A SEMI-AUTOMATIC SYSTEM FOR RADIOISOTOPE PRODUCTION

A. I. MUMINOV, B.G. KURGANOV, I.N. KONOVALOV, A.U. USMONOV

Heavy Ion Physics Department, Institute of Nuclear Physics, Tashkent 702132, Uzbekistan

Among the wide range of applied work using cyclotron beams special attention is paid to radioisotope production for medical and commercial purposes. Cyclotron-produced isotopes compare favorably with those which are reactor-produced. The high radioactivity on the target (up to 5 Cu) at the end of irradiation practically excludes the possibility of personnel presence in the irradiation chamber region and requires the creation of an installation for production which is as completely automated as possible. The cyclotron based radioisotope production system described in this paper provides for automation of 30 of the 34 existent operations.

The modern izochronous cyclotrons permit to obtain the beams of accelerated ions in wide mass and energy range. This also permit to fulfill a variety of applied works along with large volume of scientific research. Among these applied works the attention is paid to the elaboration of radionuclids for medical and commercial purposes (^{49}V, ^{57}Co, ^{67}Ga, ^{65}Ge, ^{85}Sr, ^{111}In, ^{181}W, ^{201}Te, ^{109}Cd).

Cyclotron produced isotopes differ by their higher specific activity and radioisotope purity comparing with reactor produced ones. With the use of cyclotron produced isotopes such as ^{7}Be, ^{22}Na, ^{85}Sr, ^{57}Co, ^{109}Cd isotope radiation sources are created. Cyclotron produced isotopes are widely used as short-period generators.

During the working-out of some isotopes it is desirable to obtain the maximum beam power of accelerated ions which may be 20–25 kW. The large activity (up to 5 Cu) induced in the target of the end of irradiation limits or practically excludes the possibility of presence of service personal near the irradiation chamber in the moment of target dumping. This determines the necessity of creation of set-up providing the remote feed of samples into the chamber the travel of irradiated articles beyond the active zone, the packing in polyethylene bags and their stacking in container.

During the manufacturing of short-period isotopes such as ^{201}Te and especially ^{123}J (half-life 13.3 hours) it is necessary to make minimal the duration of each operation.

Hence were determined the aims of the elaboration of set-up for isotope production: 1) the exclusion of presence of service personnel in the region of the dumping of irradiated target; 2) the minimal duration of the delivery of irradiated target outside the active zone, packing of the target in polyethylene bag with subsequent stacking in container. During the irradiation process at the internal beam in the chamber of cyclotron it is rather difficult to take off the thermal loading of 25–25 kW from the target. That is because of limited size of target restricted by the construction of cyclotron chamber and beam square of the finite radius is about several square centimeters. Using of rotated target for decrease of specific thermal load causes its vibration because of strong magnetic field available. The mean of beam extraction by stripping through thin film targets for light ions permits to decrease essentially the residual activity of cyclotron chamber parts at emission coefficient near to 100%. During this it is reasonable to irradiate targets at the external beam thus giving the following advantages:

- the dimensions of irradiated target are not limited by the construction of cyclotron chamber;
- by the use of aperture lens set before the irradiation chamber it is possible to defocus the beam till necessary dimensions;
- the pressing cone rested against the butt-end of rotating target permits to remove the vibration and unload the bearings and glands;
- the free access to irradiation chamber, target device, probe, transducers and other mechanisms and devices.

The elaborated semiautomatic set-up consists of the following main parts (see Fig. 1): irradiation chamber (9), target device (2), dumper (8), sluice (7), transporter with the hoist (10), trestle (1), control board (12), storage, container, the welding device (11), manipulator (13), inspection window (14). One cycle from the feed of non-irradiated target to the chamber till stacking it after irradiation into the container consists from 34 operations. The duration of the cycle is 12 minutes.

The sequence of fulfilling of the main operations: nonirradiated target (5) set in the vessel (6) through the transporter (10) is fed from the storage room (011) to main hall (118). By the travel of target device (2) and then of the rod (4) the setting of nonirradiated target on the head of target device (3). Before the beginning of this operation the centering of the vessel and target device frame is made. The vessel through the transporter is pulled down to the initial state in the storage room. Then the following operations are made successively: lead-in of the rod with target into the sluice (7),

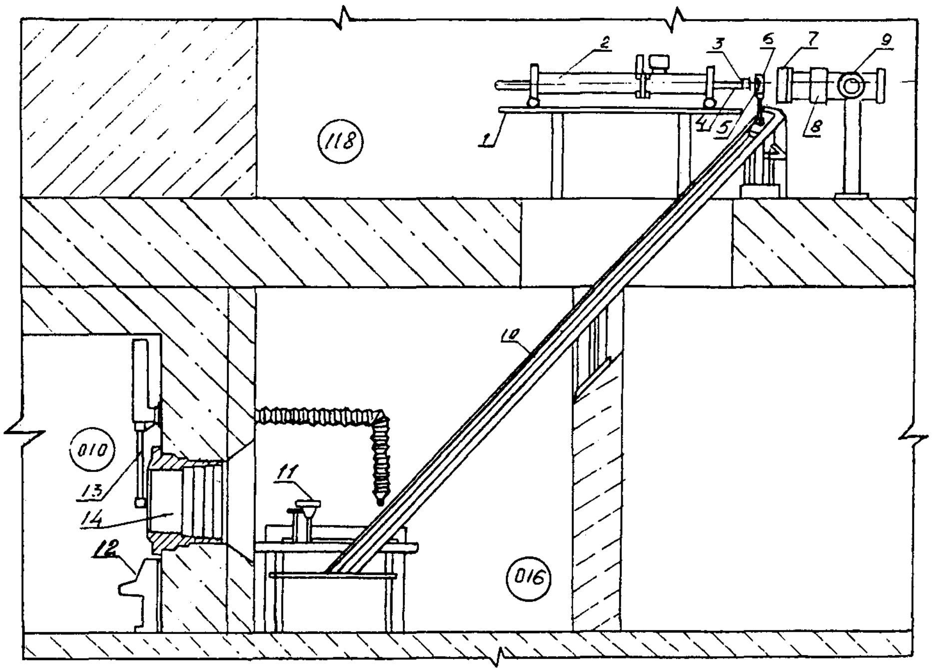

Figure. 1. The elaborated semiautomatic set-up consists

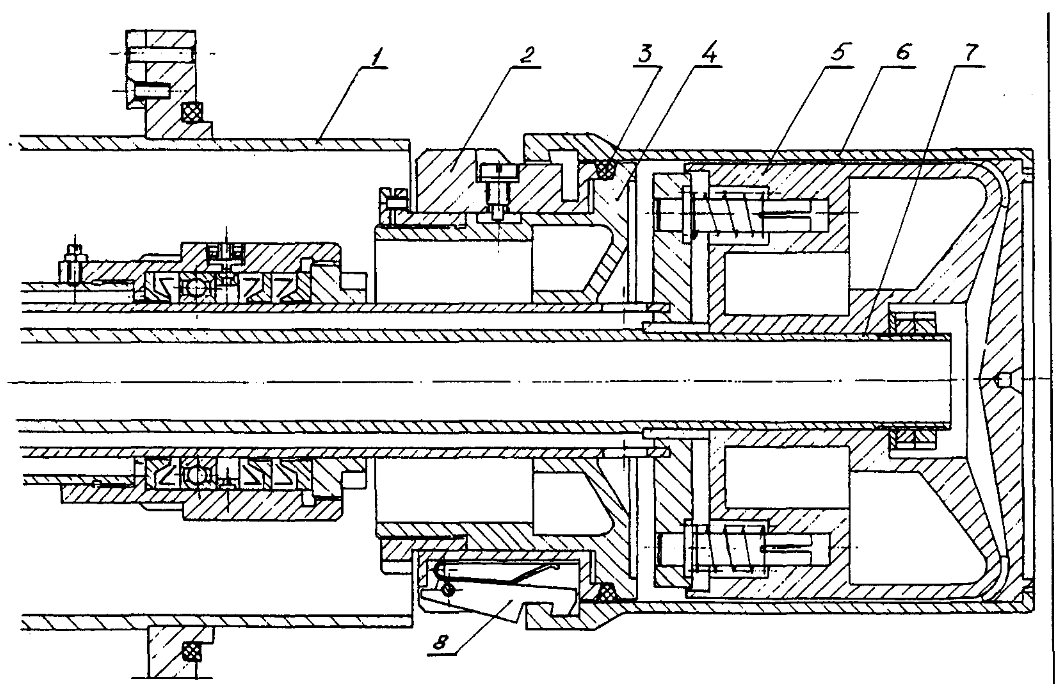

Figure. 2. The central rod

pumping out of the sluice,opening of the dumper, lead-in of the target into the irradiation chamber (9), switching on the drive of the rod rotation, the feed of cooling water into the target device system. The vacuum condensation between the target and the vessel is made by the fulfilling of the following operations: the central rod (7) (Fig. 2) with attached head (5) by the use of pneumatic piston (set on the opposite side of target device) travels forward to the given distance. To the same distance relatively the motionless frame (4) travels the target (6) and the bushing (2) which is connected with target by the ratchet (8). At this time it happens the pressing of the rubber ring (3) and the condensation of the target and frame. After the opening of the valve of the cooling system the air pressure in pneumatic piston reduced because the necessary pressing of rubber ring occurs on account of water pressure against the butt-end of the target.

The conditions of irradiation and the time of isotope elaboration is determined and controlled by the operator. After the end of irradiation the operation on delivery of irradiated target into the storage room is made in reverse succession with the exception of that before the irradiation instead of the vessel the polyethylene bag is set on the transporter carriage.

The polyethylene bag after dropping into it of the irradiated target is delivered by transporter to the welding device (11) in the storage room. The operator by the use of manipulator makes the welding of polyethylene bag with the following stacking it either in the storage cell or in the container (the storage and the container are not shown in the figure).

From 34 operations of one cycle 4 operations are made manually, namely the setting of the vessel with nonirradiated target on the transporter carriage, the replacement of the vessel to polyethylene bag, the welding of the bag with irradiated target into the storage cell or container. The manual operations are made in the beginning and in the end of the cycle. 30 operations are made automatically. If necessary every operation can be made manually. The end of each operation gives signal on the control board. The blocking system provides the fulfilling of operations strictly in given sequence. On the control board are displayed water pressure, its temperature and the rotation speed of the target. Thus the developed system permits to elaborate the wide range of radionuclids for medical and commercial purposes. During the elaboration of short-period isotopes the implementation of the operations in automatic made permits to minimize the delivery time of the irradiated target to the section of chemical processing.

The design of target device with rotating cylindrical target provides reliable heat remove at the beam power of accelerated ions till 20–25 kW. During the irradiation the safe temperature control of the target is provided.