

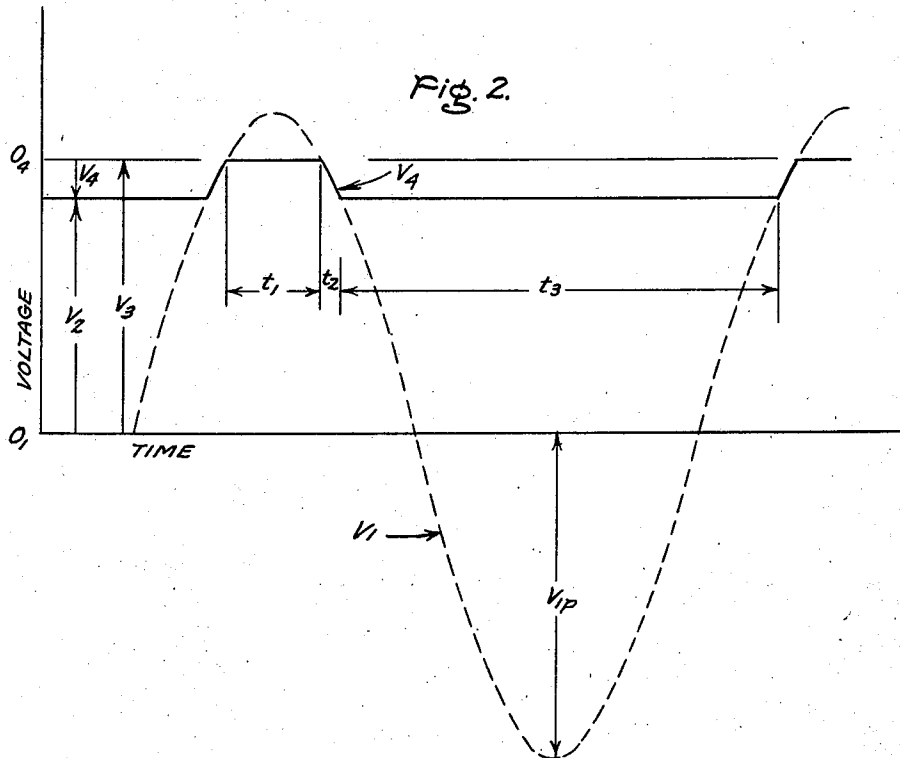
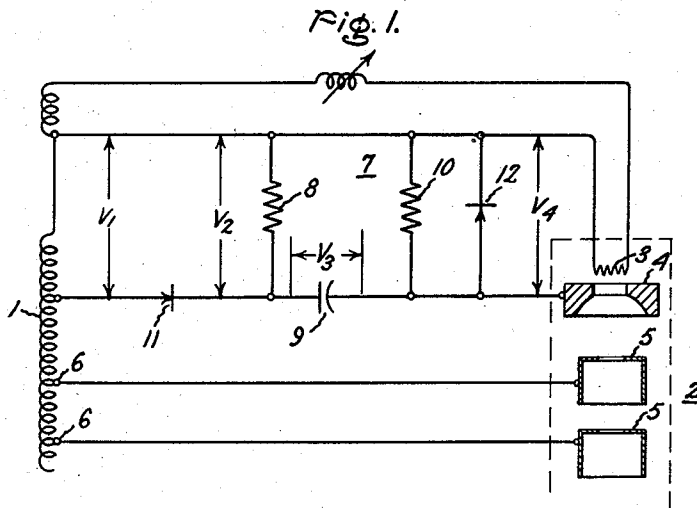
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BIAS FOR ELECTRON BEAM APPARATUS

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1

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BIAS FOR ELECTRON BEAM APPARATUS

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4 Claims. (Cl. 315-14)

This invention relates to a network for biasing electron beam apparatus and, more particularly, to such a bias network for producing a bias voltage having a wave form substantially unaffected by changes in the operating voltage range of the apparatus.

While this invention may take a variety of forms, it is ideally suited for biasing high energy electron beam apparatus of the resonance transformer type such as disclosed in my Patent 2,144,518, January 17, 1939, and in my copending application, Serial No. 518,199, filed June 27, 1955, now Patent No. 2,821,655, granted January 28, 1958, and assigned to the same assignee as this application.

In such apparatus, an electron gun provides high energy electrons in a directed beam in response to a sinusoidal applied voltage. Electrons from the gun pass through a focussing electrode and are then accelerated by successively higher potentials applied to a plurality of accelerating electrodes arrayed along the beam direction.

It is apparent that electrons accelerated from this form of equipment would have a wide range of energies including those associated with the relatively low-potential portions of the applied voltage and those associated with peak portions. Generally, the accelerating voltage has a substantially sine-wave form, and the electron energy distribution follows the same function. Such widely distributed electron velocities render focussing of the beam extremely difficult and detract from the efficiency of the apparatus since the lower energy electrons do no useful work and may result in deleterious heating effects.

My copending application, Serial No. 518,199, now Patent No. 2,821,655, referred to above, pertains to circuits for biasing electron beam apparatus to obtain a beam of electrons which is substantially mono-energetic. A peaked voltage having the proper phase, amplitude, and periodicity with respect to the accelerating voltage is applied as a bias to the control electrode so that electrons flow in the equipment only during a peak portion of the cycle of the applied accelerating voltage. This is especially advantageous in the case of X-ray equipment and in certain forms of high energy electron beam irradiation equipment. However, such a circuit employs a fixed reference for the bias voltage, a saturable core transformer. Since this reference is independent of the operating voltage, there must be provision for controls for the adjustment of bias angle and of phase whenever the operating voltage range is changed, as from 500,000 volts to 1,000,000 volts. It is apparent that simplification of operating adjustments would be desirable.

Therefore, it is an object of this invention to provide a circuit to produce a bias voltage for electron beam apparatus which circuit obviates bias adjustments when the operating voltage range of the apparatus is changed.

A further object of this invention is to provide a bias circuit for electron beam apparatus which produces a bias voltage having a wave form which is independent of operating voltage changes.

According to the illustrated embodiment of this invention, a network is provided for biasing resonance trans-

2

former electron beam apparatus. The bias voltage output is from a voltage divider circuit including a charged capacitor as a reference voltage source. Unidirectional conducting means serve to couple the voltage divider circuit with the resonant transformer and to vary the bias voltage in synchronism with the accelerating voltage supplied to the electron gun of the apparatus.

Features of this invention which are believed to be novel are pointed out with particularity in the appended claims. However, for a better understanding of the invention, together with further objects and advantages thereof, reference should be had to the following description taken in conjunction with the accompanying drawing, wherein:

Fig. 1 is a schematic diagram of a network embodying this invention as employed in conjunction with resonant transformer electron beam equipment; and

Fig. 2 illustrates wave forms useful in explaining the characteristics of the network of Fig. 1.

Referring particularly to Fig. 1, there is illustrated schematically at 1 a resonance transformer to supply the accelerating voltage for the electron gun 2. The gun comprises a continuously heated filament 3 providing a source of electrons, a control or focussing electrode 4, and accelerating electrodes 5. The accelerating potentials are supplied to the accelerating electrodes from successive taps 6 on the resonance transformer 1. The voltage supplied by the resonant transformer is cyclically varying, sinusoidal in form, so that in the absence of a biasing circuit, the electron beam would comprise electron energies varying from those associated with the low potential portions of the accelerating voltage to those associated with positive peak portions of the accelerating voltage. Biasing network 7 coupled to a portion of the resonant transformer provides the bias voltage for the control electrode 4.

The bias network comprises a series input circuit including an asymmetrically conducting device or rectifier 11 and a resistor 8 coupled across a portion of resonance transformer 1; a voltage divider circuit including resistor 8, capacitor 9 and resistor 10 for establishing a reference bias voltage; and a parallel output circuit including resistor 10 and a shunting rectifier 12 connected between the filament 3 and control electrode 4, to bias the control electrode 4 negatively with respect to the filament 3. A constant charge on the capacitor 9 provides a reference voltage for the biasing action.

During positive half-cycles of the transformer output with respect to the filament 3, rectifier 11 is conducting and after a few cycles a constant voltage will be developed on capacitor 9. This voltage on capacitor 9 causes a potential drop across resistance 10 which is applied to the control electrode as the biasing potential. Rectifier 12 in the output circuit of the network serves, when conducting, to shunt resistance 10 during positive peaks of the applied voltage from the resonance transformer, reducing the bias voltage and allowing electrons to flow in the beam from the electron gun.

The functions of the components of the biasing network 7 may be explained by means of the wave forms illustrated in Fig. 2. The input voltage V_1 from the resonant transformer with respect to the filament 3 is represented by the dashed sine wave with zero axis at O_1 . After a few cycles a voltage V_3 , nearly a constant and illustrated as a horizontal line, will be developed on capacitor 9. For purposes of illustration, the zero axis O_4 for the negative output voltage V_4 is drawn coincident with the representation of the voltage V_3 . The voltage across resistor 8 is shown as V_2 . It may be seen that $V_3 = V_2 + V_4$ since the voltage V_3 on the capacitor is shared by resistors 8 and 10 when neither rectifier is conducting.

During the time interval t_1 both rectifiers are conducting and the output voltage V_4 will be very low in magnitude and will be positive. The excess of the voltage V_1 over the capacitor voltage V_3 will be taken up by the potential drop across rectifier 11. During the interval t_2 the output voltage V_4 very nearly assumes the form of the input wave V_1 as illustrated by the displaced position of the zero axis O_4 for the output voltage. During time t_3 , both rectifiers block current flow and the output voltage V_4 equals very nearly $V_3 R_{10} / (R_8 + R_{10})$, where R_8 and R_{10} represent the resistances of resistors 8 and 10 respectively, the capacitor voltage being divided between these resistances.

It is apparent that the bias reference voltage V_3 is directly proportional to the amplitude of the input voltage V_1 and, therefore, a change in the operating voltage range can cause only a change in the amplitude scale of the output bias voltage V_4 . The output wave form does not depend upon the operating voltage range. Therefore, no adjustment of the biasing network parameters is required for operation of the electron beam apparatus at different accelerating voltage ranges.

While the present invention has been described by reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the invention. Therefore, it is the aim of the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A network for biasing electron beam apparatus having an electron gun to produce a beam of electrons and a source of cyclically varying voltage to accelerate electrons in the beam, said network comprising an asymmetrically conducting circuit coupled to said source and including a first resistor and a first rectifier in series to provide a positive voltage proportional to the accelerating voltage, a voltage divider circuit coupled to said asymmetrically conducting circuit and including said first resistor, a capacitor, and a second resistor in series to provide a reference bias voltage, and an asymmetrically conducting output circuit coupled to said voltage divider circuit and to said gun and including said second resistor and a second rectifier in parallel to apply a bias voltage to said gun in synchronism with said accelerating voltage having a wave form substantially independent of the magnitude of the accelerating voltage.

2. A network for biasing electron beam apparatus including an electron gun having an electron emitting electrode and a control electrode, and a resonant transformer

coil to provide a cyclically varying voltage to the apparatus for accelerating electrons from the gun, said network comprising a voltage divider circuit including a first resistor, a capacitor, and a second resistor, said second resistor being connected between the control electrode and the emitting electrode to supply a negative bias voltage to the control electrode, a charging circuit coupled across a portion of said coil and including in series said first resistor and a first asymmetrically conducting device to produce a charge on said capacitor, and a second asymmetrically conducting device shunting said second resistor and cooperating with said first device to vary said bias voltage in synchronism with the accelerating voltage provided by the resonant transformer coil, the wave form of said bias voltage being substantially independent of the operating voltage of said equipment to provide a beam of electrons having substantially uniform energy.

3. A circuit for producing a pulse output in response to each cycle of an input voltage, wherein the time of occurrence of each pulse in a cycle and the length of each pulse is independent of the magnitude of the input voltage, said circuit comprising: asymmetric means for rectifying said input voltage, means responsive to the output of said asymmetric means for producing a reference voltage in bucking relation thereto and of a magnitude proportional to said input voltage, voltage divider means for applying a portion of said reference voltage to the output of said circuit, and means responsive to said input voltage when it exceeds said reference voltage for applying a substantially short circuit across the output of said circuit.

4. A pulsing circuit comprising: first and second input terminals, first and second output terminals, a first rectifier and a capacitor joined in series between said first input terminal and said first output terminal, a second rectifier joined between said first and second output terminals and poled in the same direction as said first rectifier, a lead connected between said second input terminal and said second output terminal, and a resistor joined at one end to said lead and at the other end to the junction between said first rectifier and said capacitor.

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