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CYCLOTRONS FOR CLINICAL AND BIOMEDICAL RESEARCH WITH PET

Alfred P. Wolf

Chemistry Department

Brookhaven National Laboratory

Upton, NY 11973

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The purpose of this commentary is to present some background material on cyclotrons and other particle accelerators particularly with a view toward the considerations behind acquiring and installing such a machine for purely clinical and/or biomedical research use.

At present there are approximately twenty-eight institutions in North America with accelerators primarily used in conjunction with PET (cf. Table 1). At the present rate of growth, well over 50 such centers should be in existence in North America by 1990. It is also apparent that a number of centers are being developed in which a PET machine is installed without being coupled to an on-site cyclotron facility. Such centers will depend on generators such as the ^{82}Sr-^{82}Rb generator and fluorinated compounds from production centers.

Table 1

The particle accelerator is simply a source of reagents, protons and deuterons which are used to bring about the desired nuclear reactions yielding positron emitters or other radionuclides. Alpha particles and helium-3 ions are also of some interest but do not have any importance with regard to radionuclides for PET.

Cyclotrons

A cyclotron can be considered as being composed of several basic components, an ion source which provides the ions to be accelerated, an RF power source which provides the energy needed to accelerate the ions in a specially constructed vacuum chamber, a magnetic field which controls the position in space of the ions and an extraction system which allows one to remove the accelerated ions from the body of the machine. Such a simplified viewpoint does not do justice to the complexities of a cyclotron but should aid in understanding its basic operating features. The mechanism of extraction in a negative ion machine does not require the conventional septum-deflector system of a positive ion machine (vide infra).

The magnetic fields in medical cyclotrons are in the 1.5 - 1.9 Tesla range but can be higher as in the new superconducting cyclotrons. Some simple equations can be used to appreciate cyclotron principles. The kinetic energy of the emerging particle must be such that the thresholds for the nuclear reaction required are exceeded sufficiently to allow reasonable production of radionuclide. The equation which governs this energy is (eq. 1)

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