Variable Frequency in the Los Alamos Cyclotron

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The r-f system of the Los Alamos Variable Energy Cyclotron uses a self-excited, tuned-grid tuned-plate oscillator operating with two 880's in push-pull. As a consequence of the flutter-field focusing the radial stability is reduced. This has introduced some problems in the stability of the oscillator which I would like to discuss.

The radiofrequency is determined by adjusting the position of the shorting nodes, Figure 166, along the dee lines. The multipactoring difficulties are avoided by the use of a booster oscillator. It operates as a Hartley oscillator at half the cyclotron frequency. This frequency is doubled by connecting the two plates together, as shown in Figure 167.

The booster plate circuit is capactively coupled to the grid of the main oscillator. The booster grid circuit receives its bias from the grid circuit of the main oscillator and also from self-biasing action in an RC circuit. As a result, the booster runs intermittently with a low duty cycle so that the tube rating can be exceeded by a factor of 15 when the main oscillator is in the multipactoring mode. The main oscillator then acts as a power amplifier until it drives through the multipactoring region, when it biases off the booster oscillator and then runs as a self-excited oscillator.

While this system is completely satisfactory over the operating frequency range from 8.2 to 13.9 megacycles it gets into severe difficulty when the machine has appreciable beam current. Although the dee system is very rugged in a mechanical

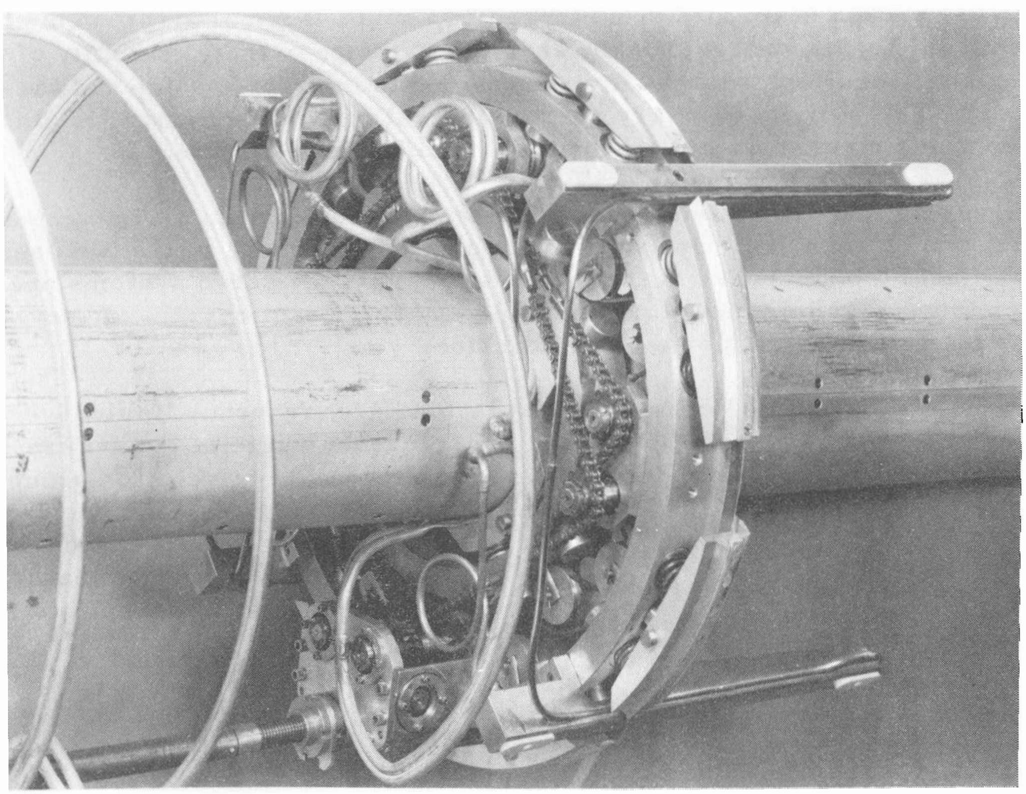

Fig. 166. Adjustable shorting bar, Los Alamos cyclotron.

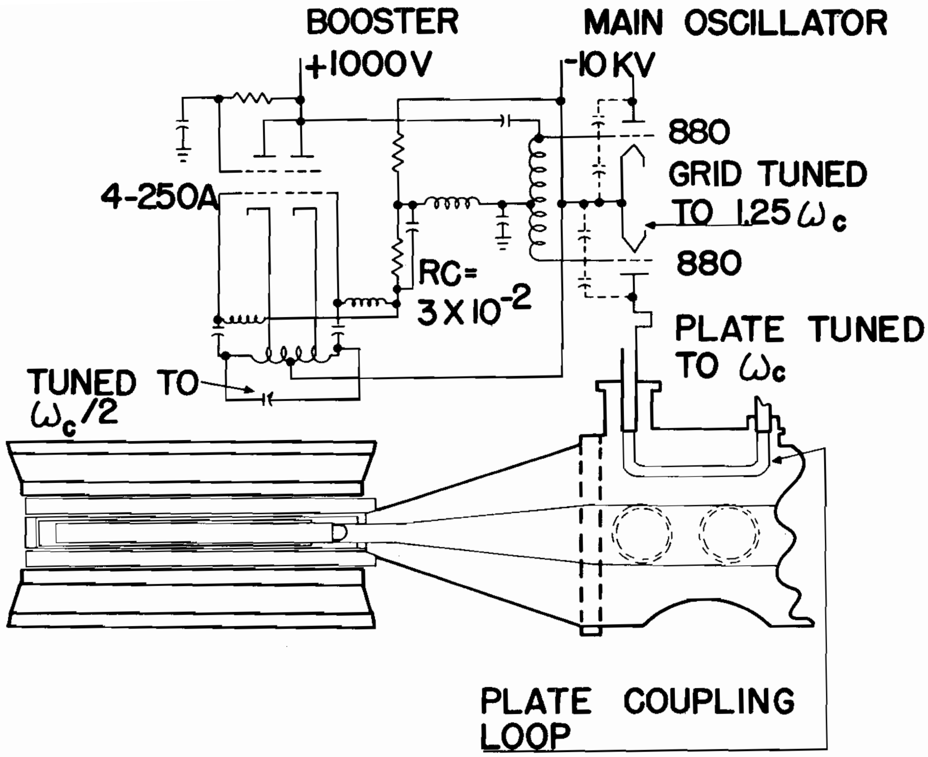

Fig. 167. R-F circuit, Los Alamos cyclotron.

sense there is enough beam loss at small radii to cause thermal drifts. This causes a slight shift in the dee voltage balance and, due to the poor radial stability of the beam, displaces the beam orbit position so that beam intercepts a dee and the drift is increased. This results in a very unstable operating condition and it is almost impossible to maintain an operating beam with manual adjustments.

To eliminate this difficulty two servo systems were added to drive compensating capacitors, one on each dee. One adjusts the electrical balance of the two dees and the other adjusts the frequency of the r-f system. With the servo systems operating it has been found possible to maintain a stable external beam current for several hours with no manual adjustments of the machine.

Since the proton and He energy of the machine are frequency limited we have investigated a number of ways of extending the frequency range of the r-f system. The most promising suggestion, due to Dale Armstrong of the Cyclotron group is to add a shorted stub to the center of each dee wall to tune out part of the dee capacity. This system has been tested on a full-scale mock-up of the r-f system and seems to operate satisfactorily. Such a stub system would shift the frequency so that it would range from 14 to 18 megacycles and not change the coupling impendence between the r-f oscillator and the dee system.

CHAIRMAN RICHARDSON: It seemed to me when I was snooping around Los Alamos a couple of months ago that you might run into trouble with your threshold dee voltage if you go up to 18 or 20 Mc/s.

BOYER: Not for helium-3. For protons it isn't clear because we can make the field rise slightly with radius rather than fall as we do now. The reason we didn't build it to be isochronous, of course, is that we thought we didn't have enough room in the dee gap for the shimming required for that higher energy. At this value we can make the field rise slightly. I am not just sure where the protons would go, but the helium-3 energy would go on up to about 42 Mev, now it stops at 27 Mev.

CHAIRMAN RICHARDSON: Do you have any information about what the actual radial oscillation frequency is in your machines? You mentioned that it was peculiarly susceptible to this unevenness of voltage on the beam.

BOYER: It varies over the range. We approach an effective n-value of about 0.15 at the higher field condition at the exit. I am sorry I don't know what it is doing inside.

WORSHAM: How do you measure dee voltage?

BOYER: We have capacity pickup plates calibrated so that as we shift frequency we readjust the voltage divider, and we have a little rectifier unit that reads the dee voltage to about 10%. We are worried about whether this shifts. I think the answer is that it does not, and it turns out that we have found a perfectly satisfactory way of obtaining the balance by looking at the plate current of the two oscillator tubes and maintaining this balance.