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A Collimator For Scanning With Low-Energy Photons

C. C. Harris,[2] J. C. Jordan,[2] M. M. Satterfield[2]
Jack K. Goodrich, M.D.,[3] H. L. Stone, Ph.D.[3]
and Rebecca Hill[3]

Oak Ridge, Tennessee and Jackson, Mississippi

Almost all collimators furnished with commercially available scanners were originally designed for gamma-ray energies in the 280-410 kev range. At the upper energies, they tend to have inadequate septal thickness; they have, however, unnecessarily thick septa and low transmission for the lower energies in this range. Some are deliberately designed to provide rather large volumes of response, *e.g.*, 19-hole collimators for 3-inch diameter crystals.

It is not surprising, therefore, that when such equipment was used at around 30 kev (*e.g.*, for I^{125} or Cs^{131}), counting rates were unnecessarily low. In addition, the ability to portray very small regions of activity was disappointingly poor, in spite of the low energy of the rays.

Excellent collimator-detector assemblies for I^{125} have been reported by Harper, *et al* (1,2) but to date these have not been made commercially available. Most clinical scanning results with I^{125} have been obtained with unmodified commercial scanners.

At the University of Mississippi Medical Center, cardiac scanning experiments on animals, using Cs^{131}, brought the inadequacies of conventional scanning equipment to a head. There was urgent need for a collimator of better resolution, coupled with the higher transmission that thin septa, permissible at this energy, could provide.

The commercial scanner on which it was to be used was equipped with a 3-inch diameter crystal and the usual assortment of collimators. Though this was clearly not an optimum detector or collimator situation for 30-kev x-rays, we felt that a simple expedient would allow better results, at least until proper equipment could be obtained.

It was decided to make a collimator of formed, tapered, hexagonal tubes by folding soft lead foil around a pin from a 61-hole collimator (3) mold. These tubes would then be used to build up a collimator array of the necessary size. A foil thickness of 0.005 inches was chosen for two major reasons. First, it was soft enough for easy forming, yet when formed, the tubes were surprisingly rigid. Second, the wall thickness of two adjacent tubes allows completely negligible leakage at 30 kev.

A large supply of the tubes was made by folding lead foil around the mold

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[2]Oak Ridge National Laboratory.

[3]University of Mississippi Medical Center.

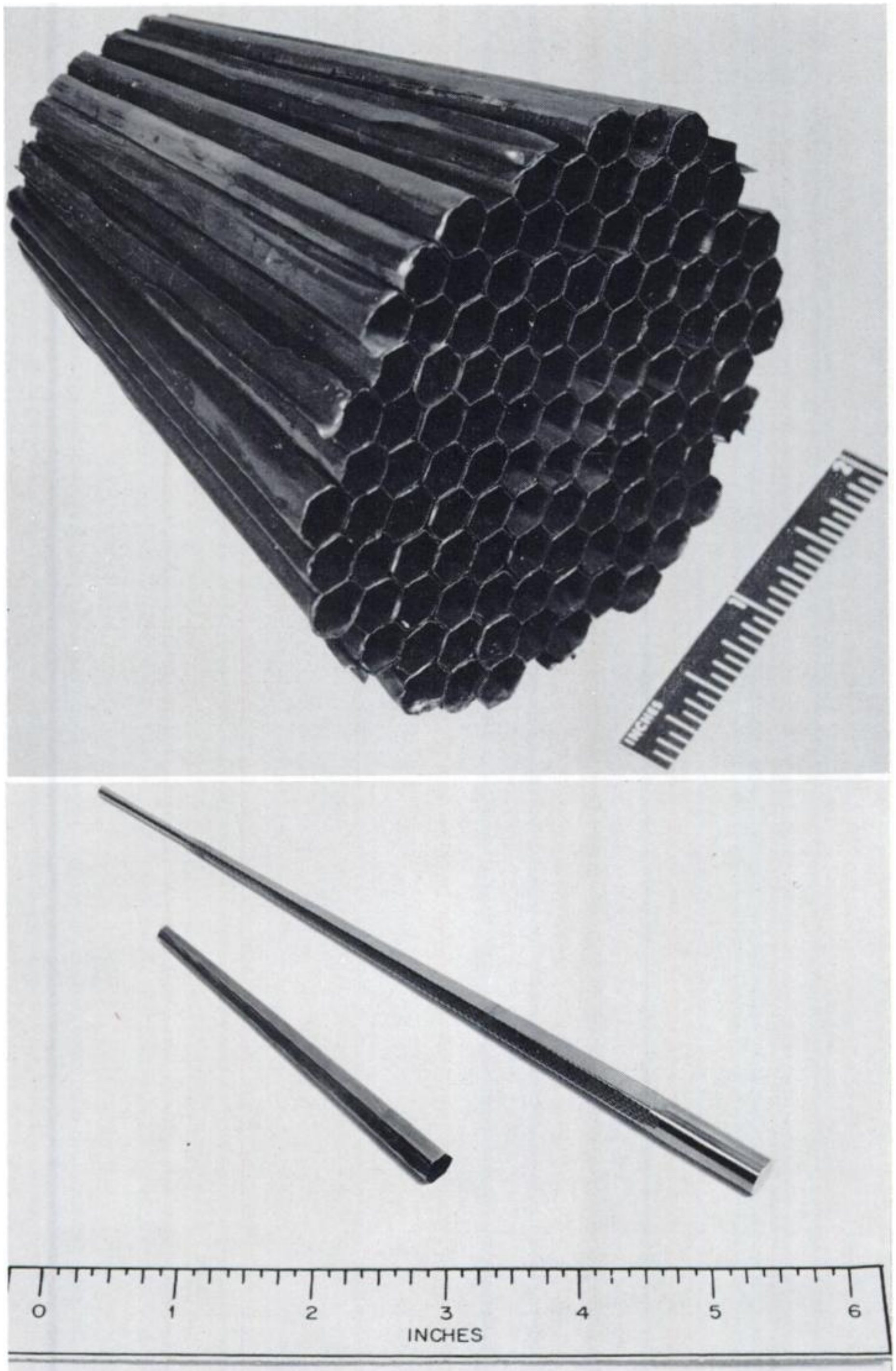

Fig. 1. Photographs showing a single, hexagonal, tapered tube, the forming pin, and the completed collimator assembly.

pin for one thickness with no overlap. A 61-hole collimator was used with the pins as a forming die, for a temporary holder for the tubes, and to serve as a gauge block for cutting the tubes to the required lengths.

The tubes were then glued together with very thin films of Pliobond[1] to make the collimator. The final assembly required 109 full tubes (and a few tubes that were split longitudinally to convert the hexagonal array to a circular one). The transmission is estimated at 85-90 per cent. Photographs are shown in Fig. 1.

DIAMETERS OF RESPONSE LEVELS AT FOCUS, 109-HOLE COLLIMATOR
POINT (0.019″) SOURCE IN AIR

Response level	*Diameter, inches* I^{125} *(23-38 kev)*	Hg^{197} *(60-90 kev)*
90%	0.08	0.09
70%	0.16	0.172
50%	0.23	0.248
30%	0.294	0.32
10%	0.41	0.424
5%	0.45	0.466
1%	0.52	0.532
0.5%	0.54	0.568
0.1%	0.58	1.1
0.01%	0.62	—

The response of the collamator to a point source of I^{125} in air is shown in the table. Isoresponse plots show that, because the tubes had uniform wall thickness, the outer tubes aim at a point more distant than the aiming point of the inner ones. The unintended elongation of response (and lowered point-source efficiency at the focus) can be corrected by using strips of foil rolled to a tapering thickness, so that the taper of wall thickness will match the taper of the tubes. This suggestion by P. R. Bell will be followed if any more collimators of this type are made, since it is rather easily done.

This collimator, designed in some haste, had the usual requirement that it must fit an already existing shield. Because this made it unnecessarily long for I^{125} work, it turned out to be reasonably good for use with Hg^{197}. Isoresponse curves for Hg^{197} do not differ significantly from those for I^{125} except at the lowest levels. The table shows that for a 60-90 kev energy band the focal response, in air, is only slightly broader than that found at 27 kev, except for the break in response diameter at about 0.2 per cent. We conclude, therefore, that for energies around 70 kev this collimator will provide resolution quite comparable to that of the 3-inch, 61-hole collimators, with the advantage that the on-target count rates will be about doubled.

[1]Goodyear Pliobond, W. J. Ruscoe Co., Akron, Ohio.

We have achieved an expedient solution to a problem. This solution, though not optimum, was obtained quickly and shows considerably improved results in the preliminary studies at the University of Mississippi Medical Center. It was felt at first that the collimator was excessively long and had an unnecessarily deep focus. Preliminary results show, however, that the collimator's length allows use at higher energies. The long focus gives good response at the depth of the heart. The construction method may be of use to those making experimental collimators for use with low-energy x- and gamma rays.

It is clear that older collimators are ill-suited for energies below about 140 kev. Properly designed collimators must be made commercially available if maximum clinical usefulness is to be realized from radionuclides with emissions in this energy range. A hexagonal-hole version (giving about 10% more transmission than round holes) of the Argonne Cancer Research Hospital low-energy collimators for use with low-energy x- and gamma rays.

REFERENCES

1. HARPER, P. V., BECK, R., CHARLESTON, D. AND LATHROP, K. A.: Optimization of a Scan-Method Using Tc^{99m}. *Nucleonics* 22 (1), 50-54, 1964.
2. BECK, R. N.: Collimators for Radioisotopes Scanning Systems, Proceedings of the IAEA Symposium on Medical Radioisotope Scanning, Athens, Greece, April 20-24, 1964 *in press.*
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Announcement

The Southeastern Section of the Society of Nuclear Medicine will hold a symposium comparing the techniques and results of scanning with ultrasonics and radioisotopes in Atlanta, Georgia, on October 22, 1964.

The morning session will be devoted to a discussion of the fundamentals and techniques used in scanning with both these agents so as to obtain scans of optimum clinical value. Dr. Robert H. Rohrer, Mr. William B. Miller, and Mr. C. Craig Harris will participate in this portion of the program.

The clinical applications of ultrasonic and radioisotopes scanning will be covered in the afternoon session. This will include the possible hazards of the techniques and the sensitivity and accuracy of the scanning information. Dr. Jack Goodrich, Dr. Richard T. Atkins, Dr. Albert J. Gilson, Dr. James Dobbs, and Dr. Joseph L. Izenstark will appear in this session of the program.

Dr. Henry N. Wagner, Jr., Dr. Douglass H. Howry, and Dr. Merrill A. Bender will discuss topics in both the morning and afternoon sessions.