Feb. 6, 1951 O. I. STEIGERWALT 2,540,764

MAGNETRON MODULATION CIRCUIT

Filed Dec. 10, 1945

FIG. 1

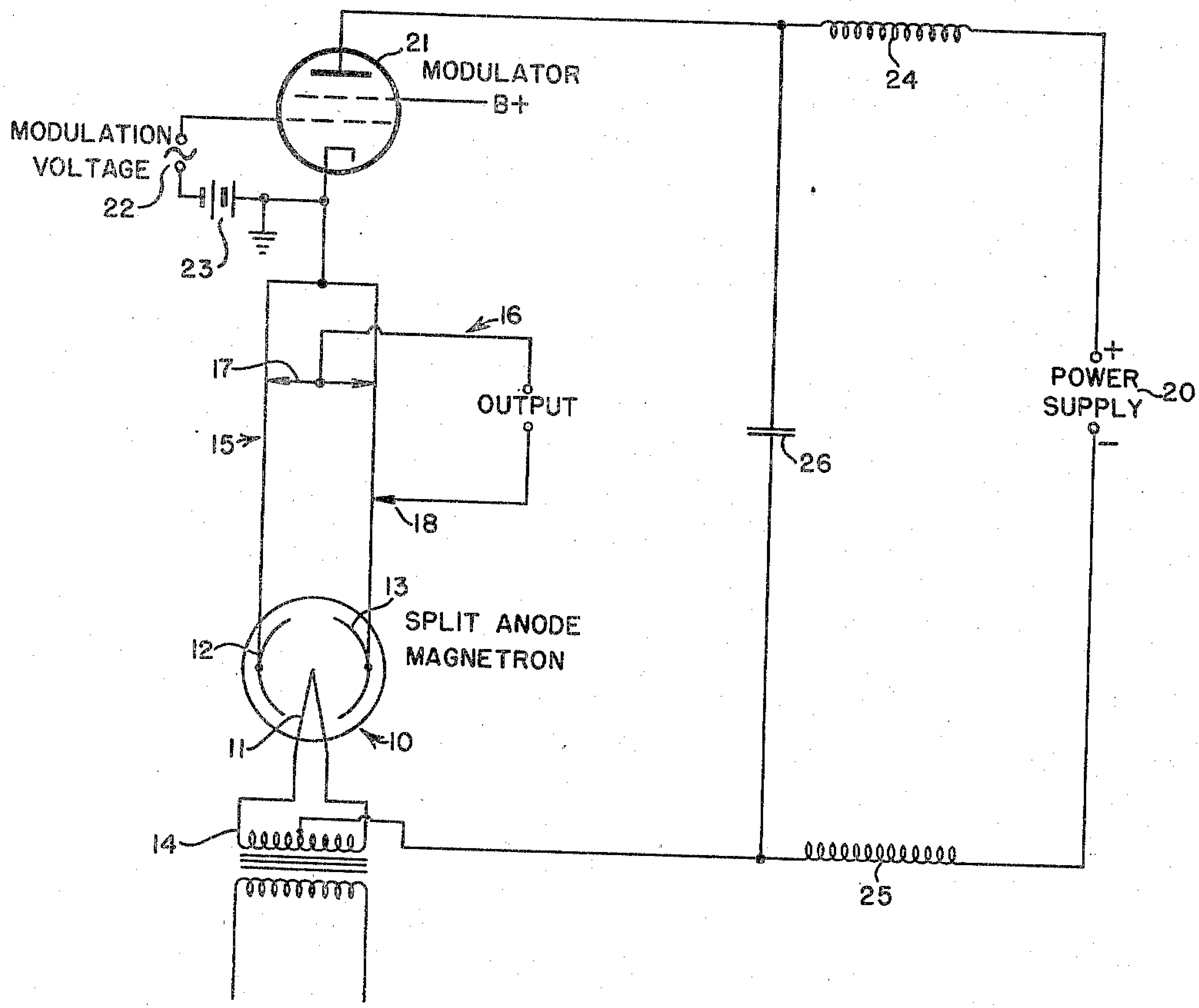
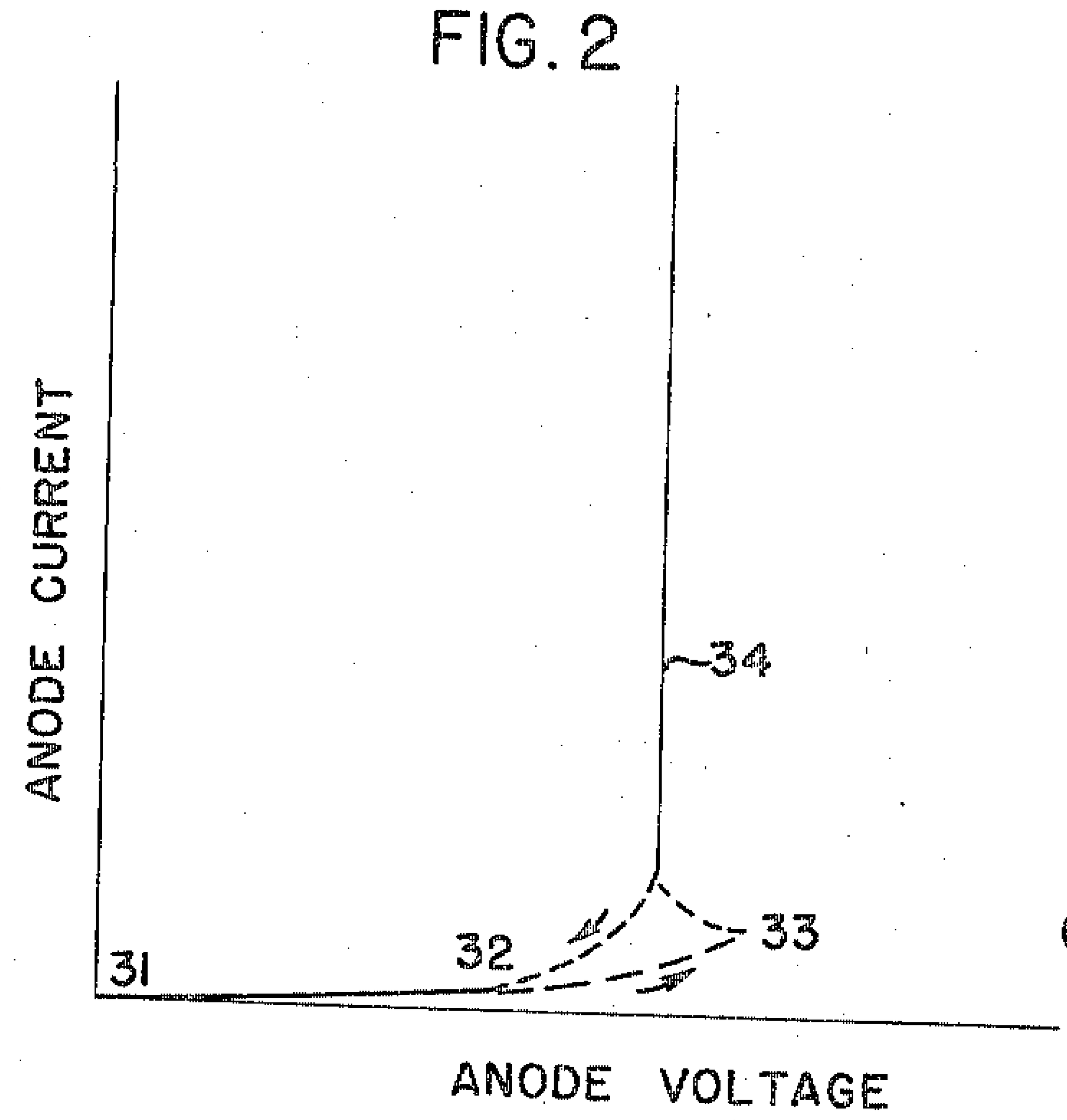


FIG. 2



INVENTOR.
OLIVER I. STEIGERWALT
BY
William D. Hall
ATTORNEY

Patented Feb. 6, 1951

2,540,764

UNITED STATES PATENT OFFICE

2,540,764

MAGNETRON MODULATION CIRCUIT

Oliver I. Steigerwalt, Erie, Pa., assignor to the United States of America as represented by the Secretary of War

Application December 10, 1945, Serial No. 634,100

3 Claims. (Cl. 332—5)

1

This invention relates to electrical apparatus and more particularly to the modulation of magnetron radio frequency oscillators.

An important object of the invention is to provide means for modulating a magnetron radio frequency oscillator with modulation frequencies in the range from low audio frequencies to upwards of 5 mc. p. s.

A further object of the invention is to prevent the magnetron oscillator from dropping out of oscillation when the modulation is applied.

Other objects and advantages of the invention will be apparent during the course of the following description.

The present invention is essentially a current-modulating device. A tetrode or pentode modulator tube is placed in series with the magnetron plate circuit. The modulation voltages are applied to the control grid of the modulator tube and vary the current through the modulator tube and magnetron.

In the accompanying drawing forming a part of this specification and in which like numerals are employed to designate like parts throughout the same:

Fig. 1 is a simplified schematic circuit diagram illustrating one embodiment of the invention; and

Fig. 2 is a typical plate current versus plate voltage characteristic for a magnetron radio frequency oscillator.

In Fig. 1, wherein is shown a preferred embodiment of the present invention, the numeral **10** designates a split-anode radio frequency magnetron oscillator having a central directly-heated cathode **11** surrounded by a concentric split-anode of two semicylindrical sections **12** and **13**. Cathode **11** is supplied by filament transformer **14**.

A variable short-circuited parallel wire radio frequency transmission line **15** is connected across anodes **12** and **13**. The radio frequency output transmission line **16** is taken off between a movable short-circuiting bar **17** and an adjustable tap **18**.

The D. C. polarizing voltage between cathode **11** and anodes **12**, **13** is obtained from power supply **20**. In series with power supply **20** and magnetron **10** is a current-modulation tetrode vacuum tube **21**.

Modulator tube **21** may be a pentode or a tetrode, its requisite being that it have a high plate resistance. The modulation voltage **22** and appropriate fixed grid bias **23** are applied between grid and cathode of modulator tube **21**.

2

In series with power supply **20** and the remainder of the circuit is a low pass filter comprising series chokes **24** and **25** and shunting condenser **26**.

The operational features of the present invention are as follows:

Split-anode magnetron **10**, as is well known, acts as a negative resistance oscillator. The variable short-circuited transmission line **15** serves as the resonant tuned-circuit for magnetron **10**. The frequency of oscillation may be varied by adjusting the length of the line **15** by means of movable short-circuiting bar **17**. Short-circuiting bar **17** is both the R. F. and the D. C. ground.

The radio frequency output is taken across the shorting bar **17** and the movable tap **18** on transmission line **15**. By means of this movable tap **18** an impedance match may be obtained between the output circuit and the magnetron oscillator **10**.

The modulator tube **21** is placed in series with the power supply **20** and magnetron **10** and functions as a current modulating device. The quiescent value of the current will be determined by the fixed grid bias **23**. Variation of the grid bias by the modulation voltage **22** will vary the current through magnetron **10** as a function of the modulating voltage **22**. The low pass filter comprising two chokes **24**, **25** and the condenser **26** keeps the modulation frequencies out of the power supply **20**.

The particular advantage of current modulation for the magnetron type of oscillator will be made clear by reference to Fig. 2. Fig. 2 is a plate current versus plate voltage characteristic curve for a typical magnetron oscillator. As the cathode-anode voltage is increased (with a constant magnetic field), the characteristic curve proceeds along the path **31**—**32**—**33**, with very little current being drawn. The tube does not oscillate until a critical voltage **33** is applied. Voltage **33** may be considerably in excess of the voltage drop across the tube once oscillation has started (i. e. voltage **34**). If voltage **33** tends to be maintained (because of good regulation of the power supply) the current through the tube will become excessive. Conversely, if the anode voltage is reduced, the magnetron will drop out of oscillation, the characteristic curve proceeding along the line **34**—**32**—**31**.

It should be evident then that variation of the anode voltage (which has been the customary method for simple on-off modulation) is unsatisfactory for magnetron modulation in general. A series current-modulating device is particularly advantageous. A modulator which is capable of limiting the current through the magnetron as well as modulating the current is embodied in the present invention. The use of the high plate resistance tetrode or pentode modulator tube 21 accomplishes the desired current modulation. The quiescent current is controlled by the fixed grid bias source 23 and modulation of the current is effected by the modulation voltage 22. The instantaneous sum of grid bias 23 and modulation voltage 22 constitutes the cathode-grid voltage of modulator tube 21.

The D. C. ground connection is placed at the cathode of modulator tube 21. This necessitates the use of an ungrounded power supply 20 but results in several advantages. The R. F. output line 16 as well as tuned-transmission line 15 and magnetron anodes 12, 13 are all kept at D. C. ground potential, thereby minimizing danger of shock to operating personnel. In addition stray capacitance effects are minimized, inasmuch as both R. F. output line 16 and modulation voltage 22 have one side of the line at R. F. and D. C. ground.

While there has been here described what is at present considered to be the preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention.

What is claimed is:

1. A modulated radio frequency oscillator including a split-anode negative resistance magnetron, said magnetron having a central filament surrounded by a concentric anode of two semi-cylindrical sections, a resonant radio frequency transmission line connected across the anode sections of said magnetron and serving as the resonant circuit of said magnetron, power supply means for maintaining a potential difference between said filament and said split-anode of said magnetron, a current-modulation vacuum tube having a control grid, said tube being connected in series with said magnetron and said power supply means, a low-pass filter connected in series with said power supply means, said tube and said magnetron, said magnetron having only its filament and anode connected to said tube and power supply means, said filter serving to minimize the radio frequency power coupled to said power supply means and means for applying modulating voltages to said control grid whereby said voltages applied to said control grid will vary the resistance of said current-modulation tube thereby modulating the current through said magnetron and the radio frequency output thereof.

2. A modulated radio frequency oscillator including a magnetron having a cathode and a plurality of anode sections, a power supply for impressing a potential difference between said cathode and said anode sections, a current-modulating vacuum tube having a control grid, said tube being connected in series with said power supply and said magnetron, a low-pass filter connected to said power supply and adapted to minimize the radio frequency power coupled to said power supply, said magnetron having only its cathode and anode sections connected to said power supply and means for applying modulating voltages to said control grid whereby the resistance of said current-modulating tube may be varied thereby varying the current through said magnetron and the radio frequency output thereof.

3. A modulated radio frequency oscillator including a split-anode negative resistance magnetron, said magnetron having a central filament surrounded by two concentric semi-cylindrical anode sections, a resonant radio frequency transmission line connected across the anode section of said magnetron and constituting the resonant circuit of said magnetron, power supply means for maintaining a potential difference between said filament and the anode sections of said magnetron, a current modulation vacuum tube having a control grid, said tube having a cathode connected to said transmission line, a connection from said cathode and said transmission line to ground, said tube having an anode connected to one terminal of said power supply means, the filament of said magnetron being connected to the other terminal of said power supply means, and means for applying modulation voltages to said control grid, whereby said voltages applied to said control grid vary the resistance of the current modulation tube thereby modulating the current through said magnetron and the radio frequency output thereof.

OLIVER I. STEIGERWALT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,125,507	Ladner	Aug. 2, 1938
2,135,199	Ponte et al.	Nov. 1, 1938
2,139,238	Linder	Dec. 6, 1938