

alternative harms our collective problem-solving ability by leaving modern industry, except in the most fundamental physical science areas, without an established way to hire "guaranteed-useful" researchers.

The other alternative is to make the distinction between engineering and physics on the basis not of goals but of methods. A physicist (or a scientist in general) then becomes redefined as a researcher equipped to apply *basic insight* in her or his field(s) of expertise to the solution of applied as well as fundamental problems, while an engineer is trained in the application of *established methods* (again to the solution of either type of problem).

To turn out bona fide "two-armed physicists" (those trained to use their basic insights in the solution of both fundamental and applied problems), educational institutions must provide their physics students with:

- ▷ intellectual relish for the solution of problems posed from without as well as from within
- ▷ the skills and inclination for getting work done and communicated by a specified time, especially within the context of externally imposed deadlines
- ▷ knowledge of and experience with tools of general use in the modern global community, including communication, fund-raising and management strategies
- ▷ experience in work on interdisciplinary and interinstitutional teams of the sort commonly required for the solution of problems posed by the outside world
- ▷ training in the temperament and skills helpful for synergistically solving short-term interdisciplinary problems posed from without while *at the same time* (and at their own initiative, if need be) making progress in more fundamental matters.

(A "natural philosophy" emphasis in each department might be established for those students who want to stick with the one-armed route.)

How many institutions provide and test for these things in their advanced degree programs in physics? I submit that those institutions that focus on "both arms" provide graduates who will be successful in a much wider range of places than will graduates of those institutions (many among the most respected) that do not.

PHIL FRAUNDORF

5/93 University of Missouri, Saint Louis

Accelerators for Neutron Therapy

Henry G. Blosser's article "Medical Cyclotrons" (October 1993, page 70) mentions the importance of linear ac-

celerators as radiation sources for photon therapy of cancer but omits mention of their importance for neutron therapy.

In fact, the scientific work that underlies neutron therapy was done with a homemade, 400-kV Cockcroft-Walton accelerator in Britain during World War II by Louis H. Gray and coworkers using monoenergetic D-D neutrons.¹ Among the several important results of that work is knowledge of the strong dependence of the relative biological effectiveness (RBE) of neutrons on their energy, so that the energy spectrum of neutrons used for treatment is essential for determination of the neutron dose.² Hence methods of neutron spectrometry (which I wrote about in *PHYSICS TODAY*, August 1967, page 39) must play an important role when using cyclotron neutron sources, which irradiate patients with polyergic neutrons whose penetration and biological effectiveness vary greatly depending on their energy. I have discussed the respective roles of cyclotrons and linear accelerators for neutron therapy in the medical literature.³

For almost 20 years a facility at the University Hospital in Hamburg-Eppendorf, Germany, has been treating patients with 14-MeV D-T neutrons from a compact, inexpensive 500-kV machine built and installed by Marshall R. Cleland and Radiation Dynamics Inc.⁴ Since 1985 that machine has been fitted with a unique, American-patented beam-handling and target system⁵ that provides an order-of-magnitude increase in the life of solid tritiated targets—a critical feature of such machines—under deuteron bombardment. The failure thus far to produce a usable, low-voltage accelerator for neutron therapy in the US has recently received critical attention⁶ and presents an important challenge to American accelerator management and technology.

References

1. L. H. Gray, J. Read, J. G. Wyatt, Br. J. Radiol. **13**, 82 (1940). L. H. Gray, J. Read, Nature **152**, 53 (1943).
2. *Neutron Dosimetry for Biology and Medicine*, Int. Commission on Radiation Units and Measurements, Geneva (1977).
3. L. Cranberg, Br. Med. J. **300**, 349 (1991).
4. M. R. Cleland, in *Proc. Wksp. on Practical Clinical Criteria for a Fast Neutron Generator*, 28–29 May 1973, Tufts-New England Medical Center, H. R. Blieden Jr., ed., NSF, Washington, D. C. (1973).
5. L. Cranberg, Bull. Am. Phys. Soc., Ser. II **36**, 97 (1991).
6. M. W. Dewhirst, T. W. Griffin, A. R. Smith, R. G. Parker, G. E. Hanks, L. W. Brady, J. Natl. Cancer Inst. **85**, 951 (1993).

LAWRENCE CRANBERG

Austin, Texas ■

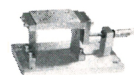
11/93

ANGSTROMTM TRANSDUCERS AND ACTUATORS

Angstrom actuators are intended to offer the designer of precision instruments and experimental apparatuses the advantages of linear elastic behavior:

Linearity

- Non-hysteretic behavior
- Sub-angstrom repeatability is available



Thermal Sensitivity

- Nominal length of the transducer is "zero"
- Transducer is entirely self-compensated



Structural Integrity and Stability

- Intended for use as prime structure
- Support a substantial mass for payload or sub-assembly

Richter Enterprises, an international electro-optics distributor, brings these features and more to the marketplace through the Alson E. Hatheway Inc. line of precision instruments:

- Angstrom Precision Actuators
- Angstrom Multi-Axis Stages

Richter Enterprises, Inc.

3232 San Mateo Blvd NE, Suite 216
Albuquerque, NM 87110-1924
Phone: (505) 836-3755
Fax: (505) 836-3775

Circle number 16 on Reader Service Card