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HIGH-FREQUENCY PROTECTIVE CIRCUITS

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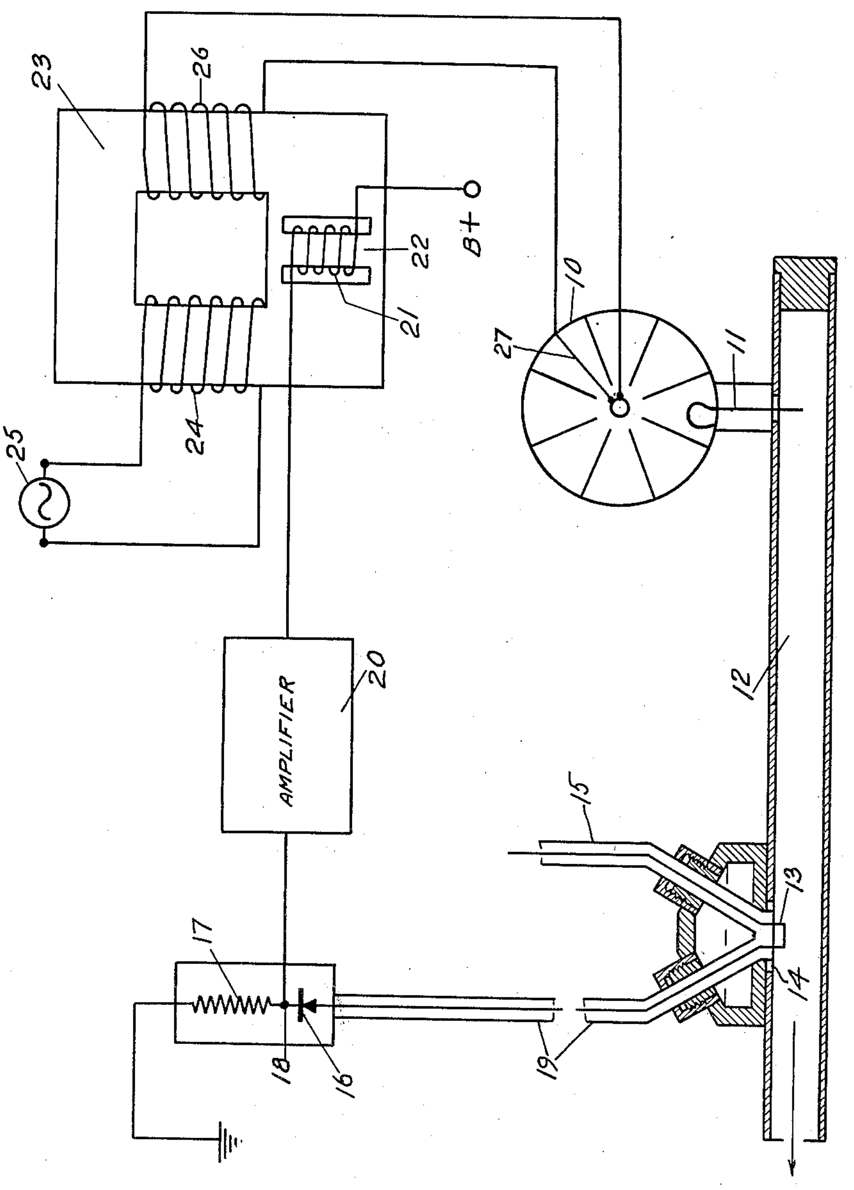

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HIGH-FREQUENCY PROTECTIVE CIRCUITS

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8 Claims. (Cl. 250—36)

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This invention relates to electrical circuits, and more particularly to a system for automatic protection of a microwave oscillator producing continuous waves.

In electron tubes used to produce microwave energy such as magnetrons, for greatest efficiency the device should work into a load of optimum value. When this is the case, the voltage standing wave ratio in the transmission line connecting the tube and the load will be found to be unity. When this is not the case, the ratio will be at some higher value. Thus the voltage standing wave ratio may be taken as an indication of match or mismatch of the load and generator. As the standing wave is created by the presence of reflected energy in the transmission line, a device, such as a directive coupler adapted to transmit energy in one direction only and terminated in a detector, can be used to detect the presence of standing waves in the transmission line.

The effect of reflected energy on the magnetron is to bombard the cathode with electrons and heat it. If this condition is not corrected promptly, serious damage may be done to the tube. Further increase in temperature of the cathode may be prevented if the filament voltage is promptly reduced.

It is the purpose of the present invention to provide means for sensing an increase in the reflected power and in response reduce the filament power. This is done by inserting a directive coupling in the transmission line and deriving from it a control voltage that in turn controls the current through a saturating winding on the filament transformer supplying filament power to the magnetron.

Such a control system automatically maintains the cathode of the tube at the optimum temperature in spite of considerable variation in load conditions. Thus the cathodes and other structures of the tube are not exposed to excessive heat for any appreciable length of time, thus prolonging the life of these relatively expensive tubes. Other automatic control devices for micro-wave tubes, such as that disclosed in Patent No. 2,498,719, depend upon critical spacing of one or more probes within the transmission line from generator to load. The present device is independent of the phase of the standing wave and so does not have to be positioned at any particular point in the transmission line.

These features make the device particularly useful in industrial application of microwave energy where the energy is used to heat various substances presenting various loads to the

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generator. It is also useful in unattended microwave communication links, such as television relays where the load conditions may change suddenly in the absence of a skilled operator.

Other and further advantages of this invention will be apparent as the description thereof progresses, reference being had to the accompanying drawing, wherein the single figure is a diagrammatic representation of a protective system according to this invention.

Now referring to the drawing, the numeral 10 refers generally to the magnetron generating microwave energy that is picked up by the antenna probe 11 and introduced into a wave guide 12. At a convenient distance a loop 13, of the type described by H. C. Early in the November, 1946, Proceedings of the Institute of Radio Engineers at page 883 and shown schematically in Fig. 1 of that article, and in greater detail in Figs. 6 and 7, is inserted into the wave guide 12 through a slot 14. One side of the loop may be connected through a coaxial cable 15 to an incident power indicator, not shown as it is no part of the present invention. The far side of the loop is connected through a length of coaxial cable 19 to a crystal rectifier 16 that is connected to ground through a resistor 17. The crystal 16 is connected in such polarity that, as the reflected power picked up by the loop 13 becomes greater, the junction point 18 becomes increasingly negative. The point 18 is connected to an amplifier 20 which may be of any conventional design adapted to amplify a slowly varying D. C. potential. The input should be of high impedance and the output of low impedance. This output is connected in series to a saturating winding 21 on the core 22 of a filament transformer 23. The primary 24 of this transformer is connected to a source of A. C. power 25. The secondary 26 is connected to the filament 27 of the magnetron 10.

When the magnetron 10 is operating normally into a matched load, the voltage standing wave ratio will be unity and there will be no reflected power to be picked up by the loop 13 and detected by crystal 16. The amplifier 20 passes a normal amount of current through the winding 21 leaving the core 22 unsaturated and permitted the magnetron filament 27 to receive its normal amount of energy.

When the load changes to create a mismatch and cause reflected energy to be picked up by the loop 13 and detected by the crystal 16, the flow of current through the saturating winding 21 increases to saturate the core 22 of the filament transformer 23. This reduces the amount of power transferred to the secondary 26 and delivered to the filament 27 of the magnetron, thus reducing the temperature of its cathode.

When the load conditions return to normal, the standing wave ratio in the transmission line 12 returns to unity and there is no reflected energy to be detected and no signal at the input of the amplifier 20. This reduces the flow of current through the saturating winding 21 on the core 22 of the transformer 23 permitting full heater energy to pass to the filament 27 of the magnetron 10 increasing its temperature, thus maintaining the cathode of the magnetron 10 at a constant temperature under a wide range of load conditions.

Any type of directional coupler could be used in place of the loop 13 shown. Also any convenient type of rectifier could be used in place of the crystal type 16 shown.

This invention is not limited to the particular details of construction and materials described, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A protective system comprising a source of radio frequency energy, a heater for said source, means for delivering energy to said heater, a transmission line for coupling said source to a load, means for detecting reflected energy in said transmission line, and means for varying the energy delivered to said heater in response to the output of the detecting means.

2. A protective system comprising a source of radio frequency energy, a heater for said source, means for delivering energy to said heater, comprising a transformer with a core and a saturating winding on said core, a transmission line for coupling said source to a load, means for detecting reflected energy in said transmission line, and means for varying the energy delivered to said heater in response to the output of the detecting means, comprising a saturable core reactance in said means for delivering energy to said heater.

3. A protective system comprising a source of radio frequency energy, a heater for said source, means for delivering energy to said heater, comprising a transformer with a core and a saturating winding on said core, a transmission line for coupling said source to a load, means for detecting reflected energy in said transmission line, and means for varying the energy delivered to said heater in response to the output of the detecting means, comprising means for coupling the output of said detector to the said saturating winding.

4. A protective system comprising a source of radio frequency energy, a heater for said source, means for delivering energy to said heater, a transmission line for coupling said source to a load, means for detecting reflected energy in said transmission line, said means comprising a rectifier coupled to said transmission line through a directional coupling means, and means for varying the energy delivered to said heater in response to the output of the detecting means.

5. A protective system comprising a source of radio frequency energy, a heater for said source, means for delivering energy to said heater, comprising a transformer with a core and a saturating winding on said core, a transmission line for coupling said source to a load, means for detecting reflected energy in said transmission line, said means comprising a rectifier coupled to said transmission line through a directional coupling means, and means for varying the energy delivered to said heater in response to the output of the detecting means, comprising a saturable core reactance in said means for delivering energy to said heater.

6. A protective system comprising a source of radio frequency energy, a heater for said source, means for delivering energy to said heater, comprising a transformer with a core and a saturating winding on said core, a transmission line for coupling said source to a load, means for detecting reflected energy in said transmission line, said means comprising a rectifier coupled to said transmission line through a directional coupling means, and means for varying the energy delivered to said heater in response to the output of the detecting means, comprising means for coupling the output of said detector to the said saturating winding.

7. A protective system comprising a source of radio frequency energy, an energy control for said source, means for delivering energy to said energy control, a transmission line coupling said source to a load, an alternating current directional coupler connected to said transmission line for detecting substantially only reflected energy in said transmission line, and means for varying said energy control in response to the output of said detecting means.

8. A protective system comprising a source of radio frequency energy, an energy control for said source comprising a saturable core reactance, means for delivering energy to said energy control, a transmission line coupling said source to a load, an alternating current directional coupler connected to said transmission line for detecting substantially only reflected energy in said transmission line, and means for varying said energy control in response to the output of said detecting means.

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