should be made for operating any or all moderators as cold (~ 20 °K) moderators with solid or liquid moderator materials. A desirable feature of the design would allow the target to be positioned axially with respect to the moderators to selectively peak the neutron flux to a given moderator.

3. Versatility

Capability to provide for experimental needs other than neutron scattering should be accommodated wherever feasible. Provision should be made for proton irradiation experiments. Additional multipurpose neutron beams should be accommodated as may be feasible. Such beam tubes may fall within the ± 45° forward direction sector. Thermal-neutron irradiation facilities ($\geq$ 2 inch inside diameter) with time averaged fluxes > 1 x $10^{12}$ $cm^{-2} \cdot s^{-2}$ should be provided where feasible.

## H. Remote-Handling Considerations for IPNS-I, N. J. Swanson, ANL

The activities associated with the handling of radioactive materials for IPNS-I are divided into two distinct categories. These are: a) the proton synchrotron and its beam-transport system, and b) the target/moderator/reflector systems for the neutron sources.

For the accelerator systems no remote handling systems, per se, are to be used. However, techniques used for remote handling applications will be applied for particular devices. These techniques will be used to permit easy and quick removal of items anticipated to require replacement. Replacements may be needed due to malfunction or failure and for improvement purposes. Included will be the application of quick disconnects for electrical connections, control and monitoring equipment, vacuum seals, water cooling piping, mounting and positioning mechanisms, and other similar devices. Shadow shields will be used for direct contact approaches by maintenance personnel. The degree of application of special techniques will be related to susceptibility for change. For example, the extraction system magnet of the Rapid Cycling Synchrotron has displayed frequent failures and contributes to poor proton extraction efficiency. Frequent changing of this magnet is expected for an indefinite period. Air pallets may be employed to assist in the removal of heavy items such as magnets.

For the target/moderator/reflector systems, the designs will include features for easy removal into shielding casks. The removal system will be as simple as possible. Removed radioactive items will be transferred to hot cells, via the casks, where remote handling can be performed efficiently with proper equipment. One of the most important factors involved with this approach is for proper communication between the IPNS personnel and the hot-cell people during the design periods. These communications are essential so that the hot-cell people can become suitably prepared for the anticipated remote handling and possibly post irradiation examination or repair activities.

## I. Neutron-Beam Currents as a Function of Proton Energy and Target Diameter in a Pulsed-Spallation Source, J. M. Carpenter and T. G. Worlton, ANL

As is well known, the total number of neutrons produced by spallation increases roughly linearly with proton energy. However, the distribution of neutrons produced in the target becomes more extended as the proton energy increases, since the cascade builds up at small angles from the incident end of the target. The total number of neutrons produced also diminishes as the target diameter is made smaller, since fewer secondary neutron-producing reactions can then take place. Offsetting this is the fact that moderators can be coupled more efficiently to small-diameter sources than to large ones.

Calculations of these effects were done recently at Argonne, using the HETC code to transport high-energy particles, and the VIM code to transport neutrons to low energies. The targets were modeled as NaK-cooled U disks, 1.2 times as long as the proton range, and of variable diameter. An annular void of 1-cm width separated the target from the moderators, which were surrounded with a Be reflector and (except for moderator "C") decoupled by boron layers. The Be reflector radius was kept equal to the target length or 30 cm, whichever was greater. The arrangement is shown in Fig. II-I.1.

Table I shows the resulting epithermal beam current per unit lethargy, evaluated at 1 eV, $EI_p(E)_{1\ eV}$ on a per-proton basis. Results were developed for the average of the four moderators, and for the highest-intensity moderator ("C"). The results for the average moderator are shown in Fig. II-I.2.

As can be seen in Fig. II-I.2, when the proton energy is increased, the beam intensity increases approximately linearly up to nearly 2 GeV, at which energy the anticipated diminishing return is evident. The results also indicate that the beam current diminishes only slightly with increasing target diameters, in the range of diameters studied.