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ARRANGEMENT FOR THE PROTECTION OF CROSS-FIELD GENERATOR TUBES OF HIGH CONTINUOUS WAVE POWER OR PULSE POWER

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Fig.1

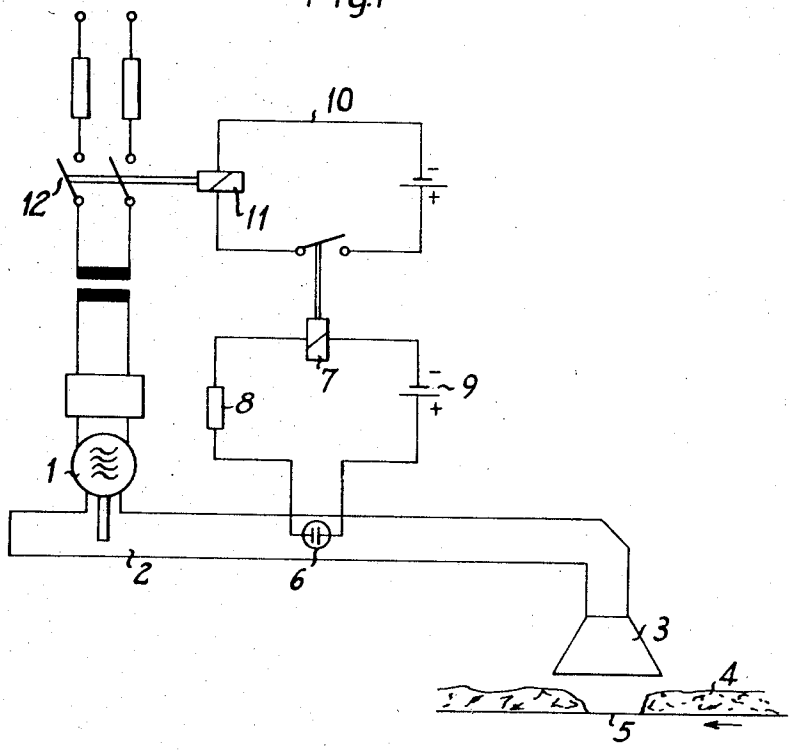
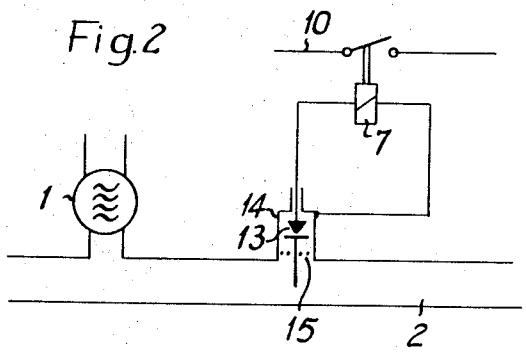


Fig.2



INVENTOR

Herbert August Püschner

by

Wolff, Greenfield Hieken + Sacks

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ARRANGEMENT FOR THE PROTECTION OF CROSS-FIELD GENERATOR TUBES OF HIGH CONTINUOUS WAVE POWER OR PULSE POWER

Herbert August Puschner, Bremen, Germany, assignor to Atlas-Mak Maschinenbau G.m.b.H., Bremen, Germany, a limited company of Germany

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ABSTRACT OF THE DISCLOSURE

A waveguide couples high power microwave energy from a C-W magnetron to a dissipative load. A glow tube is located in the waveguide and connected by a relay to a low voltage source that provides a potential just below that of the ignition potential of the glow tube so that the presence of the microwave energy field superimposed upon the potential from the low voltage source ignites the glow tube and operates the relay. During abnormal operation caused by frequency jumping and interruption of the microwave field, the glow lamp is extinguished to release the relay and thereby cause the interruption of applied energy to the magnetron. A diode may be substituted for the glow lamp. Under normal conditions it rectifies the microwave energy to operate the relay while during abnormal operation the rectified energy is too small to operate the relay.

The invention relates to an arrangement for the protection of cross-field generator tubes of high continuous wave power or pulse power, more particularly continuous wave magnetrons, in the case of frequency jumping with high load reflections.

Cross-field electron discharge tubes, more particularly continuous wave magnetrons, are subject to high load reflections in microwave heating devices and installations as a result of the strongly varying termination resistance presented by the material being heated. For some phase positions and if a predetermined maximum value is exceeded, this leads to frequency jumping, known as moding, in the tube. In this operative condition, in a continuous wave magnetron, one of two kinds of oscillation, namely ($\lambda-1$) mode and its doublet, are produced at a higher frequency than the operating frequency, which cannot be coupled out. The energy content of these two kinds of oscillation is as large as that of the coupled-out basic λ mode oscillation. This undesired oscillation condition leads to rapid destruction of the magnetron by thermal heating of the cathode, if the disturbed operating condition is not immediately interrupted. Even short duration frequency jumping can cause damage and thus reduce the life of tubes with a high output power.

It is an object of the invention, to provide an arrangement for the protection of cross-field generator tubes of high continuous wave or pulse power, from frequency jumping. In accordance with the invention this protection can be achieved in a simple manner in that a glow lamp is arranged in, or is coupled into the high frequency electromagnetic field of the output line of the generator or a working device connected to the generator. With normal operation, the glow lamp is ignited by superimposition of the high frequency electric alternating voltage and a voltage taken from a source which lies below the ignition voltage of the glow lamp, so that a relay disposed in series with the glow lamp responds. With disturbed operation, that is to say frequency jumping, the glow lamp is extinguished by the lack of the high frequency electric alternating field, whereby the relay lapses and opens a working contact disposed in a supply circuit of a main circuit breaker winding. It is thereby achieved that the generator cannot be placed into operation with a fault in the protective circuit and when in operation is immediately switched off if a fault occurs which leads to frequency jumping.

Instead of a glow lamp, alternatively a high frequency diode may be provided, in which for normal operation a current flows as a result of the rectification action, which causes a relay to respond. The HF-diode can alternatively be so used that a voltage occurs at it in the normal operation due to the rectification action, which serves for switching a relay.

The above and other objects and advantages of the invention will be clear from the following description taken with reference to the accompanying drawings which are given by way of example and in which:

FIG. 1 is a diagram of a microwave generator arrangement provided with the protection arrangement of the invention; and

FIG. 2 is a diagram of a detail of a modified embodiment.

In the illustrated embodiments, the energy provided by a microwave generator **1** with a cross-field tube, more particularly a continuous wave magnetron, is coupled into a coaxial connection line **2** with rectangular cross section and is transferred therefrom, by a radiator **3**, onto the material **4** to be heated, which is transported under the radiator by a transport belt **5**.

Between the generator **1** and the radiator **3**, a glow lamp **6** is disposed with its electrodes in the wave guides **2** and thus subjected to the electric field of the wave which travels in the direction towards the load. The glow lamp **6** is plugged into a holder which screens the high frequency alternating field from the outside. The glow lamp is connected through a relay **7** and a resistance **8** to a current source **9**.

With the glow lamp **6** ignited, the relay **7** responds and closes the current circuit **10** of the winding **11** of a circuit breaker **12** which controls the current supply for the generator **1**.

In the ignited condition, a very low voltage is present across the glow lamp **6**, which alone is not sufficient for ignition of the glow discharge. This glow discharge is only possible as a result of the high frequency electric alternating field which the glow lamp is subjected to in the wave guide **2**.

With load reflections, which for example occur in the absence of material to be treated on the transport belt **5**, the cross-field generator tube in the generator **1** is endangered. Such load reflections however make themselves noticeable in the electric field of the wave guide **2** and the glow tube **6** can readily be so arranged that it is disposed in a region of the wave guide at which, on load reflecton, the field energy suddenly sinks from its normal value to such a low value that the glow tube is extinguished. This is naturally only possible if the voltage of the relay circuit source **9** is not sufficient for maintaining the ignition of the glow tube. The glow tube is extinguished in such a case and the relay **7** lapses and the circuit breaker **12** interrupts the energy supply to the generator **1**.

A simple equivalent protection element to the glow tube in the electric field of the wave guide is represented by a high frequency diode **13** as illustrated in the embodiment according to FIG. 2. This HF-diode is arranged in a coaxial stub line **14** connected to the wave guide **2**, in which a return **15** for the connected relay current circuit with the relay **7** is provided.

Various modifications are possible within the scope of the invention. More particularly the current circuit for the glow lamp or the HF-diode may be formed otherwise than as in the illustrated embodiments. Thus, for exam-

ple, the voltage occurring at the HF-diode as a result of the rectification action in normal operation can be utilised to actuate an electric relay.

I claim:

1. Apparatus for the protection of a cross-field electric discharge tube of high power, such as a continuous wave magnetron, during moding comprising,

said electric discharge tube of high power,

waveguide means for coupling high power microwave energy from said electric discharge tube of high power to a dissipative load,

electromagnetic field sensing means inside said waveguide means in the path of high power microwave energy flow from said electric discharge tube to said dissipative load for providing a disabling signal upon sensing the intensity of the microwave field in said waveguide means being less than a predetermined value,

and protection circuit means responsive to said disabling signal for interrupting the flow of energy to said electric discharge tube of high power,

whereby with disturbed operation of said electric discharge tube resulting from moding, said electromagnetic field sensing means provides said disabling signal.

2. Apparatus in accordance with claim 1 wherein said electromagnetic field sensing means comprises,

a glow lamp in said waveguide,

and said protection circuit means comprises,

a low voltage source,

and relay means for coupling a potential from said low voltage source to said glow lamp that is less than the ignition potential of said glow lamp and operated by energy from said low voltage source when said glow lamp is ignited,

whereby with normal operation of said electric discharge tube said glow lamp is ignited by superposition of said potential from said low voltage source and the voltage provided by said microwave field while with disturbed operation resulting from moding, said glow lamp is extinguished to release said relay means.

3. Apparatus in accordance with claim 2 wherein said relay means comprises an electronic relay including a cold cathode tube.

4. Apparatus in accordance with claim 1 wherein said electromagnetic field sensing means comprises,

a diode in said waveguide,

and said protection circuit means comprises,

relay means coupled to said diode and operated by rectified energy provided by said diode upon rectifying said microwave field,

whereby with disturbed operation resulting from moding, said diode provides an insufficient signal to operate said relay means and said relay means is then released.

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JAMES D. TRAMMELL, Primary Examiner

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