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500 kV MERCURY ACCELERATOR*

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Summary

The objective of building a low-cost pre-accelerator for low energy heavy ion particle accelerator was realized by using standard, readily available material and hardware.

Some savings were obtained in the construction of the dome by avoiding welding, expensive metal spinnings and unnecessary corona rings.

Larger monetary economies were realized by a unique approach to building the high voltage column utilizing a glass tube.

I. High Voltage Dome, High Voltage Column and Insulators

The Heavy Ion Fusion Group at Brookhaven National Laboratory has built a 500 kV pre-accelerator from commercially available materials and hardware. The high voltage dome consists basically of a frame and a .062 thick aluminum skin. The dome has been constructed in a manner not requiring welding or metal spinnings. The frame is made from 1-5/8 x 1-5/8 unistrut extrusions, angles and fasteners.

The dome edges were formed into cylindrical shells with 4" rad. and appropriate lengths. Each corner of the dome was made from aluminum wire mesh, covered with epoxy, shaped into spherical forms and painted with aluminum paint. Neither the pan head screws which were used to attach the skin to the frame nor the electrically non-conductive materials used on the corners created corona related problems.

The single gap high voltage column is constructed from 18" diameter x 48" long and 3/8" average wall thickness glass pipe,** 30" diameter, 50" long and 5/16 average wall thickness fiberglass tube and 5" OD x 2" ID stainless steel electrodes.

The fiberglass tube serves only as a protection against accidental damage to the glass pipe. Figure 1 shows the high voltage column with the fiberglass tube removed and corona rings not installed.

To avoid damage to the glass pipe because of the dome's horizontal plane movement, the entire high voltage column, ion source, welded aluminum "T" with turbo molecular vacuum pump rest on a plate with four casters which ride on two channels (Figure 3).

The dome's vertical plane movement is negligible. The welded aluminum "T", which houses the ion source, also contains two Gabor Lens assemblies. Gabor Lenses focus the initial beam into the 500 kV single gap electrodes. (For more details about Gabor Lenses see paper written by R. M. Mobley.)

The dome rests on porcelain insulators.*** Two insulators were joined together to obtain the desired 45" height for each support leg. Corona rings were not used at each coupling junction. Location of power supply and isolation transformers with respect to the dome is shown on Figure 2.

II. Electronics for Low Beta Pre-accelerator

The overall goal of the project is to build a low beta linac. One tool required to meet this end is a 400 kV Cockroft Walton. Budget and manpower limits dictated that we avoid exotic electronics and control systems. Following this philosophy, the remote controls for the source and dome electronics are control rods of 1/2 inch PVC pipe. The rods are motor driven from the control room. Readouts are digital voltmeters mounted for T.V. viewing from the control room. AC power for the dome is supplied by a high voltage isolation transformer.

The source power supplies are mounted on a 50 kV high voltage deck. Source parameters are transmitted to the D.V.M.'s at dome potential, via light pipes. A pulsed valve is used as the gas control for the source. The gas pulse and arc pulses are transmitted to the dome on a single light pipe from ground level. AC power for the 50 kV H.V. deck is supplied by a 1.5 kVA 115 Vac isolation transformer.

The control rods are 1/2" PVC water pipe, 5 foot lengths, driven by slo-syn motors. PVC was selected because of it's good H.V. standoff, not to mention price and availability.

Digital voltmeters, 0 - 20 Vdc, read out the dome parameters. The meter selected is a Newport Model 200BS. The choice of meter was to conform to Brookhavens pre-lac standard meter. The digital meter also gives a clear reading on the T.V.

The transformer is supplied by Hipotronics Inc., Brewster, New York (Model D22-1LE-711).

Specifications:

Input - 240V 3 phase 60 Hz Delta
Output - 240V 3 phase 60 Hz Wye 29A
Power Rating - 12 kVA
Isolation - 450 kV dc continuous
Bleed current - less than .1 mA

This type of transformer has been successfully used in both Cockroft-Waltons at Brookhaven for several years. However, external arc protection is required. We used r.f. filters and lightning arrestors on each phase at the H.V. terminal and at the ground end. (See Figure 4). The initial problem without such filtering was high voltage transients internally in the transformer, causing breakdown across the input terminals. The manufacturer recommended tieing the mid point of the transformer to the mid point of the H.V., however, we found that not to be necessary.

The 50 kV deck was necessitated by the fact that the source be +50 kV above dome potential. The design of the accelerating gap and Gabor lenses, used for transport at dome potential, made it more practical to have them and the extractor electrode at dome potential.

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**The glass pipe and mounting flanges were purchased from Corning Glass Works under the trade name of QVF.

***The insulators were obtained from Lapp Inc. at very low cost.

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AC power to the deck is supplied by an isolation transformer in the dome. Readouts are transmitted from deck to dome potential via light pipes using analog to grequency converters.

A VEECO pulsed valve is used as the gap regulator. Pulse width can be varied from 1 ms to 50 ms. Gas pulse and arc pulse are transmitted from the control room by a single light pipe.

At present a duoplasmatron ion source is installed. The source has been operated with >200 ma H^+ as measured near the extractor. We expect to obtain ∿20 ma of Xe^+ with this source. Two Gabor lenses are used, the first to capture the divergent duoplasmatron beam and render it parallel, and the second to optimize beam size at the accelerating gap, which is about 4½ feet away from the source.†

We are testing an ion source of the Berkeley multifilament type [1] which yields ∿50 ma Xe^+. This source can be used with Hg vapor to provide 40 ma with excellent emittance.

III. 500 Kilovolt Power Supply

One of the earlier difficulties to overcome in building a preinjector was the limited area. A room 28 x 22 with a 10 foot ceiling was available. Additional height clearance was obtained by making a 3 foot deep pit. The metal walls of the room provided a convenient ground plane.

†Early operation yielded 80 ma H^+ (40 keV) in a 2 inch diameter at the gap location.

By placing the surge resistor outside the power supply the vendor was able to provide a supply having a height of 8 feet. Thus a 5 foot clearance was obtained. The supply, having a no-load to full-load regulation of 2%, is capable of supplying 500 kilovolts at 10 milliamperes. This oil immersed supply is housed in a fiberglass drum. The BNL-fabricated 5 megohm surge resistor is in a PVC pipe also filled with oil. Alternating current power for the dome is supplied by two isolation transformers. The supply, isolation transformer, and dome have been run satisfactorily at 500 kilovolts with minimum levels of corona to the walls.

IV. Conclusion

Low cost, simplicity and reliability were the factors governing the dome control system.

Reference

1. We are grateful to K. Ehlers of LBL for the loan of his original prototype.
See, for example, K. W. Ehlers, W. R. Baker, K. H. Berkner, W. S. Cooper, W. B. Kunkel, R. V. Pyle, and J. W. Stearns, Proc. of the Second Symposium on Ion Sources and the Formation of Ion Beams, Berkeley (1974), pp. 1-5.

Acknowledgement

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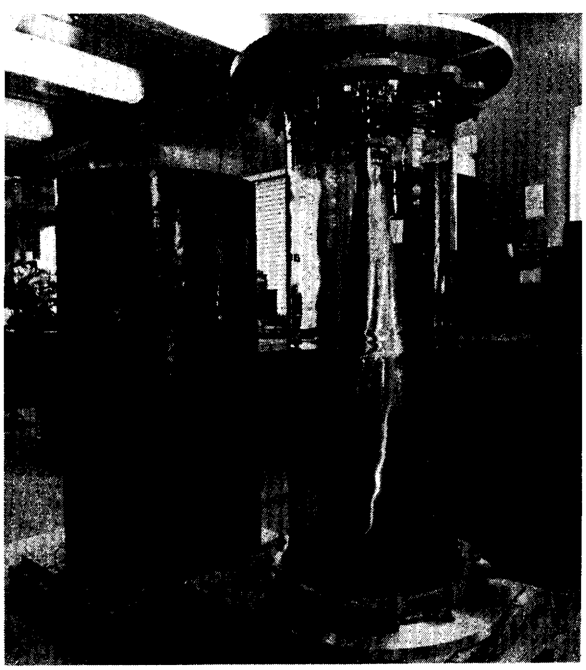

Figure 1. High Voltage Column

Figure 2. Power Supply, Isolation Transformer and Dome

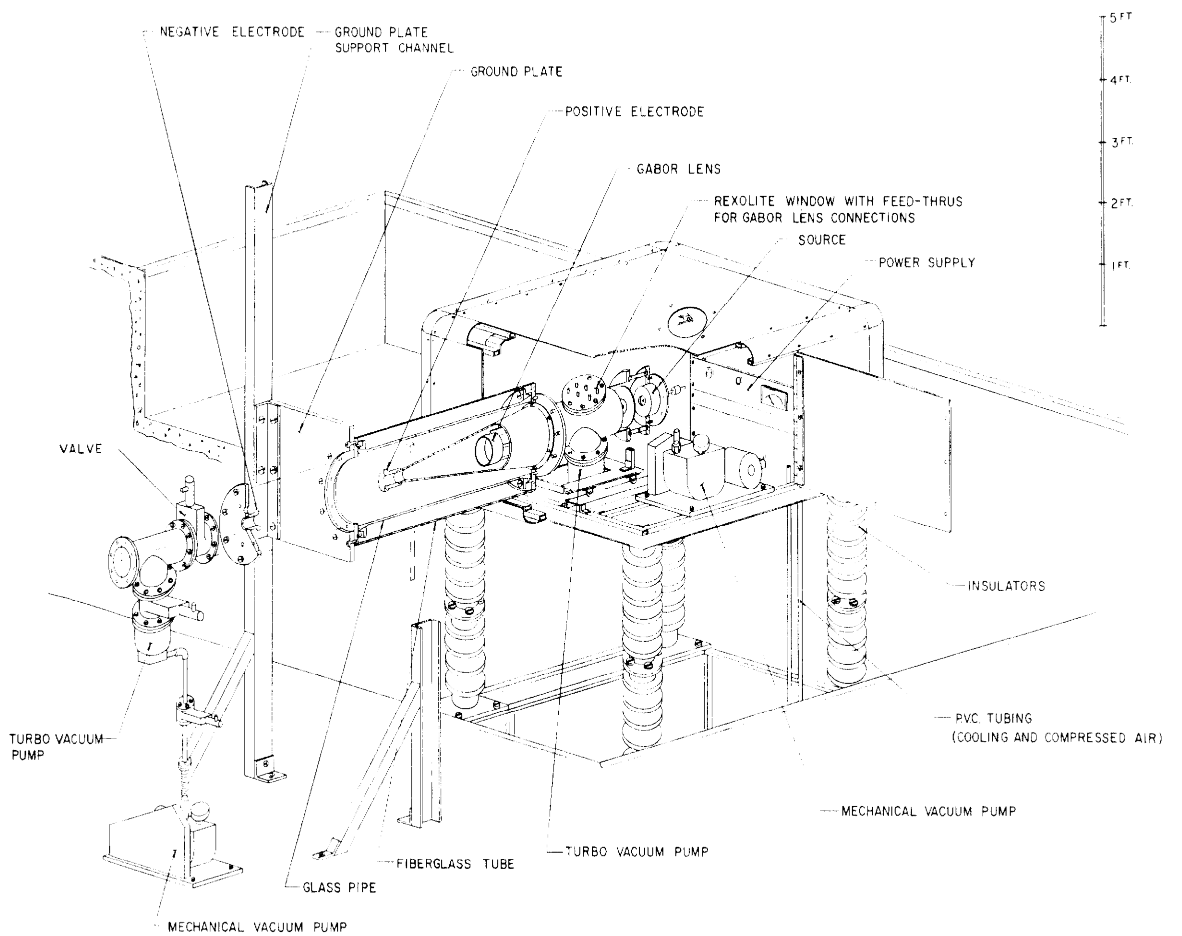

Figure 3. 500 kV Mercury Accelerator

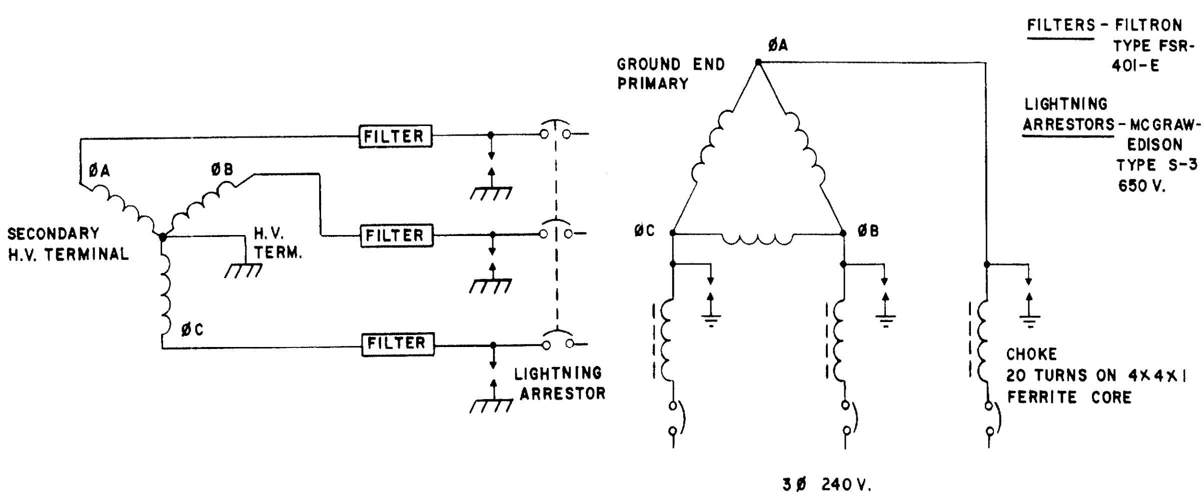

Figure 4. Isolation Transformer Schematic