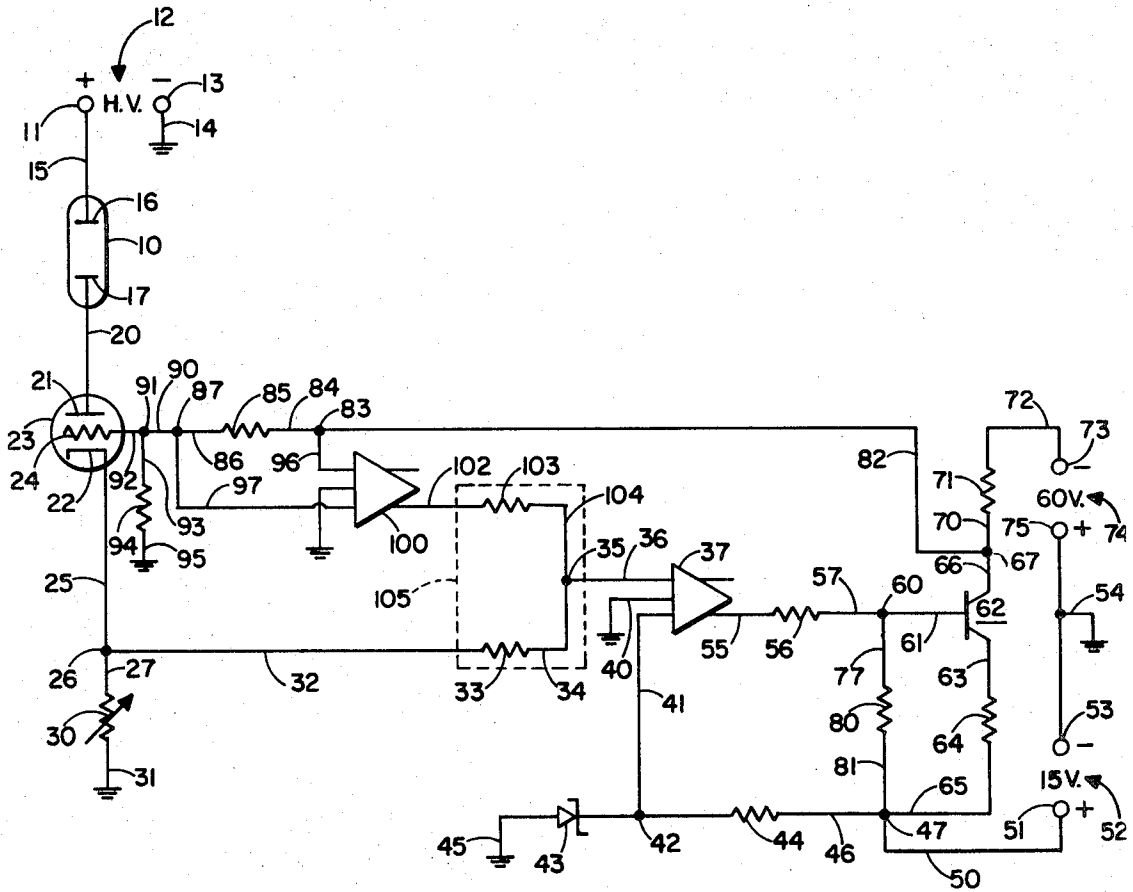


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REGULATION TUBE CONTROL APPARATUS WITH COMPENSATION
OF LOAD CURRENT AND GRID CURRENT
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2

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REGULATION TUBE CONTROL APPARATUS WITH COMPENSATION OF LOAD CURRENT AND GRID CURRENT

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3 Claims

ABSTRACT OF THE DISCLOSURE

An arrangement for regulating the current in a load of which the impedance may not be stable and may even become negative, by energizing the load in a series circuit with a regulating tube and a current sampling impedance, varying the grid voltage of the tube as the sampled current varies, and modifying the grid voltage to compensate for grid current in the sampling impedance.

This invention relates to the field of control apparatus, and more particularly to current regulating apparatus for use with such loads as the plasma tubes of gas lasers. In applications of this sort the regulator must compensate not only for changes in the supply voltage, but also for variations in the load itself: the impedances of such loads are notoriously unstable and may become negative as well. The problem is further complicated by the fact that these loads require terminal voltages in the range of one to 15 kilovolts, nearly two orders of magnitude higher than the range of known current regulators.

It is accordingly a primary object of the invention to provide improved control apparatus for maintaining constant the steady state current through a load of the nature described. More specifically, it is an object of the invention to provide apparatus for maintaining current constant in a series circuit regardless of variations and even of reversals in the impedance of a circuit element. Even more specifically, it is an object of the invention to provide such apparatus in which maximum dynamic range may be obtained by operating a control tube with its grid positive, while still maintaining a constant current through the load.

Various other objects, advantages, and features of novelty not individually enumerated above which comprise my invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and objects attained by its use, reference should be had to the drawing which forms a further part hereof, and to the accompanying descriptive matter, in which I have illustrated and described a preferred embodiment of my invention.

The single figure of the drawing is a circuit schematic for current regulating apparatus according to the invention.

In the drawing a load such as a gas laser plasma tube is indicated at 10, and is energized from the positive terminal 11 of a high voltage source 12 having its negative terminal 13 grounded at 14, the circuit being completed from terminal 11 through conductor 15, electrodes 16 and 17 of tube 10, conductor 20, the anode 21 and cathode 22 of an electron discharge device 23 having a control grid 24, conductor 25, a junction point 26, conductor 27, a variable current sampling resistor 30, and ground connections 31 and 14. Junction point 27 is connected through conductor 32, an isolating resistor 33, conductor 34, a junction point 35, and conductor 36 to one

input terminal of a differential amplifier having a ground connection 40 and a further input terminal connected by conductor 41 to a junction point 42 between the cathode of a Zener reference diode 43 and a resistor 44. The anode of diode 43 is grounded at 45, and resistor 44 is connected through conductor 46, a junction point 47, and conductor 50 to the positive terminal 51 of a 15-volt power supply 52 having its negative terminal 53 grounded at 54. Elements 42-54 act as a source of standard voltage for amplifier 37, which supplies a signal through conductor 55, a resistor 56, conductor 57, a junction point 60, and conductor 61 to the base of a transistor 62 having an emitter connected to terminal 51 through conductor 63, resistor 64, conductor 65, junction point 47, and conductor 50, and a collector connected through conductor 66, a junction point 67, conductor 70, a resistor 71, and conductor 72 to the negative terminal 73 of a 60-volt power source 74 having its positive terminal 75 grounded at 54. Junction point 60 is connected to positive terminal 51 through conductor 77, a resistor 80, conductor 81, a junction point 47, and conductor 50. Junction point 67 is connected through conductor 82, a junction point 83, conductor 84, a resistor 85, conductor 86, a junction point 87, conductor 90, a junction point 91, and connector 92 to the grid of device 23. Junction point 91 is grounded through conductor 93, a resistor 94, and ground connection 95.

In operation, a voltage drop develops across resistor 30 which is determined by the current flowing through the resistor, and this voltage is compared in amplifier 37 with the standard voltage at junction point 42. Any difference between these voltages results in an output at 55 which energizes transistor 62, adjusting the voltage on grid 23 to restore the current through resistor 30, and hence that through load 10, to its standard value. Variation in the resistance of member 30 varies the value of current therethrough at which the inputs to amplifier 37 become equal.

It will be evident that the grid bias for device 23 is derived from junction point 67, and is determined, in the absence of a signal on the base of transistor 62, by the voltages at 52 and 74 and the resistances 64 and 71. I prefer to select these parameters so that device 23 normally operates in the positive grid regime, but such operation results in grid current which flows in resistor 30 in addition to the load current, and thus introduces an artifact into the signal supplied through resistor 33 to amplifier 37, preventing the apparatus from truly holding the plasma tube current constant. I contemplate correcting this deficiency by connecting junction points 83 and 87 through conductors 96 and 97 to the input terminals of a further differential amplifier 100 having a ground connection 101 and supplying an output through conductor 102, and isolating resistor 103, conductor 104, junction point 35, and conductor 36 to amplifier 37. Since the voltage drop across resistor 85 is a measure of the grid current, the output of amplifier 100 may be made to combine, in a summer 105 made up of resistors 103 and 33, with the output from resistor 30 to give a resultant signal at 36 which is independent of grid current and hence truly represents the plasma tube current to be regulated.

The foregoing description and the drawing are illustrative of my invention, which I claim as follows:

1. Apparatus for regulating the flow of current in a load of which the impedance may not be stable and may even become negative, comprising, in combination:

an electron discharge device having a pair of principal electrodes and a control grid;

means for connecting said device and said load in a series circuit across a source of electrical energy;

means for varying the control effect of said grid in

3

accordance with the current flowing between said principal electrodes;
a sampling impedance connected in series with said grid to give a signal representative of the grid current in said device; and
means modifying said control effect in accordance with said signal.

2. Apparatus according to claim 1 in which the second named means comprises a second sampling impedance in the cathode circuit of said discharge device for developing a voltage representative of the cathode current of said device, a source of standard voltage, and means supplying an output signal to said grid in accordance with the relation between said voltages.

3. Apparatus according to claim 1 in which the second named means comprises a second sampling impedance in the cathode circuit of said discharge device for developing a signal representative of the cathode current of

4

said device, and in which the last named means comprises means combining the voltages across said sampling impedances for comparison with a standard signal.

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