This invention relates to a direct high voltage supply such as is required as a power source for the operation of Geiger-Mueller tubes, photomultiplier tubes, cathode ray tubes, electron and ion guns, high potential testing, and the like.

Direct high voltage supplies for purposes such as those just mentioned are desirably adjustable through a large range of output voltage. Control of the high voltage as such is difficult and in accordance with the present invention control of a blocking oscillator is effected to provide a continuous range of adjustment, for example from 300 to 2500 volts, or from 100 to 1200 volts, or the like, depending upon supply voltages, tube types, purpose, or the like.

A controllable voltage supply of this range may be provided in accordance with the invention in a small portable unit utilizing battery power supplies and miniature tubes.

Also in accordance with the invention there may be provided, somewhat more elaborately, close voltage regulation maintained at the top voltage limit to better than 0.5% with regard to load and to better than 0.01% with regard to supply.

The objects of the invention relate to the attainment of the results just indicated, and these and other objects relating to details of the apparatus will become apparent from the following description read in conjunction with the accompanying drawing in which:

Figure 1 is a wiring diagram showing a controllable and regulated power supply of the type described; and

Figure 2 is a wiring diagram of a simple portable battery-operated high voltage power supply provided in accordance with the invention.

Referring first to Figure 1, input terminals are indicated at 2 and 4, the latter being grounded. These input terminals may be connected to any low voltage filtered direct supply, for example providing an input of 350 volts D.C. The terminal 2 is directly connected to one terminal of a high inductance primary 6 of a transformer 8, the other terminal of which primary is connected to the anode of a pentode 10. This pentode may be of the beam type. The secondary of the transformer 8 has one terminal connected to ground and the other through condenser 14 to the control grid of the pentode 10, which grid is connected to ground through grid resistor 16. The condenser 14 and grid resistor 16 provide an RC circuit the purpose of which will be described.

The terminal 2 is connected through a suitable resistor 18 to the series arrangement of the voltage regulating tubes 20 and 22, the cathode of the latter being grounded. The anode of tube 20 is connected through a variable resistor 24 and a fixed resistor 26 to the screen of pentode 10, which screen is connected to ground through condenser 28.

Connected to the anode of pentode 10 is an arrangement of high voltage selenium or similar rectifiers shown at 30, which are in turn connected to the filter provided by condensers 32 and 34 and resistor 36, the output of the filter being connected across the resistor 38. The positive side of the filter is connected to the anode of a triode 40, the cathode of which is connected to the high voltage output terminal 42. A resistance 44 connects the cathode of triode 40 to the anode of a pentode 46, the anode of this pentode being connected at 48 to the grid of the triode 40. The screen of pentode 46 is connected by line 50 to the anode of voltage regulating tube 20, and the cathode of pentode 46 is connected through line 52 to the junction of the cathode of tube 20 and the anode of tube 22. A condenser 54 is connected between the cathode of pentode 46 and the negative output terminal of the high voltage filter and to the output ground terminal 56. An output condenser 58 is connected between terminals 42 and 56.

Also connected between these output terminals is a bleeder resistor string indicated generally at 60 and comprising, besides fixed resistors, the variable resistors 62 and 66, a potentiometer 64, and a meter 68 shunted by a variable resistor 70. The variable contact of potentiometer 64 is connected through resistor 72 to the control grid of pentode 46 and is also connected through a pair of condensers 74 to the positive output terminal 42.

The pentode 10, in association with the transformer 8 and the RC circuit 14, 16, provides a blocking oscillator which operates in the usual fashion, the plate current building up to a large value as an increasing positive voltage is fed to the control grid from the transformer secondary. As grid current starts to flow, the grid becomes positive with respect to the cathode, a charge is accumulated on condenser 14 which is negative on the grid side and builds up to a value sufficient to cut off the tube. The cut-off condition continues until the charge on condenser 14 leaks off through resistor 16 sufficiently to reduce the bias on the control grid so that tube conduction may again start. The tube is thus set into oscillation so that the plate current is in the form of a pulse, and inasmuch as the inductance of the transformer primary has a high value and a large plate current pulse flows, there is produced a correspondingly high voltage at the anode of pentode 10 which is fed to the rectifiers 30.

The use of a blocking oscillator in this general fashion to provide high output voltage is not new; but in accordance with the present invention the output voltage is controlled over a large range by control of the screen voltage through adjustment of resistor 24, or alternatively by control of feedback to the control grid, or by some other control of the gain of the system, as by control of the control grid bias.

To further improve the circuit, regulation of the output is provided. To this end the output from the anode of the pentode 10, following rectification by rectifiers 30, is filtered by the filter comprising the condensers 32 and 34 and resistor 36 and applied to the voltage regulating arrangement of triode 40 and pentode 46. The pentode controls current flow through the triode 40 and is itself regulated by connection of its cathode and screen across the regulator tube 20. A high degree of regulation is thus secured maintaining the high voltage output constant to considerably better than 1% throughout the entire voltage range, as previously indicated. The variable resistors 62 and 66 are for adjustment of the regulation and 70 is for calibration of the meter 68 which may be read in terms of the output voltage and may be calibrated against an accurate meter connected across the output terminals.

While the type of circuit illustrated in Figure 1 is desirable where there is desired not only a wide range of voltage control but close regulation, there may be provided where simplicity and portability are the major re-
requirements along with a wide range of control the simplified circuit shown in Figure 2 which may be supplied with voltage from batteries. A battery 76, for example, providing 90 volts may be connected to one terminal of the high inductance primary 78 of transformer 80, the other terminal of which primary is connected to the anode of a tube 82 which may be of miniature type having its filament heated by a low voltage battery 84. The secondary 86 of transformer 80 has one terminal connected to ground and its other terminal connected through condenser 88 to the control grid of pentode 82, the control grid being connected to ground through resistor 90 which, together with condenser 88, provides an RC circuit.

The screen of pentode 82 is connected to the positive terminal of battery 76 through a variable resistor 92 and to ground through condenser 94.

It will be clear from the description of Figure 2 that the elements so far mentioned constitute a blocking oscillator having the same characteristics of operation as that provided in Figure 1, control of the high voltage output appearing at the anode of pentode 82 being effected by control of the screen grid potential through variation of resistor 92. Alternatively, the feed back to the control grid may be controlled by connecting it to the variable contact of a potentiometer replacing the resistance 90.

The anode of pentode 82 is connected through a selenium or other suitable rectifier 96 to the simple filter arrangement comprising the condenser 98 and bleeder resistor 100 to which in turn are connected the output terminals 102 and 104, the latter being grounded. In uses such as those described only small currents are drawn and consequently it is unnecessary to provide more elaborate filtering. It has been found that using a miniature I.L.4 pentode at 82, a variation of output voltage may be secured from 100 volts to 1200 volts with no adjustment except that of resistor 92.

It will be clear that variations may be made in the circuits illustrated and described without departing from the invention as defined in the following claims.

What is claimed is:

1. A high voltage power supply comprising a blocking oscillator circuit including a thermionic tube having an anode, a cathode, a control grid and a screen grid, a transformer having a high inductance primary and providing coupling between the anode and control grid, means for adjusting the potential of the screen grid, and a voltage regulating circuit connected through rectifying means to the anode of said tube, said voltage regulating circuit comprising a thermionic tube having a control grid, the anode of which is connected to the anode of the first mentioned tube, an amplifier having its output connected to the control grid of the second mentioned tube, and means for controlling said amplifier.

2. A high voltage power supply comprising a blocking oscillator circuit including a thermionic tube having an anode, a cathode, a control grid and a screen grid, a source of positive potential for said anode, a transformer having a high inductance primary connected between said source and said anode, said transformer providing coupling between the anode and control grid, means for adjusting the potential of the screen grid, and a voltage regulating circuit connected through rectifying means to the anode of said tube, said voltage regulating circuit comprising a thermionic tube having a control grid, the anode of which is connected to the anode of the first mentioned tube, an amplifier having its output connected to the control grid of the second mentioned tube, and means for controlling said amplifier.

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