United States Patent

Anderson et al.

[15] **3,697,804**

[45] **Oct. 10, 1972**

[54] **MICROWAVE GENERATING APPARATUS INCLUDING SPURIOUS SIGNAL SUPPRESSION MEANS**

[72] Inventors: **Harold C. Anderson,** New Brighton; **David F. Graff,** Minneapolis, both of Minn.

[73] Assignee: **Litton Systems, Inc.**

[22] Filed: **Oct. 12, 1970**

[21] Appl. No.: **79,764**

[52] **U.S. Cl.** **315/105,** 333/79, 315/39.51, 315/85

[51] **Int. Cl.**.....**H05b 39/00**

[58] **Field of Search** 315/39.51, 85, 105; 333/79, 333/81

[56] **References Cited**

UNITED STATES PATENTS

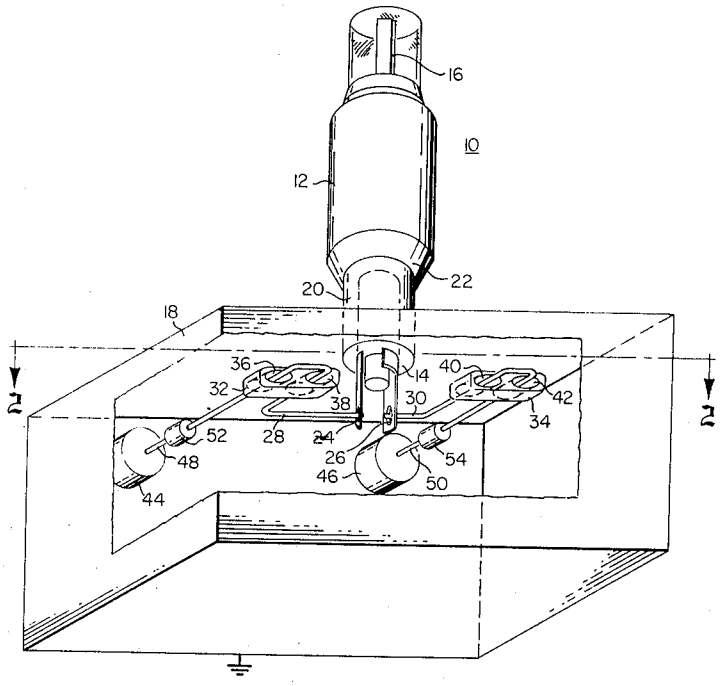
3,020,447	2/1962	Schall et al.	315/85 X
3,483,419	12/1969	Luebke	333/79 X
3,551,858	12/1970	Cielo	333/81
3,531,613	9/1970	Domenichini	333/79
2,896,120	7/1959	Spittler	315/85
3,225,249	12/1965	Krug, Jr.	333/79 X

Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Saxfield Chatmon, Jr.
Attorney—Alan C. Rose, Franklin D. Jankosky, Walter R. Thiel and Alfred B. Levine

[57] **ABSTRACT**

A microwave generating apparatus is disclosed which includes suppression means for preventing high frequency signals from being propagated out of the apparatus through its cathode terminals to be radiated away from the apparatus. The suppression means includes a shield member and a non-saturating ferrite member positioned around each of the cathode heater leads of the apparatus within the shield member. The ferrite member comprises an elongated ferrite body having at least two apertures extending therethrough, with the lead element traversing both of these apertures in opposing directions.

5 Claims, 2 Drawing Figures

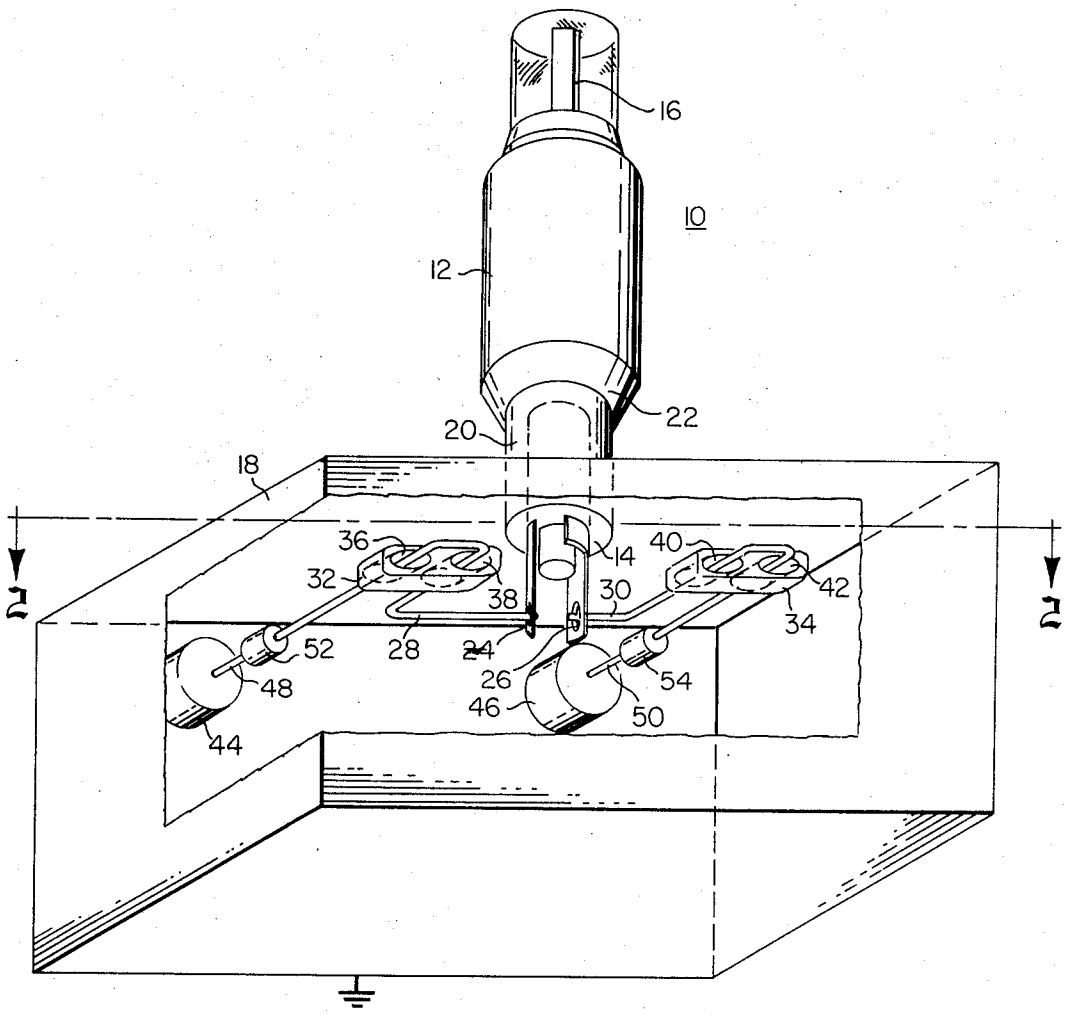


PATENTED OCT 10 1972

3,697,804

SHEET 1 OF 2

Fig. 1

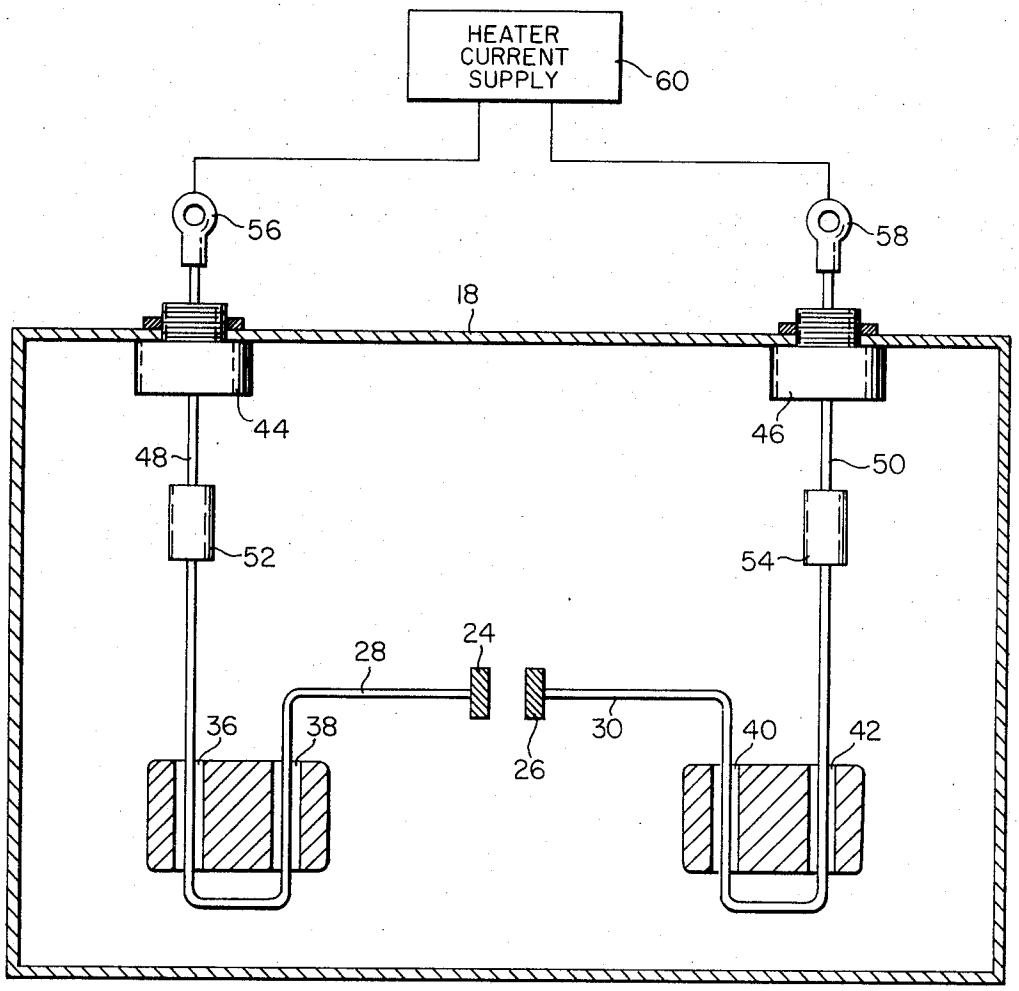


HAROLD C. ANDERSON
DAVID F. GRAFF
INVENTORS

BY Franklin D. Jankosky

ATTORNEY

Fig. 2



HAROLD C. ANDERSON
DAVID F. GRAFF
INVENTORS

BY Franklin D. Jankosky

ATTORNEY

MICROWAVE GENERATING APPARATUS INCLUDING SPURIOUS SIGNAL SUPPRESSION MEANS

This invention relates to microwave generating apparatus and more particularly to a means for suppressing spurious radio frequency radiation from such apparatus.

It is well known that microwave generators such as magnetrons which are used in microwave ovens and other electronic heating apparatus generate radio frequency energy at frequencies other than the fundamental operating frequency of the device. In order that these spurious signals do not cause interference with communication services on other frequencies, it is necessary that some means be provided to suppress or attenuate these signals to a low level.

It is known that the cathode leads of a magnetron are a point from which many of the spurious radio frequency signals are radiated. This problem is especially severe in magnetrons which have a directly heated cathode, since the cathode is positioned in a position of high field intensity and easily picks up the signals of various frequencies which exist in the magnetron cavities. Once these signals are induced in the cathode, they are propagated out of the cathode along the cathode heater lead wires and, unless suitably attenuated they are radiated into the free spaces surrounding the magnetron.

The prior art has attempted to deal with this problem in several ways. First, it is known to provide a conductive shielding box around the cathode stem of the magnetron. This shielding box is effective to prevent radiation directly from the cathode stem into free space. However, some means must be provided to bring the cathode heater lead wires out through the shielding box, and when this is done, the spurious radio frequency signals are frequently propagated out along the lead wires and are then radiated into free space from the lead wires once they are outside of the shielding box.

The prior art has attempted to deal with this problem by providing suitable filter circuits along the lead wires within the shielding box. Typically, such filter circuits have involved the use of various "L" and "Pi" filter networks composed of lump inductances and capacitances, with the inductances usually in series with the lead wires and the capacitances shunting the spurious signals from the wires to ground. However, the use of such lump element filter circuits has frequently proven ineffective, and devices using such filter arrangement sometimes radiate signals at a higher energy level than is allowed by various government regulations.

Yet another approach which is suggested in the prior art is to provide ferrite beads or cylinders around the cathode lead wires within the shielding box. Such devices have been suggested either with or without shunting capacitors to ground. The theory of this type of filter is that the ferrite bead or cylinder will present a very high inductance to any radio frequency signals propagating along the lead wires, and will cause sufficient attenuation of these high frequency signals to alleviate the problem. However, in operation this has proven to be ineffective since the cathode heater current (typically 15 to 20 amps) also flows in these lead wires, and this current saturates the ferrite to such a degree that the spurious radio frequency signals of a much lower current level cause essentially no flux change in the device. Thus, the ferrite presents essentially no inductance to the radio frequency signals and is ineffective in attenuating these signals.

It is accordingly an object of the present invention to provide an improved microwave signal generating apparatus.

It is another object of the present invention to provide an improved microwave generating apparatus with an improved means for suppressing the radiation of spurious signals from the apparatus.

It is still another object of the present invention to provide an improved filtering arrangement for the suppression of spurious radio frequency signals from the cathode leads of magnetrons used in microwave generating apparatus.

Briefly stated, and in accordance with the presently preferred embodiment of this invention, a microwave generating apparatus is provided which includes suppression means for preventing high frequency signals from being propagated out of the apparatus through its cathode terminals to be radiated away from the apparatus. The suppression means includes a shield member and a non-saturating ferrite member positioned around each of the cathode heater leads of the apparatus within the shield member. The ferrite member comprises an elongated ferrite body having at least two apertures extending therethrough, with the lead element traversing both of these apertures in opposing directions, such that heater current flowing in these lead elements induces opposing magnetic flux of substantially equal magnitude in the ferrite body, and the ferrite body is thus not saturated by the heater current. The ferrite body then presents a high inductance to any radio frequency signals which attempt to propagate along the lead elements, and attenuates these signals to an acceptable low level.

For a complete understanding of the invention and other objects and advantages thereof, please refer to the attached drawings and the following detailed description of these drawings, in which:

FIG. 1 shows a partially broken away perspective view of a microwave generating apparatus incorporating the present invention, and

FIG. 2 shows a sectional view taken along the lines 2-2 of FIG. 1.

FIG. 1 shows a perspective view, partially broken away, of a microwave generating apparatus **10** which incorporates a radio frequency spurious signal suppressing means in accordance with the present invention. The apparatus **10** utilizes a conventional high quality magnetron **12**, such as the model L-5001 magnetron manufactured by Litton Industries, Electron Tube Division of San Carlos, California, as the generating source of the microwave energy. For clarity, the magnet and the cooling fins of the magnetron **12** are not shown in FIG. 1. Magnetron **12** includes a cathode stem **14** which projects downwardly from the magnetron and an antenna **16** for radiating microwave energy generated in magnetron **12**.

A typical use for the microwave generating apparatus **10** might be as the source of microwave energy for microwave heating apparatus such as an electronic oven. If so used, antenna **16** would project into a waveguide (not shown in FIG. 1), which would conduct the microwave energy to the heating cavity of the oven.

As was mentioned above, it is important in such apparatus to prevent the spurious radiation of radio frequency signals, especially radiation of frequencies other than the fundamental frequency at which the apparatus is operating. As was also mentioned above, one of the primary sources of such spurious radiation is radiation from the cathode stem **14** and the various leads which conduct heater current to the cathode of the magnetron **12**. In accordance with the present invention, such spurious radiation is practically eliminated altogether by the use of the combination of a radiation shield member and a novel filter circuit arrangement positioned along the cathode heater leads within the shield member.

A grounded radiation shield member comprising a box **18** and a cylinder **20** made from an electrically conductive material is positioned around the cathode stem **14** of magnetron **10** and the various elements of the filter circuit and the electrical leads for supplying heater current to the magnetron **12**, which are described in more detail below. The cylinder **20** is sealed in a radiation tight manner, such as by soldering, at its bottom end to the box **18** and at its top end to the anode block **22** of magnetron **12**. Such shielding arrangement per se are well known to those skilled in the art and need not be further described herein.

A pair of cathode terminals **24** and **26** project downwardly from the cathode stem **14** of magnetron **12** into the shield box **18** for supplying heater current to the cathode of magnetron **12**. Heater current is supplied to the cathode terminals **24** and **26** through electrically conductive lead elements **28** and **30** respectively, which are securely fastened to their respective cathode terminal, as by soldering.

In accordance with one of the features of the present invention, a non-saturating ferrite member **32** and **34** is positioned around each of the lead elements **28** and **30**, respectively. Ferrite member **32** comprises an elongated body of ferrite material having a pair of axially extending and generally parallel apertures **36** and **38** therethrough. In a similar manner, ferrite body **34** has axially extending and generally parallel openings **40** and **42** therein. As is shown in FIG. **1**, lead element **28** is threaded through apertures **36** and **38** in opposing directions and lead element **30** is threaded through apertures **40** and **42** in opposing directions such that any low frequency (typically 60 hertz) heater current flowing through the lead elements **28** and **30** establishes substantially equal but opposing magnetic fluxes in each of the ferrite members **32** and **34** so as not to saturate these members. Thus, since the ferrite members **32** and **34** are not saturated by the relatively large value of the heater current, these members cause any radio frequency signals which might be propagated out of the cathode terminals **24** and **26** of magnetron **12** to be presented with an inductance having a quite large value, especially to signals of radio frequency, and these radio frequency signals are greatly attenuated by this inductance.

In accordance with another feature of the present invention, capacitors **44** and **46** are provided to further attenuate any radio frequency signals attempting to traverse lead elements **28** and **30**, respectively, by shunting such radio frequencies to ground at the shield box **18**. Preferably, capacitors **44** and **46** are coaxial capacitors such as Sprague Model No. 713C1 having a capacitance of at least 500 micro-microfarads and having the ability to withstand the high DC voltages which are applied to the cathode of a magnetron during operation.

In the shown embodiment, the axial leads **48** and **50** of capacitors **44** and **46**, respectively, are connected in series with the lead elements **28** and **30**, respectively, by the connecting terminals **52** and **54**. However, obviously the capacitors could be provided with sufficiently long axial leads so that no connecting terminals are necessary. Instead, the axial leads themselves could be threaded through ferrite members **32** and **34** and connected directly to cathode terminals **24** and **26**, respectively. The coaxial, or outer, leads of capacitors **44** and **46** are connected directly to the shield box **18**. In this manner, the capacitors **44** and **46** not only serve as bypass capacitors to shunt any radio frequency signals to ground, but they also serve as the insulators for the high voltage cathode lead-ins.

FIG. **2** shows a sectional view taken along the line **2-2** of FIG. **1** and further illustrates the lay-out of the components described above. Shown therein are the cathode terminals **24** and **26**, the cathode heater current lead elements **28** and **30**, the non-saturating ferrite members **32** and **34** having, respectively, the apertures **36** and **38** and the apertures **40** and **42**, the capacitors **44** and **46** having, respectively, the axial leads **48** and **50** and the terminals **52** and **54** connecting lead **48** to lead **28** and lead **50** to lead **30**.

Although not shown in the Figures, in practice it is usually desirable to pot the lead elements **28** and **30** within the ferrite members **32** and **34** with any suitable potting compound.

FIG. **2** also shows a pair of terminals **56** and **58** connected, respectively, to the axial leads of capacitors **44** and **46**. Heater current from any suitable heater current supply **60** is supplied through terminals **56** and **58** for the cathode of the magnetron **12**.

FIGS. **1** and **2** together illustrate another feature of the present invention. As shown therein, all of the lead elements **28**, **30**, **48** and **50** within the shield box **18** lie substantially in the same plane, which plane is substantially perpendicular or normal to the cathode terminals **24** and **26**. This arrangement minimizes any radio frequency currents which might be induced in these lead members from fields radiated from the cathode terminals **24** and **26** but which are confined within the shield box **18**.

While the invention is thus disclosed and the presently preferred embodiment described in detail, it is not intended that the invention be limited to this shown embodiment. Instead, many modifications will occur to those skilled in the art which lie within the spirit and scope of the invention. For example, the invention is not limited to use in microwave ovens. It can also be used to prevent spurious radiation from other equipment which uses microwave generating apparatus, such as radar or electronic counter measures equipment. It is thus intended that the invention be limited in scope only by the appended claims.

What is claimed is:

1. Microwave generating apparatus comprising, in combination:

a magnetron including a pair of cathode terminals for receiving heater current,

supply means for providing heater current having a predetermined frequency for said magnetron,

suppression means for preventing high frequency signals from being propagated out of said magnetron through said cathode terminals and being radiated away from said magnetron, said suppression means comprising a conductive shield member enclosing the space immediately adjacent to said cathode terminals, a pair of conductive lead elements each having a first end being connected to a respective one of said cathode terminals and a second section extending outside of said shield member, and a respective non-saturating ferrite member positioned around each of said lead elements within said shield member, each ferrite member comprising a ferrite body having at least two apertures therethrough and in which the respective lead element for said ferrite member traverses both said apertures, and

means for connecting said second sections of said lead elements to said supply means to conduct heater current to said magnetron.

2. The combination of claim 1 in which said ferrite body is elongated and in which said apertures extend substantially longitudinally along said ferrite body and are substantially parallel to the longitudinal axis of said body.

3. The combination of claim 2 in which said suppression means further includes a respective high frequency by-pass capacitor connected between each of said lead elements and said shield member.

4. The combination of claim 3 in which each of said capacitors is a coaxial capacitor positioned in a respective aperture in said sheld members and having its axial terminals connected in series with its respective lead element and having its concentric terminal connected to said shield member, whereby each of said capacitors also insulates its respective lead element from said shield member.

5. The combination of claim 4 in which each of said lead elements is positioned substantially entirely in a plane which is substantially normal to said cathode terminals.

* * * * *