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SMOOTHING CIRCUIT FOR MAGNETIC FIELD GENERATOR
IN SERIES WITH A.C.-OPERATED MAGNETRON

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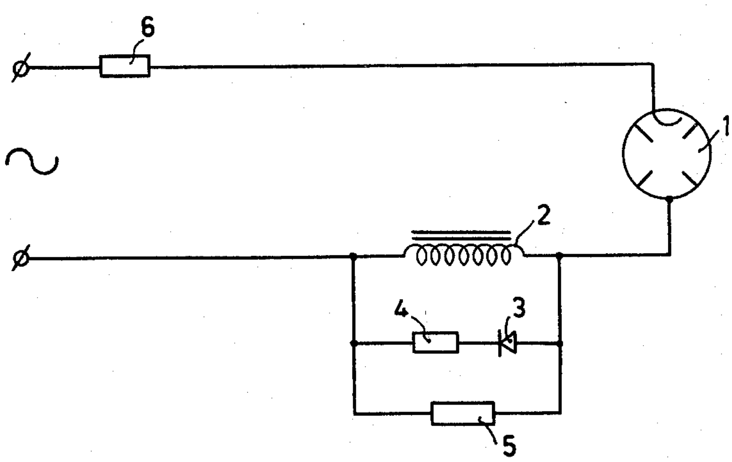

INVENTOR
KARL SVEN-OLOF REFTMARK

BY
Frank R. [signature]
AGENT

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SMOOTHING CIRCUIT FOR MAGNETIC FIELD GENERATOR IN SERIES WITH A.C.-OPERATED MAGNETRON

Karl Sven-Olof Reftmark, Danderyd, Sweden, assignor to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

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The present invention relates to a magnetron circuit in which the magnetic field for the magnetron is produced at least partly by a coil connected in series with the cathode-anode path of the magnetron. The circuit according to the invention is in particular adapted to be used with a magnetron fed directly from an alternating-current source or from a power source having an output voltage of which contains a relatively high alternating-current component, such as, for example, a single phase full wave rectifier or a 3-phase half wave rectifier.

In order to stabilize the working point of a magnetron, circuits have been provided in which the anode current produces a fraction of the magnetic field of the magnetron by means of a coil connected in the anode current circuit. A device has already been described in which magnetrons fed from a common 3-phase full wave rectifier get all their magnetic field from a coil connected in series with the respective magnetron. Such an arrangement is possible in this case when the level of the output voltage from the 3-phase full wave rectifier is relatively constant, i.e. when the harmonic content of the output voltage is relatively low. However, using of the same circuit with a magnetron fed for example from a single phase full wave rectifier or directly from the alternating-current power supply, the magnetron being operated intermittently with strong current peaks separated by periods during which the magnetron is cut-off, has been found to be undesirable due to the high alternating voltages across the coil and the strong eddy current losses produced thereby. The eddy current losses are produced in the cylinder of metal, usually copper, surrounding the interaction space of the magnetron, and also in magnetic yokes and pole shoes if present. The cylinder forms the anode of the magnetron and at the same time forms part of the vacuum-tight envelope of the magnetron.

A method often used for smoothing the magnetic field and decreasing the voltage peaks across a coil connected in a circuit wherein the current varies greatly is to connect a capacitor in parallel with the coil. The capacitor can be connected in series with a resistance. In the special case of magnetrons, such a method has the drawback, however, that the initial current flowing through the magnetron is very high at the instant the magnetron is connected to the voltage source, due to the fact that the impedance of the magnetron is low when the magnetic field is low.

According to the invention, a magnetron is provided which has a magnetic field produced at least partly by a coil connected in series with the cathode-anode path of the magnetron. A shunt circuit including a rectifying element is connected in parallel with the coil. The rectifying element has a polarity such that the shunt circuit is cut-off when the intensity of the magnetic field produced by the coil is increasing and conductive when the intensity of the magnetic field is decreasing.

An additional shunt circuit containing an impedance, in particular a resistance, is preferably connected in parallel with the coil. This resistance is always in parallel with the coil and serves to reduce the high voltage peaks produced across the coil by the current variations during the intervals when the first shunt circuit is cut-off. This impedance, which may be a voltage dependent

resistor, should have a relatively high resistance value in comparison with the resistance value of the first shunt circuit.

The invention will now be described more fully, by way of example, in reference to the accompanying drawing which shows a schematic diagram of a circuit according to the invention.

In the embodiment shown a magnetron 1 is energized from an alternating-current power supply by way of a supply transformer (not shown). The magnetron itself serves as a single phase half wave rectifier. In series with the cathode-anode path of the magnetron, there is connected a coil 2 which produces the magnetc field required for the operation of the magnetron. A first shunt circuit including a rectifier 3 in series with a resistor 4 is connected in parallel with the coil 2. An additional shunt circuit containing a single resistor 5 is also connected in parallel with the coil 2. An inductive impedance element 6 is connected in series with the whole circuit for the purpose of attenuating and smoothing the current peaks through the magnetron to a certain degree. The magnetic flux of the coil 2 is concentrated by means not shown in the drawing within the interaction space of the magnetron. These means may comprise a magnetic yoke of iron which conducts the magnetic flux to two pole shoes situated on either side of the interaction space of the magnetron. Alternately, the coil 2 may be in the shape of a solenoid surrounding the magnetron.

The operation of the circuit arrangement is as follows:

Due to the fact that the magnetron is energized directly from an alternating-current source, the magnetron operates intermittently and conducts a high current only during a small fraction of each period, while it is cut-off during the remainder of the period. During the intervals when the magnetron is conducting, a magnetic field is built up by the coil 2. The branch containing the rectifier 3 and the resistor 4 is cut-off during these intervals due to the polarity with which the rectifier is connected. The damping resistor 5 has a high resistance value, so that practically all of the anode current is compelled to flow through the coil 2. When the anode current of the conducting magnetron has reached a maximum value and is beginning to decrease together with the magnetic field produced by the coil 2, the decreasing magnetic field gives rise to a counter electromotive force having a polarity such that the rectifier 3 conducts and the energy contained in the magnetic field "discharges" through the resistor 4, with slowly decreasing magnetic field. During the succeeding current peak through the magnetron the magnetic field increases again and the process is repeated.

Due to the fact that the energy built up in the magnetic field can "discharge" through the resistor 4 of relatively low value, the voltage across the coil will attain only permissible values and the fluctuations of the magnetic field and therefore the eddy current losses decrease while maintaining the magnetic field at a high value.

As previously mentioned practically the entire anode current is compelled to flow through the coil 2 during the intervals when the magnetron is conducting. Owing to this fact, the great advantage is achieved that a high value of the anode current cannot appear without simultaneously building up a corresponding magnetic field. When initially connecting the circuit arrangement to the supply voltage source the initial current is therefore maintained within allowable limits because an increase of the current through the magnetron results in an increase of the magnetic field and therefore in an increase of the impedance of the magnetron, which counteracts the increase of the current.

The resistor 5 which can be connected as a further shunt circuit in parallel with the coil 2 has mainly the function of attenuating the voltage peaks over the coil 2 during the intervals when the magnetic field is increasing and the shunt circuit containing the rectifier 3 and the resistor 4 is cut-off. The resistor 5 is permanently connected in parallel with the coil 2 and its value must therefore be large in comparison with the direct current resistance value of the coil 2, because it would otherwise consume too large an amount of energy and decrease the magnetic field. The value of the resistance 5 is usually also considerably larger than the value of the resistor 4.

The invention is not limited to the embodiment shown and described. Thus, the circuit can be energized by any supply source, although the advantages of the invention are most apparent when energizing it from a source having relatively strong variations of the output voltage, such as energizing the magnetron directly from an alternating-current power supply, from a single phase full wave rectifier, for example in the form of a bridge rectifier, from a 3-phase half wave rectifier or the like. The impedance element 6 may be deleted. It is also possible to use the circuit with a magnetron in which only a part of the magnetic field is produced by a coil connected in series with the cathode-anode path of the magnetron. With the circuit according to the invention, it is also possible to energize two or more magnetrons in parallel from a common supply source of the kind mentioned.

What is claimed is:

1. A magnetron energization circuit comprising a magnetron having an anode and a cathode, means providing a magnetic field for said magnetron comprising an inductor, a source of operating potential having an alternating component, means serially connecting said source of potential and inductor between said anode and cathode, whereby said magnetron conducts current intermittently, and unidirectional current conducting means connected in parallel with said inductor, said unidirectional current conducting means having a polarity to conduct only when the intensity of magnetic field in said inductor is decreasing, whereby fluctuations of intensiy of said magnetic field are reduced.

2. A magnetron energizing circuit comprising a magnetron having an anode and a cathode, means for providing a magnetic field for said magnetron comprising an inductor, a source of alternating potential, means connecting said source and inductor serially between said anode and cathode, whereby said magnetron intermittently conducts current and substantially all of said current flows through said inductor, and means for smoothing fluctuations of intensity of said magnetic field comprising unidirectional current conducting means connected in parallel with said inductor, said unidirectional current conducting means having a polarity to conduct current only when the intensity of said magnetic field is decreasing.

3. A magnetron energizing circuit comprising a magnetron having an anode and a cathode, means for providing a magnetic field for said magnetron comprising an inductor, a source of alternating potential, means connecting said source and inductor serially between said anode and cathode, whereby said magnetron intermittently conducts current and substantially all of said current flows through said inductor, and means for smoothing fluctuations of intensity of said magnetic field comprising a series circuit of resistor means and unidirectional current conducting means connected in parallel with said inductor, said unidirectional current conductive means having a polarity to conduct current only when the intensity of said magnetic field is decreasing.

4. The circuit of claim 3, comprising additional resistor means connected in parallel with said inductor, said additional resistor means having a resistance substantially greater than the direct current resistance of said inductor and greater than the resistance of said first-mentioned resistor means.

5. The circuit of claim 4, in which said additional resistor means is a voltage-dependent resistor.

6. A magnetron energizing circuit comprising a magnetron having an anode and a cathode, means providing a magnetic field for said magnetron comprising an inductor, means connecting one end of said inductor to said anode, a source of alternating potential, means connecting said source between said cathode and the other end of said inductor whereby said magnetron intermittently conducts current and substantially all of said intermittent current flows through said inductor, and means for smoothing fluctuations of intensity of said magnetic field comprising a series circuit of resistor means and rectifier means connected in parallel with said inductor, said rectifier means being connected in said series circuit with its anode toward said end of said inductor which is connected to said anode of said magnetron.

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GEORGE N. WESTBY, *Primary Examiner.*

DAVID J. GALVIN, *Examiner.*