NYO-9359

# THE SPARKER, A DEVICE TO OVERCOME THE MULTIPACTOR DIFFICULTY IN STARTING THE OSCILLATOR OF A CYCLOTRON

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(AT(30-1)-875

January 3, 1961

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## Introduction

Evacuated electrical oscillating cavities frequently are found to exhibit a strong loading due to electron (or ion) multiplication, the so-called multipactor effect. This effect tends to prevent the buildup of dee voltage in cyclotrons. In conventional cyclotrons driven from external oscillators having their own resonant tank circuits the difficulties are usually slight, but in cyclotrons using a simple dee system as the tank circuit difficulties are encountered in getting the oscillator to break into full oscillation.

Two principal methods of overcoming the problem are used. The commoner method, customarily employed with FM cyclotrons, is to bias the dee and dee stem by several thousand volts with respect to ground so as to destroy the conditions required for multipactoring. The second is to drive the oscillator strongly from an external source of RF voltage so that multipactor loading, which occurs with voltages of the order of the order of a hundred, cannot build up sufficiently to prevent the rise of voltage through the multipactor region. In this case the oscillator acts as an amplifier, at least during the starting period. In some installations the driving RF power is removed automatically once the oscillations have commenced, in others it is not.

When the variable energy cyclotron at the University of Rochester was built (finished in 1954) no provision was made for overcoming the multipactor problem.* The dee biasing scheme was considered too awkward to apply, chiefly because the variable frequency requirement had already led to a rather complicated mechanical

* Preliminary Report on the New 8 Mev Variable Energy Cyclotron of the University of Rochester. NYO-6541. H. W. Fulbright, D. A. Bromley, J. A. Bruner, R. Hawrylak, A. Hamann (1954).

design. It was apparent that the second possibility, driving the oscillator to stimulate oscillation, could be used if the need arose. Multipactor troubles were encountered as expected, and they were annoying, but they were not quite bad enough to force a shutdown for rebuilding the oscillator system.

THE SPARKER

In the summer of 1959 a simple device was added to the cyclotron to shock the dee system into oscillations of such an amplitude that the multipactor loading would be ineffective. It consists of a separate small coupling loop inside the dee stem tank near the oscillator coupling loop, oriented with its plane perpendicular to the axis of the tank. A condenser and air spark gap are connected to the loop so that a high frequency discharge through the loop occurs when a spark jumps. This induces a surge of high frequency current both in the walls of the dee tank and in the plate and grid circuits, with the result that the dee circuit begins to oscillate with a dee voltage amplitude of several hundred volts. The oscillator then begins to carry the voltage on up to its full value.

Power for charging the condensers is supplied by a 30 kV source which is automatically turned on when the oscillator power is on and there is no dee voltage, but which is automatically turned off as soon as dee voltage appears. The spark gap is adjusted so that the sparking rate is roughly two per second. Ordinarily a single spark will cause oscillation to commence.

Because the loop is oriented at right angles to the axis of the cavity, the RF voltage induced in the loop is very small, even with full dee voltage. If sparks occur when the oscillator is running there is no perceptible difference in the character of the sparks.

This simple device is very effective. It is convenient to use because no new control has been added to the cyclotron; the operator simply presses the "on" button, then if the oscillator does not start instantly he hears a spark in the cyclotron room and the oscillator almost invariably starts at once. There remain certain conditions under which the oscillator will not start, for example, when the tank gas pressure is too high or when the oscillator grid loop is detuned.

Furthermore, outgassing of the dee tank after a major shutdown must begin with the shorting disc at its highest frequency position, i.e. with the smallest oscillating cavity, in order for the sparker to be effective. In spite of these limitations the device has proved quite satisfactory.

Additional Comments and Discussion

Measurements of initial dee voltage response to the sparker have been made with the oscillator plate power on and off and with the oscillator filament on and off. No significant difference was observed.

When the decay of the dee oscillations was observed (with the oscillator plate voltage off, of course) the envelope of the oscillations was found to fall smoothly until the dee voltage had fallen to a value roughly 1/3 its maximum, then for a short time to drop steeply, then afterward to decay slowly once again. The sharp drop is attributed to the multipactor effect.

Changing the tuning of the grid circuit changed the amplitude of spark-induced dee oscillation severalfold, which seems indicates the flow of considerable capacitative current through the oscillator tube.

The range of operation of the cyclotron is about 10 to 20 mc. The ringing frequency of the current in the sparker loop was found to be about 12 mc, independent of the oscillator conditions. The amplitude of ringing is found to decay 50% in about 3 cycles.

The efficiency of energy transfer from the condensers to the dee system is extremely small under the present (original) conditions. One could improve this by several means, for example, by increasing the tightness of coupling between the sparker loop and the oscillator loop. Variable tuning of the sparker loop could also be considered.

Other means of shocking the dee system are possible, and some might be better. In the beginning we considered capacitance coupling to the dee itself, but decided to try inductive coupling first, partly because it was more convenient in our case since the dee chamber is rather crowded, and partly because we thought that the RF pickup problem would cause less trouble with inductive coupling.

Acknowledgements

The author wishes to acknowledge the help of Mr. A. K. Hamann who provided the external power wiring and made some of the response measurement. Thanks are also due to Mr. Roman Hawrylak and to Mr. Miroslav Chronoviat for the mechanical design and assembly of the sparker unit.

## CAPTIONS

Figure 1. Oscillator of the Variable Energy Cyclotron

Figure 2. The Spraker Installation

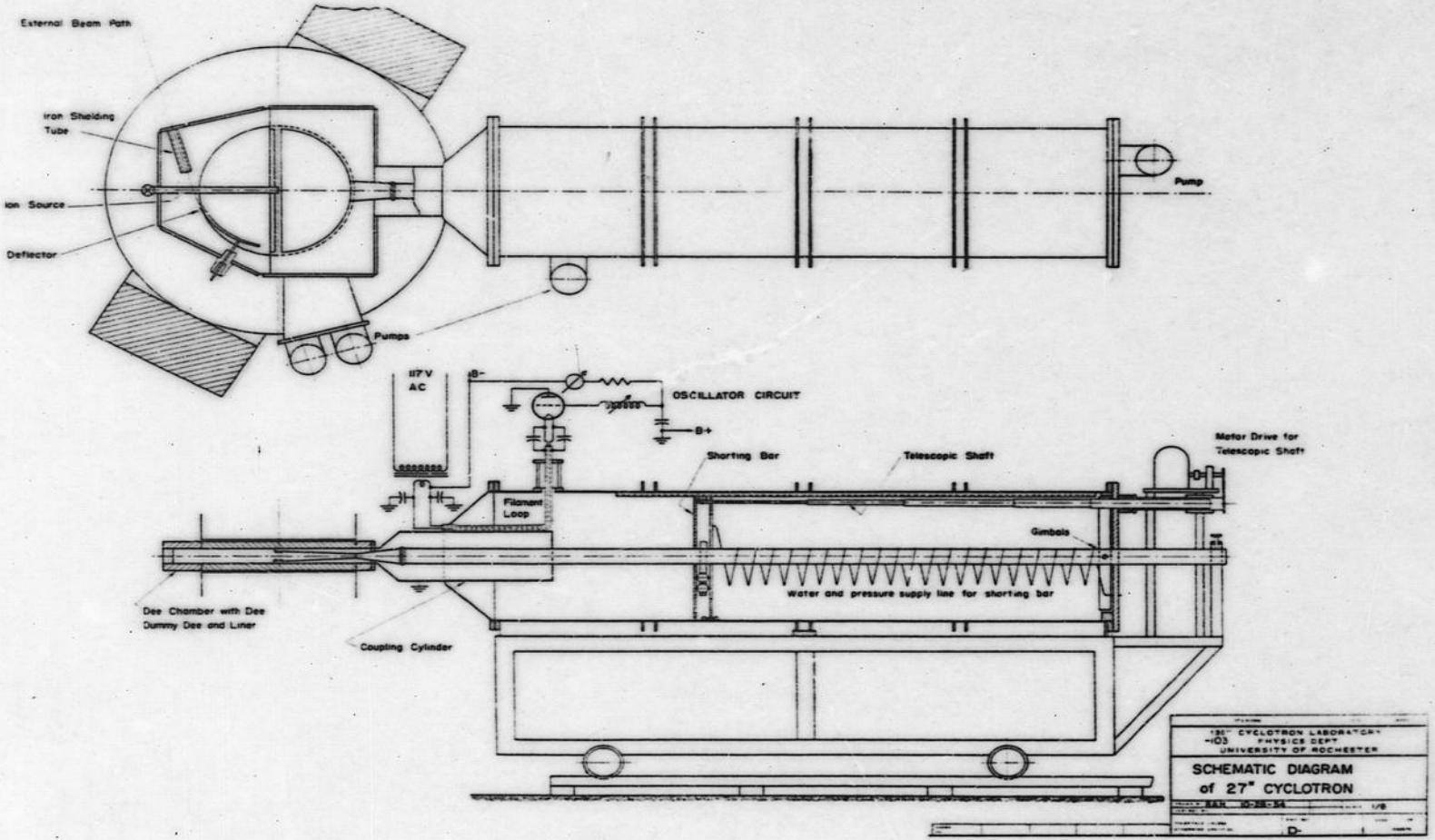
External Beam Path
Iron Shielding Tube
Ion Source
Deflector
Pump
Pumps
117 V AC
OSCILLATOR CIRCUIT
B-
B+
Shorting Bar
Telescopic Shaft
Motor Drive for Telescopic Shaft
Filament Loop
Gimbals
Water and pressure supply line for shorting bar
Dee Chamber with Dee Dummy Dee and Liner
Coupling Cylinder
SCHEMATIC DIAGRAM of 27" CYCLOTRON

Fig. 1

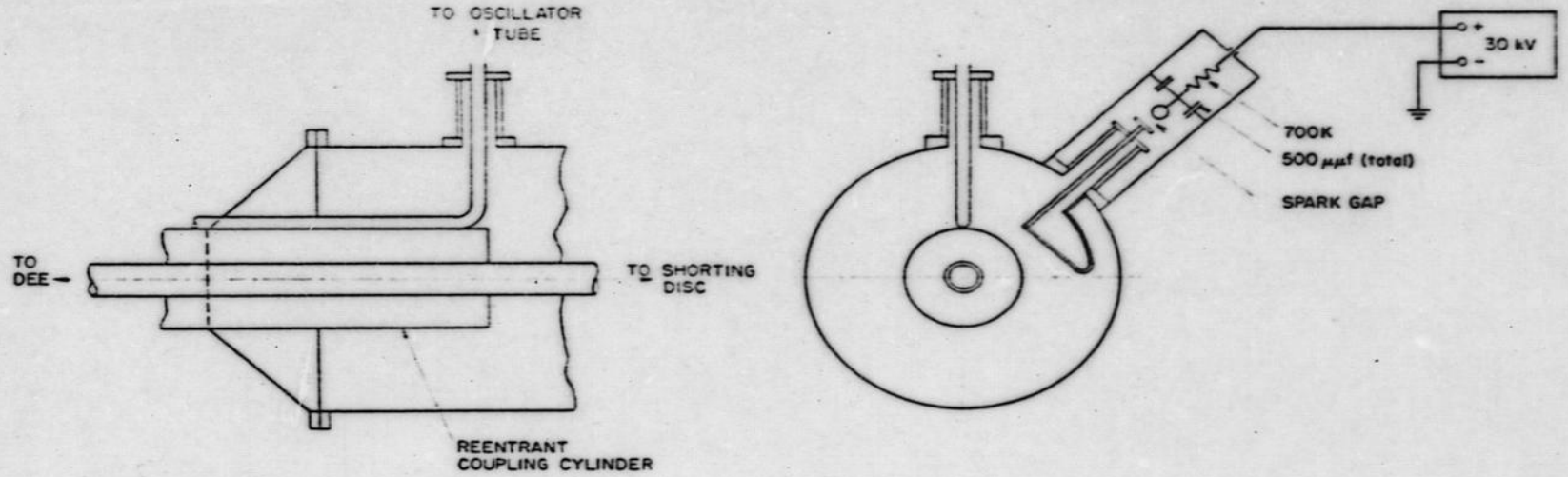


Fig. 2

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| | 130" CYCLOTRON LABORATORY<br>PHYSICS DEPT.<br>UNIVERSITY OF ROCHESTER | |
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