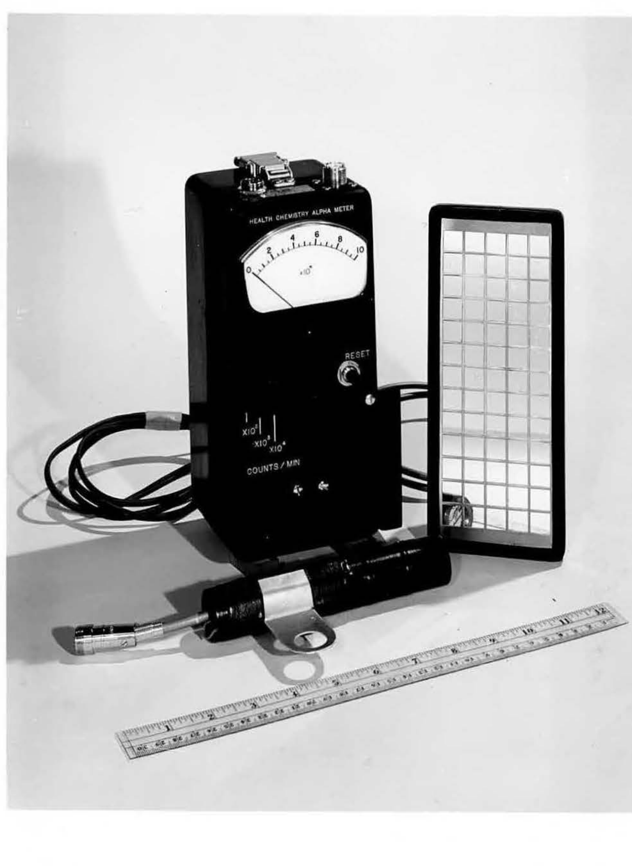

Fig. 3.

Fig. 4

Fig. 5.