ABSTRACT: In a magnetron device including a magnetron tube and a permanent magnet, cooling means is provided for cooling the magnetron tube and magnet, the cooling means defining cooling fluid flow paths in a direction substantially in parallel with the longitudinal axis of the magnetron tube.
MAGNETRON DEVICE WITH COOLING FLUID FLOW IN LONGITUDINAL DIRECTION OF MAGNETRON TUBE

This invention relates to a fluid cooled magnetron device and more particularly to improved cooling means therefor.

Generally, magnetrons are constructed to have relatively large output ratings when compared with their physical size. As a result, the quantity of heat generated by them due to power loss is large, thus requiring elaborate cooling devices to effectively cool them. As the quantity of heat generated is increased it is necessary to increase the quantity of cooling fluid or air or to increase the heat dissipating area of the cooling fins.

According to one prior arrangement shown in FIG. 1, a magnetron tube 2 is fit in the opening at the center of rectangular cooling vanes 1 and a pair of permanent magnets 3 are disposed on both sides of cooling vanes in parallel with the magnetron tube. The poles of magnets 3 are bridged by upper and lower magnetic yokes 4 which complete magnetic paths from the magnets to pole pieces (not shown) contained in the magnetron tube.

However, with this construction as the magnets are not effectively cooled, the temperature thereof tends to increase due to heat generated by the magnetron tube. As the magnetomotive force of a permanent magnet decreases with temperature, for example, at a rate of 0.02 per °C, when the temperature of the magnet rises, the magnetic flux generated thereby decreases to greatly increase the anode current of the tube, thus varying the output of the magnetron tube. Moreover, it has been difficult to effectively cool the cathode bushing of the tube.

In an electronic range or an ultra-high frequency cooking device, it is desirable to reduce the volume of the high frequency oscillator including magnetron tube in order to increase, as far as possible, the cooking space. According to a prior art arrangement, however, as magnets are disposed outside of cooling vanes it has been impossible to decrease the volume of the high frequency oscillator as desired. Disposition of permanent magnets outside of the cooling vanes also increased the spacing between these magnets and the magnetron tube. The ratio of permeability of the magnetic material comprising magnetic yokes 4, iron for example, to that of the surrounding air is approximately 10^3—10^4. Where the length of the yokes is increased, leakage flux is increased, sometimes amounting to three-fourths of the total flux.

It is therefore an object of this invention to provide an improved air cooled magnetron device with improved cooling means and which is small in size, can decrease leakage flux and can provide stable output.

SUMMARY OF THE INVENTION

According to this invention there is provided a magnetron device comprising a magnetron tube, a cooling means including cooling vanes surrounding the magnetron tube, said cooling vanes defining passages for cooling fluid flow in a direction substantially in parallel with the longitudinal axis of the magnetron tube, and at least one permanent magnet disposed in the cooling means and arranged to be cooled by the cooling fluid.

The present invention can be more fully understood from the following detailed description when taken in connection with the accompanying drawings, in which:

FIG. 1 is a perspective view of a prior art magnetron device as already described.

FIG. 2 shows a perspective view of a cooling means utilized in one embodiment of this invention;

FIG. 3 is a sectional view of the cooling means taken along a line III—III in FIG. 2;

FIG. 4 is a top plan view of a magnetron device utilizing the cooling means shown in FIG. 2;

FIG. 5 shows a side elevation of the embodiment shown in FIG. 4;

FIG. 6 shows a front view, partly in section, of the embodiment shown in FIG. 4;

FIG. 7 is a top plan view of a modified embodiment of this invention;

FIG. 8 shows a front elevation, partly broken away, of the modification shown in FIG. 7;

FIG. 9 shows a longitudinal sectional view of another embodiment of this invention; and

FIG. 10 shows a sectional view of the embodiment shown in FIG. 9, taken along a line X—X thereof.

Referring now to the accompanying drawings, FIGS. 2 to 6 inclusive illustrate a horizontal type magnetron device embodying this invention. As shown in FIGS. 2 and 3 cooling vanes 11 comprising a plurality of rectangular metal plates stacked one upon the other with a suitable gap or cooling air passage between adjacent plates are provided with a central opening 12 for accommodating a magnetron tube to be described later and two openings 13 on opposite sides of the central opening for accommodating permanent magnets. As shown in FIGS. 4 to 6, a magnetron tube 14 and a pair of permanent magnets 15 are snugly received in openings 12 and 13, respectively, and are connected by upper and lower magnetic yokes 16 to complete a magnetron device.

Generally, the magnetron tube comprises a metal cylinder 25, pole pieces 17 disposed in the metal cylinder to form a portion of the magnetic path for the magnetic flux through the magnetic yokes, an anode vane 20 connected to an antenna 19 disposed in an output dome 18, and a cathode electrode 23 on one end of a cathode support 22 supported by a cathode bushing 21 and surrounded by the anode vane 20. Each one of the cathode support 22 and cathode bushing 21 is provided with terminal leads 24 and these terminal leads are connected to an external source of supply to heat a cathode heater. Further, the cathode leads are connected to a condenser and an inductance coil (not shown) to prevent leakage of high frequency waves from the cathode. Since the construction of the magnetron tube itself is well known in the art it is believed unnecessary to describe it herein in detail.

In this embodiment the cooling air is passed in the horizontal or transverse direction to cool the anode electrode of the magnetron tube and the magnets.

Since magnets 15 are disposed in the cooling vanes, there arises the following advantages. First, the magnetron tube 14, particularly its anode vane 20, and the magnets are cooled effectively, so that a temperature rise of magnets 15 can be avoided, thus stabilizing the operating characteristics of the magnetron. Second, due to a decrease in the length of the magnetic path, leakage flux is decreased from 60—70 percent to 40—50 percent, thus increasing the utilization factor of the magnets. Due to decreased leakage flux, there are only required small amounts of a magnetizing force with the resultant reduction in the size of the magnet as well as in the size and weight of the magnetron device as a whole, thereby reducing its cost.

FIGS. 7 and 8 show a modified embodiment of this invention. Portions identical to those shown in FIGS. 2 to 6 are designated by the same reference numerals to avoid duplicate description. In this embodiment, a plurality of radial metal cooling vanes or fins 31 are secured to the outer periphery of magnetron tube 14 in parallel with the longitudinal axis of the tube to form a cooler. The inner edge of each cooling vane 31 is secured to the periphery of the magnetron tube and the lower outer edges of the vanes are inclined inwardly toward the output dome 18 of the magnetron tube. As best shown in FIG. 7, permanent magnets 15 are disposed in the space in the cooler where cooling vanes are eliminated. The cooling air passes through the passages between the cooling vanes in the axial direction of the magnetron tube and permanent magnets. Where this modified magnetron device is to be incorporated into an electronic range it is advantageous to provide a metal housing or shield 32 to enclose magnetron tube 14, magnets 15, yokes 16 and cooling vanes 31 in order to prevent noise and leakage of high frequency waves.

Further, as shown in FIG. 8, a cap member 33 of metal wire net may be removably secured to the upper end of housing 32.

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to surround cathode support 22 and cathode bushing 21 of the magnetron tube. The cap member 33 serves to prevent leakage of high frequency waves from cathode bushing 21.

This embodiment is suitable for applications where the cooling air is passed in the longitudinal direction of the magnetron tube.

A still further modification of this invention is shown in FIGS. 9 and 10. A cylindrical cap element 34 is disposed upon an upper side of the cooling vanes 31 so as to hermetically receive the cathode support 22 and the cathode bushing 21. To the inwardly inclined portion at the lower end of cooling vanes 31 on one side of permanent magnets 15 is connected an air blowing duct 41 extending at right angles with respect to the axis of magnetron tube 14. In the same manner an air receiving duct 42 is connected to the lower end of cooling vanes 31 on the opposite side. As shown by arrows, the cooling air admitted through the air blowing duct 41 flows upwardly through the space between cooling vanes on one side, horizontally through the space between the magnetron tube and permanent magnets, downwardly through the space between cooling vanes on the other side and finally flows out through the air receiving duct 42. With this arrangement not only the anode electrode and cathode bushing of magnetron tube 14 and the permanent magnets 15 can be effectively cooled, but also, as the cooling air is supplied and exhausted in the lateral or horizontal direction, it is possible to install a cooling air circulating device on the side of the magnetron device, thus decreasing the height thereof relative to the embodiment shown in FIGS. 7 and 8. This feature is particularly advantageous in electronic ranges.

Although two permanent magnets have been shown in the above-described embodiments, it will be clear that a single magnet may be sufficient.

Thus, this invention provides a small size magnetron device having improved cooling means and which is capable of operating with stable operating characteristics.

We claim:
1. A magnetron device comprising:
   a magnetron tube having a longitudinal axis;
   a permanent magnet for operating said magnetron tube,
   said permanent magnet being disposed outside said magnetron tube;
   a magnetic yoke coupling said magnet and said magnetron tube for forming a magnetic circuit between said magnet and said magnetron tube; and
   cooling means containing said magnetron tube and said permanent magnet, said cooling means comprising:
   a metal housing enclosing said magnetron tube and said magnet; and
   a plurality of cooling vanes having faces which are arranged substantially radially with respect to said longitudinal axis of said magnetron tube to define paths for the flow of cooling fluid in a direction substantially in parallel with the longitudinal axis of said magnetron tube, the inner edge of each of said cooling vanes being attached to the outer circumferential surface of said magnetron tube, and the outer edge of each of said cooling vanes being disposed adjacent to the inner surface of said metal housing.
2. A magnetron device according to claim 1, further comprising a cap member removably secured to said housing.
3. A magnetron device according to claim 1, wherein said outer edges of each of said cooling vanes are attached to said metal housing.
4. A magnetron device according to claim 1, wherein said magnet is accommodated between a pair of cooling vanes.
5. A magnetron device according to claim 1, wherein said inner surface of the magnetron tube is perpendicular to the direction of the longitudinal axis of said magnetron tube to have a cathode bushing, the other surface of the magnetron tube perpendicular to the direction of the longitudinal axis of the magnetron tube has an output dome, and one edge of each of said cooling vanes on the side of the output dome is formed with an inclined relationship to the circumferential surface of said tube, and further comprising:
   a cap element detachably connected to said metal housing on the side of said cathode bushing and receiving said cathode bushing, and
   means forming ducts for blowing and receiving cooling fluid, said duct forming means being detachably connected to the inclined side of the cooling vanes with said ducts being in a direction substantially perpendicular to the longitudinal axis of the magnetron tube, such that cooling fluid introduced to one side of the cooling vanes through said blowing duct is passed through at least some of said cooling paths, through said cap element, and through the others of said cooling paths, the cooling fluid being exhausted through said receiving duct.