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BERKELEY 88-INCH CYCLOTRON

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ABSTRACT

The ion-source tube is inserted vertically through the magnet yoke and upper pole. This position was chosen because it saves peripheral space within the cyclotron, and permits withdrawal of the ion source through the roof shielding for servicing. The source is remotely controlled and can be moved either radially or azimuthally, and can also be rotated about its own axis. The system of mechanism for providing these movements is described, as well as related equipment.

THE ION-SOURCE MECHANISM FOR THE
BERKELEY 88-INCH CYCLOTRON[†]

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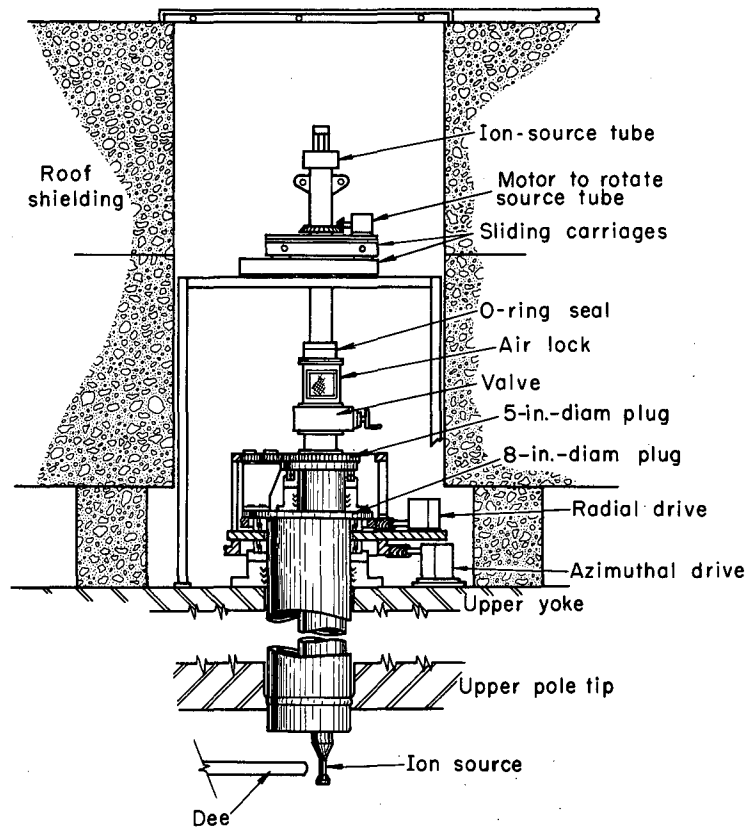
1. Introduction

Contrary to conventional design, the ion source for the Berkeley 88-inch cyclotron is inserted vertically through the upper pole and yoke.¹ Three remotely controlled motor-driven motions are provided: (a) radial motion relative to the center of the pole, (b) azimuthal motion relative to the center of the pole, and (c) rotation of the source about its vertical axis. The mechanism providing these motions is installed directly on top of the upper yoke. Access to this mechanism is through a hole in the shielding roof (see Fig. 1).

The vertical position through the pole was selected in preference to the conventional radial position for two reasons: (a) in the axial position the source tube and mechanism occupy no peripheral space, and (b) in the axial position the source may be withdrawn through the roof shielding and serviced without entering the shielding vault. With regard to the first reason, in any cyclotron the peripheral space around the pole is at a premium. A large portion of this peripheral space is, of necessity, always occupied by the rf system, pump manifolds, magnet legs, deflector, probes, and usually, the

[†]Work done under the auspices of the U. S. Atomic Energy Commission.

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Fig. 1. Schematic of the ion-source mechanism.

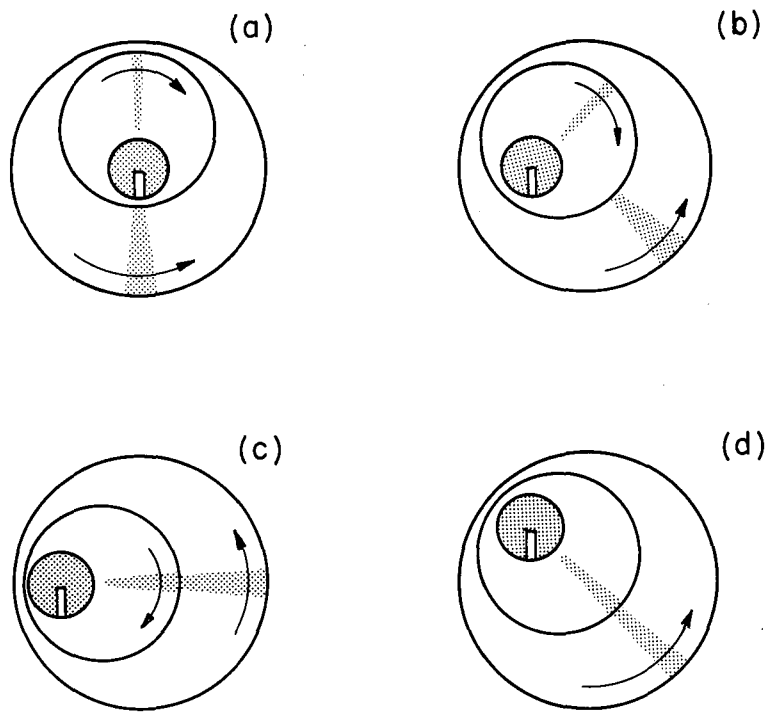
ion source. By removing the ion source from the usual radial position, this peripheral crowding is considerably relieved, and the design improved by providing greater flexibility for the future. With regard to the second reason, the ability to service the ion source without entering the vault is particularly desirable in a high-current cyclotron where the residual activity is expected to be very high and access to the shielding vault consequently severely restricted.

2. Rotatable Plugs

For magnetic reasons it is obviously desirable to have as small a hole as possible through the pole. However, to accommodate different energies and kinds of particles, the ion source must be moved relative to the center of the machine. To allow this motion without entailing a large hole through the magnet, two rotatable iron plugs, one within the other, are provided through the axis of the pole (Fig. 2). The outer plug, 8 in. in diameter, is concentric with the axis of the pole and has an eccentric bore parallel to its axis. The inner plug, 5 in. in diameter, rotates in this bore, and in turn has an eccentric 2-1/4-in. diam bore parallel to its axis. Both eccentricities measure 1-1/4 in. The ion source tube is inserted through the hole in the inner plug, and can therefore be moved radially outward a maximum of 2-1/2 in. from the center of the cyclotron.

3. Travel Devices

The ion source may be moved radially relative to the center of the pole by rotating both plugs simultaneously in opposite directions (Fig. 2 a, b, c). By rotating only the outer plug, the ion source is moved azimuthally around the center of the pole (Fig. 2d). The outer plug is rotated by means of a



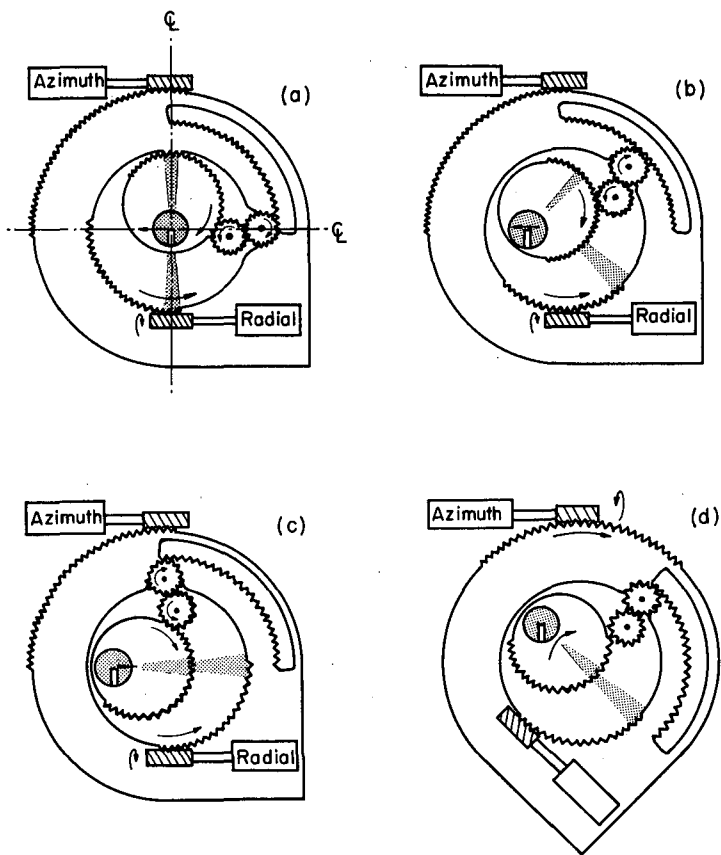
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Fig. 2. Schematic of rotatable plugs.

worm-and-gear drive (Fig. 3 a, b, c). Idler gears mounted on the outer plug mesh with an internal gear fixed to a base plate, and drive the inner plug twice as fast as the outer plug in a direction opposite to that of the outer plug. The radial speed of the ion source varies sinusoidally at an average rate of approx 0.006 in./sec.

Rotation of the base plate to which the internal gear is mounted will move the source azimuthally around the center of the pole, since both the outer and inner plugs are locked together through the idler gears (Fig. 3d). This rotation is also done with a worm-and-gear drive. The azimuthal speed varies with radius, and is 0.0075 in./sec at a radius of 2-1/2 in.

The motions described above are, of course, in "polar coordinates." The motions of the source are such that it could strike the dee if limit switches were not provided. Moreover, it is convenient to know the position of the source in "rectangular coordinates" relative to the dee edge. For these reasons it is then desirable to translate the motion of the source into rectangular coordinates. To this end, a carriage sliding on a pair of ways is mounted above the plug-rotating mechanism. These ways are in turn mounted on a second carriage sliding on a second pair of ways at right angles to the first pair. The second pair of ways are fixed with respect to the magnet and are perpendicular to the front edge of the dee. The ion-source tube fits in a bore in the first carriage. As the tube moves about, the two carriages then slide on their respective ways. In order to limit the travel of the ion source with respect to the dee, limit switches and mechanical stops are mounted on the carriages. In addition, potentiometers mounted on the carriages give an electrical readout corresponding to the rectangular coordinates of the source.



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Fig. 3. Schematic of available ion-source motions.

The ion source tube, which passes through both of the carriages, is geared to a drive motor mounted on a nonrotating platform on the upper carriage. This drive motor rotates the source tube at approx 1-1/2 deg/sec. In addition, this gearing prevents the accidental rotation of the source tube with the inner plug, due to friction of the o-ring seal mounted on the air lock of the inner plug, and so keeps the slit fixed with respect to the dee (Fig. 1).

4. Other Design Features

The source mechanism is enclosed on four sides by shielding (Fig. 1). By crossing the vault roof, entry to the area can be made through a trapdoor interlocked to the filament power supply. Periodic maintenance, i. e., changing filaments, etc., is carried out in this area, by withdrawing the source through the air lock with the building crane. Access to gas, water, air, vacuum, and power lines is also available in this area.

The vacuum and magnetic loads, in addition to the plug weights, are supported on ball bearings. The lower section of the rotatable plugs is made from steel forgings of the same material as the magnet. The upper section is made of steel tubing, for lightness, and is welded to the lower section. Hard-chromed lands are provided on the plugs to reduce rubbing friction between the outer plug and the pole tip, the plugs themselves, and the inner plug and the ion-source tube.

Chevron seals maintain vacuum-tight joints between the magnet yoke and the outer rotating plug, and between the outer and inner plugs. These seals allow the drive mechanisms to be located external to the main vacuum system. A valved air lock and a multiple o-ring seal mounted on the inner plug allow the source to be serviced without losing vacuum (Fig. 1).

In addition to the ion source, the extractor, defining slits, and probes are also remotely controlled. An electrical reading corresponding to the position of each is shown on an individual digital voltmeter in the control room. To avoid possible collisions, each time an item is moved the operator changes its position on a full-scale model of the cyclotron's central region.

REFERENCE

1. Information regarding design and development of the ion source itself is contained in another paper: Kenneth W. Ehlers, Design and Development of the Ion Source for the Berkeley 88-Inch Cyclotron, Lawrence Radiation Laboratory Report UCRL-10080 (Feb. 1962).

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