abscesses as well, permitting their detection via gamma-ray spectrography. This observation sparked the development and use of gallium-67 for detecting tumors (*J. Nuclear Medicine* 13:92–100, 1972).

Benefits A single application of gallium-67 scanning as part of a diagnostic package for detecting Hodgkin's disease demonstrates the range of potential economic benefits from the use of this radioisotope. In the diagnosis of Hodgkin's disease, patients are classified into four stages based on the number of lesions in the lymphatic system. In stage one, the disease usually involves only one lymph node region and is usually treated with radiotherapy. Stage two involves two or more adjacent lymph node regions above the diaphragm and is also usually treated with radiotherapy. Stage three involves lymph nodes above and below the diaphragm and is treated with radiotherapy, supplemented by chemotherapy in selected cases. Stage four, characterized by more diffuse and disseminated involvement of the lymph nodes and other organs, is usually treated only by chemotherapy, with only relief and no cure expected.

The benefit of gallium-67 scanning arises from the ability to discriminate between advanced stages three and four of this disease and can be estimated as the avoided cost, about $10 million/year, of radiotherapy for individuals classified as stage four. Also important is the use of gallium-67 in follow-up treatment to evaluate remission or relapse, especially when confusing signs and symptoms appear. Symptomatic patients followed yearly, for example, can have recurrent disease that gallium-67 studies allow to be treated early and possibly more effectively. Conversely, many relapse symptoms are found to be falsely positive and not indicative of disease.

Instruments That Aid in Diagnosis

A key to novel and increased uses of radioisotopes in nuclear medicine has been improved instruments. Advances in imaging equipment that resulted from the post-World War II explosion in electronics and computer development had major impacts in improving detection sensitivity and the range of diagnostic studies that could be performed. The high-sensitivity Anger camera with sodium iodide (thallium) scintillators accentuated the significance of such radioisotopes as iodine-123 and technetium-99m, whose low particulate and gamma ray emissions are appropriate for camera use. Also, use of this modern imaging system allowed thallium-201 to be developed and utilized for diagnostic scanning of coronary artery disease.

The advanced imaging equipment allowed temporary concentrations of radioisotopes in various organs to be measured with good multidimensional spatial resolution. Thus, in addition to organ structural measurements, dynamic body functions such as circulation and organ metabolism could be measured. The Positron Emission Tomography (PET) scanner provides a good illustration of function-measuring capabilities.

When nuclear instruments were first developed by isolated groups of research scientists in different laboratories and institutions, the absence of standardization was not an important issue. However, as usefulness of these instruments increased, their use moved to other laboratories and the medical service industry. The demand grew accordingly, and the total investment became large. Therefore, plug-to-plug compatibility of instruments from various sources became both a scientific and an economic necessity. To address this problem, the Nuclear Instrument Module (NIM) system was developed under the OHER Program to provide a basis for replaceable plug-in instruments that form modules in power supply and instrument racks. The Computer Automated Measurement and Control (CAMAC) system which was to provide compatibility at other electrical interfaces and in data formats followed later and is now an international standard.

The Scintillation Camera The Anger scintillation camera allows the image of a photon (gamma ray) source to be reconstructed. It is the most widely used imaging device in nuclear medicine worldwide, being used for 80 percent of the studies on patients in nuclear medicine. It was invented to replace mechanical scanning.

The Anger camera uses scintillation crystals and photomultipliers to obtain serial images of the distribution of a radioactive tracer within the body at various times after the tracer is injected intravenously. The data are analyzed and processed by a digital computer and displayed on a video screen to provide quantitative information about regional biochemistry and physiology within virtually every organ of the body.

The Anger camera consists of a lead, multihole, collimator, a 10- to 15-inch-diameter sodium iodide scintillation crystal, a two-dimensional photomultiplier tube array on the crystal face, and a positioning logic network. The lead collimator allows only those photons traveling in the preferred direction (i.e., those that can go through the holes without being absorbed by the lead) to strike the crystal and cause it to emit light. The photomultiplier tubes closest to the scintillation event (pulse of light) produce the longest signal. An energy discriminator allows only those photons associated with gamma rays of specified energy level to be detected. Thus, the camera produces a signal showing the position of every scintillation event with the appropriate photon energy. A collection of these signals over time produces an analog image of the organ being viewed in the form of a two-dimensional projection of the three-dimensional distribution of radioactivity within the patient.