qualifying statements attached to these published values, for example in NBS Handbook 69, should be closely read and understood

In each case, NBS Handbook 69 should be consulted for information on the specific radionuclide being used, and a plan for estimating internal exposure from human excretion data should then be developed (See the list of publications under the subhead "'Radioecology' literature" under "References" at the end of this chapter)

Bio-assay specimens may be analyzed by commercial laboratories

## Typical Industrial Installations and Operations

This section gives details of how to make a specific installation safe, and how to operate it safely The suggestions and procedures have been taken from "Specific Installations and Operations," by Jack Baliff, P E It is Chapter 6 of *The Control of Radiation Hazards in Industry*, published in 1959 by State of New York, Department of Labor, Division of Industrial Hygiene

### X-ray installations (industrial radiography)

PLAN X-RAY PROTECTION PRIOR TO ACTUAL INSTALLATION The primary method of control involves enclosure and shielding In the interest of economy, from the standpoint of shielding material and construction costs, consider the following in planning

- Distance to X-ray tube The installation should be as far removed as circumstances will permit from all spaces occupied by persons during operation of the equipment Spaces adjacent to the installation should, wherever practical, be restricted to storage or other purposes requiring only infrequent presence of personnel Corner locations or corner rooms are especially suited, the outside walls and windows do not require any shielding if they are sufficiently distant from other occupied buildings and areas The center of a room may not always be the best location for the installation, greater protection is sometimes gained by placing the equipment in a corner of the room or next to a wall bordering dead storage space Consideration should, however, be given to future occupancy of nearby areas
- Direction of useful (primary) X-ray beam Wherever possible, the useful X-ray beam should be directed away from all occupied spaces Where normal operation is not interfered with, devices for restricting the angulation of the tube may reduce the amount of shielding required
- Cross section of useful X-ray beam The cross section of the useful X-ray beam should be as small as practicable Whenever possible, cones should be used
- Operating conditions and workload The thickness of required shielding also depends on these two factors Thus, in addition to knowing the type and use of the proposed installation, one should know the kilovoltage, tube current, and the expected working activity of the machine The possibility of operating several machines located in the area at the same time must also be considered For accessibility and viewing, openings in radiation barriers may be necessary but these should be held to a minimum Protection for all such openings should be provided by means of suitably shielded (lead-lined) doors, leaded glass windows, or by suitable baffles equipped with mirrors Closed circuit television can be used for viewing

The structural shielding and general layout requirements of any new installation, or an existing one in which changes are contemplated, should be discussed with a qualified expert early in the planning stage He should be provided with all the previous data as well as the structural details of the building in order to properly design the necessary shielding The design of protective barriers should be computed for the maximum kilovoltage, tube current, and the proper workload and occupancy factor It is also advisable that the final plans, detailed drawings and all pertinent specifications be checked by a qualified person before construction begins

PLAN STRUCTURAL DETAILS AND LAYOUT OF RADIATION BARRIERS These are an important part of shielding Attention must be given to these details to make sure that construction is substantial as well as to minimize radiation leakage through the shielded enclosure Recommended construction spec-