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Heathcote

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[54] **HIGH POWER QUICK STARTING MAGNETRON**

[75] Inventor: **Vincent Albert Heathcote,** London, England

[73] Assignee: **The M-O Valve Company Limited,** London, England

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[58] **Field of Search** 313/337, 338; 315/39.51, 315/39.63

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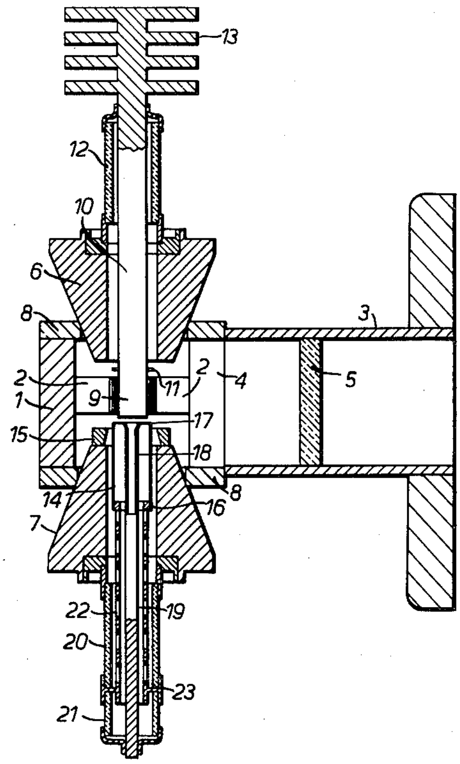
Primary Examiner—Saxfield Chatmon, Jr.
Attorney, Agent, or Firm—Kirschstein, Kirschstein, Ottinger & Frank

[57] **ABSTRACT**

A quick start magnetron comprising: an anode; a main cathode positioned adjacent the anode and providing by secondary electron emission due to electron back bombardment at least a major part of the electron current required for operation of the magnetron; and an electron gun employing a thermionic cathode of low thermal inertia arranged to direct a stream of electrons into the space between the anode and the main cathode to initiate operation of the magnetron.

9 Claims, 1 Drawing Figure



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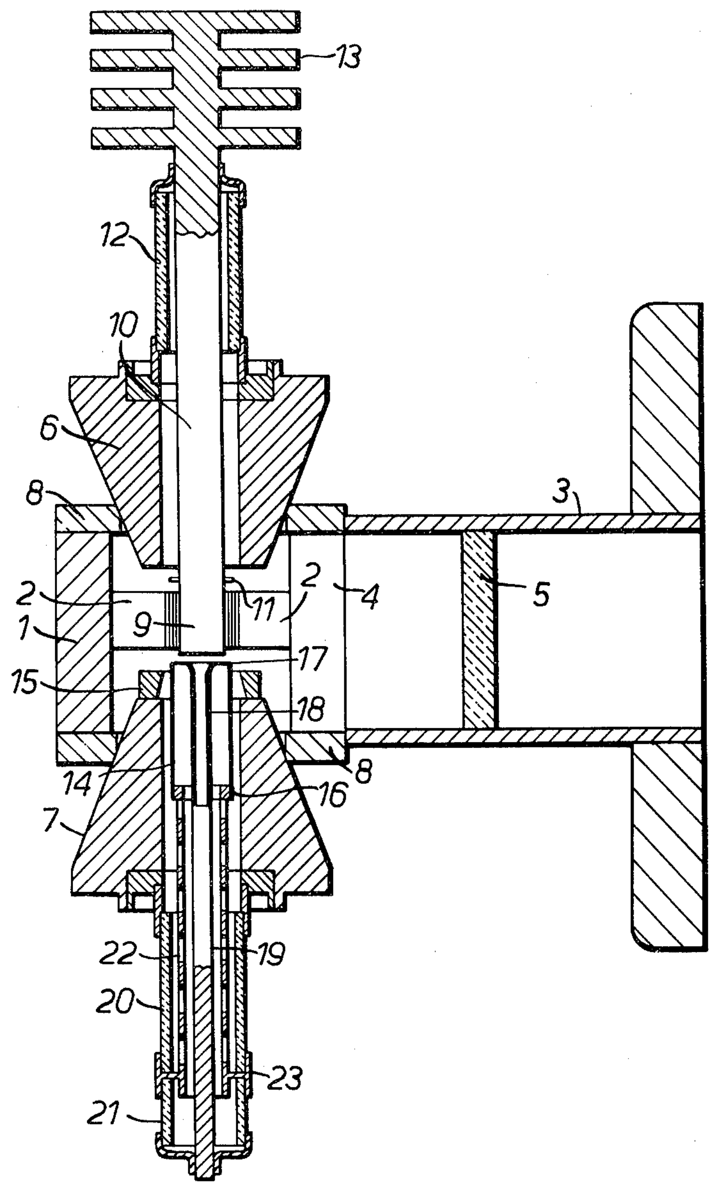

HIGH POWER QUICK STARTING MAGNETRON

This invention relates to magnetrons.

The invention relates particularly to quick starting magnetrons of high power capability.

It is known how to obtain quick starting properties in a magnetron by providing the magnetron with a thermionic cathode structure of low thermal inertia so that the cathode will heat up rapidly to its emission temperature from cold. Such a cathode structure inevitably exhibits poor heat dissipation properties, and in consequence, the temperature of such a cathode structure tends to rise in operation due to electron back bombardment, between five and ten percent of the input power to a magnetron being typically dissipated at the cathode.

As a result, the maximum power capability of known quick starting magnetrons is limited.

The present invention seeks to overcome this difficulty and provide quick starting magnetrons of higher power capability than are at present available.

According to the present invention a magnetron comprises: an anode; a main cathode positioned adjacent the anode and adapted to provide by secondary electron emission due to electron back bombardment in operation of the magnetron at least a major part of the electron current required for operation of the magnetron; and an electron gun employing a thermionic cathode of low thermal inertia arranged to direct a stream of electrons into the space between the anode and the main cathode to initiate operation of the magnetron.

Where it is desired to cool the main cathode, the main cathode suitably comprises one end of a solid rod of material of good thermal conductivity, the other end of the rod being provided with means for cooling the rod.

Where it is not desired to cool the main cathode, the main cathode suitably comprises a body of an impregnated porous refractory material.

In one particular arrangement in accordance with the invention the anode and the main cathode define between them a generally annular space and the electron gun is arranged to direct an annular stream of electrons coaxially into said space.

In such an arrangement the electron gun thermionic cathode preferably comprises a thin-walled metal tube having a coating of electron emissive material on its outer surface, the tube being disposed coaxially with the magnetron anode/cathode space and axially spaced therefrom. The metal tube is preferably arranged to be electrically heated by the passage of an electric current directly through it. Such an electron gun preferably includes a control electrode in the form of a non-magnetic annular member coaxially surrounding the end of the electron gun cathode adjacent the magnetron anode/cathode space.

One arrangement in accordance with the invention will now be described, by way of example, with reference to the accompanying drawing which is a diagrammatic sectional view of a high-power, quick-starting magnetron.

Referring to the drawing, the magnetron includes a rising sun type copper anode resonator of conventional form comprising an outer annular wall **1** from the inner surface of which a plurality of radial vanes **2** project inwardly to form a plurality of resonant cavities. An output is fed from the magnetron to a rectangular waveguide **3** via a slot **4** in the outer wall **1** of the anode, the waveguide being sealed by a ceramic window **5.**

The necessary magnetic field is provided by a permanent magnet (not shown) co-operating with two conical, iron pole pieces **6** and **7** disposed coaxially with the anode. The pole pieces **6** and **7** are disposed one at each end of the anode with their narrower ends sealed through apertures formed centrally in respective copper discs **8** sealed to opposite ends of the anode.

The main cathode of the magnetron is constituted by a platinum clad end portion **9** of a tungsten rod **10,** which end portion is disposed coaxially within the anode. Adjacent the anode vanes **2** the rod carries an 'end hat' **11** and beyond this 'end hat' **11** the rod **10** extends axially through a central bore in the pole piece **6.** The rod **10** is supported from the outer end of the pole piece **6** by means of a tubular ceramic insulator **12,** and is provided with a set of cooling fins **13** at its end remote from the anode.

The magnetron further includes an electron gun arranged to project an annular stream of electrons into the space between inner ends of the anode vanes **2** and the main cathode **9.** The electron gun comprises a cathode in the form of a coating of thermionic electron emissive material on the outer surface of a thin-walled tube **14** of highly resistive material, for example of 30% tungsten and 70% nickel. The tube **14** is disposed for the most part coaxially within a bore extending centrally through the pole piece **7,** but projects slightly from the narrower end of the pole piece **7.** The projecting part of the tube **14** is surrounded by a non-magnetic metal ring **15** secured to and in electric contact with the narrower end of the pole piece **7,** the ring **15** serving as a control electrode of the electron gun.

The tube **14** is supported between a metal ring **16** and an outwardly extending flange **17** formed at one end of a metal tube **18,** the flange serving as a second 'end hat' for the main cathode **9.** The metal tube **18** extends axially through the tube **14** at whose outer end the tube **18** coaxially adjoins a metal rod **19** which is supported from the outer end of the pole piece **7** by means of two tubular ceramic insulators **20** and **21.** The metal ring **16** is secured to one end of a perforated metal tube **22** which coaxially surrounds the rod **19** and at its other end is connected to a metal contact ring **23** sealed between the two ceramic insulators **20** and **21.**

In operation of the magnetron the electron gun cathode is energised by applying a suitable voltage between the rod **19** and the contact ring **23** to cause an electric current to pass through the tube **14.** Due to the thinness of the wall of the tube **14,** the cathode has a low thermal inertia and therefore rapidly heats up to its electron emission temperature, thus conferring quick starting properties on the magnetron.

When the magnetron is required to start oscillating the main cathode **9** and the electron gun cathode are pulsed negatively with respect to the anode by application of a suitable potential to the rod **10** and to the rod **19** or the contact ring **23,** the magnitude of the applied potential depending on the required magnetron operating conditions. Under the action of the applied potential the electrons produced at the electron gun cathode are formed into an annular stream directed into the anode/cathode space of the magnetron, the control electrode **15** assisting in the formation of the electron stream. On arrival of the electron stream in this space the magnetron immediately starts to oscillate and a sufficient supply of electrons for further operation of the magnetron is produced by secondary emission at the surface of the main cathode **9** due to electron back bombardment.

For continuous operation of the magnetron the electric supply electron gun cathode may be switched off after oscillation has started, but for pulsed operation it is normally convenient for the electron gun cathode to be energised continuously.

Due to its relatively massive form, the main cathode **9** has a high thermal inertia and the heat produced at the main cathode by electron bombardment is rapidly conducted along the rod **10** to the fins **13** where it is disposed of by radiation. As a result, the temperature of the main cathode **9** does not rise unduly in operation. It will be appreciated in this connection that since the main cathode **9** does not require to be heated to produce electrons, very efficient cooling of the main cathode **9** may be employed, if desired.

Due to the physical position of the tube **14** the electron gun cathode is not subjected to significant electron bombardment in operation so that over-heating of this cathode does not occur, even although it has a low thermal inertia.

In a modification of the magnetron described above one or more ducts are provided in the rod **10** for the passage of cooling fluid in operation.

It will be appreciated that in a magnetron in accordance with the invention the main cathode is not necessarily run at a relatively low temperature. Thus, in an alternative arrangement in accordance with the invention the main cathode may be run at a high temperature and the heat produced by electron back bombardment dissipated by thermal radiation from the cathode surface. In such arrangement the main cathode preferably comprises a body of an impregnated porous refractory material, for example, porous tungsten impregnated with barium aluminate.

I claim:

1. A magnetron comprising: a secondary electron emissive main cathode; an anode resonator which defines a cylindrical space in which said main cathode is disposed so as to provide an annular space between the anode and cathode; an electron gun employing a thermionic cathode of low thermal inertia disposed at a position outside said cylindrical space defined by the anode and arranged to direct a stream of electrons into said annular space between the anode and said main cathode to initiate operation of the magnetron, whereafter at least the major part of the electron current required for operation of the magnetron is provided by said main cathode due to electron back bombardment; said thermionic cathode being sufficiently remote from said cylindrical space to not be subjected to significant electron back bombardment.

2. A magnetron according to claim **1** including a solid rod of material of good thermal conductivity, one end of the rod constituting the main cathode of the magnetron and the other end of the rod being provided with cooling means.

3. A magnetron according to claim **1** wherein the main cathode comprises a body of an impregnated porous refractory material.

4. A magnetron according to claim **1** wherein the electron gun is arranged to direct an annular stream of electrons coaxially into said annular space.

5. A magnetron according to claim **4** wherein said electron gun thermionic cathode comprises a thin-walled metal tube having a coating of electron emissive material on its outer surface, the tube being disposed coaxially with said cylindrical space and axially spaced therefrom.

6. A magnetron according to claim **5** wherein said metal tube is arranged to be electrically heated by the passage of an electric current directly through it.

7. A magnetron according to claim **5** including a control electrode in the form of a non-magnetic annular member coaxially surrounding the end of the electron gun cathode adjacent said cylindrical space.

8. A magnetron according to claim **1** including two pole pieces for directing a magnetic field through said cylindrical space in operation, the electron gun cathode being disposed coaxially in a bore extending through one of the pole pieces.

9. A magnetron according to claim **8** including a solid rod of material of good thermal conductivity which extends coaxially through a bore in the other pole piece, one end of the rod constituting the main cathode of the magnetron and the other end of the rod being provided with cooling means.

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