5. A High Output Demountable Magnetron Oscillator at 2000 Mc/sec

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Received November 26, 1952

1. Introduction

The researches on the multi-segment magnetron of pulse oscillation which has an output powerful in peak but weak in average have to date been plentifully performed to generate oscillation in the decimeter and centimeter wave range. On the other hand, the researches on the multi-segment magnetron of continuous oscillation and of high output which is very useful for the dielectric heating, the study of microwave gas discharge, etc. have not been developed in Japan and in U.S.A. In order to supplement this deficiency, the authors have made a trial construction of the high output magnetron of continuous oscillation and of easy operation. For a powerful magnetron of continuous oscillation, because of its high power we have to pay careful considerations to the method of feeding, that of water cooling and that of matching the load to the oscillator. Taking these problems into consideration we have attempted to simplify its construction and its operation.

2. Conotruction

To obtain the magnetron of the continuous high output, the cathode which is not damaged by the powerful back heating is required. Of our trial magnetron, the anode voltage is about 10 KV and the anode current ranges of 200 mA to 400 mA and so we can not use oxide-coated or thorium-tangsten cathodes which can be used for the pulse oscillation magnetron. The cathode of our magnetron is a simple spiral of pure tungsten wire (of 0.7 mm diameter) supported by a molybdenum rod with molybdenum end hats and has 400 watts heating power. For the safety of the operator, the anode is earthed and the cathode is kept at a high potential. Then the cathode is sustained with a silica tube by which it is insulated from the anode. The entire construction is shown in Fig. 1. The anode has 8 segments of wellknown "tachibana type" as shown in Fig. 2 and two copper cylinders of 8 cm. diameter which are shown in Fig. 1. soldered to its both sides.

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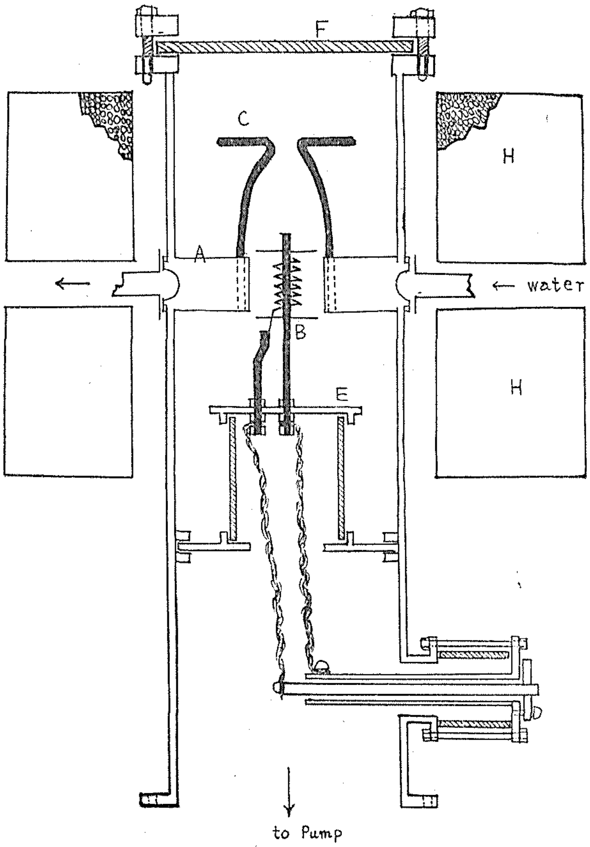

A : Anode
B : Cathode
C : Antenna
D : Copper cylinder
E : Cathode holder
F : Silica window
H : Magnetic coil

Fig. 1.
The entire construction of the magnetron.

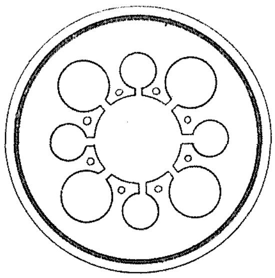

Fig. 2.
The anode cavity.

The lower part of the lower cylinder is screwed to fix the cathode holder at its proper position. In the magnetron, the applied magnetic field has a delicate effect upon the state of its oscillation, so the two magnetic coils are arranged around the cylinders and can be finely adjusted. For the convenience of the cooling device the magnetic coil is devided into two equal parts.

It is generally desirable that the oscillator has a broad and efficient coupling with the load which can have various impedances. On the other hand, it is difficult to make the feeder penetrate the silica window because of the dielectric loss of the silica. So we use the method shown schematically in Fig. 1. Namely we fix two molibdenum rods of 3 mm. diameter and 7.5 cm length perpendicularly to the anode at the points A and B shown in Fig. 2 and bend them rectangularly at the points 2.5 cm from the tops to construct a dipole antenna within the magnetron. In this method, it is possible to derive the power from the magnetron by using a circular or rectangular wave guide directly put on its upper window instead of using lecher wires or coaxial cylinders which are often used in the load coupling of the decimeter oscillator. Thus the electric waves pass through the silica window and this method allows the oscillator the smooth matching with the load which is situated within the wave guide, and the entire construction becomes very simple. Moreover, some flactuation of the oscillation frequency with the load variation cannot be avoided, but the oscillation itself is very broad and its intensity does not change very much. Consequently this method is suitable for our purpose.

In order to avoid the damage of the magnetron caused by missmatching or some accidental variation of operation conditions, the anode is usually made to be able to endure the entire input power. Therefore in this experiment, the anode is cooled by a simple device cold enough for the input power over 4 KW. The cooling device is such that into the outside of the anode a groove is cut and a cylindrical brass plate covers it with rubber packing between. And thus the cooling water is made to run in the groove. This simple method has worked conveniently and efficiently.

The magnetron has been divided into parts so that assembling and disassembling can be performed easily and at junctions the rubber packing special for vacuum purpose was used. But the rubber packing on the circumference of the silica window may be dielectrically heated by microwave field and emit a large quantity of gas, so we made the rubber ring used so thin as possible and put it in a groove. Moreover, as the mode excited at the silica window is of H-type, the heating of the rubber ring by microwave field is not strong. On the other hand, the rubber ring may be also heated by the heat radiation from the anode, but the exhaust velocity of the vacum pump used is rapid enough to make the operation undisturbed. Our exhaust-pump consists of one stage oil diffusion pump and we have been able to obtain about 5×10^{-6}mm. Hg pressure. In spite of such simplicity of the construction we have succeeded in operating the magnetron at the continuous output power 500 W and further we have confirmed the expectation that a more powerful magnetron of the same construction can be assembled.

3. Operation

In the experiment with the magnetron described above, it takes thirty or forty minutes from the start of the exhaust to be ready for the operation of oscillation. The total input power at 10 KV anode voltage and with-

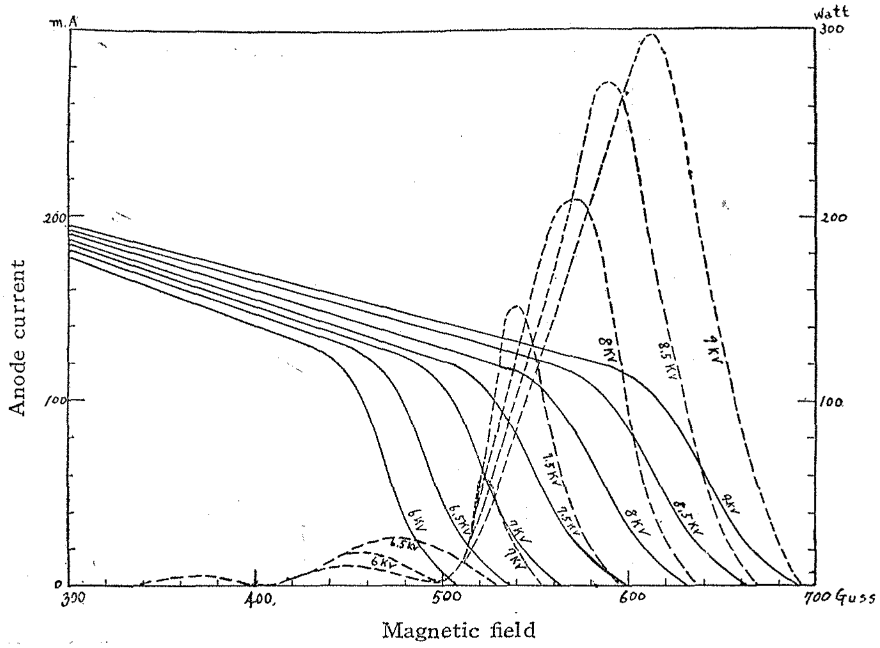

Fig. 3. The operation curves

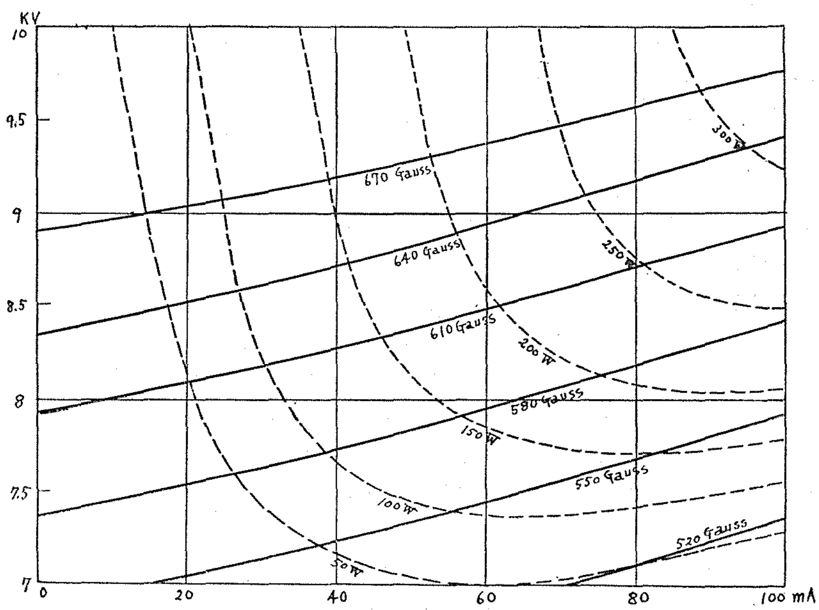

Fig. 4. The performance chart

out magnetic field is 4 KW. By increasing the magnetic field strength gradually, we have attained the oscillation at 9 KV anode voltage and the continuous output power 500 W at 14.6 cm. wave length. The operating characteristics are shown in Fig. 3 and Fig. 4. In Fig. 3, the relation of the magnetic field with the anode current is plotted with solid line for each constant anode voltage, and the dotted curves show the output powers. Moreover we can expect to obtain the output power more than 1 KW, if we only increase the emission of the cathode of this magnetron. The output power was calculated by subtracting the power absorbed by the cooling water from the total input power. In Fig. 4, the "Performance-chart" that is, the relation of the anode current with the anode voltage at constant magnetic fields is shown and the output powers are plotted against both the anode current and the anode voltage. For the anode power source we have adopted the selfrectifier system of magnetron, and applied the a. c. voltage of 60 cycles to the anode. When the discharge breaks out within the magnetron, the very high surge voltage arises, and may damage the anode transformer, so it is necessary to protect it by using choke coil and condenser.

4. Conclusion

From the above experiment, it is expected that the more powerful magnetron of the same construction can be assembled only by improving the method of cooling, enlarging the cathode emission, and increasing the exhausting velocity.

In the microwave region, we usually find it difficult to obtain the valve of required frequency. Therefore, for the purpose of the microwave experiments and the dielectric heating, the demountable magnetron of such simple construction as described above may be very useful.

The authors sincerely thank Prof. Isao Takahashi, Physical Department, University of Kyoto for his kindness that he gave helpful advices and convenience of using facilities of his laboratory.

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