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Scintillation Detector for Carbon-14

The problem:

To devise an efficient detector for determining the carbon-14 content of carbon dioxide in an unknown gas mixture. Since the original detector was intended to be part of a system for microbial life detection in space, initial requirements specified that the detector have a maximum sensitivity for carbon-14 beta rays, and a minimum sensitivity to cosmic rays and to gamma rays from radioisotope thermoelectric generators (RTG) fueled by plutonium-238.

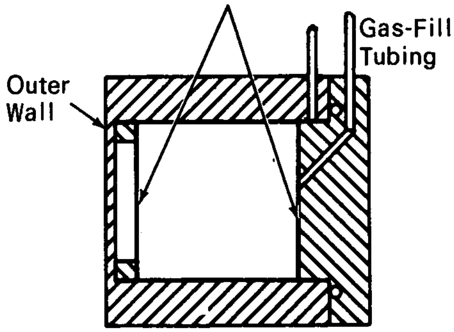

Figure 1. Scintillation Detector Cell

The solution:

A detector (Figure 1), consisting of a plastic, cylindrical double-wall scintillation cell which is filled with the gas to be analyzed. The thin, inner scintillator wall of the cell is isolated optically from the outer (guard) scintillator wall by an evaporated-aluminum coating. Each scintillator is coupled to a photomultiplier tube, and the inner scintillator is counted in anticoincidence with the outer scintillator.

How it's done:

The inner wall of the cell is made very thin (0.010 cm = 0.004 in.) in order to (a) minimize the probability of primary RTG gamma ray interactions, and (b) maximize the probability that an interaction in the inner scintillator will produce a secondary electron leak into the outer scintillator. Such a leak will produce a coincident pulse that can reject the background signal in the inner scintillator. The inner scintillator, however, is sufficiently thick to minimize or prevent the coincidence rejection of carbon-14 counts. The outer wall of the detector serves as a guard for rejecting RTG and cosmic ray background counts.

Carbon-14 beta rays produced from the gas in the cell (about 20 cc) give rise to photons which are detected with one phototube; events occurring within the outer wall are detected with a second phototube. The phototubes must have excellent signal-to-noise characteristics and high gain.

Fast circuitry (Figure 2) is employed in order to minimize accidental coincidences at high count rates. Since a coincidence resolving time of 100 nsec requires faster signals than the main amplifiers are capable of delivering, the positive signals from the last dynode are fed directly from the preamplifier to the single-channel timing analyzer which is used in the leading edge mode. The relative time jitter between the two scintillator pulses is held to less than 30 nsec; under worst conditions, the accidental coincidence rate is less than 3 pulses per minute. The anode signals are used as linear signals to obtain the pulse-height spectra.

A tapered dynode string is used at the phototube bases to extend the dynamic range, permitted by adequate tube gain. The termination duplicates the impedance of the amplifier so that pulse-height spectra can be obtained from either tube without changes in gain.

(continued overleaf)

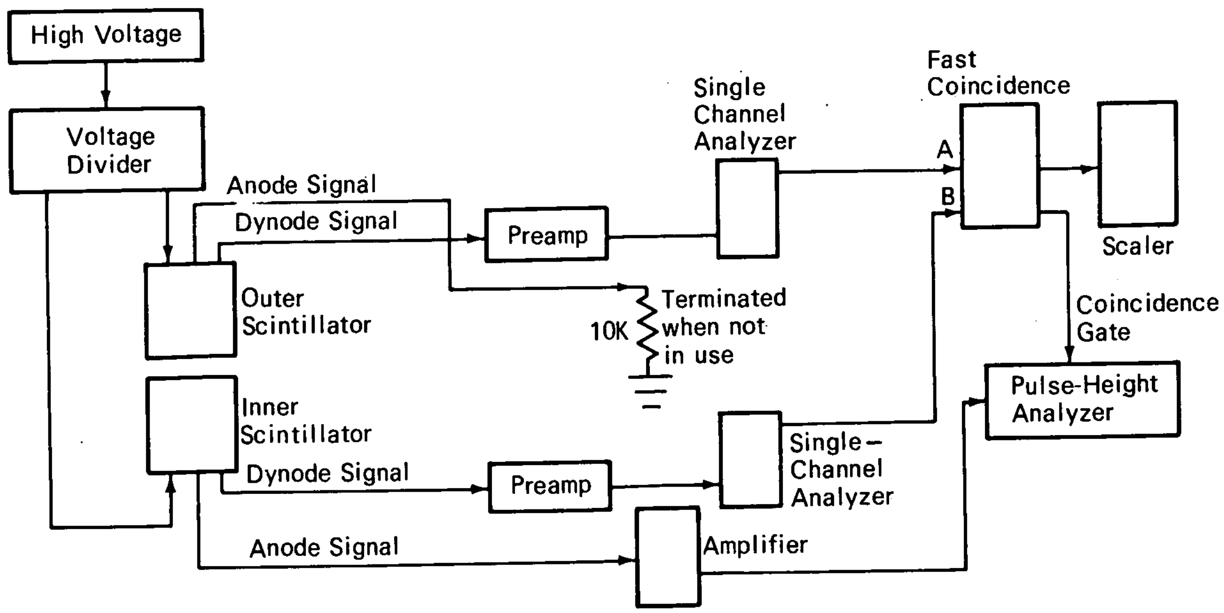

Figure 2. Detector Circuitry

Notes:

1. If the device is to be exposed to high temperatures, mechanical support must be provided for the thin, inner wall of the cell; this can be accomplished by a suitable bonding technique.
2. Dissimilar scintillation materials and pulse-shape discrimination can be employed to reduce the size of the detector; cesium iodide is recommended for the outer scintillator, and either anthracene or a special plastic for the inner scintillator. Size may be minimized by using miniaturized phototubes.
3. The following documentation is available from:

    National Technical Information Service
    Springfield, Virginia 22151
    Single document price $3.00
    (or microfiche $0.95)

    Reference:
    NASA-CR-73384 (N70-10801), An Analysis of Carbon-14 Radiation Detection Systems

4. Requests for further information may be directed to:

    Technology Utilization Officer
    Ames Research Center
    Moffett Field, California 94035
    Reference: B71-10144

Patent status:

No patent action is contemplated by NASA.

Source: Glenn F. Knoll of University of Michigan, and W. Leslie Rogers of The Bendix Corp. under contract to Ames Research Center (ARC-10378)