Highly efficient water heaters using magnetron effects

Technical task of this project is maximum heat output and minimum electric input of power. This research project has several stages of development. At first, Mr. Korobeinikov offered magnetron effects for heating, it was published in “New Energy Technologies” № 2, 2005. After this step, Mr. Frolov developed first experimental stage to get confirmation of the effect. Now we can create new team to develop this technology up to stage of commercialization.

Consider the principle of operation of the magnetron. The photo shows a conventional magnetron (section).

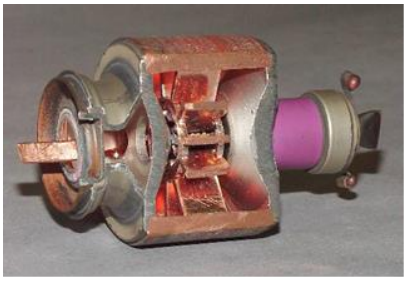

Fig. 1. Magnetron.

On the second picture is a diagram to explain the energy exchange of processes in operating magnetron.

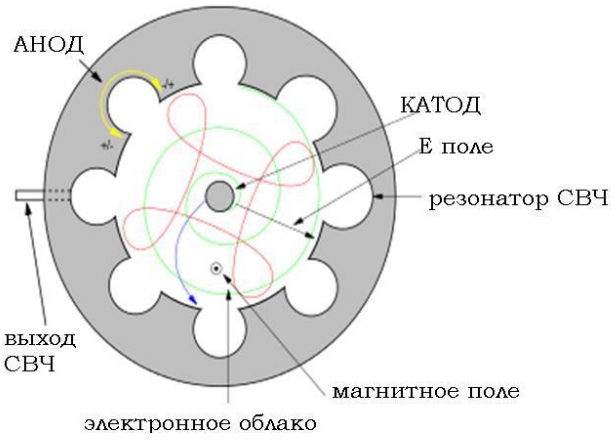

Fig . 2 Scheme of trajectories of electrons inside of the magnetron

At first, electrons are emitted from the cathode, which is located in the center of vacuum tube. The electrons are moving toward the anode, i.e. to periphery and they are accelerating by electric field placed between anode and cathode.

In space between cathode and anode, the electrons are moving in static electric field E in radial direction, also there are permanent axial magnetic field H and also there are

field of the electromagnetic wave. So, we have to consider three fields here: E, H and field of the wave.

Without magnetic field, it is ordinary vacuum tube diode and in this case the electrons are moving radially linearly from the cathode to the anode. Magnetic field changes the trajectory of the electrons due to action of the Lorentz force.

Thus, in the coaxial space between the anode and cathode of the magnetron there are some amount of moving electrons, it is so-called "electronic cloud". The electromagnetic wave here is created by movements of this electron cloud. Spontaneous instabilities here generate electromagnetic waves, these vibrations are amplified by resonators of magnetron to produce high frequency output, for example for radar or for kitchen microwave oven.

Usually, main objective of magnetron is to increase this microwave energy, which is directed through the waveguide to the workspace of the microwave oven or it is emitted in the right direction by radar. We are interested to get heat output, and it is proposed to create optimal mode of transformation of microwave energy into heat energy. In the simplest case, it is possible to provide a scattering of the electromagnetic wave on metal casing of the magnetron (in its anode). We can provide a heat exchanger in anode to use circulating coolant system.

It is important to note that the electrons are interacting with electromagnetic wave field, since they are moving in crossed electric and magnetic fields along epicycloid trajectory around the cathode. Real magnetron electron trajectory is very interesting and it has a radial component (**red line** in Figure 2). In other words, electrons periodically are moving to anode or back from anode to cathode. This oscillating radial component of motion “back-forward” is related with energy exchange between electrons and electromagnetic wave. This wave provides energy transfer to produce useful heat output.

In strong magnetic field, electron is moving along trajectory where it can not reach the anode, and in this case we can say “it is mode of magnetic locking diode”.

Figure. 3 shows such a mode of operation in which the current cathode - anode tends to zero with increasing magnetic field.

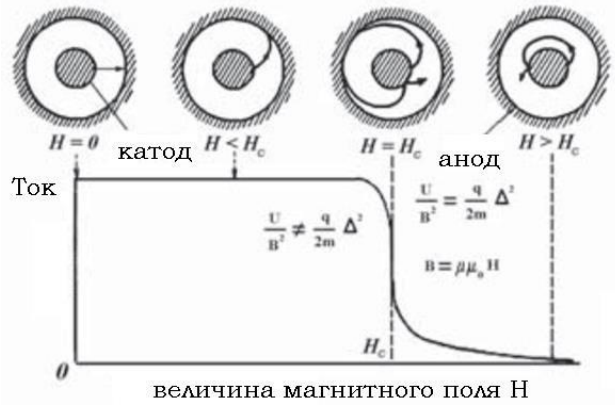

Fig. 3. Right scheme is current-less mode .

It should be clear that electric field of the electromagnetic wave produce both deceleration and also acceleration of the electrons. If average speed of rotation of the electron around the cathode coincides with phase velocity of the wave, then the electron is in area of decelerating field, and by this way the electron is giving its energy to the wave. Such electrons are grouped into clusters (so-called "spokes"), moving together with the rotating field.

In general, radial acceleration of electrons is provided by constant electric field, i.e., the electric potential difference between the anode and the cathode. After we connect source of high voltage to anode-cathode, the electric field does not require losses of input energy, if there is no conductivity current between the anode and the cathode. It is basis of high efficient mode of operation of the system.

Magnetic field is generated by permanent magnets, therefore, energy consumption for magnet field is not required.

We are interested to create “current-less” mode of operation of the magnetron. In this mode the electrons do not contacts with anode, and most of the “electrons of the cloud” is constant amount, oscillating in process of energy transfer. Electrons will lose energy, giving it to high frequency electromagnetic wave, but they again will be accelerated by the radial electric field.

Several technical solutions can be offered at this stage of the study of the problem:

1. We can try to find operating point corresponding to situation where the magnetic field H and the accelerating potential E are very accurately agreed to keep most of the electrons do not reach the anode. Since magnets are permanent, and its magnetic field can not be adjusted, we can offer automatic control of the magnitude of the accelerating potential E. The control circuit must use sensor of current between cathode and anode.

2. Instead of smooth "analog" adjusting of accelerating potential between cathode and anode we can use "digital" pulse mode. Accelerating potential E can be “ON” during a short period of time, and then it must be turned OFF at the moment of beginning of the current between cathode and anode (as quickly as possible), Figure 4.

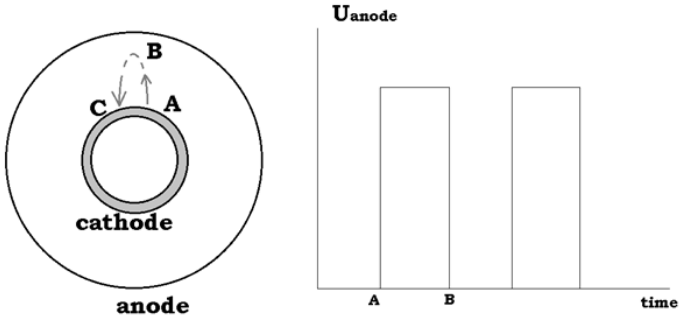

Fig. 4 Pulse mode

Powerful generator requires high accelerating potential, since the energy of the electrons depends on the square of the potential difference between cathode and anode.

Conventional magnetron use cathode heating by special low voltage source. It is not significant power losses to compare with output. For example, the filament of conventional magnetron microwave oven requires 3 volts and 10 amps. Total power input for cathode filament is about 30 watts, and at the same time this magnetron can produce thermal power of several kilowatts.

Also let's note that in special "supercritical mode" of magnetic lock, the magnetron can demonstrate effect of self-heating of cathode by returning electrons (effect of secondary emission). We can use it in case of pulsed mode of switching accelerating potential, because return of electrons on the cathode is possible only in half-period of absence of a negative potential at the cathode.

For the purposes of patenting of proposed experimental design we can use classical accelerator of particles invented by Lawrence, US Patent 1,948,384 Ernest O. Lawrence "Method and apparatus for the acceleration of ions", Figure 5.

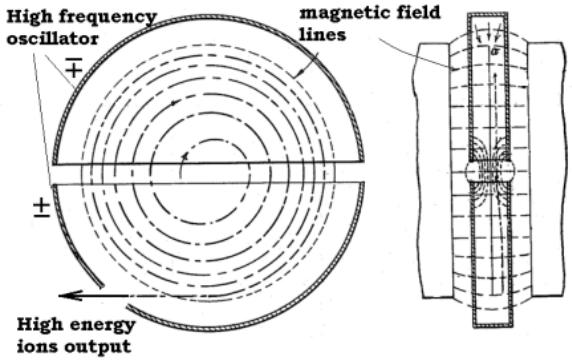

Figure 5. Lawrence accelerator (cyclotron).

The magnetic field in this scheme is permanent. The disadvantage of this scheme is variable electric field that requires significant input power. Analogy with proposed here scheme of high efficient magnetron heater is principle of acceleration of electrons by composition of E field and H field. Energy of accelerated particles is depend of strength of E and H fields and it can be used to generate heat energy, for example in processes of collision with a target.

Experiments were made by Mr. Frolov in 2006 to demonstrate possibility of increasing of heat output in critical magnetron mode. Magnetron 2M218, 2M219 and OM75P (31) were used in experiments. Heating of 8 liters of water where submerged isolated magnetron was placed allows to measure heat output with high accuracy.

Measurement with 2M218 demonstrated increase of efficiency from 0.76 up to 0.82. Magnetron OM75P (31) demonstrated ordinary efficiency 0.78, but in sub-critical mode the efficiency was about 0.96. The special sub-critical mode was provided by doubling of the permanent magnetic field that significantly improves heat power

generation. Conclusion is positive, the theory is workable. Efficiency of this type of heaters can be 100 to 1 or better. Theoretically we have no limitation. We can start design works to create powerful prototypes.

Proposals for the organization of work: we must organize patenting of the proposed technology; then to develop design for range of power from 1 kW to 100 kW. Later we can develop design of heaters for industrial application of 100 kW or more. Contact author to discuss details of this work.

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