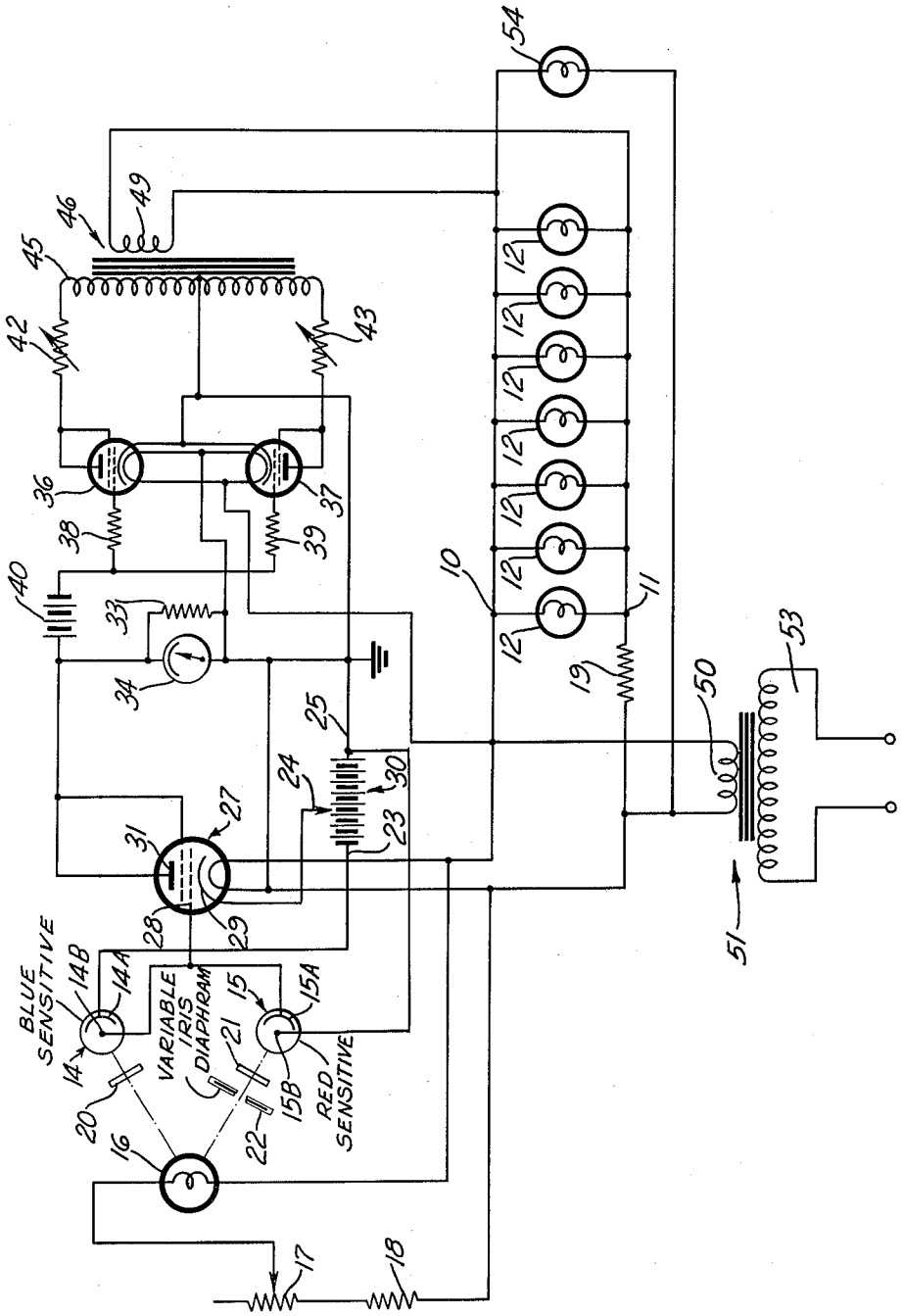
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PHOTOELECTRIC VOLTAGE REGULATOR

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PHOTOELECTRIC VOLTAGE REGULATOR

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The present invention relates to an improved regulating system and in particular to a voltage regulator for maintaining voltages substantially constant.

While different means, as will appear, may be used to carry out the inventive concepts disclosed and taught by the present disclosure, in general the present invention contemplates the use of a pair of photoelectric cells, each more sensitive to different colors, for maintaining a voltage at a substantially constant value within very close tolerance.

In the peach sorting apparatus disclosed and claimed in my copending patent application, Serial No. 80,865, filed March 11, 1949, and assigned to the same assignee as the present invention, in which an incandescent lamp is used to illuminate an object scanned by two photoelectric cells each more sensitive to different spectral distributions of light, it is necessary to maintain the voltage applied to such incandescent lamp constant within a very close tolerance. It has been my experience that the prior art voltage regulators are incapable of achieving this necessity. For example, there are many types of voltage regulators on the market today using gas discharge tubes, saturated cores or other expedients, which, although good for the purposes intended, are incapable of controlling a voltage within the close tolerances required. Of the prior art arrangements, perhaps by far the most efficient is one which employs a standard cell as a reference voltage, but this arrangement is quite expensive and large variations in regulated voltage occur in the event that precautions are not taken to maintain the temperature of the standard cell at a constant value.

It is therefore an object of the present invention to provide an improved regulating system of this type characterized by the fact that it is capable of maintaining a voltage value within a relatively small tolerance, such as, for example, required in the peach sorting apparatus described in my above mentioned copending application.

A specific object of the present invention is to provide an improved voltage regulator characterized by its simplicity and inexpensiveness.

Another specific object of the present invention is to provide an improved voltage regulator which utilizes an exceedingly steady reference voltage and effects regulation of an output voltage within very close tolerances and with substantially no drift.

Another specific object of the present invention is to provide an improved voltage regulator in which the regulating action is sensitive to exceedingly small changes in the voltage being regulated.

Another specific object of the present invention is to provide an improved regulating system of this character which functions either with alternating current, or with continuous or direct current.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

The single figure is a schematic representation of apparatus embodying features of the present invention.

In general, the purpose of the apparatus shown herein is to produce a constant regulated voltage between the conductors 10, 11 to which opposite terminals of incandescent lamps 12 are connected. These lamps 12 are utilized to illuminate peach halves to effect their separation in accordance with their particular color, i. e., ripeness, in the manner described in my above mentioned copending patent application, Serial No. 80,865. These incandescent lamps or light sources 12 may, of course, be used for many other different purposes.

In general, as is described in greater detail hereinafter, the voltage across light sources 12, supplied with current from the secondary transformer winding 50, is regulated by automatically increasing or decreasing, as the case may be, the flow of an auxiliary current component through series regulating resistance 19, to thereby control the voltage drop across resistance 19. Such auxiliary current component flows to the primary winding 49 which energizes an energy absorbing circuit which includes the variable resistances 42, 43 as components thereof.

The arrangement includes two photoelectric cells or photo tubes 14, 15, each being sensitive to different spectral distributions of light emitted from the incandescent light source 16. Thus, the photo tube 14 is predominantly more sensitive to the blue light emitted by the source 16, whereas the other photo tube 15 is predominantly more sensitive to the red light emitted by the source 16.

The light source 16 has its opposite terminals connected to the secondary winding 50 through the adjustable resistance 17 and serially connected resistance 18. The character or spectral distribution of the light emitted from the source 16 is dependent on the magnitude of the voltage applied thereto. This is a common well known characteristic of a conventional incandescent lamp. For example, when the applied voltage is low, the light emitted is predominantly more red than when the voltage applied is higher. Conversely, when the voltage applied to the light source 16 is relatively high, its filament is heated to a greater extent to cause the emission of light which is more blue than when the applied voltage is low.

Thus, assuming that the voltage between conductors 10, 11 tends to decrease, the output current components of both the red sensitive cell 15 and the blue sensitive cell 14 decreases; however, the output current component of the blue sensitive cell decreases a greater amount than the decrease in the output current component of the red sensitive cell, thus providing a differential control effect, this differential control effect being in accordance with the difference between changes in the red and blue sensitive cell output current components stimulated by the light falling thereon. Conversely, assuming that the voltage between the conductors 10, 11 tends to increase, the output current component of the blue sensitive tube increases to a greater extent than the simultaneous increase in output current of the red sensitive tube.

The photo tubes 14, 15 may inherently have the aforementioned characteristics or they may be identical tubes with a blue filter 20 in front of the photo tube 14 and a red filter 21 in front of the photo tube 15. Also, an iris diaphragm 22 may be used to control the amount of light falling onto the filter 21. Preferably, the tubes 14, 15 are each inherently more sensitive to different spectral distributions of light energy and the associated blue and red filters 20, 21, respectively, are used to impart a greater sensitivity in operation of the arrangement. For example, the photo tube 15 may be a type 919 photo tube, whereas the blue sensitive photo tube 14 may be a type 935 photo tube.

It is observed that the photo tubes 14, 15 are connected in an essentially balanced bridge circuit which includes in a first arm thereof the photo tube 15, in the second arm thereof the photo tube 14, in the third arm thereof the battery included between lead 23 and variable tap 24, and in the fourth arm thereof the battery included between the variable tap 24 and the lead 25. This substantially balanced or bridge circuit includes a "galvanometer arm" which comprises the grid-cathode of the electrometer tube 27. Specifically, the photo tubes 14, 15 are serially connected, i. e., the cathode 15A of tube 15 is connected directly to the anode 14B of the photo tube 14, and their junction point is connected to the control grid 28 of the tube 27. The cathode 29 of the electrometer tube 27 is connected to the variable tap 24 on the voltage source comprising the battery 30, which has its negative terminal connected to the cathode 14A of the photo tube 14, and its positive terminal connected to the anode 15B of photo tube 15, such positive terminal being also grounded.

Preferably, the bridge circuit thus far described is initially adjusted by first suitably positioning the variable tap 24 and then controlling the amount of light impinging on the photo tube 15 by varying the opening in the variable iris diaphragm 22. It is observed that essentially the same current flows through the photo tubes 14, 15, since they are serially connected (assuming no grid current in tube 27), but as mentioned hereinabove, the resistances of the tubes 14, 15 change in accordance with spectral distributions of light energy emitted from the light source 16, to thereby in turn produce corresponding voltage variations in the "galvanometer arm" of the bridge which includes the grid 28 and cathode 29 of the electrometer tube 27. These voltage variations applied between the grid 28 and cathode 29, respectively, are amplified in electrometer tube 27 and appear in amplified form on the anode 31. The anode 31 and its associated screen grid are connected through the load resistance 33 to the positive terminal of source 30, with a volt meter 34 connected across the terminals of resistance 33 for purposes of indicating the unbalanced condition of the aforementioned bridge circuit, i. e., for indicating the voltage applied across the terminals of the light source 16.

The amplified voltages appearing on the anode 31 may be applied to different utilization networks, and the one described with particularity hereinafter is merely exemplary of others which may be used to accomplish the same purpose.

For example, the plate or load resistance 33 may take the form of a polarized relay connected to actuate a field rheostat associated with a direct current generator to maintain its output voltage constant. Specifically, the amplified voltage appearing on the load resistance 33 is applied to the control grids of the tubes 36, 37. The cathodes of tubes 36, 37 are grounded and the control grids of these tubes 36, 37 are connected respectively through resistances 38 and 39 to the negative terminal of the bias battery 40, which has its positive terminal connected to the anode 31. Thus, the net voltage appearing across the serially connected load resistance 33 and battery 40 is applied to the control grids of tubes 36, 37. The anodes of tubes 36, 37, as well as their associated screen electrodes, are connected through variable resistances 42, 43 to the outside terminals of the secondary center tapped winding 45 of the transformer 46, the center tap on the winding 45 being connected to the cathodes of tubes 36 and 27 as well as to ground. The primary winding 49 of transformer 46 has its opposite terminals connected to the conductors 10 and 11. The tubes 36, 37 serve essentially as rectifier tubes and are productive of different amounts of current flow in the resistances 42, 43, depending upon the intensity of the voltage applied to the control grids of tubes 36, 37. Thus, assuming tubes 36, 37 draw relatively large current in the primary

winding 49, in response to a relatively high voltage applied to the control grids of devices 36, 37, the current thus supplied to the primary winding 49 passes through the series regulating resistance 19 to, in turn, cause a diminution in voltage between the conductors 10 and 11. More specifically, it is noted that the lower terminal of winding 49 is connected through lead 10 to one terminal of the secondary winding 50 of the transformer 51, while the other upper terminal of primary winding 49 is connected through lead 11 and series regulating resistance 19 to the other terminal of the secondary winding 50. The transformer 51 has the primary winding 53. A pilot light 54 or volt meter may be connected across the terminals of the secondary winding 50.

In operation, assuming that the voltage across secondary winding 50 is increased, the tendency then is for the voltage across the light sources 12 to likewise increase, but this tendency is counteracted by an increased current flow through the voltage dropping resistance 19, as demonstrated hereinafter. In response to this assumed increase in voltage across secondary winding 50, the filament of light source 16 is heated additionally to cause the amount of blue light emitted thereby to increase in proportion to the red light.

Accordingly, the control grid 28 becomes more negative with respect to its cathode 29. Consequently, the voltage drop across the load resistance 33 is decreased, and as a result thereof the control grids of tubes 36, 37 become more positive, thereby causing a greater current flow through the primary winding 49 and resistance 19. The resulting increase in voltage drop across resistance 19 thus produces a compensatory effect for the increase in voltage across the winding 50. Thus the voltage across the lamps 12 is maintained substantially constant within very close tolerance.

Preferably, for increased life and decreased aging, the lamp 16 is energized with voltage smaller than its rated voltage. Consequently, the light emitted from the lamp 16 is normally predominantly on the red side, hence, the use of the diaphragm in front of the photo tube 15. For example, the secondary winding 50 may deliver a voltage of 6.3 volts, and the lamps 12 rated at 6.3 volts are operated at 5 volts because of the voltage drop across resistance 19.

It is noted that the blue tube 14 forms a "grid leak" for the control grid 28, a conventional grid leak being omitted for purposes of increased sensitivity.

The adjustment of the resistances 42 and 43 is somewhat critical since if the resistances 42, 43 are too low the voltage across lamps 12 is overcorrected. However, once adjusted, the resistances 42 and 43 need not be changed.

It has been observed that photoelectric emission from the tubes 14, 15 in response to changes in light intensity has proven to be substantially linear and substantially unaffected by temperature changes occurring in a wide range. Preferably, the filament voltage applied to the electrometer tube 27 is below its rated voltage, for purposes of stability and increased life. The voltages on the photoelectric cells 14, 15 are maintained at approximately 22½ volts, well above that necessary to collect all electrons emitted and well below the maximum of 200 volts prescribed for these tubes.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In a voltage regulating system of the character described for maintaining a voltage substantially constant across a utilization device, a first unregulated voltage source connected to said utilization device, an incandes-

cent lamp connected to said first voltage source for developing light which varies in color with change in voltage of said source, a pair of photo tubes each more sensitive to different spectral distributions of light energy emitted from said lamp and energized thereby, each of said photo tubes having an anode and a cathode, a second direct current source, said photo tubes being serially connected with said second source with the anode of one tube connected at a junction point to the cathode of the other tube, and with the positive terminal of said direct current source connected to the anode of said other tube, the negative terminal of said direct current source being connected to the cathode of said one tube, a regulating resistance, said regulating resistance and utilization device being serially connected with said unregulated voltage source, an auxiliary load circuit, said load circuit and regulating resistance being serially connected with said unregulated voltage source, an electron tube having an anode and a control grid connected to said junction point of said serially connected photo tubes with the cathode of said electron tube being connected to a point on said second source, said electron tube having a continuously variable plate to cathode conductance with said conductance changing in accordance with minute changes of voltage of said first voltage source, and means coupled to the anode of said tube and controlling said load circuit in accordance with voltage variations on said control grid to maintain the voltage across said utilization device substantially constant.

2. In a voltage regulating system of the character described for maintaining a voltage substantially constant across an output circuit, a first voltage source subject to fluctuations and connected to said output circuit, a lamp connected to and energized by said voltage source for developing light which varies in color with change in voltage of said source, a pair of photo tubes each more sensitive to different spectral distributions of light energy emitted from said lamp, each of said photo tubes having a cathode and an anode, a second voltage direct current source, said photo tubes being serially connected with said second source with the anode of one tube connected at a junction point to the cathode of the other tube, and with the positive terminal of said second source connected to the anode of said other tube, the negative terminal of said second source being connected to the cathode of said one tube, an electron discharge device having an anode and having a control element connected to said junction point of said serially connected photo tubes with the cathode of said discharge device connected to a point on said second source, said discharge device having a continuously variable plate to cathode conductance with said conductance changing in accordance with minute changes of voltage of said first voltage source, an output circuit connected to said first source, and means coupled to the anode of said discharge device and controlled by said discharge device for maintaining the voltage across said output circuit substantially independent of said fluctuations.

3. In a regulating system of the character described, a voltage source subject to voltage fluctuations, a lamp connected to and energized by said voltage source for developing light which varies in color with change in voltage of said source, a pair of photo tubes energized by said lamp and each more sensitive to different spectral distributions of light energy emitted by said lamp, a second direct current voltage source having an intermediate tap thereon, said second source and said photo tubes being serially connected, with the anode of one of said photo tubes connected at a junction point to the cathode of the other photo tube, and with the negative terminal of said second voltage source connected to the cathode of said one photo tube and with the positive terminal of said second voltage source connected to the anode of said other photo tube, an electron discharge device having a cathode, a control grid and an anode, said control grid being connected to said junction point of said photo tubes, said cathode being connected to said intermediate tap on said second voltage source, a utilization device, a regulating resistance, said utilization device and regulating resistance being serially connected with the first-mentioned voltage source, a variable load circuit, said variable load circuit being serially connected with said regulating resistance to the first-mentioned voltage source, and means connecting said anode of said discharge device to said variable load circuit to control the same in response to voltages on said control grid.

4. In a voltage regulating system of the character described for maintaining the voltage across an output circuit substantially constant, a first voltage source subject to fluctuations, an output circuit, means connecting said voltage source to said output circuit, a light source connected to and energized by said voltage source for developing light which changes in color in accordance with the voltage of said source, a pair of photo tubes energized by said light source and each more sensitive to different spectral distributions of light energy emitted by said light source, a second direct current source, said photo tubes being serially connected with said second source and with the anode of one connected at a junction point to the cathode of the other, the positive terminal of said second source being connected to the anode of said other photo tube, and the negative terminal of said second source being connected to the cathode of said one photo tube, an electron discharge device having an anode and having a control electrode thereof connected to said junction point of said pair of photo tubes and with the cathode of said device connected to a point on said second source, said discharge device having a continuously variable plate to cathode conductance with said conductance changing in accordance with minute changes of voltage of said first voltage source, and means coupled to said anode and automatically controlling said connecting means in accordance with voltage variations on said control electrode to render said output circuit substantially free from said fluctuations and to maintain the voltage across said output circuit substantially constant.

5. In a regulating system of the character described, a voltage source subject to fluctuations, a utilization device, an impedance, said utilization device and impedance being serially connected with said voltage source, a transformer having its primary winding serially connected with said impedance and said voltage source, electron discharge means having an anode, a cathode and a control electrode, the secondary winding of said transformer being connected between said anode and said cathode, a light source connected to and energized by said voltage source, a pair of photo tubes energized by said light source and each being more sensitive to different spectral distributions of light energy from said light source, said photo tubes being serially connected with the anode of one connected at a junction point to the cathode of the other, second electron discharge means including a second anode, a second cathode and a second control grid, said second control grid being connected to said junction point of said photo tubes, a second direct current voltage source having an intermediate tap, the positive terminal of said second voltage source being connected to the anode of said other photo tube and the negative terminal of said second voltage source being connected to the cathode of said one photo tube, a load resistance connected between said second anode and said positive terminal of said second voltage source, the first-mentioned cathode being connected to said positive terminal of said second voltage source, a third direct current voltage source having its positive terminal connected to said second anode and its negative terminal connected to the first-mentioned control electrode.

6. In a regulating system of the character described, a first voltage source subject to fluctuations, a light source connected to and energized by said voltage source with said fluctuations producing different spectral distributions of light emitted by said light source, a pair of photo-

tubes energized by said light source and each more sensitive to said different spectral distributions of light emitted by said light source, and an electron discharge device having a cathode, a control electrode and an anode, said photo tubes being serially connected with the anode of one photo tube connected to the cathode of the other photo tube, said control electrode being connected to said anode of said one photo tube, a second direct current voltage source having an intermediate tap, said cathode of said discharge device being connected to said intermediate tap, a negative terminal of said second voltage source being connected to the cathode of said one photo tube, the positive terminal of said second voltage source being connected to the anode of said other photo tube, said discharge device having a continuously variable plate to cathode conductance with said conductance changing in accordance with minute changes in voltage of said first voltage source, an output circuit, means connecting said output circuit to the first-mentioned voltage source, and means connected to said anode of said electron discharge device and controlling said connecting means in accordance with voltage variations on said control electrode to render said output circuit substantially free from said voltage fluctuations.

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