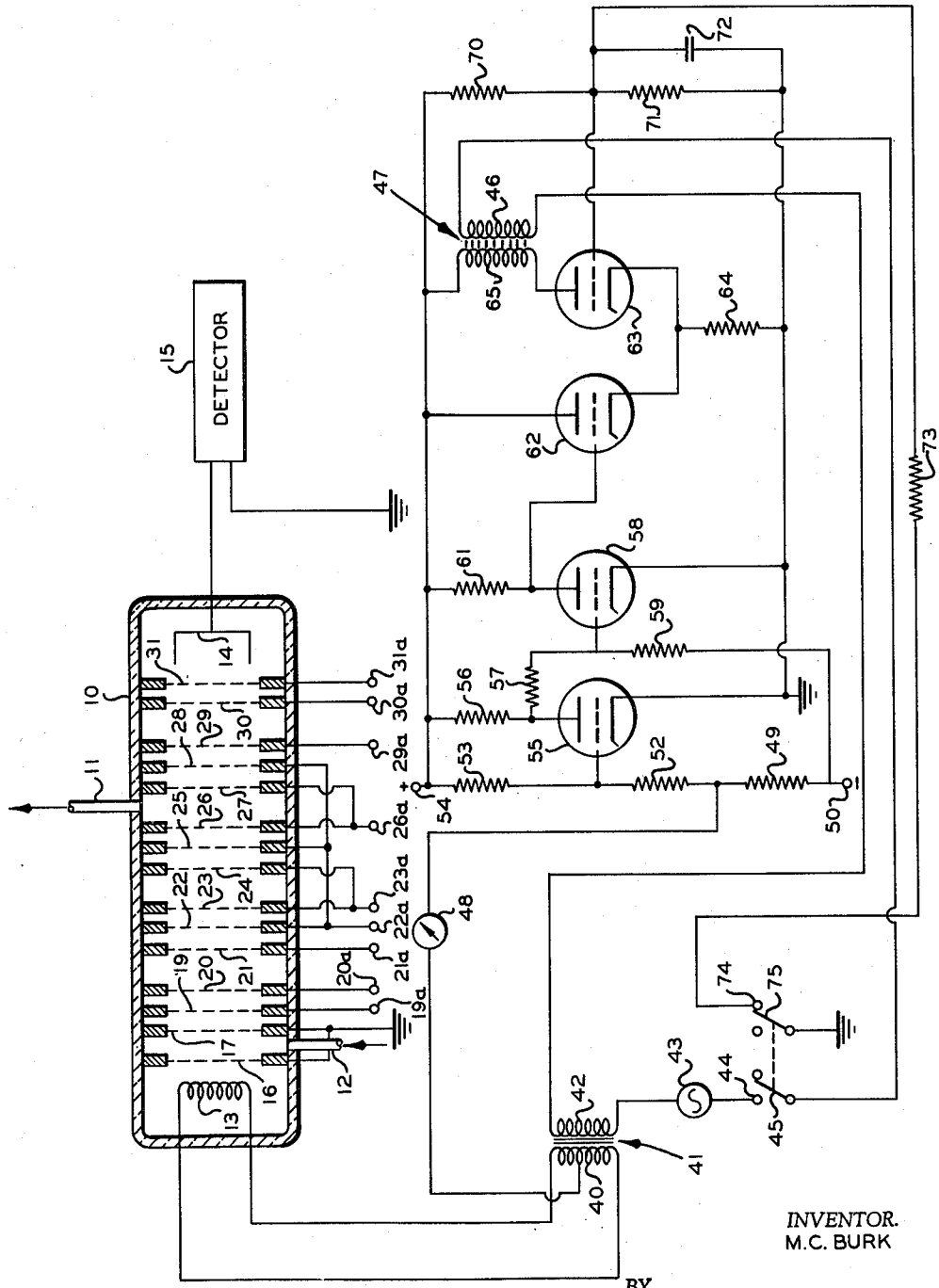
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EMISSION REGULATOR

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INVENTOR.
M.C. BURK

BY Hudson & Young

ATTORNEYS

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EMISSION REGULATOR

Marvin C. Burk, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

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4 Claims. (Cl. 315—106)

This invention relates to an improved electron emission regulator.

In various types of electronic devices, electrons are emitted from a heated filament. A mass spectrometer is one example of such a device. Ions are produced in most mass spectrometers by bombarding the gas molecules to be analyzed by a stream of electrons. The electrons generally are emitted from a heated filament and are accelerated by an electrical field into an ionization chamber which contains the gas molecules to be ionized. The resulting ions are then separated according to their individual masses to provide an analysis of the gas sample. In an instrument of this type, it is important to maintain the electron beam of constant magnitude because variations in this beam tend to introduce corresponding variances in the degree of ionization. Various types of electron emission regulators have been developed which tend to maintain the electron emission from the filament at the constant value. In this regard, one particular problem which has been encountered results from the fact that excess current often is applied initially to the filament which can result in the filament being damaged.

In accordance with the present invention there is provided an improved electron emission regulator. The electrical energy supplied to the filament is controlled by a saturable reactor. The current through the primary winding of the reactor is regulated automatically in response to the actual electron emission from the filament so as to tend to maintain the emission constant. A safety device is incorporated in the emission regulator to prevent the initial current supplied to the filament from exceeding a predetermined value. This control device comprises means to delay the flow of current through the primary winding of the saturable reactor until a signal storage means charges to a predetermined voltage. Means are also provided to discharge the storage means rapidly when the current to the filament is extinguished.

Accordingly, it is an object of this invention to provide improved apparatus for regulating the electron emission from a heated filament.

Another object is to provide an electron emission regulator having a safety device incorporated therein to prevent excessive current from being applied to the electron emitter.

Other objects, advantages and features of this invention should become apparent from the following detailed description which is taken in conjunction with the accompanying drawing which is a schematic representation of a mass spectrometer having the emission regulator of this invention incorporated therein.

Referring now to the drawing in detail, there is shown a housing **10** which contains the electrode structure of a mass spectrometer tube. The interior of housing **10** is maintained at a reduced pressure by means of a vacuum pump, not shown, which is connected to the housing by means of a conduit **11**. A second conduit **12** communicates with housing **10** to supply a gas sample to be analyzed. A filament **13** is mounted in the first end

of housing **10** to liberate electrons. An ion collector plate **14** is positioned at the opposite end of housing **10**. Collector plate **14** is connected to the first input terminal of an ion detector circuit **15**, the second input terminal of which is connected to ground.

A pair of spaced grids **16** and **17** are positioned adjacent filament **13** to define an ionization chamber. The gas sample to be analyzed is introduced into this chamber through conduit **12**. Grids **16** and **17** are connected to ground so as to be maintained at a potential which is positive with respect to the potential at filament **13**. This results in the electrons liberated from filament **13** being accelerated into the region between grids **16** and **17** to ionize the gas molecules. A pair of grids **19** and **20** are positioned in spaced relationship with one another adjacent grids **16** and **17**. Grids **19** and **20** are connected to respective terminals **19***a* and **20***a* which are connected to sources of negative potential to accelerate the ions toward collector plate **14**. A series of three grids **21**, **22** and **23** are positioned adjacent grid **20**; a second series of three grids **24**, **25** and **26** are positioned adjacent grid **23**; and a third series of grids **27**, **28** and **29** are positioned adjacent grid **26**. Two grids **30** and **31** are positioned in spaced relationship with one another between grid **29** and grid **31**. Grid **30** is connected to a positive potential terminal **30***a*, and grid **31** is connected to a negative potential terminal **31***a*. Grids **22**, **25** and **28** are connected to a terminal **22***a*. Grids **21** and **29** are connected to respective terminals **21***a* and **29***a*. Grids **23** and **24** are connected to a terminal **23***a*, and grids **26** and **27** are connected to a terminal **26***a*. Grids **21***a*, **23***a*, **26***a* and **29***a* are connected to terminals of negative potential. Terminal **22***a* is connected to sources of alternating and negative potentials.

The elecrons emitted from filament **13** are accelerated into the inoization chamber between grids **16** and **17** where they bombard the gas molecules to produce ions. The resulting positive ions are accelerated out of the ionization chamber by the negative potentials on grids **19** and **20** and are directed toward collector plate **14**. The next nine grids **21** to **29** serve to accelerate the ions by amounts which are functions of the masses of and the charges on the individual ions. Ions of a predetermined mass receive sufficient energy to overcome the positive potential applied to grid **30** and are thus able to reach collector plate **14**. The purpose of grid **31** is to repel any secondary electrons which may be formed within the tube. For a more detailed description of the operation of the accelerating grids, reference is made to U.S. Patent 2,761,974.

Filament **13** is connected across the secondary winding **40** of a transformer **41**. The first terminal of the primary winding **42** of transformer **41** is connected to the first terminal of a source of alternating current **43**. The second terminal of current source **43** is connected to a terminal **44** which is adapted to be engaged by a switch **45**. Switch **45** is connected to the first terminal of the secondary winding **46** of a saturable reactor **47**. The second terminal of winding **46** is connected to the second terminal of transformer winding **42**. When switch **45** is closed, current from source **43** is then applied to the primary winding of transformer **41**. This results in current being supplied to filament **13** to heat the filament so that electrons are liberated therefrom. The center tap of transformer winding **40** is connected through a current meter **48** and through resistors **52** and **53** to a terminal **54** which is maintained at a positive potential. Meter **48** thus provides an indication of the electron emission from filament **13**. It should be evident that the current supplied to transformer winding **42** is a function of the impedance of winding **46**. The circuit described

hereinafter operates to control this impedance so as to maintain the emission from filament 13 at a constant value.

The junction between meter 48 and resistor 52 is connected through a resistor 49 to a terminal 50 which is maintained at a negative potential. The values of resistors 49, 52 and 53 are such that filament 13 is maintained at a negative potential. The junction between resistors 52 and 53 is connected to the control grid of a triode 55. The anode of triode 55 is connected through a resistor 56 to terminal 54, and the cathode of triode 55 is connected to ground. The anode of triode 55 is also connected through a resistor 57 to the control grid of a second triode 58. The control grid of triode 58 is connected through a resistor 59 to terminal 50. The anode of triode 58 is connected through a resistor 61 to terminal 54, and the cathode of triode 58 is connected to ground. The anode of triode 58 is also connected to the control grid of a third triode 62. The cathode of triode 62 is connected to the cathode of a fourth triode 63 and to ground through a resistor 64. The anode of triode 62 is connected directly to terminal 54. The anode of triode 63 is connected to terminal 54 through the primary winding 65 of saturable reactor 47.

Triodes 55, 58, 62 and 63 and the circuit elements associated therewith thus form a direct current amplifier which controls the impedance of reactor winding 46 in response to the electron emission from filament 13. If the electron emission from filament 13 should tend to increase, for example, the potential at the control grid of triode 55 tends to increase. This increases the conduction through triode 55 so as to decrease the potential applied to the control grid of triode 58. This decreases conduction through triode 58 so as to increase the potential applied to the control grid of triode 62. The potential at the cathode of triode 62 is thereby increased, and this in turn decreases conduction through triode 63 and the primary winding 65 of reactor 47. This decreased current through winding 65 increases the impedance of winding 46 so that less current is applied to transformer winding 42. This in turn decreases the emission from filament 13. If the emission from filament 13 should tend to decrease, the above-described operation is reversed so that greater current is applied to transformer winding 42. This tends to maintain the emission from filament 13 at a constant value.

The control grid of triode 63 is connected to terminal 54 through a resistor 70 and to ground through a resistor 71. A capacitor 72 is connected in parallel with resistor 71. The control grid of triode 63 is also connected through a resistor 73 to a terminal 74 which is adapted to be engaged by a switch 75, the latter being connected to ground. Switches 45 and 75 are mechanically connected together so that one is closed when the other is opened and vice versa. Resistors 70 and 71 are both substantially larger than resistor 73. In one specific embodiment of this invention, resistors 70, 71 and 73 were 1,800,000 ohms, 1,200,000 ohms and 10,000 ohms, respectively; and capacitor 72 was one microfarad.

The mass spectrometer filament is energized by moving switch 45 into engagement with terminal 44. This results in switch 75 being moved out of engagement with terminal 74 so that the upper terminal of capacitor 72 is disconnected from ground. Capacitor 72 then charges slowly due to the current flow though resistor 71. This slow charging of capacitor 72 results in the current supplied to filament 13 being gradually increased as triode 63 conducts a greater amount of current to reduce the impedance of winding 46. This operation thus prevents large currents from being applied initially to filament 13. The filament is turned off by moving switch 45 out of engagement with terminal 44 and moving switch 74 into engagement with terminal 74. This results in the rather rapid discharging of capacitor 72 through resistor 73 to a value only slightly greater than ground potential. This substantially reduces the current through triode 63 so that the impedance of winding 46 is increased.

It should thus be evident that the safety feature of this invention provides a positive control to prevent the initial application of high voltages to filament 13. This safety feature becomes effective almost immediately after the filament is turned off so that an accidental closing of switch 45 does not result in a high voltage being applied to filament 13. An improved emission regulator is thus provided in accordance with this invention. It should be evident that this emission regulator is applicable to almost any type of electronic device wherein electrons are emitted from a heated filament, and X-ray tube being an example of such a device.

While the invention has been directed in conjunction with a present preferred embodiment, it should be evident that it is not limited thereto.

What is claimed is:

1. An emission regulator comprising an electron emitting filament, a source of current, a switch, a saturable reactor having a primary winding and a secondary winding, circuit means connecting said filament to said source through said switch and the secondary winding of said reactor, a vacuum tube having an anode, a cathode and a control grid, means connecting the primary winding of said reactor in the anode-cathode circuit of said tube, first means responsive to electron emission from said filament to control the potential on the cathode of said tube to tend to maintain constant electron emission from said filament, and second means responsive to said switch to control the potential on the control grid of said tube so that the full application of current to said filament as permitted by said first means is delayed a predetermined time following closure of said switch.

2. The emission regulator of claim 1 wherein said second means comprises a source of direct potential, first and second resistors connected in series relationship between the positive and negative terminals of said source of direct potential, a capacitor connected in parallel relationship with said second resistor, a third resistor and a second switch connected in series relationship with one another and in parallel with said second resistor, said third resistor being smaller than said second resistor, means connecting said first and second switches so that one is open when the other is closed, and means connecting the control grid of said tube to the junction between said first and second resistors.

3. An emission regulator comprising an electron emitting filament, a source of alternating current; a transformer having a primary winding and a secondary winding; a saturable reactor having a primary winding and a secondary winding; a first switch; means connecting said source of current, said first switch, the primary winding of said transformer and the secondary winding of said reactor in series relationship; means connecting said filament across the secondary winding of said transformer; a vacuum tube having an anode, a cathode and a control grid; means connecting the primary winding of said reactor in the anode-cathode circuit of said tube; means responsive to current emission from said filament to control conduction by said tube, and thereby the impedance of the secondary winding of said reactor, to tend to maintain constant emission from said filament; a source of direct potential; first and second resistors connected in series relationship between the positive and negative terminals of said source of direct potential; a capacitor connected in parallel relationship with said second resistor; a third resistor and a second switch connected in series relationship with one another and in parallel with said second resistor, said third resistor being smaller than said second resistor, means connecting said first and second switches so that one is open when the other is closed, and means connecting the control grid of said

tube to the junction between said first and second resistors.

4. The emission regulator of claim 3 wherein said means to control conduction by said tube comprises a voltage dividing network connected between the terminals of said source of direct potential, means conducting the center tap of the secondary winding of said transformer to a first point on said network, and means responsive

to the potential at a second point on said network to control conduction by said tube.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,945,160 July 12, 1960

Marvin C. Burk

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 6, for "conducting" read -- connecting --.

Signed and sealed this 31st day of January 1961.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents