RHODOTRON FIRST OPERATIONS

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1 ABSTRACT

The RHODOTRON , a new type of RF accelerator has delivered its first beam on March 20th 1990 at nominal energy (3.3 MeV) and reduced power . These first results have shown the self-focusing property of this recirculating accelerator as expected from the computer simulations and the good electrical and mechanical properties of the new type of coaxial accelerating cavity. For the development of a powerful industrial machine ,it would be possible to increase the pass number up to 10 and so decrease the accelerator price .

2 INTRODUCTION

The RHODOTRON is a new type of recirculating electron accelerator , developed for industrial purposes (food preservation , medical disposals sterilization , industrial materials treatment, polymerization etc...). Its principal characteristics are :

- a powerful 20-200 kW continuous beam in the 2-15 MeV energy range
- a relatively low cost
- a good efficiency
- easy to construct
- small dimensions

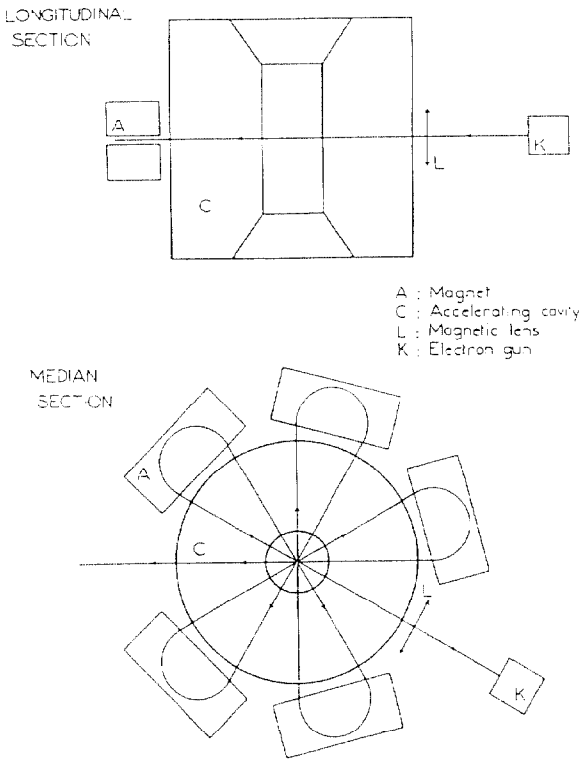

fig 1 principle scheme of RHODOTRON

The RHODOTRON has already been described in a previous paper [1] ;it uses a new type of coaxial accelerating cavity to accelerate several times the beam along different diameters of the cavity. Outside the cavity the beam is deflected by magnets (fig. 1). In the median plane of this $\lambda/2$ coaxial line, short circuited at both ends , the radial electric field E is maximum and the magnetic field B is zero (fig.2) .This plane is then convenient to accelerate a recirculating beam. The coaxial cavity has good mechanical and electrical properties (high shunt impedance [1]). The size of the RHODOTRON has been calculated to obtain a good synchronization between electron pulses and electric field phase . The self-focusing property of RHODOTRON is improved by the design of the magnets (V open faces) whose optimal shape was calculated by computer simulation of trajectories .

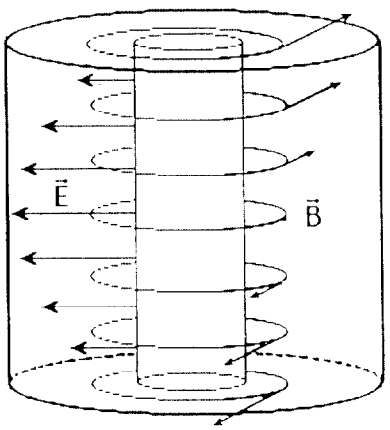

fig 2 : electrique and magnetique field in the rhodotron coaxial cavity

3 PROTOTYPE DESCRIPTION

A RHODOTRON prototype has been build to check the validity of the working concept (fig. 1 and 3). We did not try to obtain high performances with this first machine . The main characteristics of the prototype are given in table 1. The electron gun is a diode with heated wire cathode . The cavity is made of steel with 20 µm copper coating . RF continuous power generator is built using a THOMSON tetrode which has a 60% efficiency . RHODOTRON must be compact but not too small in order to avoid too precise mechanical manufacturing :A cavity diameter of 1 meter is a comfortable size . The correct dimensions are fixed by the frequency of available power generator . A frequency of 180 MHz was chosen for the prototype because of the low cost of the RF generator but for a more powerful industrial machine a lower frequency (100-130 MHz) may be used corresponding to a more powerful generator .

table 1

Characteristics of the prototype

passes number : 6
electrons final energy : 3.3 MeV
beam power : 20 kW
beam diameter: 4 mm
mean current : 6 mA
micropulse peak current : 200 mA
beam structure
0.15 ns

<---5.55 ns---->
shunt impedance : 10 MΩ
quality factor : 30000
RF frequency : 180 MHz
RF power : 50 kW
vacuum : 10-6 mm Hg
cavity outer diameter : 0.9 m
cavity inner conductor diameter:0.225 m
cavity height : 0.92 m
total height : 2 m
total diameter : 2 m
total weight : 1.5 t

4 FIRST RESULTS OF RHODOTRON PROTOTYPE

The injection of RF power in the cavity was reached at nominal level (50 kW cw) in january 1990 without difficulty . The first beam of electrons was extracted on March 20th 1990 at nominal energy (3.3 MeV) and reduced power (mean current = 4 μA) . The main tuning of the machine, alignment of different magnets with the cavity , was easier than foreseen .That means that RHODOTRON does not need a very accurate alignment . The beam was stopped in fluorescent detector after each pass to visualise its position and its shape . As expected its size decreases after each pass in the RHODOTRON because of the self-focusing property .After the 6th pass the diameter is 4mm . The current was mesured with Faraday cusp after each pass to check the good transfer of the beam through the accelerator . The electrons are injected in the accelerator continuously , among the few percents that cross the first pass at the right phase condition ,more than 50% are accelerated to 3.3 MeV on the output . The actual electron gun is not satisfying .We are developing a new electron injection system with improved performances to increase the output current up to a few mA (20 kW output power). The emittance and energy dispersion have not been yet measured . The depth penetration of few MeV electron is low (a few cm) . The treatment of thicker material requires intense gamma source which can be obtain by the X ray conversion of an electron beam . We are developing such an X ray conversion device for very intense electron beam . The computer simulations show that converting ratio is about 5% at 3.3 MeV .

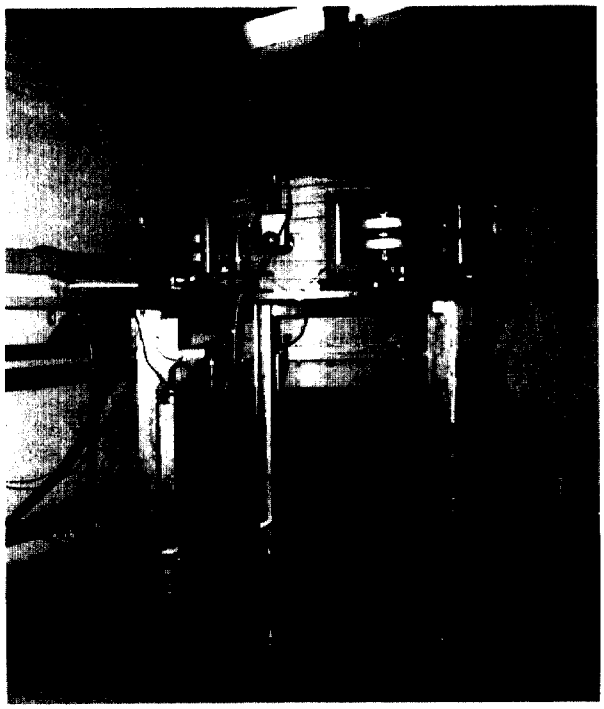

fig 3 RHODOTRON prototype

5 CONCLUSION

The first results of RHODOTRON prototype show that the construction of a powerful industrial accelerator is possible in the 1 - 15 MeV energy range with the simple and relatively inexpensive technique of RHODOTRON. A more powerful beam will soon be obtained by using the electron gun under study . Then using X ray conversion devices ,RHODOTRON should constitute a very intense X ray source (up to 10 kW).

references:

[1] J. POTTIER ,A new type of RF electron accelerator : the RHODOTRON
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