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Sickafus

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[54] **ELECTRON BEAM REGULATOR**

[75] Inventor: **Edward N. Sickafus,** Livonia, Mich.

[73] Assignee: **Ford Motor Company,** Dearborn, Mich.

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Related U.S. Application Data

[63] Continuation of Ser. No. 61,156, Aug. 5, 1970, abandoned.

[52] **U.S. Cl.** ..... **315/30,** 315/31 R, 315/307

[51] **Int. Cl.** **H01j 29/52**

[58] **Field of Search** ..... 315/30, 31 R, 239, 307

[56] **References Cited**

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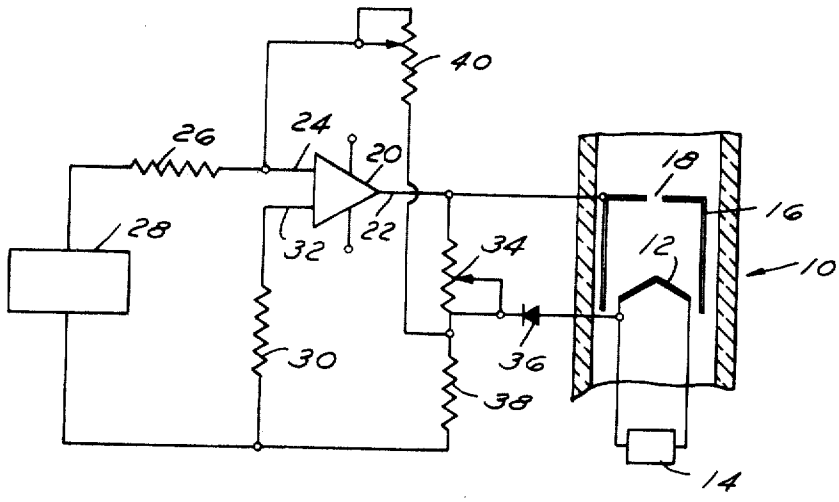
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Primary Examiner—Carl D. Quarforth
Assistant Examiner—P. A. Nelson
Attorney, Agent, or Firm—Glenn S. Arendsen; Robert A. Benziger; Keith L. Zerschling

[57] **ABSTRACT**

A resistor connected between the filament and a filament can of an electron beam device also is connected to an auxiliary operational amplifier that establishes and controls an auxiliary current through the resistor. The operational amplifier can be connected to maintain a constant current through the resistor or a constant potential difference across the resistor despite wide variations in the potential of the filament power supply, the electron producing ability of the filament, or other operational disturbances. In addition, the operational amplifier can be programmed to produce predetermined variations in the quantity of electrons making up the electron beam with a much wider band width.

5 Claims, 2 Drawing Figures



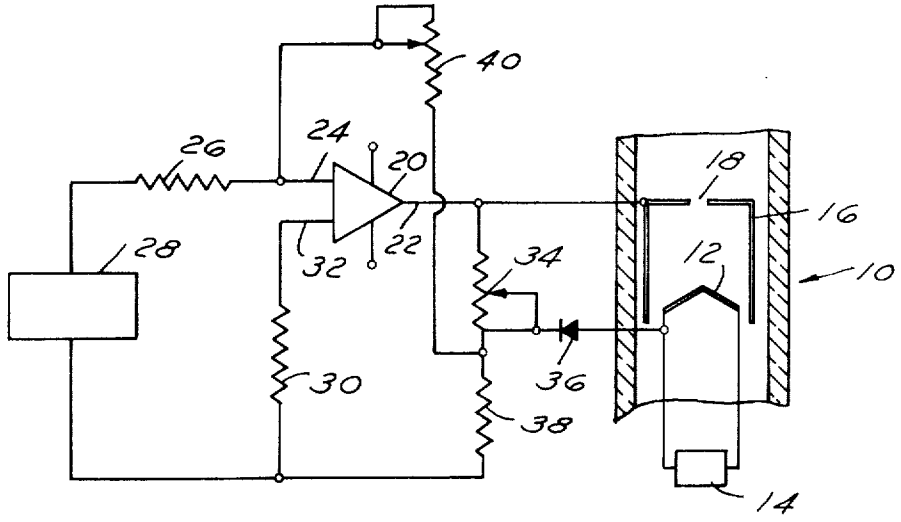


FIG. 1

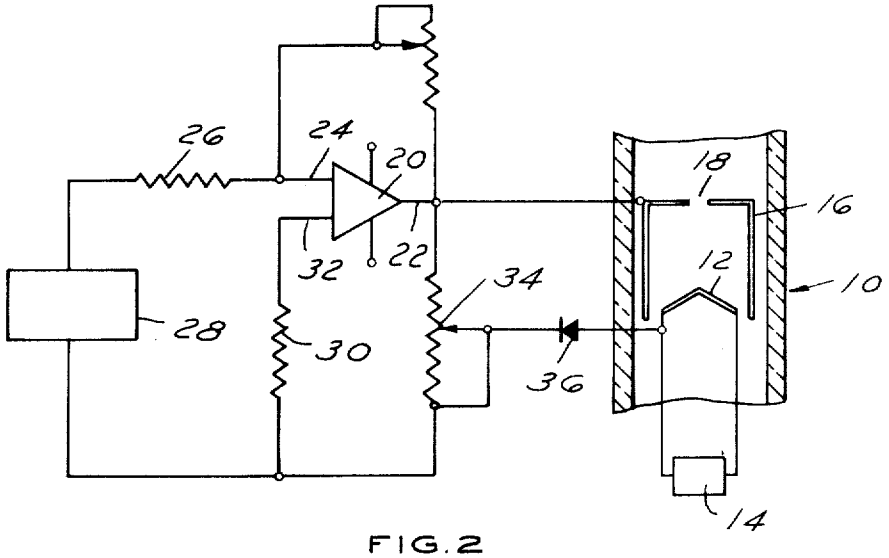


FIG. 2

INVENTOR
EDWARD N. SICKAFUS
BY
John R. Faulkner
Glenn S. Arendsen
ATTORNEYS

ELECTRON BEAM REGULATOR

This is a continuation of application Ser. No. 61,156, filed Aug. 5, 1970.

SUMMARY OF THE INVENTION

Electron beam devices are being used in an increasing number of industrial applications in addition to the widely used cathode ray tube of television sets. Spectrographic analysis equipment and electron microscopes are examples of just a few of the numerous types of laboratory equipment that use such devices. Heavy industry uses the devices to cure the new electrocuring paints, initiate and control chemical reactions, and perform other chemical and electrochemical functions. While the conventional cathode ray tube of a television system produces electrons on a substantially continuous basis once the unit has been activated, many of the other applications require highly specialized continuous control over electron production. Certain laboratory devices require an exactingly constant supply of electrons while other laboratory devices require electron production to vary in some prescribed manner including high frequency modulation. Industrial equipment typically requires carefully controlled periods of substantially constant electron production interspersed with periods of minimal electron production.

This invention provides a system for regulating the intensity of the electron beam produced by an electron beam device according to any predetermined plan. The system comprises an electron aperture member that has an aperture for passing the electrons forming the beam and another member in the electron beam that is at a potential differing from the potential of the aperture member. The aperture member is connected to the other member by an impedance element. Some of the electrons are intercepted by the operative member and flow through the impedance element to the other member. Auxiliary circuitry is connected across the impedance element to modify the potential difference established across the impedance element by the flow therein of the intercepted electrons, and the modified potential difference determines the number of electrons passing through the aperture.

The aperture member can be a filament can that is spaced a short distance from the electron producing filament which serves as the other member. Such filaments typically are heated by some external device and produce electrons by thermionic emission. A resistor can be used as the impedance element.

An operational amplifier is preferably used in the auxiliary circuitry. The output terminal of the amplifier is connected directly to the aperture element. One input terminal is connected to a power source and the other input terminal is connected through the impedance element to the output terminal. Depending on the type of operation desired, a feedback resistor is connected directly to the output terminal or to the impedance element.

Any electron producing element can be used in the system. Beam intensity can be varied at much higher frequencies and with much faster response times than the prior art technique of changing the temperature of the electron filament. Instead of connecting the impedance element directly to the electron producing filament, it can be connected between any two operative elements that operate at different potentials of an electrostatic lens system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram showing the system of this invention coupled to the filament and filament can of an electron beam device in a manner producing constant current control.

FIG. 2 is a schematic in which the system is coupled in a manner producing constant voltage control.

DETAILED DESCRIPTION

The neck portion of the envelope of an electron beam device is represented in the drawing by numeral **10.** A heated filament **12** located in the neck portion serves as the cathode. Filament **12** is provided with electrical power by an externally located power source **14.** A filament can **16** that serves as an aperture element is located forwardly of filament **12** and at least partially surrounds the front portion of filament **12.** Filament can **16** contains an aperture **18** in the center portion of its forward end.

Referring to FIG. **1,** an operational amplifier **20** has its output terminal **22** connected directly to aperture element **16.** The inverting input terminal **24** of operational amplifier **20** is connected through a resistor **26** to a voltage supply **28.** A resistor **30** grounds the noninverting terminal **32** of operational amplifier **20.**

A resistor **34** connects aperture element **16** to the cathode of a diode **36** that has its anode connected to filament **12.** Resistor **34** can be varied manually as shown. A resistor **38** connects the cathode of diode **36** to ground and a feedback resistor **40** connects the cathode of diode **36** to inverting terminal **24.** Feedback resistor **40** also can be variable manually if desired.

In operation, power source **14** heats filament **12** to the point where the filament produces electrons by thermionic emission. Some of these electrons pass through aperture **18** while others strike filament can **16** and flow back through resistor **34** to filament **12.** This electron flow establishes a base current in resistor **34,** and the voltage drop of that base current establishes a base potential difference between element **16** and filament **12.**

Operational amplifier **20** produces an auxiliary current in resistor **34** that either adds to or subtracts from the base current. The sum or difference of these currents establishes the instantaneous potential difference between aperture element **16** and filament **12.** This potential difference in turn determines both the quantity and, to a lesser extent the character, of electrons that pass through aperture **18** to form an electron beam.

Turning to FIG. **2,** the circuit shown therein differs from FIG. **1** by the elimination of resistor **38** and connection of the feedback resistor **40** directly to output terminal **22** of the operational amplifier. With a substantially constant voltage source **28,** the FIG. **2** circuit maintains a constant potential difference between filament **12** and element **16** despite considerable variations in the voltage applied to filament **12** by power source **14.**

In either the FIG. **1** or FIG. **2** system, the operational amplifier can be programmed to produce any desired beam variations. The entire system also can be operated at any desired voltage. Adapting the system to an electrostatic lens involves merely connecting resistor **34** across any two operative elements that operate at different electrical potentials so one of the elements in-

tercepts a portion of the electrons making up the electron beam.

Thus this invention provides a system for regulating the electron beam produced by an electron beam device. The system can maintain a constant beam intensity or it can vary the intensity over a wide band width.

I claim:

1. In an electron beam device of the type having an apertured electrode member and a source of electrons including an electron emitting filament and a power supply for this filament wherein the electron beam is comprised of electrons emitted by the source and which pass through the aperture of the electrode member, an electron beam regulating means comprising in combination:

means, including an independent power supply, for electrically biasing the apertured electrode member to a predetermined electrical potential with respect to the source of electrons; and

impedance means interconnecting the apertured electrode member and the filament for referencing to, but not otherwise directly affecting, the voltage of the filament, said means for biasing including negative feedback means for maintaining the apertured electrode member at said predetermined electrical potential.

2. The electron beam regulating means of claim **1** wherein the means for biasing further include an operational amplifier having an output terminal and an inverting input terminal said output terminal connected to the apertured electrode member and the independent power supply connected to said inverting input terminal, said negative feedback means interconnecting said inverting input terminal and said impedance means.

3. The electron beam regulating means for claim **2** wherein said feedback means interconnect the output of said operational amplifier with the inverting input.

4. The electron beam regulating means of claim **2** wherein said feedback means interconnect the inverting input of the operational amplifier with a point of said impedance means having a constant potential with respect to the filament.

5. The electron beam regulating means of claim **4** wherein said impedance means include a unidirectional current flow device having two electrodes with a first electrode connected to the filament and arranged to permit electron flow therethrough from the filament, said negative feedback means being connected to the other electrode of said unidirectional current flow device.

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